THE SCOPE FOR THE APPLICATION OF CONTINUOUS IMPROVEMENT TO THE PROCESS OF NEW PRODUCT DEVELOPMENT

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Abstract

This is an investigation into the scope for applying continuous improvement (CI) to the process of new product development (NPD). The thesis makes two main contributions to knowledge. Firstly, it brings together the fields of continuous improvement of processes and NPD, which both have their own literature and research activity but have hitherto remained somewhat separated from each other. Secondly, it develops and tests an analytical model to support the implementation of CI within NPD.

Continuous improvement is described in terms of the CI Capability Model which views CI as a set of generic behaviours that appear to be essential for long-term success with CI. These behaviours develop over time and may be encouraged by a wide range of enabling mechanisms, or enablers, which take many forms and vary between firms. The thesis demonstrates the extension of the CI behaviours to a product development setting, proposing how each CI behaviour might appear within the context of NPD processes and highlighting aspects of 'good practice' NPD which have particular relevance for CI. Real-world examples of CI behaviours and enablers found within NPD processes are provided by the field work, the most important source being a case study carried out in an international telecommunications firm.

The results from detailed company case studies, together with the findings of two workshops and a postal survey, are combined in a discussion of key issues in the application of CI to the NPD process. The thesis concludes that the application of CI to NPD is appropriate both in theory and in practice, though firms may experience difficulties turning theory into reality. Nevertheless, the evidence suggests that the scope for applying CI within NPD is broad, in that CI can be applied to development processes in a wide variety of firms, regardless of size, industry sector, technology, and type of product, although there may be some areas where limits are found. The research supports the generic aspect of the CI Capability Model and, at a practical level, certain enablers are identified that not only encourage CI behaviour but could help to institutionalise it. There appear to be factors or characteristics which work in favour of CI in NPD and others which work against it. Finally INCIDE, a diagnostic tool designed to guide semi-structured interviews with NPD personnel, is shown to be a useful instrument for collecting data to be analysed against the framework of the CI Capability Model, but with some limitations as an assessment or evaluative tool.
Contents

List of Tables ................................................................................................. 9
List of Figures ............................................................................................... 11
Preface and Acknowledgements .................................................................. 12
Author's Declaration ................................................................................... 14
Chapter 1 Introduction ................................................................................ 15
1.1 Introduction ........................................................................................... 15
1.2 The current context for new product development .............................. 16
  1.2.1 The need to improve new product development processes .......... 17
  1.2.2 Institutionalising the concept of improvement within new product development .................................................. 17
  1.2.3 Attempts by companies to improve new product development processes .................................................. 19
  1.2.4 The need for research .................................................................. 20
1.3 The research questions .......................................................................... 21
1.4 Overview of dissertation structure ....................................................... 23
Chapter 2 Continuous Improvement ............................................................. 26
  2.1 Introduction ......................................................................................... 26
  2.2 Definition of continuous improvement ............................................... 27
  2.3 History of continuous improvement ................................................... 27
  2.4 The early CIRCA gear model 1992-4 .................................................. 29
    2.4.1 Background ................................................................................ 29
    2.4.2 The model content .................................................................... 30
    2.4.3 Limitations of the gear model .................................................... 32
      Contingent aspects of CI ................................................................. 32
      How to embed CI deeply in an organisation .................................. 33
      Appropriate structures for implementing and evolving CI .......... 33
      Conclusion ..................................................................................... 35
  2.5 Re-evaluation ...................................................................................... 35
    2.5.1 Capabilities and competencies ................................................... 35
    2.5.2 Organisational learning ............................................................ 37
    2.5.3 Routines and behaviours .......................................................... 39
    2.5.4 Contingency ............................................................................. 40
    2.5.5 Development of CI over time ................................................... 40
    2.5.6 Summary .................................................................................. 41
  2.6 The CI Capability Model ...................................................................... 41
    2.6.1 Overview ................................................................................... 41
      Core abilities and key behaviours ............................................... 41
      Enablers ......................................................................................... 43
      Conclusion ..................................................................................... 45
    2.6.2 The model in detail: core abilities, key behaviours, and enablers .. 45
    2.6.3 Development of CI capability over time ................................... 60
      Moving between levels .................................................................. 61
Chapter 3 Current State of Knowledge in the Area of New Product Development

3.1 Introduction .................................................................................................................. 64
3.2 New product development ............................................................................................ 64
3.3 Review of NPD process models and approaches ......................................................... 65
3.4 Current 'good practice' within NPD ............................................................................ 73
  3.4.1 Process view .............................................................................................................. 75
  3.4.2 Strategic approach ................................................................................................... 75
  3.4.3 Interfirm integration ................................................................................................. 77
  3.4.4 Organisational style and control ............................................................................. 78
  3.4.5 Flexibility ............................................................................................................... 78
  3.4.6 Learning ................................................................................................................. 78
  3.4.7 Top management .................................................................................................... 79
  3.4.8 Supportive management style ................................................................................ 80
  3.4.9 Roles ....................................................................................................................... 80
  3.4.10 Shared values within an innovative culture ........................................................... 81
  3.4.11 Structures ............................................................................................................. 81
  3.4.12 Integration ............................................................................................................ 82
  3.4.13 Parallel approach .................................................................................................. 84
  3.4.14 Effective communication and information evaluation ......................................... 85
  3.4.15 Tools and methods ............................................................................................... 87
    Quality Function Deployment (QFD) ............................................................................. 87
    Design for Manufacturability (DFM) ........................................................................... 87
    Design of Experiments ................................................................................................. 88
    Computer-based tools .................................................................................................. 88
    Prototypes ..................................................................................................................... 88
    Target cost management (TCM) .................................................................................. 89
    Summary ...................................................................................................................... 89
  3.4.16 Product design strategies ....................................................................................... 89
  3.4.17 'Lean' product development .................................................................................. 90
  3.4.18 Summary .............................................................................................................. 90
3.5 Learning, process improvement and quality management ........................................... 91
  3.5.1 Learning ............................................................................................................... 91
  3.5.2 Process improvement .............................................................................................. 93
  3.5.3 Quality management practices .............................................................................. 95
3.6 NPD processes in the future ....................................................................................... 96
3.7 Conclusion ................................................................................................................... 97

Chapter 4 A Framework for Evaluating CI in NPD ......................................................... 99
4.1 Introduction ................................................................................................................. 99
4.2 Extending CI to NPD .................................................................................................. 99
4.3 The CI Capability Model from an NPD perspective ................................................... 101
  4.3.1 CI behaviours and enablers within NPD ................................................................. 103
Summary .................................................................................. 117
4.3.2 Maturity models in NPD ......................................................... 117
4.4 INCIDE – a tool for investigating Cl in NPD ............................... 121
4.4.1 The CI RCA mapping tool ....................................................... 121
4.4.2 Considerations governing the design of INCIDE, a tool to investigate Cl within NPD processes .......................................................... 123
  Purpose .................................................................................. 123
  Scope .................................................................................. 123
  Unit of analysis .................................................................. 123
  Interviewees ..................................................................... 124
4.4.3 INCIDE ........................................................................... 124
4.5 Conclusion .......................................................................... 126
Chapter 5 Research Methodology ..................................................... 128
5.1 Introduction ....................................................................... 128
5.2 Research philosophy ............................................................. 128
5.3 Research strategy ................................................................ 129
  5.3.1 Original plan ................................................................ 129
  5.3.2 Adoption of multi-methods approach ............................... 130
  5.3.3 Overview of methods used ............................................. 131
5.4 Practical details of the methods used ........................................... 134
  5.4.1 Preliminary interviews ...................................................... 134
     Crendon Group Ltd.............................................................. 135
     IBM .............................................................................. 135
  5.4.2 Workshops ................................................................... 136
  5.4.3 Survey ......................................................................... 136
  5.4.4 Company cases ............................................................. 138
     TM Products ................................................................ 139
     Ericsson Ltd. ................................................................ 140
5.5 Critical review of the methodology ............................................... 141
  5.5.1 Workshop discussions ...................................................... 141
  5.5.2 Survey ......................................................................... 141
     Internal validity ................................................................ 141
     External validity .............................................................. 142
     Reliability .................................................................... 143
  5.5.3 Company cases based on detailed interviews ....................... 144
  5.5.4 Triangulation ................................................................. 144
5.6 Conclusion .......................................................................... 145
Chapter 6 Research Findings ............................................................. 146
6.1 Introduction ....................................................................... 146
6.2 Preliminary interviews ............................................................. 146
  6.2.1 Crendon ................................................................. 146
  6.2.2 IBM ......................................................................... 150
  6.2.3 Implications for the research ........................................ 151
6.3 Workshop sessions .................................................................................. 152
   6.3.1 Workshop findings ............................................................................. 153
   6.3.2 Implications for the research ............................................................... 155
      Implications for research process ............................................................. 155
      Implications for research content ............................................................. 156

6.4 Survey ..................................................................................................... 156
   6.4.1 Survey results ..................................................................................... 156
   6.4.2 Implications for the research ............................................................... 159
      Implications for research process ............................................................. 159
      Implications for research content ............................................................. 160

6.5 Company cases ....................................................................................... 160
   6.5.1 TM Products ..................................................................................... 161
      Background ............................................................................................. 161
      NPD process and organisation ................................................................. 162
      Improvement of the NPD process ............................................................ 164
      Analysis .................................................................................................... 164
      Summary ................................................................................................. 175
   6.5.2 Ericsson .............................................................................................. 176
      Background ............................................................................................. 176
      NPD processes and organisation ............................................................. 177
      Improvement of the NPD process ............................................................ 178
      Analysis .................................................................................................... 179
      Summary ................................................................................................. 193
   6.5.3 Implications for the research ............................................................... 193
      Implications for research process ............................................................. 193
      Implications for research content ............................................................. 194

6.6 Conclusion .............................................................................................. 194

Chapter 7  The Application of CI to the Process of NPD ..................................... 195
7.1 Introduction ............................................................................................. 195
7.2 Is CI an appropriate concept for NPD? ..................................................... 199
7.3 Is it practicable to apply CI to the process of NPD? ................................. 202
   7.3.1 Do we see evidence of companies applying CI to the NPD process? ... 203
   7.3.2 If firms are applying CI to NPD, do they benefit from doing so? ........ 205
   7.3.3 Conclusion ......................................................................................... 206
7.4 How wide is the scope for CI within the NPD context? ............................. 206
   7.4.1 What is the possible range of application for CI within NPD? ............. 206
   7.4.2 Are there any limits to the application of CI within NPD? ................. 210
   7.4.3 Further research ................................................................................ 211
   7.4.4 Conclusion ......................................................................................... 212
7.5 Are there any factors peculiar to NPD which facilitate or impede the implementation of CI? ............................................................................................................. 213
7.6 To what extent might it be possible to institutionalise the practice of CI to the NPD process? ................................................................. 216

7.7 How appropriate is INCIDE for investigating the application of CI in NPD? ................................................................. 218
  7.7.1 Effectiveness ........................................................................ 218
  7.7.2 Efficiency .......................................................................... 219
  7.7.3 Usability ........................................................................... 220
  7.7.4 Usefulness ......................................................................... 221
  7.7.5 Conclusion ........................................................................ 222

7.8 Conclusions ............................................................................ 222

Chapter 8 Validation ....................................................................... 224

8.1 Introduction ............................................................................ 224

8.2 Validity .................................................................................. 225
  8.2.1 Definitions of validity .......................................................... 225
  8.2.2 Threats to construct validity, external validity and internal validity ................................................................. 226
    Construct validity .................................................................... 226
    External validity ...................................................................... 227
    Internal validity ....................................................................... 228
  8.2.3 Threats to validity faced by this research ............................... 228
    Construct validity .................................................................... 228
    External validity ...................................................................... 230
    Internal validity ....................................................................... 231
  8.2.4 Conclusion .......................................................................... 232

8.3 Validation methodology ............................................................. 232
  8.3.1 Company interviews ......................................................... 233
  8.3.2 Workshop ........................................................................... 235

8.4 Results of validation cases ......................................................... 237
  8.4.1 Concord Lighting ................................................................. 237
  8.4.2 Hosiden Besson ................................................................. 241
  8.4.3 Conclusion .......................................................................... 245

8.5 Results of validation workshop .................................................... 246
  8.5.1 Delegates' verdict on analytical framework ...... 246
  8.5.2 Delegates' verdicts on research conclusions ..................... 246
  8.5.3 Future research ................................................................. 248
  8.5.4 Conclusion .......................................................................... 249

8.6 Discussion ............................................................................. 249

8.7 Conclusion ............................................................................. 251

Chapter 9 Conclusion .................................................................... 253

9.1 Introduction ............................................................................. 253

9.2 Summary of findings ................................................................. 254

9.3 Future research ...................................................................... 255

9.4 Conclusion ............................................................................. 258

Appendix 1: INCIDE – A tool for investigating CI in new product development processes 260

Appendix 2 Article published in R&D Management ........................................ 269
Appendix 3 Report to the Engineering and Physical Sciences Research Council
describing the development of the CI Capability Model ........................................... 284
Appendix 4 Questions in INCIDE and the CI behaviours to which they primarily relate .......... 299
Appendix 5 Schedule of questions for interviews in Crendon ........................................ 305
Appendix 6 Survey questionnaire ................................................................................. 310
Appendix 7 Questionnaire used at validation workshop .................................................. 318
Glossary and Abbreviations .......................................................................................... 323
References .................................................................................................................. 326
List of Tables

Table 2.1 Key components of the first CIRCA model for CI ................................................. 30
Table 2.2 Definition of terms used to describe CI capability .................................................. 42
Table 2.3 CI core abilities and their associated behaviours ...................................................... 44
Table 2.4 Literature references with relevance to the CI Capability Model ................................ 46
Table 2.5 Examples of enablers to encourage the linking of CI activity to company goals and objectives ................................................................................................................. 50
Table 2.6 Examples of enablers to encourage strategic management of the CI system .............. 52
Table 2.7 Examples of enablers to encourage managers to lead CI ........................................ 53
Table 2.8 Examples of enablers to encourage participation in CI ............................................ 55
Table 2.9 Examples of enablers of cross-boundary working .................................................... 56
Table 2.10 Examples of enablers to encourage individual and group learning ....................... 57
Table 2.11 Examples of enablers for capturing, sharing and transferring learning .................... 58
Table 2.12 Examples of enablers to encourage individual and group learning ......................... 59
Table 3.1 Taxonomy of models of the NPD process, based on Saren (1984) and updated to include more recent additions ........................................................................................................... 66
Table 3.2 Features of current ‘good practice’ NPD compared with the traditional approach ..... 74
Table 4.1 Factors making the implementation of TQM easier in R&D than in other functions, and factors making it harder ........................................................................................................... 101
Table 4.2 Examples of enablers of cross-boundary working within the NPD context found in the literature ......................................................................................................................... 109
Table 4.3 Examples of enablers to encourage individual and group learning within the NPD context found in the literature ....................................................................................................... 111
Table 4.4 Examples of enablers for capturing, sharing and transferring learning within the NPD context found in the literature ....................................................................................................... 113
Table 4.5 Comparison of the main interview schedules used for CIRCA mapping tool v4.0 and v5.0 and the INCIDE tool ............................................................................................................. 122
Table 5.1 Summary of methods used in the research ................................................................. 132
Table 5.2 Comparison of the organisations in which detailed interviews were conducted ...... 138
Table 5.3 Relative strengths (+) and weaknesses (-) of the methods used in the research .... 144
Table 6.1 Implementing CI within the NPD process: differences in the NPD context compared to a shop floor environment .......................................................... 153
Table 6.2 Implementing CI within the NPD process: facilitating factors (aids) and inhibiting factors (barriers) ..................................................................................................................... 154
Table 6.3 Strategies for generating CI within the NPD process ................................................ 155
Table 6.4 Profile of companies where CI is focused on the NPD process ........................................157
Table 6.5 Strategic approach to CI ..................................................................................................................159
Table 6.6 Enablers and disablers of participation in CI within the NPD process at TM Products ..........................................................171
Table 6.7 Enablers and disablers of participation in CI found in ETL/R .................................................187
Table 6.8 Enablers of effective communication and cross-boundary working at ETL/R ......................189
Table 6.9 Formal mechanisms for sharing learning and improvements at ETL/R ..............................191
Table 7.1 Key insights from each source on the issues covered in the discussion ..............................197
Table 8.1 Threats to construct validity and actions that can be taken to reduce them ......................227
Table 8.2 The methods used to validate the research conclusions .......................................................233
Table 8.3 Profile of the companies involved in the validation interviews ........................................234
Table 8.4 Delegates to the validation workshop ......................................................................................235
Table 9.1 Issues for further research ........................................................................................................256
List of Figures

Figure 1.1 Key sources used to investigate the research questions ........................................23
Figure 1.2 Dissertation structure and chapter objectives ..................................................25
Figure 2.1 The first CIRCA model for CI .................................................................32
Figure 2.2 CI as a capability .........................................................................................42
Figure 2.3 Evolution of CI over time ............................................................................60
Figure 3.1 Examples of models of the NPD process .......................................................68
Figure 3.2 A typical stage-gate new product system .......................................................71
Figure 4.1 Common themes between current NPD ‘good practice’ and the key behaviours in the CI Capability Model ........................................................................102
Figure 4.2 The architecture of the Software Engineering Institute’s Capability Maturity Model ........................................................................................................119
Figure 4.3 Questions in INCIDE and the CI behaviours to which they primarily relate ....125
Figure 5.1 The main research activities carried out during the project .........................133
Figure 6.1 The research activities and their role in the development of this thesis ..........147
Figure 6.2 Experience of CI vs. the impact CI has had on NPD time ............................158
Figure 6.4 Examples of process improvements at TM Products ....................................169
Figure 6.5 The development process at ETL/R in theory .............................................177
Figure 6.6 Examples of ideas implemented by staff at ETL/R ......................................185
Figure 7.1 The role of theory and practice in the questions addressed to explore the scope for the application of CI to the NPD process ........................................196
Figure 7.2 Possible spread of CI within NPD ...............................................................208
Figure 8.1 Questions used to structure analysis of the interview data .......................237
Figure 9.1 Outline programme for further research into the application of CI to the process of NPD ..........................................................257
Preface and Acknowledgements

I came to the Centre for Research in Innovation Management (CENTRIM) at the University of Brighton in August 1992 and have been continually involved with the research and development of continuous improvement (CI) for six years. I joined CENTRIM to work on the CIRCA (Continuous Improvement Research for Competitive Advantage) project led by Professor John Bessant. This project, sponsored initially by the Department of Trade and Industry and subsequently by the Engineering and Physical Sciences Research Council, gave me the opportunity to become immersed in CI from a practical as well as theoretical view, since the work involved close collaboration with many companies. My research into the application of CI to the process of new product development (NPD) was carried out in parallel with the CIRCA project, and the latter gave it impetus. I would therefore like to express my gratitude to both John Bessant and my former colleague Steve Webb, for setting up the CIRCA project which has provided a jumping off point for my own research. I am also grateful to other researchers who joined the project at various times during its course and helped to sustain its momentum: John Gilbert, Dave Paskins, Sara Austin, and Maeve Gallagher.

It was John Bessant who first pointed me in the direction of NPD as an area with the potential for CI application. I already had an interest in product development having myself been an actor in the NPD process, as a designer of multi-media training packages and also, before that, as a product manager marketing scientific books and journals.

John Bessant has been my Director of Studies and supervisor for this research and I am grateful for his support and encouragement over the years. My other supervisor has been Dr Paul Coughlan of Trinity College, Dublin. I first met Dr Coughlan during the 2nd International Product Development Management Conference in Gothenburg in May 1994, at a time when I was pulling together my initial thoughts for a proposal for this research. In our first conversation he offered ideas on different ways of looking at the NPD process and suggested some useful references. It was fortunate for me that when I later asked him to be my second supervisor he agreed. I would like to thank him for the many hours he spent reading and rereading chapter drafts. His insights and comments were often challenging but always constructive and helpful.

Some of my research activities were conducted as the UK contribution to European projects, namely the CI survey and the Ericsson study. I am grateful to EuroCINet, the Europe-wide network of researchers and others working in the field of CI, which orchestrated these opportunities. My thanks also go to Roel Schuring of the University of Twente, in the Netherlands, who co-organised the workshop on 'CI in NPD' at the 1996 R&D Management Conference at which I was able to discuss some of my early findings with a mixed industrial/academic audience.
The empirical work contained in this thesis would not have been possible without the cooperation of many industrial practitioners of NPD. I am particularly grateful to the companies who participated in case studies, and to the individuals who gave up their time to be interviewed in Concord Lighting Ltd, Crendon Holdings, Ericsson Ltd, Hosiden Besson Ltd, IBM, and TM Products Ltd.

I would like to thank all my colleagues in CENTRIM, past and present, who have offered moral support and encouragement to me throughout this endeavour. Special thanks go to Pauline Nissen and Maeve Gallagher who helped with the administration of the validation workshop; Max Silano, who input the survey data; and Graham Perrin who never seemed to tire of sorting out my computer problems.
Author's Declaration

The author played a key role in developing the CIRCA Cl Capability Model which provided a starting point for exploring the application of Cl to the process of NPD. However, the model was the product of a team and lies outside this thesis, although it is described in sufficient detail to allow the reader to follow the case for its application to the NPD context. So although this thesis co-evolved with the CIRCA Cl Capability Model it focuses on the application of Cl to NPD processes, which the CIRCA work did not address.

Some of the material in Chapter 2 describing the content and evolution of the Cl Capability Model was subsequently included in a conference paper (Caffyn and Bessant, 1996) and two reports written by the author for the Engineering & Physical Sciences Research Council on conclusion of the CIRCA project (Caffyn, Bessant et al., 1997; Caffyn, Gallagher et al., 1997). Some of the early research findings were presented in a workshop at the R&D Management Conference in March 1996 (Caffyn, 1996) and were subsequently published (Caffyn, 1997).
Chapter 1  Introduction

1.1  Introduction

This thesis explores the scope for the application of continuous improvement (CI) to the process of new product development (NPD). In doing so it makes two main contributions to knowledge. First, it brings together the two fields of continuous improvement of processes and NPD, which both have their own literature and research activity, but which hitherto have remained somewhat separated from each other. Second, it develops and tests an analytical model to support the implementation of CI within NPD. The outputs from this research also include INCIDE, a diagnostic tool designed to gather data on CI activities taking place within NPD (Appendix 1); and a published paper (Appendix 2).

For the purpose of this investigation, continuous improvement is defined as "an organisation-wide process of focused and sustained incremental innovation" (Bessant and Caffyn, 1997). New product development is taken as referring to the process by which new products are developed in companies, from the generation of an idea until the product is launched onto the market. CI can be directed at improving both products and processes. While much has been written on continuous improvement of the product, this thesis is concerned with continuous improvement of the process of NPD, an area which is relatively uncharted. It should also be noted that the phrase 'continuous improvement' refers not only to the improvement of products or processes but also to the mechanisms whereby this can be achieved.

The key questions driving the research encompass both theory and practice:

To what extent could continuous improvement be applied within the new product development process?

To what extent is continuous improvement being applied within the new product development process?

The thesis bridges the domains of CI and NPD by taking a pre-existing conceptual model of CI, which the author had played a key role in developing, and rebuilding it into an analytical model which can be used to describe and explain the application of CI within NPD processes. There are two main stages in this process of model development. First, the existing CI Capability Model is reinterpreted, in terms of the NPD context theoretically, with reference to the literature. Then data generated using a variety of research methods are analysed to provide a picture of the application of CI within NPD in practice.
The rest of this chapter will review the current context for NPD, focusing on the need for improved performance; explain the research questions and the issues they seek to address in more detail; and provide an overview of the thesis structure.

1.2 The current context for new product development

New product development is now a crucial concern for a growing number of companies. The Product Development and Management Association's (PDMA) 1990 survey of North American companies found respondents anticipating increasing reliance on new products to grow their businesses during the 1990s, with a typical firm expecting nearly 52% of sales in 1995 to be from products introduced since 1990 (Page, 1993). In the event, the most successful firms in a 1995 survey achieved 49.2% of sales from products less than five years old (twice the rate of the rest of firms), and expected this proportion to increase to 53.3% of sales for the next five years (Griffin, 1997). In many organisations issues such as time-to-market and customisation are high on the agenda (Hart and Berger, 1993; Clark and Fujimoto, 1989; Sasaki, 1991; Pine II, Victor et al., 1993).

There is a large NPD literature. Much of the research into NPD over the last 20 years has looked at product success i.e. what makes for a successful product, in terms of both product attributes and process/program management (Johne and Snelson, 1988b; Johne and Snelson, 1988a; Cooper, 1992), or has considered innovation at the level of the organisation (Pavitt, 1991). More recently, in an attempt to meet the challenges faced by NPD, researchers have addressed particular aspects of NPD such as project management, communication, rapid prototyping and simultaneous engineering (Pearson and Ball, 1993; Moenaert and Caeldries, 1996; Costanzo, 1993; Pawar and Riedel, 1993; Swink et al., 1996).

At the same time there has been increasing recognition of the need to think of development activities in terms of a process (Davenport, 1993; Thomas, 1993; Wheelwright and Clark, 1992). Cooper and Kleinschmidt (1993) conclude that process, rather than external forces like market place and competition, "dominates the success equation". The literature on NPD processes mostly looks at templates or blueprints for NPD and covers a wide range of approaches, from phase review to stage gate to overlapping and parallel processing models (Saren, 1984; Cooper, 1988; Cooper, 1994; Cooper and Kleinschmidt, 1993; Imai, Nonaka et al., 1985; Thomas, 1993; Hart, 1995). In considering what will shape the next generation of new product processes, Cooper (1994) looks beyond structures to the implications these more flexible and complex processes have in terms of, for example, risk taking, wider participation in decision making, and learning.

Many firms have been relatively slow to pick up on the messages about the importance of process for NPD. Cooper and Kleinschmidt (1993) found that a minority of firms used a formal product
delivery process or 'stage-gate' system, while the PDMA's 1990 survey revealed that only 54.5% of
the firms surveyed had a well-defined NPD process (Page, 1993) increasing to around 60% by
1995 (Griffin, 1997). Even among companies that do follow a process for NPD there is room for
improvement. Cooper and Kleinschmidt (ibid.)) claimed that "...there are serious deficiencies in the
typical firm's new product process".

1.2.1 The need to improve new product development processes

Managers with responsibility for their firm's NPD process, or for specific tasks or phases within it,
are under increasing pressure to improve performance of the process. The nature of the
improvement sought varies between companies, but typical objectives include the following:

- reduction in development cycle time;
- reduction in development costs;
- increase in product design 'quality';
- greater 'innovativeness' of design;
- increased market share.

The 1990 PDMA survey found that although certain practices had improved during the 1980s the
overall performance of the NPD activity within the surveyed companies had not improved (Page,
1993). The conclusion drawn was that the respondents may be running harder to stay in the same
place. In another survey 87% of managers responsible for NPD said that the development process
needed improving, though details of what they thought should be improved were not reported
(Barclay, 1992b).

Over the years academics have addressed the question of how to be more successful at
developing new products, and how to improve particular activities within the NPD process.
However, it takes time for research findings to trickle out into practice. Barclay (1992a) found that
very few companies knew about, or had applied, the findings from research studies carried out into
the NPD process since the 1950s. Thus the need to improve NPD processes remains very real,
and indeed the issue of improvement grows ever more critical as competitive pressures continue to
escalate.

1.2.2 Institutionalising the concept of improvement within new product development

One way to help disseminate the results of academic work to those in the field may be via industry
awards and standards. There are several industry awards and standards which require evidence
of procedures for continuous improvement of all company processes including NPD. For example,
in the US the Malcolm Baldrige National Quality Award criteria cover translating customer
requirements into design requirements, validating designs, and continuous improvement of the new product introduction process (Krehbiel, 1993; Evans, 1996). Companies entering for the European Quality Award (EQA) are required to demonstrate, amongst other things:

- How the organisation promotes the involvement of all its people in quality and continuous improvement;
- How process performance parameters, along with all relevant feedback, are used to review key processes and to set targets for improvement;
- How the organisation stimulates innovation and creativity in process improvement (Ghobadian and Woo, 1996)

The UK Quality Award and most of the other European national models use similar criteria to the EQA. Many firms use these models and evaluation criteria as the basis for a self-assessment process without going on to enter for the award.

There are also industry-specific models which promote process improvement, for example the Software Engineering Institute's Capability Maturity Model (CMM) for software development. This was first inspired by Crosby's quality management maturity grid and evolved through many iterations between 1987 and 1993 to culminate in CMM v1.1 (Paulk, 1995).

The CMM encompasses five levels of process maturity: initial; repeatable; defined; managed; optimised (Software Engineering Institute, 1991). The questions used to assess the level a company is at include several which relate specifically to process improvement. For example,

At Level 4:
- Is a mechanism used for periodically assessing the software engineering process and implementing indicated improvements?

At Level 5:
- Is a mechanism used for error cause analysis?
- Are the error causes reviewed to determine the process changes required to prevent them?
- Is a mechanism used for initiating error prevention actions?

At Level 5 "The data on the process are used iteratively to improve the process and achieve optimum performance" (ibid.), which clearly indicates the presence of systematic process improvement. A model such as this, aimed at technical specialists, should encourage staff working on product development to take a more systematic approach to their work.
1.2.3 Attempts by companies to improve new product development processes

Some companies have responded to the challenges they face by modifying or re-engineering their process for NPD. For example, in the early stages of this research the author visited a multi-national computer systems company which had recently moved from a formal phase process to a very informal process in order to reduce development time. However, a one-off change in the NPD process may not be enough, because the competitive pressures continue to intensify. This has been recognised by some larger organisations who consequently have introduced ongoing processes for improvement within NPD. The approaches adopted vary considerably, as the following examples illustrate.

Philips Electronics launched a Product Creation Process (PCP) improvement project because there was a widely felt need to share the learning between different product divisions, but no structure for doing so (Olthuis, 1996). An assessment tool was developed which enables dedicated improvement actions, exchange of experiences and benchmarking within the PCP. The tool takes 6 key success factors (KSF) and measures them at 5 levels following the SEI Capability Maturity Model (see above), and at 3 phases in the process (preparation, realisation, market). The tool is in two parts: a short, high level overview completed by managers, and a much more detailed document completed by operational lines in which each of the KSFs has been broken down into a series of statements. This PCP tool is seen as a catalyst for process improvement, providing both a tool for analysis of strengths and weaknesses, and a tool for measuring progress in improvement. Other aspects of the PCP improvement drive include the organisation of PCP, a PCP newsletter, a series of small events focusing on issues like throughput time reduction and architecture, and a PCP Day to facilitate networking. After 3 years this initiative was reported to have succeeded in creating awareness of the PCP, a common language, an environment for exchange of experiences, and a platform for further improvement.

At Siemens the innovation initiative within the Time Optimised Processes (TOP) programme involves mobilising five 'levers for innovation': product; process; management and employees; information systems; and structure (Jahn, 1996). An example of work on the product lever is a project which reduced product complexity through a modular construction system. This reduced the number of components by 70%, the number of printed circuit boards by 60%, and the number of modules by 50%. As a result product costs decreased from 25-43% and development time was cut by 25%. The reduction of complexity and of cost and time meant that products were customer neutral until assembly and more variants could be produced. The company gained a higher market share, and benefited from a shorter development schedule, reduced development costs and lower overall costs. Siemens has adopted a decentralised approach to improving the product generation process, with business units able to choose their own approach to improvement, the only restriction being that they have to be successful. Although Siemens have ISO certification, certification did
not make the processes faster or the products more reliable. This is why TOP was adopted to streamline and improve the processes. The company also uses the SEI CMM to measure process maturity. About 45-50 Siemens departments have used it and, in 1996, they ranged from around Level 2.5 to 4.

British Aerospace Defence Ltd has adopted a 'pull approach' to the implementation of continuous improvement (Caffyn, 1995). In 1990 the company started to focus on improving its manufacturing operation and subsequently moved CI back into the organisation, as an improved process in one area created a demand for improvement in other parts of the company. Thus the systematic approach to improvement spread first from Manufacturing to Manufacturing Systems Design (1992), then to Product Design (1994) and Systems Design (1995). Common themes from this process, applied in all areas, include demand pull, teamwork, and waste elimination; training underpins all CI activities. The concept of teamwork spread from manufacturing to design, and small integrated design teams were given responsibility for developing a particular part of a product or manufacturing system. Attention then turned to the new product introduction process, the idea being to develop integrated support teams, the composition of which may vary, to focus on a particular part of the product. Each integrated production team (IPT) owns a particular process and is constantly problem solving to improve it. Several teams were coming up with similar problems so the idea of Continuous Improvement Activity Groups (CIAG) was introduced. Now, if a common problem is identified a CIAG investigates it and generates a universally accepted solution which is fed back to the IPTs. There is also a participation scheme which rewards individuals and teams for improvements.

1.2.4 The need for research

So, in the present competitive climate, firms need to continuously monitor their NPD process and improve it, to enable them to achieve their goals in this area. Existing models for NPD tend to describe the stages in the process, but do not include feedback loops for process learning i.e. how learning about the process that could lead to an improvement in its future operation may be incorporated into the company's official NPD process. There is relatively little written on using incremental innovation to improve the process of NPD (as opposed to improving a product) on an ongoing basis. Barclay's review of research into NPD found that

"little has been reported on practical evaluation and improvement methodologies. Most of the methodologies that have been suggested are specific and not comprehensive. ..... They are, in effect, 'one off' solutions that are not continuous, not taking into account future changes affecting the NPD process." (Barclay, 1992b).

However, some researchers have started to address the need for on-going changes to the NPD process (McKee, 1992; Wheelwright and Clark, 1992; Thomas, 1993). More recently there have
been studies focusing on the application of Total Quality Management (TQM) practices to R&D (May and Pearson, 1993; Miller, 1995; Debackere et al., 1997).

Two important themes in the innovation management literature are particularly relevant in the context of NPD processes: organisational capabilities and organisational learning. Both concepts are now regarded by many as essential for firms if they are to survive in the present highly competitive and volatile business climate. Several writers have suggested how development projects can be used to create and expand distinctive capabilities (Adler, Riggs et al., 1989; Bowen, Clark et al., 1994a; Leonard-Barton, Bowen et al., 1994; Wheelwright and Clark, 1992). Like other organisational capabilities, "in order to be a source of sustainable advantage, development capability must be continually expanded, upgraded, and improved" (Wheelwright and Clark, 1992, p.311). Over a decade ago a study of NPD in Japanese companies highlighted the important role of learning in enabling companies to achieve speed and flexibility within the development process (Imai, Nonaka et al., 1985). However, organisations attempting to stimulate learning within NPD face problems peculiar to the nature of the development process (Wheelwright and Clark, 1992; Bartezzaghi, Corso et al., 1997). So, there is pressure on firms to increase the performance of their NPD processes. As a result, some larger firms have implemented methodologies which will allow their NPD processes to be modified and improved on an ongoing basis. However, this area is relatively uncharted, and there has been little research into developing process improvement and learning within the context of NPD.

1.3 The research questions

At the same time as the demands on the NPD process have increased, there are a growing number of cases where improvements in speed and flexibility have been made in manufacturing processes as a result of applying continuous improvement practices (Bessant, 1992; Bessant and Caffyn, 1997; Locke and Jain, 1995; Mann and Kehoe, 1994). The question then arises, can similar benefits be achieved by extending the application of CI to the processes of NPD and, if so, how can CI be implemented successfully in this area? Despite the growing emphasis on organisational learning, in which CI practices (problem solving, experimentation etc.) play a key role (Garvin, 1993) the application of CI to the NPD process remains largely unexplored.

This thesis sets out to redress this gap in knowledge by investigating the scope for CI in NPD processes, and developing a framework for the evaluation of CI practice within development organisations. Dictionary definitions of 'scope' include 'range', 'field or opportunity of activity' and...
'room for action'. In other words, we need to consider what the opportunities are for applying CI to processes within NPD, and these opportunities may be potential (i.e. they exist but are not yet acted on) or realised. This suggests a number of questions that the investigation needs to address.

First the research must establish whether such opportunities do in fact exist i.e. whether CI is relevant and applicable to NPD processes in theory. If a theoretical case for extending CI to NPD processes can be made, the research then needs to examine the extent to which it is both possible and feasible to implement CI within NPD in practice. In order to discover the range of opportunity or 'room for action' for applying CI to NPD processes we also need to consider the NPD context. For example, how might variations in the NPD context (e.g. type of organisation, industry, process or product) affect the applicability and practicability of implementing CI in NPD? The issue of context may be further explored by examining whether there any characteristics inherent in the NPD process that may help or hinder the implementation of CI. The definition of CI given above refers to a sustained process of incremental innovation. With this in mind, the research will seek evidence on whether it might be possible to institutionalise the practice of CI within NPD processes. Thus the overarching research issue, 'What is the scope for the application of CI to NPD processes?' may be broken down into the following questions:

- Is CI an appropriate concept for NPD?
- Is it practicable to apply CI to the process of NPD?
- How wide is the scope for CI within the NPD context?
- Are there any factors peculiar to NPD which facilitate or impede the implementation of CI?
- To what extent might it be possible to institutionalise the practice of CI to the NPD process?

We will return to these questions in Chapter 7 where they form the basis of the discussion resulting from the research.

The nature of this investigation is primarily hypothesis generating rather than hypothesis testing. During the course of the work, an existing model of CI is mapped onto the NPD context in order to develop propositions and an investigation tool, which in turn generate data to help answer the questions listed above. As will be seen, this process gives rise to hypotheses which would repay further investigation and testing.

The CIRCA\(^2\) CI Capability Model provided a starting point from which the framework for CI within NPD was evolved. The author played a key role in developing this model, but it was the product of

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1 Source: Chambers Twentieth Century Dictionary, 1993.
2 CIRCA – Continuous Improvement Research for Competitive Advantage, a five-year research project carried out at the University of Brighton 1992-7.
a team and lies outside this thesis (Caffyn and Bessant, 1995; Caffyn and Bessant, 1996; Caffyn, Bessant et al., 1997). In this dissertation the model is described in sufficient detail to allow the reader to follow the case for its application to the NPD context. Readers requiring more information about the model’s development and validation are referred to Appendix 3. In short, this thesis co-evolved with the CIRCA CI Capability Model but focuses on the application of CI within NPD, which the CIRCA work did not address.

1.4 Overview of dissertation structure

This thesis draws on a number of sources to address the research questions, as shown in Figure 1.1. It uses information and data gathered from the literature, industry practitioners of R&D, companies which took part in case studies, and respondents to a survey; and builds on work carried out by the author during development of the CI Capability Model.

![Figure 1.1 Key sources used to investigate the research questions](image)

The thesis is expanded in the following chapters (Figure 1.2).

Chapter 2 introduces the concept of CI with a brief discussion of the meaning of the phrase ‘continuous improvement’ and a short overview of the history of CI. This is followed by a description and evaluation of the CIRCA model for CI which preceded the CI Capability Model, and a review of the key themes which influenced development of the latter. The rest of the chapter gives an overview of the CI Capability Model and examines in detail its constituent parts.
Chapter 3 presents the state of current knowledge in the area of NPD. Extensive reference is made to the literature in order to review the most significant NPD processes and models put forward over the years, and to describe what are currently regarded as 'good practice' approaches to organising and managing product development activities.

Chapter 4 argues for the extension of CI to NPD. It highlights common themes between current NPD 'good practice' and the CI Capability Model before showing how, in theory, the key elements in the CI Capability Model may appear within an NPD organisation. The last part of the chapter describes the instrument designed to investigate CI within NPD as practised in firms.

Chapter 5 explains the underlying research philosophy of this thesis and the strategy followed. It describes and critically evaluates the main methods used to carry out the investigation.

Chapter 6 presents the key findings from the different methods of enquiry used in the research.

Chapter 7 discusses and evaluates the research results. It draws on all the sources used in order to consider the application of CI to the NPD process and provide answers to the questions listed in Section 1.3.

Chapter 8 describes the steps taken to test and validate the conclusions drawn about the application of CI within NPD, and the analytical model.

Chapter 9 summarises the conclusions reached on the basis of the arguments and evidence presented in the thesis, and sets out an agenda for future research in this area.
Chapter 1: Introduction
• provide context for research
• present research questions

Chapter 2: CI
• introduce CI concept
• describe CI Capability Model

Chapter 3: NPD
• explore nature of NPD process
• discuss 'good practice' approaches to NPD

Chapter 4: Framework for CI in NPD
• argue for extension of CI to NPD
• describe tool to investigate CI within NPD processes

Chapter 5: Research Methodology
• describe & critically review the research methodology

Chapter 6: Research Findings
• report findings from research activities

Chapter 7: Application of CI to Process of NPD
• discuss the research findings
• answer the research questions

Chapter 8: Validation
• describe & evaluate activities carried out to validate the research conclusions

Chapter 9: Conclusion
• summarise conclusions reached
• present an agenda for future research

Figure 1.2 Dissertation structure and chapter objectives
Chapter 2  Continuous Improvement

2.1 Introduction

The theme of this thesis is the application of continuous improvement (CI) within the new product development (NPD) process. Before examining the findings of the new research carried out to investigate this issue, it is appropriate to review the relevant literature in the fields of CI and NPD. This chapter will focus on CI, in particular the CI Capability Model which underpins the thesis. In Chapter 3 we will look at current thinking and practice on NPD, and reflect on NPD processes in the future.

The CI Capability Model was the result of research in which the author was heavily involved. The author played a key role in developing the model to the point where it was usable in manufacturing settings, and it is used as a starting point for the present investigation into the application of CI within the context of NPD.

In retrospect the process of theory development which resulted in the CI Capability Model can be seen to have two distinct phases. First, there was the development of the CIRCA4 'gear' model for successful CI. This model proved useful but weaknesses became apparent. There followed a period of re-evaluation in light of the large amount of data gathered, and taking account of contemporary thinking reported in the literature. The outcome was an initial outline of the CI Capability Model. This was followed by an iterative, refining process which resulted eventually in the model as presented in this thesis.

The chapter begins with a brief discussion of the meaning of the phrase 'continuous improvement'. This is followed by a concise overview of the history of CI. The rest of the chapter is devoted to the CI capability model and it precursor. Section 2.4 describes the first model and gives a critical evaluation, in order to explain the basis from which the CI Capability Model evolved and why it takes the form that it does. Next, the key themes influencing the re-evaluation of the CIRCA data and model are reviewed. Section 2.6 then gives an overview of the model followed by a detailed examination of its constituent parts. Since this thesis is taking the model as given, the emphasis will be on the content of the model. A description of the process whereby the capability model was developed and validated can be found in Appendix 3.

3 The research project was known as CIRCA – Continuous Improvement Research for Competitive Advantage. The author was a member of the research team for all but the first six months of the project’s five year duration.
4 See note 3.
2.2 Definition of continuous improvement

Continuous improvement (CI) is a simple phrase which can mean different things to different people. However, in the context of organisational change and management, interpretations of CI usually include reference to 'mass involvement', 'small-scale improvement', 'never ending'. The definition used in this thesis captures these elements: an organisation-wide process of focused and sustained incremental innovation (Bessant and Caffyn, 1997). This implies a systematic approach to improvement in which staff throughout the firm (at all levels and in all areas) are engaged in an on-going effort to implement changes which, though often small-scale, cumulatively will impact on the goals and objectives of the business.

The Japanese word kaizen\(^5\) is often used synonymously with continuous improvement. According to Imai, whose 1987 book Kaizen --The key to Japan's success brought the concept to prominence in the west, “KAIZEN is an umbrella concept covering most of those "uniquely Japanese" practices that have recently achieved such world-wide fame” (Imai, 1987, p.4). The practices he was referring to include customer orientation; total quality control; robotics; quality control circles; suggestion scheme; automation; discipline in the workplace; total productive maintenance; kamban; quality improvement; 'just-in-time'; zero defects; small-group activities; cooperative labour-management relations; and productivity improvement.

Continuous improvement has been referred to as one of three fundamental principles underlying Total Quality Management (TQM), the others being customer orientation and process orientation (Hill and Wilkinson, 1995). Berger (1996b, p.18) has demonstrated the close relationship between CI and TQM but concludes that CI "should rightfully be regarded as a general development perspective, applicable with or without the context of TQM". Indeed, TQM is just one of several routes down which companies have journeyed to arrive at CI. For example, in some cases CI has followed the adoption of 'Japanese manufacturing techniques' such as 'just-in-time'. Other firms have sought improved performance from higher levels of participation through 'productivity through people' programmes. More recently some companies, who see knowledge as the basis for competition, have started to try and develop 'learning organisations' by increasing involvement in innovative problem-solving (Bessant and Caffyn, 1997).

2.3 History of continuous improvement

The historical roots of CI can be traced to companies in the UK and USA as far back as the nineteenth century. For example, Schroeder and Robinson (1991) describe how suggestion schemes were introduced by the Scottish shipbuilder, Deny of Dumbarton, in 1871; by the National

\(^5\) Kai means 'change' and zen means 'better'. Taken together kaizen may be translated as 'continual improvement'.
Cash Register Company, Dayton, Ohio in the 1890s; and by the Lincoln Electric Company in the US in 1929. James T Lincoln, of the latter company, also designed an "incentive management" system to encourage continuous improvement and tried to lower barriers between management and workers. However, these were relatively isolated examples involving enlightened employers.

During the first half of the twentieth century the prevailing paradigm was Scientific Management. This movement aimed "to develop methods that would enable managers to study and solve production problems 'scientifically', and to set proper piece-rates and labor standards based on tightly controlled time-trials" (Robinson, 1991, p.xxvii). Among the advocates of this approach were Frederick Taylor, who believed that inefficiency lay mostly in the workers; and Frank Gilbreth, who believed that it was management's responsibility to find the simplest and easiest way to do the work.

During the second world war munitions factories in particular experienced a high level of process innovation in order to keep up with ever increasing demands. In 1940 the US government set up the very effective Training Within Industry (TWI) service to boost industrial output and productivity on a national scale. It included Job Methods Training, a program designed to teach supervisors the importance and techniques of continuous methods improvement. The TWI courses were subsequently included in the massive management training programs initiated in Japan by the US occupation forces. Indeed, many of the ideas underlying 'Japanese management' have their roots in US management philosophy and practice. They were introduced via these training programs and by US management experts like W Edwards Deming, Joseph Juran, and Dr Lillian Gilbreth (Robinson, 1991).

Over the following years, the Japanese adapted and developed these ideas. The term quality control, used originally to refer to quality control of the manufacturing process, acquired a much broader meaning as it grew into a management tool for kaizen, or ongoing improvement involving everyone (Imai, 1987). Impressed by Japanese economic success, western companies tried to emulate practices they saw in Japan, a prime example being the attempts to set up Quality Circles during the early 1980s, many of which failed. This lack of success stemmed from a misunderstanding of the nature of the Japanese Total Quality Control (TQC) movement, in which Quality Control Circles were just one element in a company-wide effort of quality improvement and change (Lilrank and Kano, 1989; Lilrank, 1995; Brennan, 1991). Later, Total Quality Management (TQM) programmes which recognised the need for an all-encompassing approach became popular in the West.

As the practice has spread there has been a growth of organisations promoting CI, some doing so as part of a TQM philosophy (e.g. European Foundation for Quality Management), others promoting the approach of a particular 'guru' (e.g. British Deming Association, Crosby Associates),
while there are national standards and awards which encourage a continuous improvement approach without prescribing how it is to be achieved (e.g. UK Quality Award).

2.4 The early CIRCA gear model 1992-4

2.4.1 Background

As noted above, one of the key reasons western firms were often unsuccessful in attempts to transfer Japanese organisational innovations was that they ignored the wider contexts in which the Japanese structures functioned. Lillrank (1995) illustrates this very clearly with the case of the Quality Control Circle (QCC), showing how companies in the US and Europe initially tried to copy QCCs without paying sufficient attention to the Japanese organisational and historical context. However, it should be noted that some Japanese companies were successful at transferring their 'organisational technology' to businesses in other locations. For example, Matsushita did so after buying the US manufacturer Motorola, and the Japanese firm Bridgestone used such techniques to turnaround an ailing US tyre manufacturer (Bessant, Burnell et al., 1993).

By the late 1980s a better understanding of the need for a more holistic approach to CI was starting to emerge. Imai (1987) made very clear the wide-ranging nature of the concept of kaizen, Lillrank and Kano (1989) provided a detailed study of how Japanese QCCs work as part of a company-wide effort of quality improvement and change, while Melcher et al.'s (1990) comparison of standard-maintaining and continuous-improvement systems covered both organisational processes and structural characteristics. It was becoming clear that CI is more complicated than many people had previously thought, that there is more to CI than a suggestion scheme or Quality Circles or a production system.

This move to consider the wider context for CI is reflected in the CIRCA gear model which builds on preliminary work carried out by Steve Webb6 (1995). At this time Webb's PIPT model for CI was an outline framework comprising the philosophy of continuous improvement; the infrastructure required to support the philosophy; the process by which CI is achieved; and the tools that promote action in the process. Webb and others associated with the initial CIRCA work used the literature to support and illustrate this approach, adding a strategic dimension and recognising that existing organisational culture is likely to be a major barrier to CI (Bessant, Burnell et al., 1993).

It was at this point that the author became involved with the model development. The next stage was to fill out the detail under the headings. Research activities carried out with a core group of

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6 Steve Webb was a member of the CIRCA research team from the start of the project in February 1992 until November 1992.
7 The author joined CIRCA in August 1992.
collaborating companies and members of an industrial CI network, together with an analysis of cases in the literature, resulted in a model for generating and sustaining CI, which became known as the 'gear' model because of the metaphor often used to explain it.

### 2.4.2 The model content

In the first CIRCA model the elements considered necessary for successful CI are grouped into five areas: strategy, culture, infrastructure, process and tools. A summary of some of the key components within each area is given in Table 2.1.

<table>
<thead>
<tr>
<th>Area</th>
<th>Key components</th>
</tr>
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<tbody>
<tr>
<td>Strategy</td>
<td>• clear strategic framework for CI</td>
</tr>
<tr>
<td></td>
<td>• long-term goals and short-term targets</td>
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<tr>
<td></td>
<td>• communication of CI strategy to all employees</td>
</tr>
<tr>
<td></td>
<td>• top management commitment</td>
</tr>
<tr>
<td></td>
<td>• long-term, company-wide perspective</td>
</tr>
<tr>
<td>Culture</td>
<td>• shared belief in the value of small improvements</td>
</tr>
<tr>
<td></td>
<td>• belief that all employees have creative potential</td>
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<td></td>
<td>• treating failure as a learning opportunity</td>
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<td>Infrastructure</td>
<td>• flattened hierarchy</td>
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<td></td>
<td>• teamworking and flexibility</td>
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<td></td>
<td>• devolution of decision making and empowerment</td>
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<td></td>
<td>• effective communication channels</td>
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<td></td>
<td>• commitment to training and personnel development</td>
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<tr>
<td></td>
<td>• CI facilitators</td>
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<tr>
<td></td>
<td>• CI 'vehicles' such as problem solving groups or CI teams</td>
</tr>
<tr>
<td>Process</td>
<td>• formal CI/problem solving cycle</td>
</tr>
<tr>
<td></td>
<td>• capture and transfer of learning</td>
</tr>
<tr>
<td></td>
<td>• recognition and reward of CI activity</td>
</tr>
<tr>
<td>Tools</td>
<td>• company 'toolbox' with a range of CI tools</td>
</tr>
<tr>
<td></td>
<td>• 'toolbox manager'</td>
</tr>
</tbody>
</table>

Table 2.1 Key components of the first CIRCA model for CI

According to this model, a prerequisite for CI success is a clear strategic framework, with related targets and milestones, which is clearly communicated to all employees. CI programmes also need to be managed strategically. This implies guidance at the highest level together with regular planning, monitoring and, where necessary, intervention to ensure that CI can be sustained in the long term. To take root and flourish in an organisation, CI requires an underlying culture, or set of values and behavioural norms, that support it. This would include, for example, a widely held belief
in the value of many small improvements and in the ability of everyone to contribute. Another cultural value associated with successful CI is the importance attached to learning, with failure being regarded as a learning opportunity rather than a trigger to apportion blame.

CI also needs a supporting infrastructure. There are two components to this: a general context within which CI can thrive and develop, and a specific CI-enabling infrastructure. Although there is no blueprint for the 'right' organisation form for CI – it is very much a matter of adapting both organisation and CI programme to suit each other – key areas appear to be the extent of devolution of autonomy, the communication and decision-making processes, the level of teamworking and, within teams, of flexible and multiskilled working, the degree of integration in inter-functional relations, and the approach to training and personal development. The CI infrastructure will include a fleet of CI vehicles to mobilise CI throughout the organisation, ranging from mechanisms that encourage individual proposals for small-scale local improvements, through team activities, to company-wide top management driven projects (Caffyn, Gilbert et al., 1994).

At the heart of CI is a repeated problem-solving and learning cycle, moving from identification, through exploration and selection of improvement suggestions to implementation and review. Each stage of the cycle needs to be supported with appropriate facilitation and tools. Important issues here are how to capture the learning arising from such activity and deploy it around the organisation; and how best to recognise participation in CI activity in order to motivate continued involvement. According to the model, a successful CI company would have a balanced range of CI tools and techniques in its toolbox to support teams and individuals in their improvement activities.

This model is described in more detail and illustrated with case examples in Bessant, Caffyn et al., 1994.

To aid communication and emphasise the interdependency between the areas, the model was depicted graphically as five meshing gear wheels representing the key areas, the teeth on the gears being the specific features (actions, attitudes, conditions etc.) that can enhance or damage CI in a company (Figure 2.1). The argument was that although incremental innovation may be found naturally occurring in an organisation, its potential will not be fully realised if it is sporadic and left to chance; to succeed, the organisation will have to work in each of the areas represented by the gears. According to this model, if any of the 'gears' is missing the CI will fail sooner or later; a gear without a full set of teeth will result in a bumpy ride.
The first CIRCA model for CI: the 'gear' model

The model seemed to work empirically. It was a simple way of representing complexity which proved popular with companies. The model also provided the research team with a good framework for looking at the CI system in any company, and formed the basis of the CIRCA diagnostic tool. The latter enabled a fairly accurate 'snapshot' of a company's CI to be constructed in a short space of time (Caffyn, Gilbert et al., 1995). In using the model in this way to benchmark a company against a notional model of good practice there were similarities with the approach taken by, for example, the European Quality Award (EQA) and the Malcolm Baldrige National Quality Award assessments, though in this case the focus was restricted to CI and factors affecting it.

2.4.3 Limitations of the gear model

Prior to the gear model, CI was an amorphous cloud to which the model brought some structure and clarity. However, as the research progressed the limitations of this model became increasingly apparent. In particular, the author identified three important issues that it does not address: contingent aspects of CI; how to embed CI deeply in an organisation; and appropriate structures for implementing and evolving CI.

Contingent aspects of CI

The gear model is largely a generic model, making little distinction between generic and contingent factors. It assumes that to succeed at CI a company must have a whole range of specific features (the details represented by the gear 'teeth') whereas in reality the desirability and necessity of
some of these features will depend on the organisation in question and its particular circumstances. As the research activity widened out, taking in organisations ranging in size from 60 to over 20,000 people, and from diverse types of operation, it became clear that there were different ways of achieving a particular end in different situations. So that although many companies doing quite well with CI had made similar changes (e.g. flattening structures) there was no single 'best' way.

Adler and Cole, contrasting the experiences at New United Motor Manufacturing Inc. (NUMMI) in the USA and Volvo's Udevalla plant in Sweden, challenge the view that hierarchy, standardisation, time-and-motion etc. prevent CI, learning, and creativity. Although they accept that Udevalla's human-centred model of organisation has more opportunity for personal learning, they claim that the lean production, 'democratic Taylorism' model at NUMMI provides more opportunity for organisational learning (Adler, 1993; Adler and Cole, 1993). For example, they claim that NUUMI's short work cycle times (60 seconds) and highly standardised processes make it easier for workers to identify problems and improvement opportunities and to diffuse improvements. The layers of middle management at NUUMI are 'layers of experience' and the function of the hierarchy is not to control but to support.

Work in Sweden identified several categories of determinants which will influence CI, including product/process characteristics; previous experience of change; strategic clarity/commitment; and organisation structures and capabilities.8

How to embed CI deeply in an organisation
A second weakness of the gear model is that it does not show how to move from superficial CI to CI as a deep-rooted, 'automatic' way of behaving. For example, one company studied during the CIRCA research seemed to be doing very well with CI, attributing £1.3M of its £5.7M profit in 1992 to CI activities. In early 1993 it came out quite well when assessed using the mapping tool based on the model: there was a strong teamworking culture, high levels of involvement, genuine commitment to CI by top management, etc. Although the diagnostic exercise did find some weaker areas and identified a plateauing effect, with hindsight it did not highlight the full extent of the problem. Subsequently there was a big decline in CI activity, and the initial momentum petered out despite the company having in place many of the elements the model said it should have.

Appropriate structures for implementing and evolving CI
A third issue, spanning both the previous points, which the gear model does not address adequately is what form of structures are appropriate for initiating and sustaining a CI programme, and how might they change over time. The model does emphasise that CI should not be seen as

8 P. Lindberg and A. Berger personal communication to author.
an optional 'add on' to the rest of the business but should have a clear strategic framework (the strategy gear). However it also favours, or appears to through the language it uses, some form of parallel structure (CI vehicles, CI tools, CI steering committees etc.), reflecting the most common form of practice at the time the model was first developed, which in turn was influenced by the Japanese experience.

Reports began to appear of companies starting to adopt a more seamless approach. At Honeywell, for example, the quality organisation blended with the regular structure, the three quality councils in effect being the senior management (Heller, 1993). This trend was also noticed in some of the companies CIRCA worked with. One of them, a mutual life company with around 1,800 employees, had started quality improvement by following the Crosby approach. This had led to a somewhat bureaucratic hierarchy of councils and other structures. After several years a conscious decision was taken that in future the Quality Improvement Team would be synonymous with the management team. This attempt to integrate quality improvement into the way the business operated (as well as making it impossible for managers to opt out of responsibility for improvement) was successful and the concepts of CI are now fully integrated into the strategy and business planning process.

Researchers at Sheffield Hallam University identified three distinct approaches to implementing Total Quality (visionary, planning, learning) and found that companies achieving long term success with TQ followed one approach, but when the TQ needed regeneration switched to one of the others, and so on. They labelled this approach 'transformational total quality' or TTQ (Smith, Tranfield et al., 1994).

In Sweden, Lindberg and Berger were developing a model based around two basic typologies for CI: organic, systematic CI which is driven by targets and strategic dialogue, and carried out by multi-functional, permanent workgroups (seen, for example, in Asea Brown Boveri); and the 'controlled matrix' where teams are set up to deal with identified themes (e.g. Ericsson Radio Systems, Saab Automobile); with many companies combining elements of both. They went on to devise a typology of organisational designs for CI based on two dimensions: task design (group vs. individual) and level of integration of improvement tasks (parallel vs. integrated) (Lindberg and Berger, 1997). On this they were able to plot five distinct models for organising and supporting CI: Quality Control Circles, organic CI, expert task force CI, wide-focus CI, and individually based improvement work. Lindberg and Berger's study of CI application in Sweden also revealed that national work life characteristics (e.g. decentralisation and participation) had led to significant modification of traditional kaizen practices found in Japan. In particular, presumably as a result of the strength of the autonomous workgroup concept in Sweden, CI there tends to be integrated in

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9 Information presented by A. Berger and P. Lindberg to EuroCI.Net meeting in Gothenburg, June 1995.
the regular work routines and work organisation, rather than being a function of a parallel structure as is usually the case in Japanese firms.

Krishnan e.g. al. (1993) point out that although parallel structures can be good at generating enthusiasm and inter-departmental collaboration, they can lead to conflict between the quality management and the formal functional structure. Parallel structures may also lead to excessive administrative costs and slow decision making.

**Conclusion**

So, although the gear model provides a useful means for representing the complexity surrounding CI, its generic and static nature results in several limitations. It makes no allowance for the many different contexts in which firms are trying to implement CI or how, over time, the approach adopted as well as supporting structures may need to change in order to generate deep-rooted, sustainable CI. Realisation of the model's short comings led to a re-evaluation of both the data and the relevant literature, which is described in the next section.

**2.5 Re-evaluation**

The limitations of the gear model, together with the problems that many companies had sustaining CI, led the research team to re-evaluate the data and look at CI from a different perspective. It had become clear that implementing CI, which appears at first sight to be such a simple concept, is a complex issue fraught with difficulties which all too often ends in failure and disappointment (Kearney, 1992; Marsh, 1996). What were these companies really trying to achieve? In hindsight, it appeared that firms committed to CI were attempting to build what could be termed a *capability* in continuous improvement, and that there were a number of different routes towards this goal. The CIRCA research, and the findings of researchers in Sweden, USA and the UK referred to above, supported this shift away from a prescriptive approach to CI.

Several themes that were then becoming more prominent in the literature influenced the re-evaluation of the data and the search for a way to represent the concept of CI capability, in particular: capabilities and competencies; organisational learning; and routines and behaviours. This section will review these strands then consider briefly the (relatively few) points made in the literature which relate to the limitations of the gear model, that is contingent aspects and the development of CI over time.

**2.5.1 Capabilities and competencies**

In recent years the concept of 'organisational capabilities' has been discussed and developed in the strategic innovation management literature, and there has been increasing emphasis on the
need for companies to grow such capabilities in order to survive in today's highly competitive, ever-changing business environment. However, the debate has become somewhat confused by the lack of a common definition of 'capability'. Some writers describe capabilities in terms of 'core competencies' which are formed by consolidating corporate-wide technologies and production skills, for example Sony's capacity in miniaturisation (Prahalad and Hamel, 1990). Others argue that capabilities are "more broadly based, encompassing the entire value chain" and derive from business processes and organisational practices relating to, for example, communication and cross boundary working (Stalk, Evans et al., 1992). This view attributes Honda's success to capabilities in dealer management and product realisation without which, it is argued, the company could not have achieved so much from its engine competence. A third approach defines distinctive competencies as "the set of activities that a firm can organize and coordinate better than other firms" and describes 'dynamic capabilities' as being the capacity of an organisation to renew, augment and adapt its core competencies over time (Teece, Pisano et al., 1992).

A broader interpretation regards capabilities as comprising a combination of technical competencies and business processes and systems (Wheelwright and Clark, 1992; Leonard-Barton, 1995). Leonard-Barton (1995) believes that capabilities grow through the actions of members of the firm, and she shows how companies can nurture capabilities by encouraging staff to engage in shared problem solving, integration of new methodologies and process tools, constant formal and informal experimentation, and pulling in expertise from outside. There is a danger, however, that core capabilities may become core rigidities, "inappropriate sets of knowledge", which inhibit progress (Leonard-Barton, 1992a). This is why it is so important for companies to find a way to continually improve and develop their core technologies and the business processes and systems through which they are co-ordinated and applied.

Thus there is growing recognition of the importance of capability as a source of strategic advantage. For Hayes and Pisano (1994) the power of improvement programmes such as CI and Total Quality lies in their ability to build new capabilities – they argue that using such programmes merely to correct specific weaknesses (e.g. to improve quality) will not bring the firm competitive advantage because its competitors can do the same things.

The concept of capability is central to the model used in this thesis to explore the application of CI within NPD processes. To avoid any confusion over terminology it should be made clear that 'capability' in innovation management is taken here to refer to how companies manage the process of innovation – examples of distinctive capabilities might include the ability to produce new products more quickly than competitors, or the ability to manage complex projects. The term 'technological competence' is held to represent the accumulated knowledge about a technological area available to the firm, embodied in products and processes as well as in tacit form. So two
companies may have a similar level of technological knowledge but deploy the competence in different ways, reflecting their different capabilities.

2.5.2 Organisational learning

Learning processes are critical to both accumulating technological competence and building innovation management capability. Learning, on an individual, group and organisational scale is also an important facet of CI. The last decade has seen increasing interest in the concepts of the 'learning organisation' and 'organisational learning'. Again, there are different interpretations of what these phrases mean and much has been written on the issues, from various perspectives. As there is insufficient room here to examine the organisational learning literature in detail we will restrict this review to a few of the key ideas most relevant to CI.

The first point is recognition that developing knowledge and learning are now essential activities for firms wanting to succeed in the 1990s and beyond. Reflecting on present day society Drucker (1993) comments that "knowledge is the primary resource for individuals and for the economy overall". However, specialised knowledge is only productive when it is integrated into a task and it is the purpose and function of organisations to bring about this integration. Back in 1989 Ray Stata of Analog Devices Inc. argued that "the rate at which individuals and organizations learn may become the only sustainable competitive advantage, especially in knowledge-intensive industries" (Stata, 1989). The experience of Analog had shown that quality improvement is an effective way of accelerating organisational learning. This was achieved by means of temporary structures or teams which cut across the organisation, improving communication and cooperation as they did so.

The second theme is how organisational learning takes place. Although individual and organisational learning both entail new insights and modified behaviour, Stata (op. cit.) pointed out that organisational learning differs in that it occurs through shared insights, knowledge and mental models and depends on institutional mechanisms (e.g. policies, models) to retain knowledge. For Nonaka (1991), making personal knowledge available to others is a key activity of the knowledge-creating company. He attributes the success of Japanese companies like Honda, Canon, NEC and Kao to their approach to managing the creation of new knowledge. This involves "tapping the tacit and often highly subjective insights, intuitions and hunches of individual employees and making those insights available for testing and use by the company as a whole".

Kim (1993) attempted to explain the link between individual and organisational learning, defining the latter as "increasing an organization's capacity to take effective action". In his model organisational learning depends on individuals improving their mental models (i.e. their view of the world, both implicit and explicit) and then making them explicit so that new shared mental models can be developed. These mental models cover both operational learning i.e. learning at the
procedural level which accumulates and changes routines, and conceptual learning which thinks about why things are done in the first place, challenging prevailing conceptions and leading to new frameworks in the mental models. This approach follows the distinction Argyris (1977) made between single-loop and double-loop learning. Single-loop or adaptive learning refers to action taken to correct a situation without changing existing policies or objectives, as in Kim's operational learning. Double-loop learning involves challenging underlying organisation policies and objectives, and depends on questioning one's own assumptions and behaviour (Argyris, 1994). The sharing of individual learning is also at the heart of organisational learning for Locke and Jain (1995), who describe the concept in terms of "the processes and products of learning acquired by individual members and shared widely among the members". They claim that organisational learning is a fundamental requirement for the organisation of the 1990s and a precondition for CI and organisational growth.

Thirdly, there is the issue of how a firm can turn itself into a learning organisation. Leonard-Barton (1992b) coined the phrase 'learning laboratory' to refer to an organisation dedicated to knowledge creation, collection and control. She argued that learning requires the creation and control of internal and external knowledge for both current and future operations. The four activities identified as necessary in order to achieve this are independent problem solving; integration of internal knowledge; continuous innovation and experimentation; and integration of external knowledge. There are similarities here with Garvin's 'building blocks' of learning organisations: systematic problem solving; experimentation with new approaches; learning from their own experience and past history; learning from the experiences and best practices of others; and transferring knowledge quickly and efficiently throughout the organisation (Garvin, 1993). Garvin stresses that a learning organisation is one that not only acquires new knowledge but applies it. For Nevis et al. (1995) learning organisations strive towards a constantly enhanced knowledge base which allows for the development of competencies and incremental or transformational change. They distinguish between three stages of the learning process: knowledge acquisition, knowledge sharing, and knowledge utilisation; and develop a two part model of organisations as learning systems. The first part of this model is descriptive and comprises seven 'learning orientations', which are the values and practices that reflect where learning takes place and the nature of what is learned (e.g. knowledge source: internal vs. external; product-process focus: what? vs. how?). The second part is normative and is made up of ten 'facilitating factors', i.e. the structures and processes that affect how easy or hard it is for learning to occur and the amount of effective learning that takes place (e.g. concern for measurement, involved leadership, systems perspective). Nevis et al. suggest that to improve its learning capabilities an organisation should focus on one of the three stages of learning and then decide whether to concentrate on improving its learning orientations; to select two or three facilitating factors to improve on (this assumes that the existing style is effective); or to change both learning orientations and facilitating factors.
Finally, on a more theoretical note, Luthans et al. (1995) describe the three concepts characteristic of learning organisations as being the presence of tension and conflict; the presence of systems thinking; and a culture which facilitates learning. Hodgetts et al. (1994) argue that fine distinctions can be made between a TQM organisation, a learning organisation and a world class organisation. For example, they claim that while a TQM organisation adapts in response to a change in the environment, a learning organisation anticipates change. The three types of organisation form a hierarchy, with a learning organisation including dimensions of a TQM organisation, while a world class organisation takes in characteristics of both TQM and a learning organisation. They specify CI as being one of the six ‘major pillars’ of world class organisations.

2.5.3 Routines and behaviours

As learning takes place, individuals adopt new approaches and organisations develop new ‘routines’ for dealing with particular situations or aspects of organisational processes. Routines embody ‘firm-specific competencies’ and they adapt and change as the result of learning (Pavitt, 1991). In other words, new behaviours may be learned by individuals and groups and subsequently repeated until they become incorporated as part of the organisation’s ‘culture’. Behaviour changes are necessary for both capability development and organisational learning. Indeed, at the heart of many of the so-called management ‘fads’, including TQM, is the need to adopt a set of new behaviours, and it is possible to recognise generic CI behaviours amongst them. Locke and Jain (1995) argue that the best way to build a CI culture is to use the tools and techniques of organisational learning "to instil the values and behavioural norms representative of such organizations".

Porras and Hoffer (1986) presented a ‘partial model of organisations’ in which individual behaviour is the link between organisational interventions and their subsequent outcomes. This model has various ‘system elements’ clustered into four broad categories: organising arrangements; social factors; technology; and physical setting. They argue that “organizational interventions change system elements so that they send organization members new messages about which behaviours are desired and will be rewarded”. In order to deliver a consistent message about desired behaviours it may be necessary to change many elements in the internal environment. One reason why some organisation development efforts fail is that they may not have addressed enough of the system elements. Porras and Hoffer carried out research which enabled them to specify behaviour common to successful planned change efforts, and found particularly high commonality on ‘communicating openly’ and ‘collaborating’.
2.5.4 Contingency

The CIRCA research and the work of others reported in the literature showed similarities between attempts to implement CI in manufacturing and in other sectors (e.g. service sector, public sector), both in terms of the approach taken (e.g. focus on the customer) and the behaviours the organisations sought (e.g. participation, leadership). At the same time, however, some writers were hinting at the issue of contingency. For example, Hill and Wilkinson (1995), having discussed the wide range of views on the nature of involvement and participation promoted by TQM, suggest that empowerment may depend "contingently on other factors" such as how standardised the processes are. Pfeffer (1995) describes 13 interrelated practices for managing people to achieve competitive success (e.g. self-managed teams, information sharing) and notes that which practice is most critical for a firm will depend partly on the company's particular technology and market strategy.

2.5.5 Development of CI over time

The reported experiences of companies associated with the CIRCA research (e.g. Atkinson, 1995; Clark, 1994) and others described in the literature (e.g. Sirkin and Stalk, 1990) suggest that organisations pass through several developmental stages or levels of maturity as they introduce, consolidate and further develop continuous improvement. A similar trend is found in related areas. For example, Garvin (1991) described three common profiles of firms at different stages down the Baldrige road, those with high scoring quality programs, medium-rung performers, and low scorers. On the human resources side, Eccles (1993) discusses three different levels of empowerment: suggestion involvement, job involvement, and high involvement. He suggests that they are hierarchical, questioning whether it is possible to move to job enrichment before there is suggestion involvement on the shop floor. Cupello (1994) proposes four levels of TQM maturity: Playing, Demonstrating, Committed, and Actualised. He combines these maturity levels with four types of measures (diagnostic, planning, screening, control) to form a measurement-maturity matrix. Based on the findings of a McKinsey study of 167 automotive suppliers between 1987-91, Rommel et al. (1996) propose four levels of quality, defined in terms of design quality and process quality. These levels are inspection, quality assurance, prevention, and perfection.

The Capability Maturity Model (CMM) for software developed by the Software Engineering Institute has five phases through which companies progress. It is a hierarchical model with each level building "a foundation for succeeding levels to leverage for implementing processes effectively and efficiently" (Paulk, Curtis et al., 1993). The software process maturity framework was first inspired

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10 See, for example, Raffio (1992) on the approach taken by an insurance company, Delta Dental Plan of Massachusetts; and Dyason and Kaye (1995) for the attempt by South and South East Hampshire Magistrates Court (UK) to develop CI.
by Crosby's quality management maturity grid which applies five stages to six measurement
categories in subjectively rating an organisation's quality operation (Paulk, 1995). Early versions of
the CMM (up to v0.6 in 1991) adopted a 'continuous' improvement approach with key process
areas spanning several maturity levels. However, a decision was subsequently taken to redefine
the key process areas as residing at a single maturity level (the 'staged' model), and Paulk (1995)
discusses the pros and cons this approach.

2.5.6 Summary

So, the CIRCA research and that of others, together with reported company experiences, led to a
re-evaluation of the data. It had become clear that uniform approaches to CI implementation failed
and that a more contingent approach was needed. The re-evaluation took place at a time when
there was increasing coverage in the literature of the concepts of strategic capabilities and
organisational learning. There seemed to be a natural link between these concepts and CI, which
is concerned with both individual and organisational learning, and with developing a sustainable
approach which will bring strategic advantage to the firm in the long term. Underlying all these
concepts is the behaviour of individuals within organisations, and the question of how behaviour
can be influenced and changed. Such issues are relevant for all organisations, regardless of
industry type, sector and ownership. As we shall see in the next section, these strands combined
to help shape the model that emerged from the re-evaluation process, the CI Capability Model.

2.6. The CI Capability Model

2.6.1 Overview

A diagrammatic representation of the CI Capability Model, and the relationships between the
elements it comprises, is given in Figure 2.2. The terminology used to describe CI capability is
defined in Table 2.2.

Core abilities and key behaviours
A close look at specific CI implementations of varying degrees of success suggests that in those
companies which appear to be getting closer to achieving CI capability there are two developments
taking place, at different levels but closely linked. At the level of the organisation, there is an
emerging set of abilities which drive and support CI. At the level of the individual (or group), there
are certain behavioural norms which seem to be essential if CI is to be developed to its full
potential.
The CI Capability Model identifies six core abilities. These abilities relate to the organisation rather than to particular individuals within it, for example 'the ability to link CI activity at all levels to company strategy'.

**Figure 2.2 CI as a capability**

**Table 2.2 Definition of terms used to describe CI capability**

| CI capability | The ability to gain strategic advantage by extending involvement in innovation to a significant proportion of the organisation. |
| Core abilities | Abilities at the level of the organisation, all of which must be well established to achieve genuine capability in CI. The core abilities are generic – they must all be present, though the form in which they are manifested will vary between organisations. |
| Key behaviours | Behavioural norms displayed by individuals and groups which reflect, and result from, the core organisational abilities. The key behaviours are also generic and must be present to achieve CI capability. |
| Sub-behaviours | Lower level behaviours into which the key behaviours can be disaggregated. |
| Enablers | Mechanisms through which an organisation can encourage development of the key behaviours. Some enablers appear to be critical, while others are 'nice to haves'. The enablers are contingent and take many different forms. |
The model also identifies nine\textsuperscript{11} behavioural norms or \textit{key behaviours} which underpin successful CI. These are behaviours displayed by individuals and groups but they relate closely to the core organisational abilities. For example, the presence of the behavioural norm 'proactive participation in incremental improvement' reflects, and is the result of, the organisation's ability to 'generate sustained involvement in incremental innovation'. The core abilities and associated key behaviours are summarised in Table 2.3, together with some real-life examples of the behaviours as observed in companies during the CIRCA research.

The key behaviours are high level descriptions and can be broken down into lower level sub-behaviours. For example, a sub-behaviour of B2 'The CI system is continually monitored and developed' is 'a designated individual or group monitors the CI system and measures the incidence (i.e. frequency and location) and results of CI activity'. Decomposing the key behaviours makes it easier to assess the extent to which they are present, thus making it clearer what steps could be taken to further develop a particular behavioural norm. The author broke down each of the nine key behaviours in the CI capability model into three sub-behaviours. This is an arbitrary figure, but is sufficient to clarify the key behaviour without producing an overlong list of lower level behaviours. The sub-behaviours are itemised and discussed in more detail in the next section.

Both the core abilities and the key behaviours are generic, i.e. they apply to all organisations, and must be present in any company aspiring to CI capability. The organisational abilities are unlikely to be found naturally occurring in a firm. People in positions of influence have to work consciously at developing the abilities, and the degree to which the key behaviours are present demonstrates how successful they have been at doing this.

\textit{Enablers}

Developing the desired behaviours is not easy. It is a long-term activity which involves 'unlearning' the old behaviours and practising and reinforcing the new ones until they become routine. Despite the difficulties, there are still many actions a company can take to help create or reinforce the desired behaviour patterns. The CIRCA research identified a range of enabling mechanisms, the use of which supports development of each of the core abilities and encourages the appropriate key behaviours. These enablers are contingent and vary between organisations depending on the company's history, structure, prevailing culture, commercial environment etc. Examples of enablers include a problem-solving methodology, facilitators, role models, legitimation of time spent on improvement activity, measurement systems, movement of staff between different functional or product areas. Some of the enablers appear to be critical, while others are less

\textsuperscript{11} In 1996 the author split the first behaviour into two, to aid development of the CIRCA CI Self-Assessment Tool. For consistency all the final CIRCA project reports, including that in Appendix 3, refer to ten key behaviours. However, the research carried out for this thesis used the nine behaviour version of the model.
<table>
<thead>
<tr>
<th>Core Abilities</th>
<th>Associated Behaviours</th>
<th>Examples of behaviours seen in practice</th>
</tr>
</thead>
</table>
| **A** The ability to link CI activity at all levels to the company strategy | 1 Individuals and groups use the organisation’s strategic goals and objectives to focus and prioritise their improvement activities | • CI teams assess potential impact on company objectives when evaluating alternative solutions to problems  
• All department members together identify and prioritise improvements to help meet the department’s objectives |
| **B** The ability to strategically manage the development of the CI system* within the organisation’s structures | 2 The CI system* is continually monitored and developed | • The frequency, location and outcome of improvements are monitored  
• The CI system* as a whole is reviewed periodically and actions are taken to improve its effectiveness |
| 3 Ongoing assessment ensures that the organisation’s structure/infrastructure and the CI system* consistently support and reinforce each other | | • The work organisation was restructured to facilitate teamworking  
• Before the merger took place a Director assessed the impact this would have on CI activity and action was taken as a result |
| **C** The ability to generate sustained involvement in incremental innovation | 4 Managers at all levels display active commitment to, and leadership of, CI | • Senior managers deliver CI training  
• Managers release people from the line to participate in improvement work |
| 5 People participate proactively in incremental improvement | | • People at all levels initiate CI activity  
• Process measurement is used widely |
| **D** The ability to work effectively across internal divisions and external boundaries | 6 Effective working by individuals and groups across internal divisions (vertical and lateral) and external boundaries at all levels | • High level of co-operation between departments and functions  
• Production staff meet key suppliers to discuss problems and improvements |
| **E** The ability to enable learning to take place and to be captured and shared at all levels | 7 People learn from their own and others’ experiences, both positive and negative | • Problems as well as achievements are freely discussed with colleagues  
• Take part in post project reviews |
| 8 The learning of individuals and groups is captured and deployed | | • A matrix tool is used to identify other areas where the improvement could be applied |
| **F** The ability to articulate, demonstrate and communicate the CI values | 9 People are guided by a shared set of values underpinning CI as they go about their everyday work | • When something goes wrong people look for reasons why, rather than for someone to blame  
• The office staff believe that making improvements is part of their job |

* The 'CI system' comprises all the processes, procedures and enabling mechanisms put in place to encourage adoption of the key behaviours.

Table 2.3 CI core abilities and their associated behaviours
significant 'nice to haves'. However, even the critical enablers (e.g. strategy deployment) take many different forms, depending on the organisational context.

When such enablers are first used the resulting behaviours will be at a superficial level. By repeated use of the enablers and other forms of reinforcement, such as training, the behaviours of individuals, and the organisational abilities they reflect, gradually become more deep-rooted with people starting to behave naturally in that way. CI capability is attained only when the behaviours have become so ingrained that they are enacted automatically.

**Conclusion**

The CI Capability Model represents a very different way of looking at CI from commonly presented approaches and frameworks. It emphasises the behaviours that need to be developed in order to achieve an ingrained process of CI, rather than a particular implementation methodology (first do A, then do B) or specific mechanisms or artefacts that 'must' be in place (e.g. teams, councils, suggestion schemes). Although the CI Capability Model recognises the potential value of such mechanisms, it gives them a supportive role, as enablers of CI which may or may not be appropriate in a given context, rather than a mandatory role in which their implementation represents an end in itself.

Nevertheless, it is possible to see similarities with some of the literature reviewed in the previous section. For example, there is some overlap between the key behaviours of the CI Capability Model and Garvin's (1993) building blocks of a learning organisation, and Leonard-Barton's (1995) knowledge creation activities. The concept of enablers is reflected, to a certain extent, in some of Nevis et al.'s (1995) 'facilitating factors', Rommel et al.'s (1996) 'levers of quality', Locke and Jain's (1995) techniques for building a CI culture, and Leonard-Barton's (1992b) 'managerial systems' which support the four knowledge creation and control activities. Porras and Hoffer's (1986) research led them to the conclusion that

"different models and approaches for changing organisations might converge to produce common behavioural changes. That is, a state of equifinality may exist in which numerous paths lead to the same changes in behaviour."

This directly reinforces the generic/contingent divide in the CI Capability Model.

**2.6.2 The model in detail: core abilities, key behaviours, and enablers**

This subsection looks in more detail at the core abilities and key behaviours. It explains why they are important, describes the sub-behaviours associated with them, and gives examples of enablers that can help encourage the appropriate behavioural norms to develop.
The issues covered by the CI Capability Model are wide-ranging and there are many references in the literature which having a bearing on them – supporting the importance of a behaviour, describing a potential enabler, and so on. In order to keep this section as concise as possible the references that relate to the author's elaboration of the model, described in the following text, are presented in Table 2.4.

<table>
<thead>
<tr>
<th>Core Ability</th>
<th>Source</th>
<th>Relevance for CI Capability Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Link CI to strategy</strong></td>
<td>Imai (1987); Lilrank and Kano (1989); Westbrook and Barwise (1994)</td>
<td>• policy deployment</td>
</tr>
<tr>
<td></td>
<td>Sundbo (1996)</td>
<td></td>
</tr>
<tr>
<td><strong>Manage CI system strategically</strong></td>
<td>Berger (1996b)</td>
<td>• managing CI from a strategic perspective</td>
</tr>
<tr>
<td></td>
<td>Westbrook and Barwise (1994); Capozzoli (1994); Ghorpade and Chen (1995); Kearney (1991); Kaufman (1992); Hill and Wilkinson (1995)</td>
<td>• conflict / incongruities between existing practices and systems and CI</td>
</tr>
<tr>
<td></td>
<td>Berger (1996b)</td>
<td>• mutually reinforcing development of improvement practices and organisational arrangements</td>
</tr>
<tr>
<td></td>
<td>Leonard-Barton (1995)</td>
<td>• mutual adaptation i.e. adapting new technology to conform to work environment and simultaneously adapting the organisation to use the new technical systems</td>
</tr>
<tr>
<td></td>
<td>Shani and Rogberg (1994)</td>
<td>• interplay between contextual factors within which quality is addressed and nature of the quality programme itself</td>
</tr>
<tr>
<td><strong>Generate sustained involvement in CI</strong></td>
<td>Westbrook and Barwise (1994)</td>
<td>• e.g. of firm with comprehensive mechanism to assess CI progress</td>
</tr>
<tr>
<td></td>
<td>Marsh (1996)</td>
<td>• poor management causes many quality efforts to fail</td>
</tr>
<tr>
<td></td>
<td>Locke and Jain (1995)</td>
<td>• importance of management and leadership for CI</td>
</tr>
<tr>
<td></td>
<td>Ghorobadian and Woo (1996)</td>
<td>• quality awards (e.g. Baldrige, European Quality Award) emphasise management leadership and responsibility for quality</td>
</tr>
<tr>
<td></td>
<td>Champey (1994); Luthans, Rubach et al. (1995); Eccles (1993)</td>
<td>• new style of leadership required – managers as teachers, stewards, designers of organisations etc. but allocate resources, make rules etc.</td>
</tr>
<tr>
<td></td>
<td>Robinson (1991, p.xxxi)</td>
<td>• kaizen requires: (1) operating practices which expose improvement opportunities; (2) making every employee want overall improvement; (3) training employees in problem-solving techniques so that they are able to make improvements</td>
</tr>
</tbody>
</table>

Table 2.4 Literature references with relevance to the CI Capability Model (continued on next page)
<table>
<thead>
<tr>
<th>Core Ability</th>
<th>Source</th>
<th>Relevance for CI Capability Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generate sustained involvement in CI (continued)</td>
<td>Emulti, Kathawala et al. (1992); Kohn (1993); Westbrook and Barwise (1994); Kaplan and Norton (1992)</td>
<td>• negative effects of performance appraisal and incentive systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• involvement in TQ in job descriptions / as a criteria in appraisals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• measurement to stimulate involvement in improvement</td>
</tr>
<tr>
<td>Work effectively across internal divisions and external boundaries</td>
<td>Hodgetts, Luthans et al. (1994); Leonard-Barton (1995)</td>
<td>• dialogue - a technique to overcome basic differences between subcultures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• shared problem solving, creative abrasion, mechanisms for managing conflicting 'signature skills'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• creating porous boundaries</td>
</tr>
<tr>
<td>Enable learning to take place, be captured and shared</td>
<td>Nonaka (1991); Garvin (1993); Luthans, Rubach et al., (1995); Wiggenhorn (1993); Argyris (1993); Argyris (1994); Leonard-Barton (1995); Krishnan, Shani et al. (1993); Adler (1993); Adler and Cole (1993); Krishnan, Shani et al. (1993); Buckler (1996); Leonard-Barton (1995); Buckler (1996); Leonard-Barton (1995); Garvin (1993); Buckler (1996); Leonard-Barton (1995); Garvin (1993); Luthans, Rubach et al. (1995); Leonard-Barton (1995); Hodggetts, Luthans et al. (1994); Luthans, Rubach et al. (1995); Kim (1993); Luthans, Rubach et al. (1995); Krishnan, Shani et al. (1993); Stata (1989); Nonaka (1991)</td>
<td>• building knowledge creating companies, learning organisations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• companies building educational systems e.g. Motorola University</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• obstacles to learning: defensive reasoning, 'no blame' attitude</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• knowledge inhibiting activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• standard operating procedures may delay search for new procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• standard operating procedures, standardisation as recondition for organisational learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• management support / leadership of learning and knowledge building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• learning from failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• learning from prototypes and experiments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• avoiding riskless projects because they do not give opportunity to out learn competitors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• scenario analysis (helps people learn how to revise mental models)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• learning laboratories</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• immediate application of training to workplace</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• systems dynamics tool to facilitate individual and organisational learning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• convert tacit knowledge to explicit knowledge e.g. using figurative language</td>
</tr>
</tbody>
</table>

Table 2.4 continued Literature references with relevance to the CI Capability Model (continued on next page)
<table>
<thead>
<tr>
<th>Core Ability</th>
<th>Source</th>
<th>Relevance for CI Capability Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enable learning to take place, be captured and shared (continued)</td>
<td>Leonard-Barton (1995); Garvin (1993); Luthans, Rubach et al. (1995)</td>
<td>• integrating internal knowledge, transferring knowledge e.g. via apprenticeships, training and education, reports and tours, case studies, staff rotation schemes</td>
</tr>
<tr>
<td></td>
<td>Leonard-Barton (1995); Garvin (1993); Luthans, Rubach et al. (1995)</td>
<td>• integrating external knowledge, learning from experiences and best practice of others e.g. alliances, networks, benchmarking, joint ventures, reciprocal trading of information with other firms, temporary assignment of employees with suppliers, partners, customers</td>
</tr>
<tr>
<td></td>
<td>Nonaka (1991); Luthans, Rubach et al. (1995)</td>
<td>• embodying user knowledge in design of new processes/tools, observing customers in action</td>
</tr>
<tr>
<td></td>
<td>Dale and Allan (1993); Kransdorff (1996)</td>
<td>• building redundancy (i.e. overlap of managerial responsibilities, business activities, and company information) via internal competition, rotation, free access to company information; redundancy helps transfer tacit knowledge and spread new explicit knowledge</td>
</tr>
<tr>
<td></td>
<td>Kim (1993)</td>
<td>• use of 'know-how' notes in Japan</td>
</tr>
<tr>
<td></td>
<td>Pathak (1992)</td>
<td>• oral diary to capture data about ongoing projects to aid post project review and learning audit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• systems archetypes, a tool for mapping an individual's insights</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• creativity circles used in Japan to transfer an individuals' insights and learning into organisational knowledge</td>
</tr>
<tr>
<td>Articulate, demonstrate and communicate CI values</td>
<td>Leonard-Barton (1995)</td>
<td>• values critical to creating a learning environment: respect for the individual, tolerance of failure, openness to ideas from outside</td>
</tr>
<tr>
<td></td>
<td>Luthans, Rubach et al. (1995)</td>
<td>• cultural values associated with learning organisations: experimentation and improvisation at all levels; openness, genuine concern for suggestions of subordinates</td>
</tr>
</tbody>
</table>

Table 2.4 continued Literature references with relevance to the CI Capability Model
A. The ability to link CI activity at all levels to the company strategy

Linking CI to company strategic goals ensures that all the effort put into CI helps to move the company in the direction it wishes to go. One reason many CI implementations failed is that they were treated as a 'nice to have' add-on to the 'real' business of running the company. This attitude is almost inevitable unless the contribution that CI is expected to make to achieving the company's goals and objectives is clearly understood and articulated. Linking the CI to company strategy gives the CI a focus and ensures that everyone is pulling in the same direction. Moreover, aligning the CI to strategic aspirations helps CI become an integral part of organisational life and demonstrates the importance the organisation attaches to CI.

The successful development of this ability is dependent on mobilising the commitment of those who form and articulate strategy; and on the effective communication of strategy and the role of CI, to employees at all levels.

If an organisation lacks this core ability the effort put into CI activity will not produce maximum benefit, and may be counterproductive (e.g. time wasted on irrelevant issues with no strategic or operational significance) or even damaging (e.g. changes implemented which run counter to company objectives, or which impact negatively on another part of the business). For example, one company had successfully managed to engender enthusiasm for CI. People were encouraged to use CI tools and techniques to solve problems. However it got to the point where one group was putting its time and effort into working out how to recycle pencil sharpenings! Subsequently the company introduced a four phase cycle to be followed by individuals or teams who wished to work on an improvement proposal. The first phase included having to show how the proposal would help the department to meet its objectives (which in turn were linked to strategic objectives).

The behavioural norm indicative of this ability is: *Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities.* This is disaggregated into the following subbehaviours:

• Everyone understands (i.e. is able to explain) what the company's or department's strategy, goals and / or objectives are.

• Individuals and groups (e.g. departments, CI teams) assess their proposed changes (before embarking on initial investigation and before implementing a solution) against departmental or company objectives to ensure they are consistent with them.

• Individuals and groups monitor/measure the results of their improvement activity and the impact it has on strategic or departmental objectives.
A range of enablers may be necessary to encourage this sort of behaviour, including some to aid communication of company objectives and others to help steer the activities of employees in the desired direction. Examples of such enablers are given in Table 2.5.

- A formal CI process which requires reference to departmental or company objectives before CI activity is undertaken.
- A clear statement of the role of CI in achieving strategic goals, which is made explicit at all levels.
- A process of policy deployment.
- Use of milestones, stretch targets.
- Department and individual level objectives that clearly link company strategy to individual work roles.
- Translation of business objectives into CI objectives and a CI plan (e.g. through a CI steering committee).
- Regular monitoring and measurement to demonstrate the impact of CI on strategic objectives.
- Regular and effective communication of the link between strategy and CI using a variety of media such as cascade meetings, team briefings, open forums, senior management briefings to all employees, booklets, newsletter, videos.
- Opportunities for upward communication during strategy development (e.g. discussions and feedback sessions).
- Involvement of all members of a department / work area in defining local objectives based on the company strategy (e.g. using Department Purpose Analysis).

Table 2.5 Examples of enablers to encourage the linking of CI activity to company goals and objectives

**B. The ability to strategically manage the development of the CI system within the organisation's structures**

This ability is fundamental to the effort of sustaining the momentum of the CI in the long term. It has two aspects. The first, with an internal focus, is about monitoring the CI system so that it can be developed strategically and in such a way that it continues to be relevant and appropriate. The second, with an external focus, is about ensuring that the CI system and other organisational systems remain compatible. Use of the phrase 'CI system' does not necessarily imply a parallel structure. It refers to all the processes, procedures and enabling mechanisms put in place to encourage adoption of the key behaviours; such processes and mechanisms may well be integrated in-line.

There are two behavioural norms indicative of this ability, reflecting the different aspects. The first, the CI system is continually monitored and developed, is made up of the following subbehaviours:
• Designated individual or group monitors the CI system and measures the incidence (i.e. frequency and location) of CI activity and the results of CI activity.

• Designated individual or group follows a cyclical planning process whereby (a) the CI system is regularly reviewed and, if necessary, amended (single-loop learning) and (b) there is periodic review of the CI system in relation to the organisation as a whole which may lead to a major regeneration (double-loop learning).

• Senior management make available sufficient resources (time, money, personnel) to support the ongoing development of the CI system.

The second behaviour, which looks beyond the CI system, is: *Ongoing assessment ensures that the organisation's structure / infrastructure and the CI system consistently support and reinforce each other.* Developing and maintaining congruity between the organisation's structure and the CI system is very important. A mismatch can undo all the effort put into developing CI. For example, a hierarchical, command and control structure, and the culture associated with it, would make it hard to develop a CI system aimed at empowering people to try out new ways of doing things and to implement their own improvements. No matter how well a CI system has been designed to encourage teamwork and cooperation, if the compensation system continues to reward individual rather than group achievement there will be difficulties sustaining the CI approach. Another example of mismatch is a shift to a cross-functional, process way of managing while the financial reporting remains functional. Thus it is necessary for the design of the CI system to take account of the constraints presented by the organisation's structure and infrastructure, and for action to be taken to mitigate any adverse impact organisational structures or changes may have on the CI system. The subbehaviours reflect this:

• The individual/group responsible for designing the CI system design it to fit within the current structure and infrastructure (e.g. in selecting the type of CI 'vehicles' that are most appropriate to the work organisation).

• Individuals with responsibility for particular company processes/systems (e.g. the reward system, the CI system, the personal development process, the production process) hold ongoing reviews to assess whether these processes/systems and the CI system remain compatible, and take action as necessary (e.g. changing from an individualistic to a group based reward system if the company is trying to encourage team-based CI; e.g. to take account of the effect of a change in shift patterns on involvement in CI activity).
• Person(s) with responsibility for the CI system ensure that when a major organisational change is planned its potential impact on the CI system is assessed and adjustments are made as necessary.

Some enablers which help the organisation develop the ability to strategically manage development of the CI system within its structures and encourage the behaviours associated with it are listed in Table 2.6.

| • A procedure formalising regular review of the operation of the CI system. |
| • A procedure formalising periodic review of the CI system in relation to the organisation as a whole. |
| • Regular assessment of the CI system – either self-assessment or carried out by experienced outsider. |
| • Inclusion of review of the CI system as a permanent agenda item for a regular senior management meeting. |
| • Sufficient resources (time, money, personnel) to support the strategic development of the CI system. |
| • Assignment of the responsibility for co-ordinating the CI system to an individual or group. |
| • Appropriate measures of the quality and quantity of participation in CI vehicles. |
| • Requirement on individuals and teams to record the benefits accruing from their improvement activity. |
| • Mechanisms for measuring the outputs of CI vehicles. |

Table 2.6 Examples of enablers to encourage strategic management of the CI system

C. The ability to generate sustained involvement in incremental improvement

CI requires the involvement of many employees from all levels and areas of the organisation in making improvements on an ongoing basis. The ability to generate sustained involvement in incremental innovation therefore lies at the heart of CI. How successful a company is at this is demonstrated by the level of participation in continuous improvement and the extent to which that involvement is natural and proactive rather than extrinsic and reactive.

There are two behavioural norms indicative of this ability. The first applies to those in managerial or supervisory positions: Managers at all levels display active commitment to, and leadership of, CI. The second, People participate proactively in incremental improvement, applies to staff throughout the organisation, whatever their position.
Looking at the subbehaviours helps clarify what management commitment and leadership of CI means in practical terms:

- Managers spend a significant proportion of their time on CI-related activities (e.g. as members of an improvement team, delivery of CI training, incorporating CI into business plans, leading local initiatives).

- Managers encourage their people to take part in CI activities (e.g. as facilitators, CI team members) for example by allowing them time to do so and by recognising people's involvement.

- Managers demonstrate awareness of the role of measurement and target/objective setting in CI (e.g. by encouraging people to measure their own processes as a means of problem solving / uncovering opportunities for improvement; by using targets or objectives to help improve the process and not to blame people if the targets are not met; in the way they measure their own processes and set strategies).

There are various enablers which may encourage managers to get involved with CI and demonstrate their commitment and leadership of it, including those listed in Table 2.7.

<table>
<thead>
<tr>
<th>Table 2.7 Examples of enablers to encourage managers to lead CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Managers have specific CI-related responsibilities and/or objectives.</td>
</tr>
<tr>
<td>- Managers are encouraged to get involved with delivery of CI courses on a regular basis.</td>
</tr>
<tr>
<td>- Senior managers record how much time they spend on CI-related activity.</td>
</tr>
<tr>
<td>- Managers' performance is assessed against the criteria of demonstrated commitment to CI. (During appraisals managers demonstrate their practical involvement in CI and how they have developed it in their area.)</td>
</tr>
<tr>
<td>- Demonstrated leadership of CI is a criterion for promotion.</td>
</tr>
<tr>
<td>- Senior managers who champion CI and a CI style of management act as role models to other managers.</td>
</tr>
</tbody>
</table>
People participate proactively in incremental improvement includes the following subbehaviours:

- Individuals and groups follow a problem solving / improvement opportunity finding cycle.

- Individuals and groups draw on a wide range of appropriate tools and techniques including process measurement to assist with CI activity.

- Individuals and groups, at all levels, initiate CI activities and carry them through to completion.

As noted at the beginning of this chapter, CI implies a systematic approach to improvement involving staff throughout the firm. Following some form of problem solving or improvement opportunity finding cycle, which need not be complex or bureaucratic, helps sustain a systematic approach. Using problem solving tools also results in a more systematic and thorough approach. Although in the early days of implementing CI it may be quite easy to identify problems and areas to improve, later on more advanced tools and techniques may be required to uncover such opportunities. CI is about genuine participation in improvement and goes beyond identifying problems for someone else to deal with, or simply improving something at the behest of a manager. For CI to be most effective, employees should be both initiating improvement activity and working on implementing the improvement themselves, as far as is possible.

There are at least three groups of enablers of sustained involvement in CI. Firstly, people need to be given the means to participate by providing appropriate vehicles and processes for CI, and equipping people with the necessary knowledge and skills to make use of these vehicles and processes. Then, if people are to have a real involvement in implementing innovation, rather than being limited to raising suggestions for improvement, they also need to be given the authority to take decisions and implement their ideas and solutions. Whilst these first two categories of enablers will allow people to fully participate, they are unlikely to do so unless they also have the desire or motivation to do so. The third category of enablers is concerned with encouraging and reinforcing involvement by providing information, role models and recognition. Table 2.8 provides examples of each type of enabler.
Enablers offering the means to participate

- Provision of appropriate vehicles for involving individuals and teams in all areas and at all levels.
- Training to ensure that people understand the how the vehicles operate and how they can participate in them.
- Legitimising time spent on improvement activities. For example, by specifying dedicated improvement time, releasing people to participate, allowing people to spend a certain % of work time pursuing their own ideas.
- Adequate provision of trained facilitators to support improvement activity.
- Training in a problem solving / improvement cycle and in appropriate CI tools.
- Skills assessment and planning to develop the required skills portfolio, e.g. through skills matrices, performance reviews and appraisals.
- Alignment of the personal development needs of individuals with those of the organisation, e.g. through personal development plans.

Enablers conferring authority to participate

- Allowing individuals/teams to decide for themselves what problems to work on.
- Freedom for people to instigate formal or informal CI activity on their own initiative.
- Providing everyone with access to a problem-finding / problem-solving process and to a CI tool kit.
- During the problem-solving process decision-making remains with the team.
- Management support of staff in problem-solving activity (through coaching, encouragement, provision of resources etc.) but without trying to solve the problem for them.
- Allowing individuals/teams to follow through their ideas, etc. to implementation.
- Provision of adequate resources for implementing solutions.

Enablers to foster motivation to participate

- Positive attitude to mistakes.
- Incentive systems to recognise people's participation (monetary or non-monetary).
- Requirement that improvement suggestions receive quick, constructive response.
- Communication of the benefits of CI that have been realised in the company (at micro level as well as at a company level).
- Key personnel act as role models.
- Ensuring everyone is well informed about the overall performance of the organisation and understands how they can contribute.
- Encouraging people to monitor the performance of their local work area and use this to identify improvement opportunities.
- Structured analysis of processes, inputs and output within work area and of local objectives.
- Inclusion of requirement to continuously improve work processes in job description.
- CI as a category considered in appraisal.
- Local process measurement. Measurement of parts of the process targeted for improvement.

Table 2.8 Examples of enablers to encourage participation in CI

D The ability to work effectively across internal divisions and external boundaries

This ability is important in order to ensure that problems or opportunities spanning more than one work area can be handled effectively, and to avoid suboptimisation. The practice of cross-boundary communication and co-operation encourages a more holistic view of the business and gives people a greater understanding of how other areas operate and the problems and constraints they face. Effective lateral communication across separate work areas is essential to this ability, and is also a potential conduit for dissemination of the learning arising from CI activity (see Ability E).
The behavioural norm indicative of this ability is: *Effective working by individuals and groups across internal (vertical and lateral) divisions and external boundaries at all levels*. It comprises the following subbehaviours:

- Everyone shares a holistic view of the organisation (common goals) and has a good understanding of what other departments/functions etc. do.

- People at all levels naturally (i.e. automatically, not because they are directed to do so) cooperate and work effectively across internal boundaries (e.g. between departments, functions, divisions).

- People work effectively with outside agencies e.g. customers, suppliers.

Enablers of this key behaviour are concerned with communication, breaking down internal boundaries, and extending contact beyond the firm to as many employees as possible. Examples are given in Table 2.9.

<table>
<thead>
<tr>
<th>Enablers of cross-boundary working</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Regular lateral communication at all levels (e.g. of functional heads to align respective strategies; of CI team leaders to share learning).</td>
</tr>
<tr>
<td>• Regular cross-functional working, for example through task forces, development teams and cross-functional improvement teams.</td>
</tr>
<tr>
<td>• Movement of staff between different functional / product areas (forms of job rotation).</td>
</tr>
<tr>
<td>• Inter-site visits.</td>
</tr>
<tr>
<td>• One company operating on multiple sites in the UK got each site to make a video of all its people which introduced them and what they did. Everyone had the opportunity to watch the videos, many saw for the first time people they dealt with to carry out their job. It helped to make the contacts by phone or memo more personal, and as a result inter-site communication and co-operation improved markedly.</td>
</tr>
<tr>
<td>• Regular meetings between key suppliers and the shop floor employees who use the materials supplied.</td>
</tr>
<tr>
<td>• Visits by shop floor staff to customer sites, to see the product they make in use.</td>
</tr>
</tbody>
</table>

Table 2.9 Examples of enablers of cross-boundary working

*E. The ability to enable learning to take place, and to be captured and shared, at all levels*

Learning is central to the CI cycle. An organisation needs to encourage its people to adopt a learning approach: to be inquisitive, challenge the status quo, experiment, and learn from both mistakes and positive outcomes. To get the most from the learning taking place a company needs to make sure it is transferred into the organisation's 'memory', thus making it permanently accessible for use by other employees now and in the future, either formally, e.g. via procedures,
or informally as part of the ‘culture’. The organisation should also build on the learning (for example by connecting related learning or knowledge which comes from different sources) and maximise its usefulness by deploying it from one area to another, or from one project to future projects.

There are two behavioural norms indicative of this ability, *People learn from their own and each other’s experiences, both positive and negative*, and *The learning of individuals and groups is captured and deployed*. The first of these concerns individuals and groups of employees, subbehaviours being,

- Everyone learns from their experiences, both positive and negative (i.e. they do not repeat actions that gave rise to a negative experience, they build on or repeat actions that resulted in positive outcomes).

- Individuals seek out opportunities for learning and personal development (e.g. actively experiment, set their own learning objectives).

- Individuals and groups at all levels share (make available) their learning from *all* work experiences (i.e. not just those relating to specific CI activities), both positive and negative, formally and informally (e.g. participate openly in development project reviews, feed into the organisation learning and insights acquired from outside the organisation, do not try to hide negative experiences, talk to colleagues).

Enablers of this behavioural norm are shown in Table 2.10.

<table>
<thead>
<tr>
<th>Examples of enablers to encourage individual and group learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Open, ‘blame-free’ environment in which people are able to admit to errors without disadvantaging themselves.</td>
</tr>
<tr>
<td>• A disciplinary policy which seeks to help individuals avoid making repeated mistakes rather than dismissing an employee who makes frequent errors.</td>
</tr>
<tr>
<td>• Encouragement of experimentation and (calculated) risk taking.</td>
</tr>
<tr>
<td>• Encouragement of self-analysis e.g. as part of personal development process.</td>
</tr>
<tr>
<td>• Formal mechanisms to encourage people to share learning e.g. requirement to do summary report of learning gained from attending external events; space allocated on network, newsletter, etc.; project reviews.</td>
</tr>
<tr>
<td>• Informal mechanisms to encourage people to share learning / insights e.g. areas where people can meet informally; reviews during courses; part of team briefing / department meeting allocated specifically for sharing learning.</td>
</tr>
<tr>
<td>• Self-assessment and audits at the level of the project, the team, the department, etc.</td>
</tr>
</tbody>
</table>

Table 2.10 Examples of enablers to encourage individual and group learning
The second key behaviour arising from this ability breaks down into actions that would be the responsibility of subsets of people i.e. people in supervisory roles; teams and individuals who have undergone a learning experience; and those tasked with implementation and operation of mechanisms for capturing and sharing the learning. Subbehaviours are:

- Managers accept and, where necessary, act on all the learning that takes place (i.e. even if it implies criticism of a system or process they are responsible for).

- People and teams ensure that their learning is captured by making use of the mechanisms provided for doing so (e.g. incorporating improvements into written procedures, completing appropriate documentation such as post project report forms).

- Designated individual(s) (use organisational mechanisms to) deploy the learning that is captured across the organisation (this is more than just communication).

Some enablers for capturing and spreading learning are given in Table 2.11.

<table>
<thead>
<tr>
<th><strong>Table 2.11 Examples of enablers for capturing, sharing and transferring learning</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• An improvement/problem solving cycle which includes a review stage.</td>
</tr>
<tr>
<td>• A review stage built into all business processes and projects e.g. development project reviews, strategy reviews.</td>
</tr>
<tr>
<td>• Mechanisms to capture and consolidate learning. For example, improvement teams record learning points, focus groups to capture learning across variety of teams, central database of improvements.</td>
</tr>
<tr>
<td>• Mechanisms to share and communicate learning. For example, through newsletters, storyboards, meetings to share experiences.</td>
</tr>
<tr>
<td>• Mechanisms to deploy learning e.g. implementation matrix to check other areas where a solution may be applied.</td>
</tr>
<tr>
<td>• Amend written procedures to incorporate the learning.</td>
</tr>
<tr>
<td>• Action learning networks.</td>
</tr>
</tbody>
</table>

**F. The ability to articulate, demonstrate and communicate the CI values**

CI is underpinned by a number of core values, such as:

- small-scale improvement is worth bothering about;
- everyone has a contribution to make;
- mistakes are learning opportunities.
The Cl values need to be consistently reinforced so that they become integral to all aspects of organisational life and people know what is expected of them. Managers play a key role in demonstrating and communicating the values by acting as role models.

The behavioural norm indicative of this ability is: *People are guided by a shared set of values underpinning CI as they go about their everyday work,* and this is exemplified by the following subbehaviours:

- The 'management style' reflects commitment to CI values (e.g. to the belief that everyone can make a contribution, by adopting a facilitating rather than directive approach; in their reaction to individuals when things go wrong; in attaching importance to smaller achievements; in not letting go of CI principles when under a lot of pressure).

- When something goes wrong the natural reaction of people at all levels is to look for reasons why rather than to blame individual(s).

- People at all levels demonstrate a shared belief in the value of small steps and that everyone can contribute, by themselves being actively involved in making and recognising incremental improvements.

Enablers that help to promote CI values include those listed in Table 2.12.

<table>
<thead>
<tr>
<th>Table 2.12 Examples of enablers to encourage individual and group learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Regular articulation and communication of the CI values, verbally and in writing, both internally and externally. For example, through induction courses, company literature, presentations and training sessions, various artefacts (e.g. cards, desk calendars with mission).</td>
</tr>
<tr>
<td>- Alignment of all systems and structures with the CI values. For example, through single status benefits, team based reward systems, ensuring that people are seen to be treated equitably, recognition of people and their achievements, promotion criteria which reflect the CI values.</td>
</tr>
<tr>
<td>- Formal and informal systems and procedures which recognise that mistakes are learning opportunities, not cause for blame.</td>
</tr>
<tr>
<td>- Provision of opportunities for everyone, at all levels, to contribute to innovation in the business.</td>
</tr>
<tr>
<td>- Recognition of incremental improvement (small ideas are shown to be valued).</td>
</tr>
<tr>
<td>- Encouragement (e.g. through training, appraisal or promotion criteria, senior management example) of management to reflect the CI values in their behaviour.</td>
</tr>
</tbody>
</table>
2.6.3 Development of Cl capability over time

The previous section described in some detail the behaviours an organisation needs to promote in order to achieve Cl capability. Clearly, establishing these behaviours and developing them to the point where they have become an integral part of the firm's culture will take a long time. The Cl Capability Model recognises the evolutionary nature of the Cl implementation process and in doing so addresses one of the limitations of the earlier ‘gear’ model for Cl.

As noted in Section 2.5.5 above, the experiences of companies suggest that they pass through several developmental stages, or ‘levels of Cl maturity’ as they move towards Cl capability. The Cl Capability Model identifies these phases as:

- Level 1: pre-Cl
- Level 2: formal Cl
- Level 3: goal-directed Cl
- Level 4: proactive, autonomous Cl
- Level 5: strategic Cl capability

Organisations move through the levels by building the core abilities and developing the Cl behavioural norms. The extent to which Cl brings the organisation significant advantage increases as the company progresses through these levels (Figure 2.3).

![Figure 2.3 Evolution of Cl over time](image)

According to the Cl Capability Model, an organisation at Level 1 does not have any of the core abilities, and none of the key behaviours is present. Although there may be some ‘naturally
occurring' improvement the company typically operates in 'fire fighting' mode, innovation is the province of specialists and what problem-solving there is occurs randomly. A company at Level 2 has some enablers in place and there is evidence that aspects of some of the key behaviours are starting to be enacted consciously. Common characteristics of this level include systematic problem-solving, training in the use of simple CI tools, some form of idea management system, and the introduction of appropriate vehicles to encourage involvement. At Level 3 the organisation has mastered certain of the abilities, and the behaviours supporting these abilities have become the norm. The problem-solving taking place is directed at helping the company achieve its goals and objectives, and there is effective measurement and monitoring. By the time it reaches Level 4 the CI is mostly self-driven, with individuals and groups instigating activities and seeing them through to completion, whenever an opportunity arises. At Level 5 the organisation has the full set of abilities, and all the behaviours underlying them have become ingrained routines. Many of the characteristics ascribed to the 'learning organisation' are present (Luthans, Rubach et al., 1995; Nevis, DiBella et al., 1995).

While reviewing what others have written about the development of CI over time (Section 3.5.5 above) reference was made to the Capability Maturity Model (CMM) for software which also adopts an evolutionary approach to learning to manage a process. However, whereas the CMM currently follows a staged approach, with key processes residing at particular stages, the CI capability model follows a continuous improvement approach. In other words, the key CI behaviours are present in some form at each of the levels on the model. The form that each behaviour takes will evolve and mature over time. The following example illustrates how one aspect of problem solving, namely what it is directed towards, changes as the behaviour matures. At Level 2 the main concern is to stimulate involvement in problem solving and equip employees with appropriate skills. The emphasis is on increasing participation rather than what the CI activity is aimed at. By Level 3 problem solving activity is more focused, being directed towards helping to achieve company or department objectives. The direction may be management inspired (e.g. managers allocate relevant projects to improvement teams) or the result of individual or group decisions. At Level 4, 'proactive CI', the CI is largely driven by individuals and teams who steer and monitor their own improvement activities.

Moving between levels

Within each level the embedding and practising of appropriate behaviours occurs as part of a process of single-loop learning,12 with the help of a range of enablers (training, tools, recognition, etc.). However, it would appear that to make the transition to a higher level a company needs to engage in double-loop learning, to take a step back, review progress and ask what changes are required (both to the organisation and to the CI system) to move the CI forward. Simply doing

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12 The distinction between single-loop and double loop learning in organisations was described by Argyris (Argyris, 1977) and is explained in Section 2.5.2 above.
more of the type of behaviour associated with the stage the company is at will consolidate its current position but will not move it into the next level. Take, for example, key behaviour 6: 'Effective working by individuals and groups across internal divisions and external boundaries at all levels'. At Level 2 this behaviour may be displayed to a limited extent by, say, participation in multi-discipline CI teams. At Level 3, however, a cross-functional approach would be part of 'normal' working, even if it were still largely management driven (e.g. scheduled meetings attended by representatives from several functions, such as product development meetings and quality reviews). A Level 4 company would be highly integrated, with cooperation across boundaries being self-driven by all organisational members as and when necessary.

It may be appropriate for some firms to remain at a lower level (e.g. in a mature, mass production industry Level 3 may be considered sufficient) but this needs further investigation.

**Measuring performance**

As noted in Chapter 1, improvements in speed and flexibility have been made in manufacturing processes as a result of applying continuous improvement practices (Bessant, 1992; Bessant and Caffyn, 1997; Locke and Jain, 1995; Mann and Kehoe, 1994). However, it may be easier to attribute performance improvements to the practice of CI during the early stages of CI implementation, when CI activities are often quite distinct (for example, process improvement teams may be set up to resolve specific problems). When a firm is at a more advanced level of CI maturity, with the CI behaviours deeply ingrained and less use made of distinct CI enablers, it may be harder to state with confidence the contribution made by CI to improved performance. Work underway in Europe is starting to address this issue by linking a company's ability to improve its performance with the level of CI maturity it is at (Gieskes, Boer et al., 1998). However, more research is needed into how the impact of CI can be measured.

### 2.7 Conclusion

It is clear from an overview of the history of CI that the concept is not new. In essence it is about recognising a new set of behaviours, many of which are, or have been, promoted under a wide range of banners (TQM, lean production, employee involvement, etc.).

This chapter has described how the CI Capability Model evolved in response to the limitations of earlier models, and to developments in company experience, other research, and other aspects of managing innovation. The CI Capability Model gets to the heart of what CI is about – changing individual, group and corporate behaviour to produce an environment where participation in innovation and learning are the norm. The model takes account of the particular needs and requirements of different organisations; it provides an explanation of how CI evolves over time to move from conscious, often superficial actions, to a set of ingrained behavioural norms; and it
recognises that a company's approach to CI may undergo various changes, indeed such changes may be essential for the further development and sustaining of CI.

The aim of this thesis is to explore the application of CI to the process of new product development. It takes the CI Capability Model as the starting point from which to carry out this investigation. Thus it has been necessary to explain in some detail the content of the model, and the theories and experiences which influenced its development. The next chapter will consider the NPD context and examine current thinking on, and practice in, this area.
Chapter 3  Current State of Knowledge in the Area of New Product Development

3.1 Introduction

The purpose of this thesis is to examine the scope for continuous improvement (CI) within the process of new product development (NPD). The previous chapter argued that CI is essentially about adopting a new set of behaviours, and described in some detail the CI Capability Model. In this chapter we will look at the current state of knowledge surrounding NPD, and consider the multi-faceted nature of the NPD process.

The main aims of this chapter are:

• to highlight the issues in the NPD literature germane to the thesis;
• to demonstrate the emerging consensus amongst writers of the need to manage the NPD process more systematically but without stifling creativity and flexibility, and in a way which allows for ongoing change to the process.

In order to achieve these objectives, and to provide the background necessary to understand the NPD context which is central to the thesis, the bulk of the chapter is given over to a discussion of the elements currently considered to represent 'good practice' NPD. Several themes found within the NPD literature are of particular relevance to this thesis, namely learning, process improvement, and quality management, and they will be examined in more depth. However, before moving into the detail of NPD practices we will take a holistic view of NPD, addressing the questions: What is NPD? How should it be operationalised? Different representations of the NPD process will be presented, showing how they have evolved over time, and the salient features of current and emerging models will be highlighted.

3.2 New product development

NPD in this thesis refers to the process by which new products are developed in companies. This comprises "the range of activities and decisions from the time when an idea is generated (from whatever source) until the product is commercialised (i.e. launched onto the market)" (Hart, 1995, p.21). Typically these activities include some or all of the following tasks listed by Cooper and Kleinschmidt (1986):

• initial screening
• preliminary market assessment
• preliminary technical assessment
• detailed market study/market research
• business/financial analysis
• product development
• in-house product testing
• customer tests of product
• test market/trial sell
• trial production
• precommercialisation business analysis
• production start-up
• market launch

The extent to which these activities actually take place, how they are organised, and the manner in which they are enacted varies between companies. What is considered 'best' or 'good' practice changes over time. Before looking at what constitutes current 'good practice' we will review briefly some of the key approaches to NPD and models of the process that have been proposed in the literature.

3.3 Review of NPD process models and approaches

In order to carry out the research for this thesis it was necessary to develop a framework for looking at CI within NPD processes, and a tool for investigating the practice of CI within NPD. A preliminary stage in these developments was to gain an understanding of what is meant by 'NPD process', since many different interpretations have been proposed over the years.

The following overview of models of the NPD process covers a broad spectrum, ranging from highly theoretical frameworks devised by academics to more practical methodologies adopted by companies. The main categories into which the models fall are summarised in Table 3.1. The discussion will be at a generic level, though of course there are many variants within each category, and in practice firms modify the processes they use to suit their particular needs. A recent study of eight discontinuous product development projects indicates that the development process for such products is significantly different to that for less innovative products (Veryzer, 1998). Adler's (1992) typology of mechanisms for the coordination of product and process design provides a good illustration of the contingent aspects of applying particular approaches or methods within NPD. His typology is based on four generic mechanisms (standards, plans, mutual adjustment, and teams) the form of which varies according to the phase the product development is in (pre-project phase, design phase, manufacturing phase). In order to select the most appropriate mix of mechanisms for a specific project and its phases, managers are advised to consider both the novelty of the problem and the level of analysability (i.e. the difficulty of the search for the answer to the problem).
Types of models

Saren's categories

1. Departmental-stage
   - The innovation moves sequentially through various departments as it progresses from concept to finished product.

2. Activity-stage
   - The process is described in terms of the activities undertaken to develop the new product.

3. Decision-stage
   - The process is broken down into a series of decisions. The decisions may be grouped according to the departments or activities they affect, or shown in the sequence in which they are addressed.

4. Conversion process
   - The process is represented as a 'system' which transforms inputs (e.g. scientific knowledge, customer needs) into outputs (new products).

5. Response models
   - The process comprises the stages involved when a firm develops a response to an internal or external stimulus, which results in it adopting or rejecting an innovation.

Additional categories

1. Holistic
   - A project team works together throughout the process, which takes the form of overlapping development phases.

2. Networking
   - The emphasis is on interorganisational collaboration and the integration of internal and external networks.

Table 3.1 Taxonomy of models of the NPD process, based on Saren (1984) and updated to include more recent additions

Many models of the NPD process have been produced over the years (Figure 3.1). In his review Saren (1984) classifies conceptual models of the innovation process in the firm according to his taxonomy of five different types: departmental-stage models, activity-stage models, decision-stage models, conversion process models, and response models. In 'departmental-stage' models the innovation moves from its conception as an idea through various departments sequentially until it emerges into the market as a new product. 'Activity-stage' models focus on the particular activities that take place during the process. They may consist of a number of broad stages containing certain types of activities (e.g. idea generation, problem solving, implementation; or planning, development, evaluation); or of a series of sequential stages each devoted to a specific activity (e.g. idea generation, screening, commercial evaluation, technical development, commercialisation). Elements of these first two types of model can be combined to show how the activities in the process are linked to particular departments or teams. Saren's third category is 'decision-stage models'. These break down the NPD process into a series of decisions. In some models the decisions are grouped according to the activities or departments they affect, in others the decisions are shown in sequence reflecting the point in the process at which they have to be addressed. Saren stresses that the decision points exist between activity stages and determine when an activity stage or phase starts and ends. The last two types of process model take a holistic view of the innovation process. 'Conversion process' models treat the NPD process as a 'system' which transforms inputs (e.g. raw materials, scientific knowledge, manpower, Continued at foot of next page
those falling into the first three categories, do reflect NPD processes enacted by companies (for example, the department-stage model reinforces the functional approach which is characterised by an 'over-the-wall' attitude to communication). However, such models were often developed to help academics understand the innovation process better, or as a framework for further research, rather than as practical guides to help firms improve the way they developed new products. In order to ascertain current 'best practice' and what it replaces we will look at some models which capture types of process applied in practice and which were considered 'best practice' in their time.

One of the earliest attempts to apply a systematic process approach to NPD was phased project planning (PPP) developed by NASA in the 1960s (Cooper, 1994). PPP, now commonly referred to as Phased Review Process, provided the basis of the first generation of stage-gate systems. It broke development into discrete phases with review points, or 'gates', at the end of each phase. The process was primarily a measurement and control methodology – a project could not proceed to the next phase until all the tasks of the current phase had been completed. It was also very engineering-driven, applying only to the design and development of the product and concerned solely with technical risks. Cooper (1994) reports mixed reviews of the Phased Review Process. Although it brought discipline and reduced technical risks (though not business risks) it was cumbersome, slow, too narrow and too functional. Even so, research has suggested that moving from no formal process for product development to a simple formal phase review process may reduce time to commercialisation by as much as a third (Griffin, 1993).

A firm's perception of what does or should drive the NPD process will influence how it organises and manages the process. At the time that the early Phased Review Processes were being applied by companies simple linear models of the innovation process prevailed. In his review of industrial innovation Rothwell (1992) shows how the first generation 'technology-push' model dominant during the 1950s was followed in the late 1960s by the 'market-pull' model. Both models viewed NPD as a linear process from scientific discovery through R&D, engineering and manufacturing which resulted in a new marketable product or process. The difference was that according to the earlier model the process was driven by R&D – the market gets what R&D give it, while under the 'market-pull' model R&D is reactive, producing innovations in response to customer needs. Elements from both these simplistic models were later combined into the 'interactive' or 'coupling' model. This recognised the influence on NPD of both the needs of society and the marketplace, and the state of the art in technology and production. There was more balance between R&D and marketing, and the interface between these functions was emphasised. Like its predecessors, the coupling model, which held sway from the late 1970s to the early/mid 1980s, was sequential though it did include feedback loops.

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14 Stage-gate systems fall into Saren's 'decision-stage' category.
(a) Departmental-stage model

IDEA → R&D Department → Design Department → Engineering Department → Production Department → Marketing Department → NEW PRODUCT

(b) 'Activity' model of the innovation process

Current state of society's aims and needs and the marketplace

- Recognition of a new societal or market need
- Idea generation
- Project definition
- Problem solving
- Design and development
- Production
- Marketing

State of current scientific, technical and production know-how

(c) Innovation as a conversion process (i) Product orientation (ii) Marketing orientation

(i) Product orientation

Inputs

- Materials
- Knowledge

Conversion

- R&D → Design
- Manufacture

Outputs

- NEW PRODUCTS

(ii) Marketing orientation

Inputs

- Scientific knowledge
- Customer needs

Conversion

- Technical concept
- Product design
- Manufacture

Outputs

- Products

Figure 3.1 Examples of models of the NPD process (Source: Saren, 1984)
By the early 1980s it became apparent that some leading Japanese companies organised their NPD activities in a very different way to that suggested by these innovation models and the Phased Review Process. A study of the innovation process in five Japanese manufacturing companies found that they had adopted a holistic and overlapping approach to phase management, instead of the analytical and sequential approach of PPP (Imai, Nonaka et al., 1985). The holistic approach involved a team working together during the entire process – the game of rugby was used as an analogy to contrast it with the ‘relay race’ approach exemplified by PPP (Takeuchi and Nonaka, 1986). The degree of overlapping varied among the companies studied: in some the overlap occurred only at the border of adjacent phases, in others it extended over several phases. An important feature of the Japanese approach to product development is utilisation of interorganisational networks, of affiliated companies, of suppliers, and of research institutions.

This approach not only resulted in greater speed and increased flexibility, it also had a number of ‘soft’ benefits relating to the people involved in the process. The latter include shared responsibility, cooperation, involvement, commitment, problem-solving focus, initiative taking, diversified skills, and heightened sensitivity toward market conditions (Takeuchi and Nonaka, 1986). On the downside, the holistic approach demands much more process management (coordination, dissemination of information etc.) and creates more tension and conflict within the group. It requires tremendous effort from all project members and may not be appropriate for all types of project (very large projects, for instance, or breakthrough projects which require revolutionary innovation).

The reported experience of these Japanese companies influenced thinking on NPD. However, there are legitimate concerns about the study in terms of, for example, how representative it was and how ‘successful’ the projects examined were, and about the desirability of some of the practices the companies had adopted which put NPD staff under intense pressure (Doyle, 1985). Moreover the projects studied were concerned with durable goods (photocopier, automobile, camera, personal computer, printer) giving rise to the question whether the same approach would work as well for, say, consumer packaged goods or industrial products (Thomas, 1993).

During the 1980s western firms increasingly adopted stage-gate processes which provided them with “a road map from idea to launch consisting of discrete stages, each stage preceded by a Go/Kill decision point or gate” (Cooper, 1994). For example, in 1985 Northern Telecom introduced its Gate Procedure, with four stages and four gates, in order to achieve product manufacturability and meet tight schedule commitments (Wood and Coughlan, 1990). A typical stage-gate process is shown in Figure 3.2. However, as a result of experience and research, companies modified the processes in an attempt to overcome the shortcomings of the early versions modelled on the Phased Review Process. For example, research had shown that often key activities were omitted or poorly carried out, especially those relating to up front, pre-development activities (e.g. initial
screening, market analysis) (Cooper, 1988). To counter this a well-designed stage-gate system would build in such upfront activities as compulsory tasks within a project (Cooper and Kleinschmidt, 1993). Reports of the performance of Japanese product development processes may also have helped to shape the revised processes. For example, a study of car producers in Japan, the US and western Europe found that, even allowing for differences in project characteristics such as complexity, Japanese companies had lead time advantages of 13-14 months. The researchers concluded that the main source of this advantage was "an organizational design that emphasises stage overlapping, intensive communication, manufacturing capability, and supplier engineering" (Clark and Fujimoto, 1989).

Although the second-generation process still had discrete stages preceded by review points it was in all other respects very different to the Phased Review Process. The idealised stage-gate process taken into the 1990s was very much cross-functional, using a multidisciplinary team and team leader to drive the project through to post launch, thus avoiding hand-offs between departments. It was also market oriented, and rapid, with activities occurring in parallel rather than in series (Cooper and Kleinschmidt, 1993).

Research by Cooper and Kleinschmidt (1993) suggests that application of such a stage-gate system can achieve "impressive" results. A third of the managers interviewed from nine divisions across five companies which had implemented this type of system reported that the biggest impact was on improved success rates of new products and greater customer satisfaction. Another third said that the biggest pay-off was being on time and on budget. Major benefits cited by respondents, in rank order, are: improved teamwork; less recycling and rework; higher new product success rate; better launch; earlier detection of failures; shorter cycle time. However, the same study did identify some weaknesses of stage-gate systems (Cooper and Kleinschmidt, 1991). Managers were most concerned about over reliance on interfunctional cooperation; the amount of time required to execute the new product process well (in terms of person days needed rather than elapsed time); and a fear that the process stifles creativity. In his recent assessment of the second-generation stage-gate processes Cooper (1994) highlights a number of other problems. For example, the need to complete a stage before starting the next makes overlapping virtually impossible. In some firms the systems are somewhat rigid, requiring that all projects go through all gates and stages. Moreover, there is no mechanism within the system for comparison across projects, so projects are not prioritised and resources are not targeted on the most important ones. Other problems arise when models are far too detailed so that they are rarely universally implemented (or alternatively get followed blindly), and when the process becomes over bureaucratic.

15 The average overall project lead times (i.e. concept generation to market introduction) without taking project characteristics into account were 3.5 years for the Japanese companies and 5 years for the American and European firms (Clark and Fujimoto, 1989).
Figure 3.2 A typical stage-gate new product system (Source: Cooper and Kleinschmidt, 1991)
It is at this point that the rather theoretical innovation models produced by academics and the processes actually used by companies appear to merge. There are many similarities between Cooper's descriptions of the implemented second generation stage-gate processes and Rothwell's conceptual 'fourth generation' innovation process. Dating from the second half of the 1980s, the latter is "a close approximation to actual global best practice to-day" (Rothwell, 1992). It is an 'integrated' model which takes a parallel approach to development using integrated development teams. There is emphasis on integration between R&D and manufacturing, and closer links with suppliers and leading edge customers. Increased horizontal collaboration (joint ventures, strategic alliances) also impacts on the process and how it is managed.

Other writers confirm the desirability of an integrated process with parallel activities (Wheelwright and Clark, 1992; Barclay, 1992b). There is also growing interest in interorganisational collaboration and the role of networks in NPD (Ingham and Mothe, 1998; Inkpen, 1998; Lambe and Spekman, 1997; Ragatz et al., 1997; Wasti and Liker, 1997). Hart's (1995) 'multiple convergent process' model is derived from the idea of parallel processing but also takes account of the importance of networks in NPD. The model has functionally distinct tasks being carried out simultaneously at specific points throughout the NPD process. The results from these tasks converge at various points during the process (examples of convergent points are idea generation, idea(s) evaluation, concept evaluation and choice). Third parties such as customers and suppliers can easily be included in the framework. Some companies, including Kodak, Douglas Aircraft and Boeing, have already started to integrate external and internal networks in order to successfully develop new products (Biemans, 1995).

In this section we have seen how the dominant views of innovation and the best way to carry out product development have changed over the years and will continue to do so. Work in this field has evolved from academic analysis of what happens towards more prescriptive approaches which offer firms practical guidelines. Today there are companies following processes related to any one of these models, modified versions of them, and combinations of different approaches. For example, Cooper writing in 1994 noted that some units at Hewlett Packard still used a modified version of the Phased Review Process (Cooper, 1994).

None of the types of NPD process model listed in Table 3.1 on its own adequately describes the NPD process. For example, Northern Telecom's Gate procedure referred to above could be classified as a 'decision-stage' process; however, staff worked in departments and carried out activities. Hart's 'multiple convergent process' model combines features of the holistic and networking approaches whilst also including functionally distinct tasks. This suggests that a complete description of the development process should include all seven dimensions: departments, activities, decisions, conversion of inputs to outputs, the firm's response to change, features of the holistic approach, and networking. Although it is not the purpose of this thesis to
produce a definitive model of NPD, it is important to recognise the multi-faceted nature of the NPD process. This will help to ensure that the framework for CI within NPD developed in this thesis, and the tool designed to investigate CI practices in the NPD context, can be applied to any NPD process, regardless of which dimensions are emphasised.

The next section moves from looking at the NPD process as a whole to highlight specific practices and methods considered 'best practice' today – in other words, at the type of development organisation firms are being encouraged to adopt by academics, consultants, government and industry bodies.

3.4 Current 'good practice' within NPD

The previous discussion showed how models of the NPD process have changed over time in an attempt to become more efficient and effective. Earlier ways of organising and managing product development activities have been modified or replaced with methods and practices considered more desirable. The NPD literature includes many reports of such practices which, taken together with the process models, shed light on what might be regarded as current good practice. Table 3.2 shows how features of current NPD 'good practice' compare with the traditional approach.

There are many 'good practices' reported in the NPD literature. While some of these are very wide in scope, for example organisational style or recognition of the importance of learning, others relate to aspects of NPD that can be more narrowly defined, for example, those concerned with people or with performance. The following discussion will start by considering the broader themes related to the overall approach to NPD within a firm. It will then examine two of the more narrowly defined clusters of practices: people and the roles they play in NPD; and factors involved in the operationalisation of the process. These two areas have been selected for review since, as demonstrated in the previous chapter, people and processes are at the heart of what CI is about. The individual themes appear under the following headings:

**Overall approach to NPD**

- process view
- strategic approach
- interfirm integration
- organisational style and control
- flexibility
- learning
<table>
<thead>
<tr>
<th>Traditional NPD Practice</th>
<th>Current NPD 'Good Practice'</th>
</tr>
</thead>
<tbody>
<tr>
<td>no formal process</td>
<td>formal process, process view (3.4.1)</td>
</tr>
<tr>
<td>tactical approach</td>
<td>strategic approach (3.4.2)</td>
</tr>
<tr>
<td>decisions taken on project by project basis</td>
<td>portfolio approach to prioritising and resourcing of projects  (3.4.2)</td>
</tr>
<tr>
<td>insular</td>
<td>horizontal cooperation (joint ventures, strategic alliances) (3.4.3)</td>
</tr>
<tr>
<td>take customers and suppliers for granted</td>
<td>close links with customers and suppliers (3.4.3)</td>
</tr>
<tr>
<td>tight or loose or no control</td>
<td>loose-tight control (3.4.4)</td>
</tr>
<tr>
<td>not responsive</td>
<td>responsive to changes in environment and customer needs (3.4.5)</td>
</tr>
<tr>
<td>learning not an issue</td>
<td>emphasis on learning (3.4.6)</td>
</tr>
<tr>
<td>top management have little involvement</td>
<td>top management involved, support teams and leaders (3.4.7)</td>
</tr>
<tr>
<td>management style autocratic</td>
<td>management style democratic, supportive (3.4.8)</td>
</tr>
<tr>
<td>ignorance or hostility towards Technology</td>
<td>key roles e.g. Technology Gatekeeper, Product Champion are recognised and encouraged (3.4.9)</td>
</tr>
<tr>
<td>Gatekeeper, Product Champion</td>
<td></td>
</tr>
<tr>
<td>culture is resistant to change</td>
<td>widespread acceptance of change (3.4.10)</td>
</tr>
<tr>
<td>rigid - all projects treated the same</td>
<td>flexible – projects may differ and require</td>
</tr>
<tr>
<td></td>
<td>• different process</td>
</tr>
<tr>
<td></td>
<td>• different structures (types of team)</td>
</tr>
<tr>
<td></td>
<td>(3.4.11)</td>
</tr>
<tr>
<td>functional segregation</td>
<td>functional integration, especially R&amp;D, marketing and manufacturing (3.4.12)</td>
</tr>
<tr>
<td>individuals and functional groups</td>
<td>methodologies to improve integration e.g. QFD, DFM (3.4.12, 3.4.15)</td>
</tr>
<tr>
<td>sequential stages</td>
<td>teams, cross-functional, multi-discipline (3.4.12)</td>
</tr>
<tr>
<td>activities carried out in series</td>
<td>overlapping stages (3.4.13)</td>
</tr>
<tr>
<td>the new product and the tools used in its</td>
<td>activities carried out in parallel (3.4.13)</td>
</tr>
<tr>
<td>manufacture are developed separately</td>
<td>concurrent engineering (3.4.13)</td>
</tr>
<tr>
<td>upstream-downstream communication: serial/batch communication, one-way, at end of upstream phase</td>
<td>upstream-downstream communication: intensive two-way information processing from start of project (3.4.14)</td>
</tr>
<tr>
<td>information largely technical</td>
<td>evaluative information including market and technical aspects (3.4.14)</td>
</tr>
<tr>
<td>limited use of technology</td>
<td>exploitation of technology e.g. CAD/CAM/CAE; electronic databases; electronic communication and linkages (3.4.15)</td>
</tr>
<tr>
<td>limited use of development tools and methods</td>
<td>greater use of development tools and methods e.g. FMEA, Design of Experiments (3.4.15)</td>
</tr>
<tr>
<td>design strategy: each new product is unique</td>
<td>better use of prototypes (3.4.15)</td>
</tr>
<tr>
<td></td>
<td>design strategies: various e.g. modularisation; design families; incremental product improvement (3.4.16)</td>
</tr>
</tbody>
</table>

Table 3.2 Features of current 'good practice' NPD compared with the traditional approach. Figures in brackets refer to the subsection in which the item is discussed.
People

- top management
- supportive management style
- roles
- shared values within an innovative culture

Operationalising the process

- structures
- integration
- parallel approach
- effective communication and information evaluation
- tools and methods
- product design strategies
- lean product development

As well as discussing what has been written about each of these 'good practices', the extent to which the practice has been adopted by firms is reported, where quantitative data is available. In several cases, writers have expressed reservations about a practice and these, too, are noted.

3.4.1 Process view

There is widespread consensus that taking a process view is a good practice feature of NPD (Wheelwright and Clark, 1992; Adler, Mandelbaum et al., 1996; Davenport, 1993). Even so, by the early 1990s relatively few companies had adopted a process view and institutionalised it into a formal product delivery process (Cooper and Kleinschmidt, 1993). A 1990 survey in the USA found that only 54.5% of companies had a well-defined NPD process (Page, 1993). The figure for UK companies is very similar. Here a study found that 52.5% of firms used a form of new product guide to help manage their development process, and for most of them use of such a guide was relatively new (Barclay, 1992b). However, formal processes for managing NPD are becoming more common and by 1995 around 60% of surveyed US firms had some form of cross-functional stage-gate process (Griffin, 1997).

3.4.2 Strategic approach

Strategy, including the linking of NPD to corporate strategy, strategic orientation and synergy with existing activities, is one of six key themes identified in the literature as being crucial to the success of NPD (Hart, 1995). Adler et al. (1989) contrast the traditional, tactical approach to NPD with an emerging, strategic approach. Under the latter business managers rather than technical specialists are responsible for development; downstream functions are actively involved in each phase of
product development; product generation maps are used for planning; competitive advantage is protected by continuously renewing know-how and capabilities; and development projects are seen as being integral to extending technological capabilities. However, changing a firm's product development strategy in order to build the capabilities needed may require a major effort to overcome established organisational structures and corporate politics (Karlsson and Åhiström, 1997).

Strategic factors involved in sustained corporate innovation include a long-term corporate strategy in which innovation plays a key role, to build on past successes and capitalise on emerging strengths, and long-term commitment to major projects (Rothwell, 1992). If development projects are designed and managed strategically they can be used to build new development capabilities (Bowen, Clark et al., 1994a; Wheelwright and Clark, 1992, p.109). For example, a project may provide an opportunity to introduce a new CAD system or to try out a new approach to project organisation. Companies adopting the holistic, 'rugby' approach are warned to recognise that NPD will result in more than new revenue-generating products. The hectic pace and sense of crisis that comes from carrying out NPD in this way enable it to act as a catalyst to bring about change in the organisation (Takeuchi and Nonaka, 1986).

Developing a vision and setting appropriate goals are important aspects of a strategic approach to NPD. High performing companies have been found to strengthen their commercialisation capability by, amongst other things, setting goals to focus the effort; these goals are specific, aggressive, limited in number, and used for several years (Nevens, Summe et al., 1990). Another study found that "guiding vision" was one of seven elements found to optimise development, foster learning and initiate change throughout an organisation (Bowen, Clark et al., 1994a). The holistic approach followed by some Japanese companies involves top management deciding the broad strategic direction and setting goals with challenging parameters but letting the development team operate how they want to achieve the goals (Imai, Nonaka et al., 1985).

Strategic management of the development organisation also requires that a broad view is taken across the entire portfolio of projects, and that there is a process for setting priorities and allocating resources among projects (Wheelwright and Clark, 1992; Davenport, 1993; Cooper, 1994). The product development process should fit with the company's objectives (Thomas, 1993). If, for example, the emphasis is on improving quality a process built around Quality Function Deployment would be appropriate, but if a breakthrough product was sought a more 'chaotic' approach would be better. All effective development processes make sure that the process is consistent with the competitive, market and technical challenges a project faces (Wheelwright and Clark, 1992, p.163).
Despite the growing recognition in the literature of the importance of the role of strategy in product development, only 56.4% of US companies surveyed in 1990 had a specific NPD strategy (Page, 1993), increasing to 62.7% by 1995 (Griffin, 1997).

### 3.4.3 Interfirm integration

Interfirm integration is becoming increasingly relevant for NPD. Rothwell’s (1992) predictions for NPD in the 1990s include more collaboration during product development, a large increase in collaboration in pre-competitive research, and a growing number of strategic technology-based alliances. R&D partnerships and technology-sourcing alliances offer powerful learning opportunities and lead to tangible performance improvements, but need to be properly managed (Ingham and Mothe, 1998; Inkpen, 1998; Lambe and Spekman, 1997). Many UK companies are now engaged in some form of collaboration. A recent survey into innovation practices found that 82% of manufacturing companies were involved in collaborative activities with academics, 80% were collaborating with other companies, 78% with consultants, and around 70% with Government and commercial research organisations (CBI/NatWest, 1996).

Close relationships with customers and suppliers are a feature of product development in Japan (Funk, 1993). There interorganisational networks of suppliers have helped to speed up product development and increase flexibility (Imai, Nonaka et al., 1985). Several studies have found that integrating key suppliers early on in the product development process can bring significant performance improvements including, for example, innovations in the system architecture, improvements in product design, and more consideration given to design for manufacturability (Bozdogan et al., 1998; Ragatz et al., 1997; Wasti and Liker, 1997). It is important, though, that customers give their suppliers an appropriate level of responsibility, to avoid wasting their own resources (e.g. by involving suppliers too early in concept sessions) and those of their supplier (e.g. by requiring suppliers to develop capabilities which will not be fully utilised) (Karnath and Liker, 1994). As noted earlier, strong upstream supplier linkages are characteristic of the fourth generation 'integrated' innovation model, and strategic integration with primary suppliers, including co-development of new products and linked CAD systems, is a feature of the fifth generation model (see Section 3.6 below) (Rothwell, 1992).

Customer focus is a basic principle that applies to all effective development processes (Wheelwright and Clark, 1992). We have already seen that a well-designed stage-gate process is market oriented (Cooper and Kleinschmidt, 1993) and that close coupling with leading edge customers is a feature of the fourth generation innovation model (Rothwell, 1992). The more successful innovators actively involve customers in the development process (Rothwell, 1992). Customer needs change so it is important for a company to maintain interactive communication with major stakeholders throughout the development process (Thomas, 1993).
3.4.4 Organisational style and control

There is agreement among a number of writers that an organic organisation is conducive to innovation while a mechanistic one stifles innovatory activity (Baker, Brown et al., 1983; Rothwell, 1992; Johne and Snelson, 1988b). Rothwell (1992) has extracted from the literature the characteristics of organic and mechanistic organisations. The former is participative and informal, non-hierarchical, outward looking, flexible, lacks rigid rules; in this type of firm many views are aired and considered, departmental barriers are broken down, information flows downward as well as up, and communication is face-to-face. The mechanistic organisation, on the other hand, is hierarchical and bureaucratic; there are rigid demarcations between departments, many rules, formal reporting and long decision chains; individuals have little freedom of action and while information flows upwards, directives flow downwards.

However, the degree of innovation required at different stages of the NPD process varies and the management style needs to reflect this. The organic style is best suited to the early, more creative part of the innovation process. As the project moves through prototype production to manufacturing and out into the market, the innovation becomes better defined and the activities required are more routine, making the use of more formal controls appropriate (Baker, Brown et al., 1983; Rothwell, 1992; Johne and Snelson, 1988b). In other words, the recommended approach is for firms to shift between 'loose' and 'tight' forms of co-ordination and control during the NPD process.

3.4.5 Flexibility

Flexibility is a feature of good practice NPD. Corporate flexibility and responsiveness to change is a strategic factor involved in sustained corporate innovation, and flexibility – of the organisation, the product, and manufacturing – is increasingly important (Rothwell, 1992). The NPD process should be flexible enough to cope with different types of new product (e.g. breakthrough, incremental) and to allow continuous changes to be made in response to changes in the environment and customer needs (Cooper, 1994; Thomas, 1993; Barclay, 1992b). Flexible or 'agile' design allows firms to quickly develop a broad portfolio of niche market products, build products to order, mass customise individual products at mass production speed and efficiency, and introduce a steady stream of 'new' (variant) products (Anderson, 1997).

3.4.6 Learning

The connection between learning and successful product development within certain Japanese companies was highlighted in the mid 1980s (Imai, Nonaka et al., 1985; Takeuchi and Nonaka, 1986). These companies possessed "an almost fanatical devotion to learning" and had adopted
strategies to assist the transfer of learning, while recognising the need to 'unlearn' the past. The researchers coined the phrase 'multilearning' to reflect the nature of the learning: a continual process of trial and error ('learning by doing') which took place at the individual, group and corporate level and across functions. This 'learning in breadth', whereby 'non expert' members of development teams are encouraged to acquire the necessary skills and knowledge on the job, contrasted with the 'in depth' specialisation by functional experts favoured in the west. Nonaka (1991) describes how Japanese firms like Honda, Canon and Matsushita, noted for their ability to rapidly develop new products and dominate emergent technology, manage the creation of new knowledge, using techniques to make the tacit insights and learning of individuals available to the rest of the organisation.

The issue of learning in the context of NPD has been taken up by other writers. McKee (1992) describes the role of organisational learning in innovation, while Thomas (1993) stresses that NPD should be viewed as an "ongoing process of learning and renewal". A study in Europe concluded that systemic learning from past experiences is fundamental to effective management of the early phases of product development processes, and essential for successful feed-forward planning (Verganti, 1997). The most successful development projects in another research study were found to be those where teams operated in a learning environment where the emphasis on learning included learning objectives for development projects and learning audits (Bowen, Clark et al., 1994a). Adler's research into design for manufacturability (DFM) identified several factors that seem to be particularly powerful in encouraging a firm to adopt a more aggressive learning path: business crises; demands from above; technological pressure; and environmental pressures (Adler, 1992). Adams et al. (1998) found that some people are able to overcome the organisational barriers which impede learning about markets for new products by building on and leveraging from the established routines.

3.4.7 Top management

There is agreement in the literature that the behaviour of top management is a crucial factor in NPD (Hart, 1995). Top management commitment and visible support is essential for successful NPD (Johne and Snelson, 1988b; Rothwell, 1992). Writers give many prescriptions for how senior managers should behave to support NPD. For example, senior managers must accept risk and know how to learn from failures (Rothwell, 1992). As a company moves towards a strategic (as opposed to tactical) approach to NPD top management should become more deeply involved in NPD and pay particular attention to managing the interfaces between key functional areas (Adler, Riggs et al., 1989). Firms which are good at NPD make commercialisation capability a top management priority and get managers directly involved in the commercialisation process, to speed up actions and decisions and to demonstrate to the rest of the organisation that it should be taken seriously (Nevens, Summe et al., 1990). Another important role of senior executives in
product development is to develop effective leaders by expecting leadership, supporting leaders and rewarding leaders (Bowen, Clark et al., 1994b).

Imai et al. (1985) show how in Japanese companies following a holistic, overlapping approach, top management act as a catalyst by setting goals which are vague but have very challenging parameters, thus creating a tension which, if managed properly, "helps to cultivate a 'must-do' attitude and a sense of cohesion" among the project team members. To support the iterative and dynamic process characteristic of this holistic approach management must adopt a highly adaptive style (Takeuchi and Nonaka, 1986). Examples of actions senior managers can take to support heavyweight development teams include drawing up the project charter, which includes a mission and broad performance objectives, and acting as an executive sponsor (Wheelwright and Clark, 1992). The latter role involves coaching and mentoring the team and its leader, and serving as a liaison channel between the team and other executive staff.

3.4.8 Supportive management style

A review of a number of research studies, carried out from the 1950s to the late 1980s, which had looked at the factors influencing NPD success found that many of these factors were associated with "open-minded, supportive and professional management" (Barclay, 1992a). In fact, this attribute accounted for 30 of the 140 factors identified in total and had been identified in over three quarters of the studies. Other research has led to the conclusion that an organic management style is better than a mechanistic approach in helping to develop a culture appropriate to innovation, while a more horizontal management style with increased decision-making authority at lower levels influences speed to market (Rothwell, 1992). Recent work in the UK suggests that practice may be moving in the same direction as theory with an increasing number of companies adopting "a more democratic, professional and supportive management approach" (Barclay, 1992b).

3.4.9 Roles

There is some discussion in the literature of specific roles associated with successful NPD. For example, Roberts and Fursfield identified the following work roles as being critical to innovation: idea generating; entrepreneuring and championing; project leading; gate keeping; sponsoring and coaching (Hart, 1995). The gate keeping role may be fulfilled by a 'technological gatekeeper' while a 'product champion' embodies the entrepreneuring and championing role. A technological gatekeeper brings into the firm relevant technical information gathered from seminars, conferences, a network of external contacts and literature, and disseminates this information internally to others within R&D (Rothwell, 1992). A product champion enthusiastically supports an innovation and is personally committed to it, helping the project to maintain momentum when it
runs into difficulties (ibid.). Despite the importance given to this role in the literature, a 1990 US survey found that only 43.4% of companies encouraged product champions; another 31.7% acknowledged the existence of product champions, 18% were indifferent and 6.9% had none or discouraged them (Page, 1993). In a similar survey carried out five years later 15.4% of responding firms made no use of champions, while 77% used champions to lead and/or support the more innovative projects (Markham and Griffin, 1998). A recent study of eight discontinuous product development projects found that champions were a driving force in all but one of the projects (Veryzer, 1998).

The data from the PDMA's 1995 survey led Markham and Griffin (1998) to conclude that although champions seem to have an indirect impact on firm-level performance by improving program performance and operating in concert with processes and strategies, using champions does not lead to generally more successful NPD. They also suggest that, as more firms adopt NPD processes, the role of champions may be changing from leading projects to supporting the processes in which projects are embedded.

3.4.10 Shared values within an innovative culture

A feature of best practice NPD is a shared belief in the value of change. Acceptance of the need for change is a prerequisite for successful NPD (Johne and Snelson, 1988b). Sustained corporate innovation requires an organisational culture that is "innovation-accepting and entrepreneurship-accommodating", and is best achieved "when 'championing change' becomes an integral part of the firm's culture" (Rothwell, 1992). Openness and interchange between different functions and units at all levels of the organisation can help to foster such an innovating culture (Johne and Snelson, 1988b). Highly innovative companies in the US, Japan and Europe share a set of characteristics, qualities and behaviours and recognise the importance of strong alignment between organisational and personal purpose (Zien and Buckler, 1997).

3.4.11 Structures

Organisational structure is another of the themes identified in the literature as crucial to the success of NPD (Hart, 1995). A variety of structures, leadership styles and ways of organising NPD have been described, including the merits of matrix structures, organic structures and free standing business units (Johne and Snelson, 1988b). However, there is growing recognition that different types of structure are appropriate to different types of product development project (Johne and Snelson, 1988b; Bowen, Clark et al., 1994b; Wheelwright and Clark, 1992; Hart, 1995). Current 'best practice' in this respect can therefore perhaps be described as having the understanding and ability to apply the most appropriate form of organisational structure on a project by project basis.
Wheelwright and Clark (1992) review the strengths and weaknesses of each of the four basic categories of development team structure: functional, lightweight, heavyweight, and autonomous. The key distinction between these structures is the extent to which responsibility and authority rest with functional managers or with the leaders of development projects. While the authors stress that different types of team structure are appropriate for different types of project they warn that organisations tend to have a 'dominant orientation' which determines the range of approaches the firm can hope to apply successfully. The functional and the heavyweight models represent dominant orientations. A firm with a functional orientation will be able to also run lightweight teams but it is unlikely to succeed with heavyweight teams. However, a company with the heavyweight team as the dominant orientation should be able to adjust the standard approach to accommodate all four types of team. The recommendation is, therefore, that if a firm wants to have the capability to run heavyweight teams it must create the heavyweight team as its dominant orientation.

The popularity of heavyweight teams has increased, no doubt influenced by the practice of successful Japanese companies. For example, self-organising teams which are completely autonomous, devise their own very challenging goals, and enable cross-fertilisation of thought processes and behaviour patterns between members from different disciplines, have been identified as contributing to speedy and flexible product development in certain Japanese firms (Imai, Nonaka et al., 1985). However, some companies have found that a combination of large engineering organisations and heavyweight project managers can result in too much product variety (Cusumano, 1994). These firms are now placing limits on the budgets and discretion of heavyweight project managers in an attempt to reduce the number of unique parts and product variety.

3.4.12 Integration

As seen in the review of NPD processes above, the current prevailing view is that the development process should be designed to enable the inputs of separate functions to be integrated effectively. It is now over thirty years since Lawrence and Lorsch (1967) highlighted the links between cross-functional integration and performance, and since then much has been written about the need for better cross-functional coordination and the use of multi-discipline development teams. Concurrent Engineering is an important approach for achieving integration encompassing a range of mechanisms and is discussed below under 'parallel approach'.

Functional coordination has been identified in the literature as crucial to the success of NPD (Hart, 1995). Integration, including joint decision making among all functional units and divisions involved in a project, is a key element in optimising development (Bowen, Clark et al., 1994a). Kahn (1996) defines integration as comprising both interaction (i.e. meetings, documented information flows) and collaboration (i.e. various departments working collectively toward common goals). He found
that although a certain level of interaction between departments is necessary throughout the NPD process, it is collaboration that differentiates between success and failure. Survey data indicate direct links between collaboration and performance, and between collaboration and employee satisfaction (Kahn and McDonough, 1997). Another study found that the strongest drivers of cross-functional co-operation and NPD performance were perceived to be internal facilitators such as evaluation criteria, reward structures and management expectations (Song et al., 1997).

Much attention has been given to the need to improve the R&D/marketing interface and to build marketing activities into the development process from the outset (John and Snelson, 1988b; Cooper, 1988; Pearson and Ball, 1993; Hart, 1995; Griffin and Hauser, 1996). Souder et al. (1998) found that although R&D/Marketing integration and direct R&D/customer integration both have a positive impact on NPD effectiveness they affect it in different ways. Others emphasise the need for early manufacturing involvement and for integrated product and manufacturing strategies such as design for manufacturability (DFM) (Rothwell, 1992; Wheelwright and Clark, 1992). Wood and Coughlan (1990) argue that in addition to DFM techniques and cross-functional teams, integration of design, manufacturing and marketing requires a disciplined management approach, such as that provided by a stage-gate procedure. Quality Function Deployment (QFD) is put forward as one mechanism for dealing with issues at the interface between engineering, manufacturing and marketing, though it is best suited to projects concerned with incremental product innovation rather than radical change (Davenport, 1993). Firms leading the field in terms of commercialisation of technology have gone beyond QFD and DFM in their quest to develop cross-functional skills, for example by building extensive networks connecting R&D, manufacturing, sales, distribution and service (Nevens, Summe et al., 1990; Harryson, 1997).

The cross-functional, multi-discipline team is seen as an important mechanism for achieving integration (Cooper and Kleinschmidt, 1993; Swink et al., 1996). A team approach can help to overcome the differences and resistance to change among people from different parts of the organisation who should be working together (Thomas, 1993). Japanese companies have a number of practices to promote multi-functional problem solving. These include, for example, getting engineers involved in a wider range of tasks (e.g. purchasing, marketing, sales, manufacturing cost analysis) and evaluating subunits and employees against a broader set of performance measures than in US firms (Funk, 1993).

Use of multi-disciplinary teams is an aspect of ‘good practice’ NPD which many companies have adopted. The PDMA’s 1995 survey found that multi-disciplinary teams were used for 64% of all projects (Griffin, 1997). Although in general they were much more common for more innovative projects, the best performing firms used multi-functional teams in the majority of their NPD projects regardless of the level of innovativeness. An earlier study of product development practices in UK firms revealed “an increased emphasis on teamwork and teamwork training” (Barclay, 1992b).
However, not all writers favour total integration. Several suggest that a some differentiation should be preserved to allow high quality inputs derived from specialised expertise. Hart (1995) takes a contingency view, proposing that managers select the most appropriate approach, on a continuum from 'boundary spanning' to 'boundary eliminating', depending on the particular project in question and the organisational context. Similarly, although Wheelwright and Clark (1992) stress the importance of integration across the functions and propose a framework for cross-functional integration with integrated milestones, they also point out that not all development projects need deep, cross-functional integration. Adler (1992), too, advocates a contingency approach to the use of co-ordination mechanisms within product and process design. The amount and kind of integration needed depends on the specific circumstances such as the phase of the project and the inherent project complexity (Griffin and Hauser, 1996; Song et al., 1998).

3.4.13 Parallel approach

Parallel processing within a development project, with activities taking place concurrently rather than in series, is a feature of all the current 'good practice' models reviewed earlier: the holistic, overlapping ('rugby') approach; a modern stage-gate process; the 4th generation 'integrated' innovation model; and the convergent process model (Imai, Nonaka et al., 1985; Cooper and Kleinschmidt, 1993; Rothwell, 1992; Hart, 1995). Parallel processing provides the means to have a complete development process while reducing time-to-market and, because of the simultaneous involvement of different functions, avoiding ineffective hand-offs between departments (Cooper, 1988).

Overlapping the stages of the NPD process inevitably leads to at least some parallel activity, during the overlap. As noted above in the review of the Japanese holistic approach, the degree of overlapping observed there varied between companies with some having overlap only at the border of adjacent phases, and others ensuring that overlapping extended over several phases. US companies have adopted the practice of overlapping phases and incorporated it into their stage-gate processes. However, they manage overlapping differently to the Japanese: the latter start die design and cutting earlier but still have lower costs for re-engineering charges (Clark and Fujimoto, 1989). The explanation given for this is that many US companies have failed to introduce the intensive information processing necessary to make the most of overlapping. Research in Europe found that overlapping was successful in those cases where it was an explicit approach and the flexibility it needs was properly planned and activated (Verganti, 1997).

Some commentators seem to use the phrases 'parallel development' and 'concurrent engineering' (CE) interchangeably (e.g. Davenport, 1993). This thesis takes the view that parallel development is a wider concept, applying to all activities e.g. business analysis, market investigation and supplier involvement, not just to engineering and design tasks. Hart's (1995) convergent process
model is a good example of this interpretation. CE "consists of the paralleling of the design and manufacturing activities of a product" (Pawar and Riedel, 1993) and is considered a good practice feature of engineering and design processes (Davenport, 1993). The phrase CE encompasses a range of integration mechanisms and companies use different combinations of them depending on their particular situation and needs (Swink et al., 1996). Pawar and Riedel (1993) have reviewed a number of studies from which they identify the following generic elements amongst the integration mechanisms:

- cross-functional teams;
- computer integrated design and manufacturing methods such as CAD, CAM, and CAE;
- analytical methods to optimise a product's design and its manufacturing and support processes, including Design of Experiments, Taguchi Methods, Design for Manufacturability and Assembly, and Quality Function Deployment.

Techniques for achieving the integration necessary for effective CE include TQM, co-location of design and manufacturing engineers, up-fronting, design modification control, integrative prototyping, and production modification control (Pawar and Riedel, 1993). Ward et al. (1995) have described a variation on CE which they call 'set-based concurrent engineering'. Under this system engineers and managers delay making decisions and give suppliers partial information, while exploring numerous prototypes. The researchers found this method to be prevalent at Toyota and believe it is the reason for that company's speed and efficiency in product development.

Some firms using CE have documented savings in overall product development costs of approximately 20%, and reductions in engineering design changes of 45-50% (Swink et al., 1996). However, despite the benefits to be gained from parallel processing, a comparison of the time companies spent on each development activity with the reported time to develop a new product suggested, that in the early 1990s, US firms were not engaging in much concurrent working (Page, 1993).

**3.4.14 Effective communication and information evaluation**

The importance of good communication and co-ordination for successful NPD is a recurrent theme in the literature (Lawrence and Lorsch, 1967; Barclay, 1992a; Hart, 1995). The current emphasis on parallel processing means that effective information flow between those involved is essential for the smooth working of the 'best practice' NPD process models.

For Clark and Fujimoto (1989) the main reason why US companies apply the concept of overlapping development stages less effectively than Japanese firms rests with differences in their approaches to information processing. They claim that a typical US company following the overlapping approach engages in 'batch information processing' at the end of the upstream stage.
This means that those involved with downstream activities have had to start work without any early information about the upstream output. The common approach in Japanese companies, however, is for a continuous stream of data on upstream events to be released downstream, and vice versa. Such 'intensive information processing' avoids any confusion or surprises when the project moves downstream. Wheelwright and Clark (1992) have defined four modes of interaction between upstream and downstream groups. In Mode 1, 'serial/batch', communication is "sparse, infrequent, one-way, and late; the information is serial and lengthy". In this mode downstream activity does not start until after the batch communication has been made. Mode 2, 'early shot in the dark', and Mode 3, 'early involvement' are the same as Clark and Fujimoto's 'batch information processing' and 'intensive information processing'. In Mode 4, called 'integrated problem solving', the intensive two-way communication starts much earlier, before any downstream activities are underway.

There is more to the effective use of information in NPD than communication between participants in the process. Information needs to be acted upon. Research has found a very strong relationship between market information processing (that is, the getting, sharing and usage of market information) and new product success (Ottum and Moore, 1997). Although all three activities are necessary, information usage is the one most strongly linked to success. Data has to be evaluated in order for good decisions to be made, for example, whether or not to move on to the next stage, or whether to abandon a project. The 'gates' built into a stage-gate process serve as evaluation points where such key decisions are taken based on an assessment of the relevant information (Cooper, 1988; Cooper and Kleinschmidt, 1993). Evaluations should include both the market and technical aspects (Hart, 1995).

There are tools available to help teams in the evaluation process. These include NewProd, a software-based new product screening, evaluation and diagnostic tool (Cooper, 1992), and Value Planning Process (VPP). The latter is a methodology which enables development teams to assess, on an ongoing basis, the value of a proposition in light of the constant changes in the environment (Hughes and Chafin, 1996). Its developers claim that VPP goes beyond Cooper's third generation process (see Section 3.6 below) and can be used to transform the front end of processes like phase-review and stage-gate into a continuous and iterative process focused on customer value.

In short, a feature of current best practice NPD is effective information processing and dissemination. Rosenthal and Tatikonda (1992) identify six key information-processing functions associated with product design and development\textsuperscript{16} and illustrate how particular design tools and practices (e.g. DFA, QFD, CAD, Gantt charts) can strengthen one or more of these functions.

\textsuperscript{16} Rosenthal and Tatikonda’s six information-processing functions are: translation; focused information assembly; communication acceleration; productivity enhancement; analytical enhancement; and management control.
3.4.15 Tools and methods

There are a number of tools and methodologies associated with current 'good practice' NPD. They include:

- Quality Function Deployment;
- Design for Manufacturability;
- Design of Experiments;
- Computer-based tools;
- Prototypes;
- Target cost management.

Quality Function Deployment (QFD)

QFD is a methodology which uses a series of matrices to translate customer requirements into design parameters (Wheelwright and Clark, 1992). It requires multi-functional involvement thus helping to overcome problems caused by departmentalism (Eureka, 1988). Although QFD increases the time spent upfront defining the product, overall development time is reduced as a result of focusing priorities and better documentation and communication (King, 1989). Benefits claimed from the application of QFD include: better understanding of customer needs; comparison and analysis of competitors' products are facilitated; shorter product development cycles; fewer design changes; fewer manufacturing start-up problems; improved quality and reliability; cost savings through product and process design optimisation (Eureka, 1988; King, 1989). Pilot applications of QFD within a European multi-national company had a positive impact on the fuzzy front end of the innovation process, bringing clarity and consistency to problem-framing and definition (Debackere et al., 1997). However, it has been pointed out that a lot of development activity takes place between the matrices (e.g. testing a concept would come between the first and second matrices) and so is not included as part of the formal QFD method (Ettlie, 1992). Although in western firms QFD is most commonly used as a technique for translating the requirements of one functional group into the supporting requirements of a downstream functional group (e.g. from marketing to product engineering to manufacturing), it can also be used as a comprehensive organisational mechanism for planning and control of NPD (Rosenthal and Tatikonda, 1992).

Design for Manufacturability (DFM)

DFM is about bringing issues of manufacturability into the design process earlier. It encompasses a wide variety of methods including: design rules, which state the boundaries within which the manufacturing process is capable of meeting design requirements; and design for producibility, which is concerned with the interaction between specific parts and products and the manufacturing system (Adler, 1992; Wheelwright and Clark, 1992). Analysis of over 60 applications of one particular design for assembly/manufacturing analysis (DFA/MA) methodology found an average part count reduction of 46% and average assembly cost savings of 47% (Miles and Swift, 1998).
Design of Experiments

Design of Experiments involves taking a disciplined, systematic approach to planning experiments rather than responding to problems in a haphazard manner. Statistical methods are used to determine the optimum settings for one or more product or process parameters (Rommel, Brück et al., 1996). A number of techniques have been developed to overcome difficulties in analysing experiments that occur when the repeatability of measurements is low and the effects of a factor depend on the settings of the others. These include Taguchi methods (used mainly in design and problem prevention), Shainin methods (used mainly for problem solving in processes), and Evolutionary Optimisation (used for the gradual improvement of current processes) (Bandurek, 1992). Although usually associated with design and engineering, Design of Experiments can be useful for other functions within the innovation process and it has many applications in sales and marketing (Starkey et al., 1997).

Computer-based tools

Technology has helped to cut development time. For example, in the mid 1980s Canon's semiconductor equipment division used CAD tools to eliminate some phases of project management and overlapped others. The results were impressive: development costs were cut by 30% and time-to-market by 50%, and the division launched two generations of equipment in the time it took competitors to introduce one (Nevens, Summe et al., 1990).

Several writers (e.g. Davenport, 1993; Rothwell, 1992) suggest other ways in which technology can influence speed to market, including:

- groupware technology such as Lotus Notes, which supports horizontal communication and allows all team members to work on the most up-to-date version of the design, thus helping to reduce the number of change notes – but implementing groupware is not always straightforward (Ciborra and Patriotta, 1998);
- computer-based laboratory modelling and analysis – used by 54% of respondents in a survey of UK manufacturing companies (Maffin et al., 1997);
- computer-based field trials and communication of results;
- fully developed internal databases including integrated design databases, standard component databases, and component performance history databases;
- efficient upstream data linkages and inter-company liaison;
- conferencing systems;
- using expert systems as a design aid;
- and replacing physical prototyping by simulation models based on research data.

Prototypes

Prototypes have been found to optimise development, foster learning and initiate change throughout an organisation (Bowen, Clark et al., 1994a). The focus on prototyping in the research
stage at Canon and Sony encourages researchers to exchange knowledge with manufacturing up-front, and makes R&D application-driven (Harryson, 1997). Prototypes are a powerful tool for outbound communication and to elicit information, and rapid prototyping cycles enable development teams to learn quickly (Leonard-Barton, 1995). Since the process of stereolithography was invented in 1984 a number of other techniques for rapid prototyping have been developed (Costanzo, 1993). Wheelwright and Clark (1992) put forward four 'best practices' derived from industry experience which any company can use to improve its prototyping process. These include making better use of low-cost prototypes (e.g. simple industrial design models and simulation models), and avoiding overlapping prototyping cycles. They also advocate the use of 'periodic prototyping'. This is achieved by restructuring the sequence, number and duration of prototyping cycles into a periodic pattern of prototyping which the authors claim is particularly beneficial for platform or next generation projects carried out by a cross-functional team.

**Target cost management (TCM)**

A very high proportion – up to 80 or 90% – of the life cycle cost of a new product is built in during the design and development phase; target cost management (TCM) is a technique applied to keep the cost within specified limits (Tanaka, 1996). Before the design work starts, the cost target for the new product is established taking into account all the activities of the product's life cycle (including, for example, sales, usage, and disposal costs). The designs for the product are accepted at the concept, basic design and detailed design stages only when they meet the cost target assigned. If the target is not met the designers will have to alter the designs, perhaps by using value engineering techniques.

**Summary**

Use of these tools and techniques can result in significant gains. For example, Polaroid achieved a 50% reduction in development time through a combination of CE, CAD and rapid prototyping (Baxter, 1995). Rosenthal and Tatikonda (1992) argue that design tools and practices such as those described above promote two strategic capabilities, cross-functional integration and an efficient and effective NPD process, which can then become a source of competitive advantage.

### 3.4.16 Product design strategies

Various product design strategies are advocated in the literature. They include Design for Manufacturability (Davenport, 1993; Wheelwright and Clark, 1992); 'carry over' strategies whereby elements of previous models are used in new designs (Rothwell, 1992) and modular design (Wheelwright and Clark, 1992); designed-in flexibility ('robust' designs which can evolve into design families) (Rothwell, 1992); and incremental improvement of products (Rothwell, 1992; Funk, 1993). The latter is illustrated by Hewlett Packard's 'soft' product changeovers intended to reduce the time it takes to hit total-quality targets in new products (Anon., 1995). Instead of replacing production of
the Mark 1 version with the Mark 2 in one fell swoop, which leads to a dip in quality, the features of
the Mark 2 are gradually incorporated into selected production runs of the Mark 1. The Mark 2 is
officially launched when this gradual roll-over has been completed successfully. More recently
these design strategies have been grouped together and referred to as 'agile product development'
(Anderson, 1997).

The focus of advanced NPD processes is increasingly on product quality and other non-price
factors (Rothwell, 1992).

3.4.17 'Lean' product development

Some of the new practices listed in Table 3.2 and described above are encompassed within the
concept of 'lean product development'. The 'lean' label was originally coined to describe
manufacturing and engineering practices in the Japanese automobile industry which led to much
higher levels of productivity and flexibility. Continuous process improvement is one of the
principles underpinning the lean prescription. In the context of product development, 'lean' refers
to a number of interrelated techniques taken together: supplier involvement from the beginning of
the project; cross-functional teams; concurrent engineering; integration (as opposed to
coordination) of various functional aspects of each project; use of a heavyweight team structure;
and strategic management of each development project by means of visions and objectives rather
than detailed specifications (Karlsson and Ählerström, 1996).

However, lean product development has not been without problems. Honda and other Japanese
companies used the shortened development cycles it brought to follow a strategy of rapid model
replacement and frequent model-line expansion. These were high cost strategies. The problems
caused by too much product variety, environmental concerns and recycling costs caused the
companies to rethink (Cusumano, 1994). These companies subsequently decided to produce
fewer model replacements and variations, and to increase the sharing of parts across projects and
the amount of parts and materials recycling. To force more commonality across products project
managers were made less 'heavily weighted' by limiting their authority.

3.4.18 Summary

This review of current 'good practice' within NPD presents a very different picture to the traditional
approach. As highlighted in Table 3.2, many of the new practices are diametrically opposed to
earlier custom (e.g. formal process vs. no formal process; functional integration vs. functional
segregation; parallel activities vs. serial activities). Other practices, such as the emphasis on
learning and the increased exploitation of technology, are additions or extensions to the old way of
doing things and reflect a new awareness of what is important. Despite the largely positive
coverage the new practices have received in the literature, some elements of them may not be appropriate for every firm. Several recent studies suggest that what represents best practice for any one company will depend on its own particular context (Griffin, 1997; Maffin et al., 1997).

To replace the traditional practices with contemporary 'good practice' implies major changes in the conduct of NPD. Changes are necessary at a strategic level, at an operational level, and at the level of the individual. However, in practice firms may start to adopt some of the new practices piecemeal as they learn from outside sources about the benefits of, say, multi-discipline teams or closer links with customers and suppliers. A thread running through many of these new practices is flexibility: at the level of the firm, in its response to changes in the external environment; at an operational level, in terms of applying the practices and structures that are most appropriate for a particular development project; and at the level of individuals and groups, who need to be open to change and prepared to adapt accordingly.

The new practices described here have been stimulated by changes in the NPD context in which firms operate, for example, new technology; customer demands for greater product customisation; and increased competition on a global scale. The practices are consistent with such changes and are helping companies to cope with the demanding situations they find themselves in. However, even if firms are able to survive in the present climate, the future will bring new challenges, thus the need to improve remains. The next section will look at the underlying processes of learning and improvement that may help firms move from where they are now to where they want to be.

3.5 Learning, process improvement and quality management

Learning, process improvement and the application of quality management practices within product development are subjects of growing interest to academics and practitioners alike. These issues are directly relevant to the thesis as they are closely linked with continuous improvement. This section looks in more detail at what the literature has to say on these themes in the context of the NPD process.

3.5.1 Learning

As noted in the previous section, the role of learning within the NPD process is recognised in some of the more recent literature. The ideal product development process becomes in effect "a learning process unto itself", with the learning occurring among everyone involved in the process, including stakeholders (Thomas, 1993).

In the early 1980s, Maidique and Zirger's (1985) study of new product success and failure in the electronics industry demonstrated the importance of learning from failure. They found that failure
in NPD was often followed by success and vice versa. This was because companies learnt from failure and used the learning to improve the success of subsequent projects, but success often resulted in complacency, or unlearning the very process that had led to the original success. The authors advised firms to tolerate failure in order to achieve future success.

A study in Japan at about the same time revealed the important role of learning within NPD in certain firms there, which went beyond learning from failure to influence many aspects of the development process (e.g. human resource practices) (Imai, Nonaka et al., 1985; Takeuchi and Nonaka, 1986). In these companies learning, which takes place across multiple levels (individual, group, company) and across multiple functions, "plays a key role in enabling companies to achieve speed and flexibility within the new product development process" (Imai, Nonaka et al., 1985, p.354). The researchers advocated the use of a company-wide programme to foster learning at the corporate level, citing the example of Fuji-Xerox which had "used the total quality control (TQC) movement as a basis for changing the corporate mentality", enabling it to develop a more creative and speedy NPD process (Takeuchi and Nonaka, 1986).

The role of learning within NPD was subsequently taken up by US academics, in particular in the context of developing organisational capabilities. In contrasting the traditional, tactical approach to NPD with an emerging, strategic model, Adler et al. (1989) describe how the latter views development projects not just as opportunities to apply past learning but also to generate new learning. In this context, each new development project should include as a key objective development of new technical know-how and new organisational capabilities. Firms adopting this more strategic perspective should therefore make the fostering, encouragement and support of learning a top management priority.

Wheelwright and Clark (1992, p.284) stress the importance of learning to the process of building development capability, claiming that "The ability to sustain significant improvements in development over long periods of time rests on the capability to learn from experience." They warn that organisational learning from development projects does not happen automatically and suggest a more structured approach to capturing learning about the NPD process. Post project learning is seen in terms of closing the continuous improvement loop, making sure that the lessons that can be learnt from each project are "identified, shared, and applied throughout the organization" (ibid. p.52). This emphasis on going beyond reviewing what happened and extracting lessons to actually apply the lessons learnt - "capturing the insight and incorporating it into behaviors (that is, into the way the organization does development)" (ibid. p.300) - concurs with a definition of a 'learning organisation' (Garvin, 1993). An in-depth study of 20 development projects which had been carried out from the mid-1970s to 1992 led researchers to conclude that "the key to becoming and remaining a leader is not just getting it right one time but developing a system for applying what was learned in one project to subsequent projects" (Bowen, Clark et al., 1994a).
Other recent work has looked more closely at the type of learning that takes place within NPD. A distinction may be made between single-loop, or adaptive, learning which refers to action taken to correct a situation without changing existing policies or objectives; and double-loop learning which involves challenging underlying organisation policies and objectives (Argyris, 1977). McKee (1992) relates these concepts to the type of innovation companies are engaged in. He argues that firms involved with incremental innovation need single-loop learning skills, while firms doing discontinuous innovation must have double-loop as well as single-loop learning skills. However, companies who engage in both types of innovation routinely must also be able to generalise learning from particular projects to the next innovation, a process McKee terms 'meta-learning'. Meta-learning involves institutionalising the ability to learn. It is focused on "the organisation's generalised ability to improve its performance at a class of tasks (e.g. to learn to innovate)" and involves management seeking "to learn to improve the effectiveness of future innovation projects based on experience with previous product innovations, both successful and unsuccessful." In short, meta-learning is about using learning to improve the NPD process.

Bartezzaghi et. al (1997) elaborate on the concept of meta-learning in their examination of inter-project learning in NPD. Inter-project learning involves abstracting knowledge from each project and generalising it so that it can be used on subsequent innovations. Project after project a firm progressively refines its stock of abstract and general knowledge, giving rise to a set of meta-models which the company uses as a basis for building the models used by future projects. Like the models used by specific projects, meta-models may relate to the context in which the product will be developed or sold, the product, or the project. The authors claim that inter-project learning can enhance performance in the long term and should be an additional objective within a single NPD project.

3.5.2 Process improvement

While these writers emphasise learning, which may be used to improve the process of NPD as well as future products, some of them and others also make specific reference to process improvement and continuous improvement of the NPD process. Adler et al. (1989), describing a firm's ability to organise new product and process development projects as a 'key capability', exhort senior managers to "ensure that the whole organization knows the importance of continual improvement in the management of the development process". Some firms appear to have recognised this to a certain extent. For example, the Gate Procedure introduced by Northern Telecom in 1985 was not intended to be rigid, but was modified and improved by each division in light of experience (Wood and Coughlan, 1990).
Barclay (1992b) recommends that an NPD process should be designed to "allow continuous changes to be made, to react incrementally in line with changing environmental needs". However, his review of research into NPD found that "little has been reported on practical evaluation and improvement methodologies. Most of the methodologies that have been suggested are specific and not comprehensive. ..... They are, in effect, 'one off' solutions that are not continuous, not taking into account future changes affecting the NPD." His own study of 149 UK firms found little evidence of continuous improvement of NPD methodologies. Other research in the UK discovered that "a majority of companies did not have appropriate resources and mechanisms in place to identify and implement opportunities for process improvement" (Maffin et al., 1997). Although Barclay (1992b) identified a move towards adopting certain practices associated with good practice NPD, such as teamwork, CI was not built in to the NPD process. He found that responsibility for ideas and process changes rested with new product staff in 24% of firms, with a review system or committee in 26% of cases, and with a specified individual in 7% of companies; in just over two thirds of the firms senior management were responsible (in some companies there were dual responsibilities).

Wheelwright and Clark (1992, p.53) also refer specifically to the continuous improvement of the NPD process, claiming that "the most successful organizations at learning and improving are those that follow a path of continuous improvement in the fundamental capabilities that drive development performance. Each project results in an incremental, but cumulatively significant, improvement in the capabilities of the organization."

Sustained learning is the goal of those companies trying to build development capability "and inevitably that requires a systematic, managed process of improvement. It simply does not happen by chance or good fortune." (ibid. p.313) "Those firms that do achieve systematic improvement in development seem to do so on a continuous, incremental basis." (ibid. p.327)

Continuous improvement has also been discussed in the context of mass customisation. Pine at al. (1993) argue that companies aspiring to mass customisation first need to go through CI, in order to obtain the high levels of quality and skills, and low costs, required by mass customisation. They claim that although the two approaches require very different organisational structures, values, management roles and systems, learning methods and ways of relating to customers, CI can be a subset of mass customisation (there can be CI within autonomous operating units) though not vice versa.

Krehbiel (1993) states management must support the NPD team by providing resources that are necessary to continuously improve the process. However, it is not clear if he sees responsibility for generating ideas for improvement lying with managers or team members. Moreover, the examples
he gives of ways in which the process can be improved appear somewhat costly and technology inspired (e.g. application of tools like CAD and CAE systems, 3D modelling and analysis software, electronic data interchange capabilities) rather than incremental, creative solutions.

The Japanese product development strategy which Funk (1993) refers to as 'learning' is all about NPD staff improving the development process. He points out that the decentralised approach to improving the NPD process followed by Mitsubishi's Semiconductor Equipment Department (i.e. via incremental improvements using small, decentralised working groups) sounds "very similar to the methods of improvement used by Japanese factories". Adler et al. (1996) also highlight the transferability to NPD of process improvement techniques that have produced results in production settings. They argue that process management, which has revolutionised manufacturing, can be used to streamline the product development process. Companies adopting this approach have cut development times by 30% to 50%.

CI developed in some manufacturing organisations alongside the implementation of lean production. Similarly, Karlsson and Åhlström (1996) believe that a move toward lean product development should be seen as

"an initiation of a journey on the road of continuous improvement. The implication of this is that lean should not be seen as a state, but as a direction. There is always room for improvement, and the aim is to continue to improve organizational practices in the direction indicated by lean product development."

3.5.3 Quality management practices

Much has been written about Total Quality Management (TQM) during the last decade, most of it in the context of either manufacturing or in general terms relating to an organisation as a whole. More recently, however, some researchers have focused on the applicability of TQM and quality methods to NPD. There are very close links between continuous improvement and TQM, with CI commonly held to be one of the key principles underlying TQM. It is therefore appropriate to look briefly at literature spanning TQM and NPD.

May and Pearson (1993) conclude from a review of the literature that "TQM is relevant to R&D and produces results, particularly in reducing product development time". This is confirmed by their own research carried out in 1990 into the applicability of TQM to the R&D function. Of the 14 R&D departments studied in the UK and Canada, 11 had initiated TQM. The authors found that "despite being in the early stages, these initiatives are regarded as being successful, and TQM is accepted as being highly applicable to the R&D function". Miller (1995) drew a similar conclusion after examining quality approaches to R&D in 45 multi-national firms in North America, Europe and Japan. Another study, this time in New Zealand, was carried out to investigate the findings of May
et al. Using data derived from responses of 89 Chief Executive Officers to questions relating to the incorporation of TQM in R&D the researchers concluded that "TQM principles could play an important role in R&D activities" in these firms (Fisher, Kirk et al., 1995).

Miller found that the penetration of quality practices was uneven in the firms he studied. A hierarchical cluster analysis revealed four clusters, each of which emphasised different types of practices for managing R&D. The clusters are: managing R&D at the science frontier; managing R&D in revenue-dependency contexts (where internal clients buy research services from the R&D division); managing R&D for TQM integration; and managing R&D in the strategic arena (i.e. using R&D as a major tool for the strategic development of the firm). In the cluster geared to TQM integration the emphasis is on cross-functional integration and reducing cost and lead time, while the most commonly used quality management practices are technology assessment, competitive analysis, new product development systems, strategic audits, and international quality certification (Miller, 1995).

A case study of the implementation of TQM in a large complex laboratory concluded that implementing TQM in R&D is more likely to be successful if, rather than taking existing TQM systems from manufacturing and marketing and modifying them for R&D, organisational analysis is used as a basis to design a bespoke system (Taylor and Pearson, 1994). Having studied a company in which quality principles were introduced to R&D via the application of Quality Function Deployment, Debackere et al. (1997) concluded that "the uncertain and ambiguous nature of R&D activities requires that TQM be implemented in a systemic manner rather than a mechanical, procedural manner".

3.6 NPD processes in the future

The three previous sections have shown how NPD processes and practices have evolved over the years to correct deficiencies which would have caused severe problems for companies had they been left unchecked. However, these changes are unlikely to be sufficient to cope with future challenges caused by changes in the NPD context, such as increased globalisation and advances in highly specialised areas of science and technology. The need for firms to change, and to continue to change, is as real now as ever, which begs the question, what might NPD processes look like in the future?

Some companies are already experimenting with new forms. For example, an organic network structure for NPD has been proposed (Ayas, Debackere et al., 1994). The basic operating units are multi-disciplinary, self-managing action teams which split off from the core team as tasks demand, to be re-absorbed as these tasks are completed. The organic structure of the network allows it to grow and contract in response to changing requirements of the project. It is claimed
that even in very complex projects no more than three layers of team are necessary (two is usually enough). Ideally, the NPD networks are connected by a master NPD team which is formed by all the leaders of core teams of ongoing projects. Proponents of this network structure claim that it not only provides the flexibility required for effective and efficient NPD, but also the means with which knowledge can be accumulated and transferred.

To overcome the problems associated with second generation stage-gate processes, Cooper (1994) suggests that the next generation process will have the following characteristics:

- It will be fluid and adaptable, with overlapping stages.
- The gates will be 'fuzzy' – in certain situations 'conditional Go' decisions (rather than absolute ones) may allow the project to proceed even though some information is currently missing.
- The process will be given focus by building in prioritisation methods that look at the entire portfolio of projects and concentrate resources on the 'best bets'.
- Flexibility will allow each project to have its own route through the process, with steps being done or left out according to its specific circumstances.

Rothwell (1992) claims that some companies are already introducing elements of the fifth generation innovation model. This 'systems integration and networking' model (SIN) "represents a somewhat idealised development of the integrated model, but with added features". Key aspects are the 'electronification of innovation' (e.g. the use of expert systems and simulation modelling, CAD systems linked with suppliers) and multi-institutional networking. The latter includes strong linkages with leading edge customers, strategic integration with primary suppliers including co-development of new products, and increased emphasis on horizontal linkages (joint ventures, collaborative research groupings, collaborative marketing arrangements etc.).

In the late 1990s co-development of new products is on the increase, and there is growing interest in interfirm product development networks. In particular, companies engaged in developing complex product systems (CoPS) frequently participate in multi-firm development projects:

"Perhaps the most salient image of CoPS is that of many organisations working together to realise markets, carry out production and agree innovation decisions ex-ante and during production, rather than in the conventional arms-length market setting." (Hobday, 1998)

### 3.7 Conclusion

NPD involves many activities which can be grouped into a number of phases or stages. The extent to which these activities are carried out in practice is variable and they are organised, managed and operationalised in numerous ways. This chapter has presented a variety of the models for NPD proposed over the last 40 or so years, ranging from highly conceptual models used by
academics to try and make sense of the innovation process, to prescriptive approaches which offer firms practical guidance. These models and frameworks are constantly evolving, adopting features that will make NPD more efficient and effective such as a cross-functionality, concurrency, and a strong market orientation. Leading edge NPD is very much concerned with networking in all directions – with customers, suppliers, research partners etc. – and it seems that this will be a key feature of NPD processes in the future, along with increasing use of technology.

The review of NPD practices and what is considered desirable today shows that there are significant differences with the way in which NPD has been operationalised in the past, including the general approach (which is now strategic and process-oriented); building external linkages; the role of management; adoption of parallel working, functional integration and more intensive information processing methods; exploitation of technology; and use of tools and methodologies. Of particular relevance to this thesis, we have seen that both theory and practice have started to recognise the importance of learning and ongoing improvement applied to the process of NPD (as opposed to the product under development).

A theme apparent throughout all the discussion of process form and 'good practice' which needs to be actively addressed is flexibility. There is now a prevailing view that different types of NPD project (platform, incremental etc.) will require different types of process and project organisation to be most effective (Thomas, 1993; Bowen, Clark et al., 1994b; Hart, 1995; Wheelwright and Clark, 1992; Johne and Snelson, 1988b). These will incorporate so called 'best practices' to a greater or lesser extent, depending on circumstances. However, certain elements, including learning and process improvement, apply in all situations. For this thesis it does not matter which process model a company is following – the aim is to find a way of looking at CI in NPD, regardless of the specific process model(s) used by the company.

Companies are under increasing pressure to improve development performance, especially in terms of reducing cost and cycle time. In NPD people are the source of knowledge and must be nurtured – slashing the head count is unlikely to be a sensible option for reducing development costs in the long term. At the same time there is a clear need to keep design under control, since so much of a product's life cost is fixed at this early stage. Adopting a process for developing new products and then refining and improving it on an ongoing basis provides a means of bringing development under control and increasing productivity. The next chapter will argue the case for extending continuous improvement to product development processes, and describe a framework for investigating the practice of CI within NPD.
Chapter 4  A Framework for Evaluating CI in NPD

4.1 Introduction

The objectives of this chapter are:

- to present an argument for the extension of CI to NPD;
- to show how, following from this, an instrument was developed for investigating the implementation of CI in NPD.

As the discussion in Chapter 3 demonstrated, the NPD process is multi-dimensional and can be operationalised in many different ways. Any model or investigative tool to be used in the NPD context must allow for this.

The first objective will be achieved in two stages. First, Section 4.2 elaborates the distinction made in the CI Capability Model between the generic nature of the key CI behaviours, and the contingency issue of how these may be encouraged in different parts of an organisation, thus supporting in theory the extension of CI to NPD. Then the following section looks in more detail at the CI Capability Model from an NPD perspective, describing how each of the key behaviours might appear within a development context, and suggesting many potential enablers of CI. It also discusses the application of maturity models within the NPD context.

The case for extending CI, as represented in the CI Capability Model, to NPD having been made, Section 4.4 goes on to describe the basis on which an instrument was developed to identify the existence of the key behaviours, and of actual or potential enablers, in practice.

4.2 Extending CI to NPD

The CI Capability Model was described in Chapter 2. One aspect of this model is that as CI develops over time the new 'CI behaviours' not only become more deeply ingrained, they also spread out across the organisation as they are adopted by an increasing number of employees. The model argues that the strategic potential of CI will not be realised until the key behaviours are the norm in all areas and at all levels of the organisation (i.e. Level 5). It follows that although the emphasis is often on the operations side of the business, the principles and practices of CI should also be applied to other business processes.

As we have seen, the CI Capability Model is made up of three main elements: organisational abilities, key behaviours or behavioural norms, and enabling mechanisms to support the development of the abilities and behaviours. The first two are generic, they are considered the basic minimum set required if CI is to be successfully developed and sustained to the extent where
it can confer strategic advantage. The enablers, however, are contingent. Which enablers are appropriate, and in what form, will depend on the particular situation, taking into account factors such as prevailing culture, personnel, history, size of organisation, nature of work/business, etc. Just as these factors vary between organisations so they often distinguish different parts of a single organisation. For example, there are often different sub-cultures within a company, even within the same division or business unit (Schein, 1991). The type of personality, skills, knowledge and work processes required to sell a complex product to demanding customers is likely to be very different to those required by, say, the people building the product or those processing the paperwork.

It follows that there may be an issue of *internal contingency* when considering an organisation-wide CI implementation. In other words, it may be necessary to take a different approach to the introduction of CI in the NPD area than that used in other parts of the organisation, and to use different enablers or tailor them to meet the specific needs and concerns of NPD personnel. For example, a training course on simple CI tools (e.g. the 7 QC Tools) may need to be modified to take account of different levels of prior knowledge amongst different groups of employees. Taylor and Pearson (1994) touch on this contingency issue when they conclude that TQM is more likely to be successfully implemented in R&D if the TQM system is designed specifically for the R&D unit in question, rather than applying a modified version of a system used elsewhere in the organisation.

May and Pearson's investigation of the applicability of TQM to the R&D function supports this contingency view (May and Pearson 1993). They looked at 11 R&D departments which had initiated TQM and found "considerable variation in the tone of the TQM introductions". Some were low-key, contrary to TQM doctrine. The authors suggest that perhaps a low-key introduction may be peculiar to R&D because of the small size of R&D departments; their informal, open cultures; and the high, internal motivation of most R&D staff.

May and Pearson identify factors which make the implementation of TQM harder in R&D than in other functions, and those that make it easier (see Table 4.1). They claim that "The latter factors can compensate for, or outweigh, the former so that TQM can be implemented as easily, or more easily, in R&D than in other functions." Their suggestions for how TQM should be adjusted to suit R&D include:

- reducing the exhortations to adopt TQM and replacing them with advice as to how to adopt TQM;
- reducing the jargon and avoiding mention of 'right first time' at an early stage;
- selecting appropriate R&D examples;
- bringing training material up to the intellectual level of the participants;
- monitoring overall progress using qualitative means to identify trends, or quantitative indicators, rather than using cost of quality;
- using familiar project methods to structure Quality Improvement Plans;
• checking that existing project proposal / allocation procedures, which may dispense with the need for customer-supplier agreements, really do address customer requirements.

<table>
<thead>
<tr>
<th>Factors aiding implementation of TQM in R&amp;D</th>
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<tbody>
<tr>
<td>• higher level of education of personnel</td>
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<td>• analytical approach and habitual recording of work</td>
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<tr>
<td>• internal motivation, existing control over processes and open climate reduce the culture change required</td>
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<tr>
<td>• less diverse departmental functions</td>
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<td>• little union resistance</td>
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<tr>
<td>• many of the department's customers will be in the same company and so may have a similar culture and TQM approach</td>
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</table>

<table>
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<tr>
<th>Factors hindering implementation of TQM in R&amp;D</th>
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<tbody>
<tr>
<td>• activities are more conceptual, intuitive and dependent on individuals</td>
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<tr>
<td>• non-repetitive processes</td>
</tr>
<tr>
<td>• difficulty in assessing the quality of the 'product', which is information</td>
</tr>
<tr>
<td>• Cost of Quality is not an appropriate measure due to the difficulty of assigning a value to the price of non-conformance</td>
</tr>
</tbody>
</table>

Table 4.1 Factors making the implementation of TQM easier in R&D than in other functions, and factors making it harder (Source: May and Pearson, 1993)

In short, according to the CI Capability Model the nine key behaviours, or behavioural norms, should be present in the NPD area of a company aspiring to CI capability, but the manner in which CI is introduced, and the processes, mechanisms etc. used to encourage development of the CI behaviours, may need to be tailored to suit local conditions. The next section considers how the behaviours and enablers of the CI model might appear in the NPD context.

4.3 The CI Capability Model from an NPD perspective

The CI Capability Model was developed in a largely manufacturing environment. However, there is some resonance between the model and the new style of NPD process advocated by both practitioners and theorists, as summarised in Table 3.2 in Chapter 3. Figure 4.1 indicates the areas where the most significant overlaps occur between the key behaviours represented in the CI Capability Model and NPD 'good practice'.

<table>
<thead>
<tr>
<th>Key to the Behaviours in Figure 4.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities.</td>
</tr>
<tr>
<td>B2 The CI system is continually monitored and developed.</td>
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<tr>
<td>B3 Ongoing assessment ensures that the organisation's structure/infrastructure and the CI system consistently support and reinforce each other.</td>
</tr>
<tr>
<td>B4 Managers at all levels display active commitment to, and leadership of, CI.</td>
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<tr>
<td>B5 People participate proactively in incremental improvement.</td>
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<tr>
<td>B6 Effective working by individuals and groups across internal divisions and external boundaries at all levels.</td>
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<tr>
<td>B7 People learn from their own and others' experiences, both positive and negative.</td>
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<tr>
<td>B8 The learning of individuals and groups is captured and deployed.</td>
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<tr>
<td>B9 People are guided by a shared set of values underpinning CI as they go about their everyday work.</td>
</tr>
<tr>
<td>Current NPD 'Good Practice'</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Formal process, process view</td>
</tr>
<tr>
<td>Strategic approach</td>
</tr>
<tr>
<td>Portfolio approach to prioritisation and resourcing of projects</td>
</tr>
<tr>
<td>Horizontal cooperation; close links with customers and suppliers</td>
</tr>
<tr>
<td>Loose-tight control</td>
</tr>
<tr>
<td>Responsive to changes in environment and customer needs</td>
</tr>
<tr>
<td>Emphasis on learning</td>
</tr>
<tr>
<td>Top management involved, support teams and leaders</td>
</tr>
<tr>
<td>Management style democratic, supportive</td>
</tr>
<tr>
<td>Key roles e.g. Product Champion, Technological Gatekeeper encouraged</td>
</tr>
<tr>
<td>Widespread acceptance of the need for change</td>
</tr>
<tr>
<td>Flexible – projects may differ and require different process, different structures</td>
</tr>
<tr>
<td>Functional integration, especially R&amp;D, marketing and manufacturing</td>
</tr>
<tr>
<td>Methodologies to improve integration e.g. QFD, DFM</td>
</tr>
<tr>
<td>Teams, cross-functional, multi-discipline</td>
</tr>
<tr>
<td>Overlapping stages</td>
</tr>
<tr>
<td>Activities carried out in parallel</td>
</tr>
<tr>
<td>Concurrent engineering</td>
</tr>
<tr>
<td>Upstream-downstream communication; intensive two-way info. processing</td>
</tr>
<tr>
<td>Evaluative information including market and technical aspects</td>
</tr>
<tr>
<td>Exploitation of technology e.g. electronic databases; electronic communication</td>
</tr>
<tr>
<td>Tools and methods e.g. Design of Experiments, FMEA</td>
</tr>
<tr>
<td>Better use of prototypes</td>
</tr>
<tr>
<td>Design strategies: modularisation; incremental product improvement</td>
</tr>
</tbody>
</table>

*The key behaviours are listed on the previous page

Figure 4.1 Common themes between current NPD 'good practice' and the key behaviours in the CI Capability Model
The rest of this section looks in more detail at the CI Capability Model from an NPD perspective. First, it proposes how each of the key behaviours might look within an NPD organisation. Then, taking account of the evolutionary aspect of the CI model, it considers the use of maturity models in NPD.

### 4.3.1 CI behaviours and enablers within NPD

In this subsection the NPD context is brought together with the key behaviours of the CI Capability Model. For each of the behaviours the discussion begins by considering the area of overlap with 'good practice' NPD highlighted in Figure 4.1. Supporting references from the NPD literature are given where appropriate, and potential enablers reported by other researchers are noted. The discussion concludes with a proposition about the form the behaviour might take within NPD.

#### B1 Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities

This CI behaviour shares elements of the NPD 'good practice' that may be summed up as the adoption of a strategic approach. Several writers refer specifically to the practice of goal setting within NPD. Takeuchi and Nonaka (1986) relate how in the Japanese companies taking a holistic, overlapping approach to NPD, top management give teams both a general strategic direction and extremely challenging goals. Nevens et al. (1990) found that companies who lead the field in commercialising technology strengthen their capability in this by setting goals to focus the effort. These firms have only a few goals and use the same ones for several years. The goals are specific and aggressive. These companies also practise competitive benchmarking.

In the NPD context, this behaviour would mean staff working in this area understand the company's strategy and goals for NPD, and are aware of their own function/department/team objectives. In terms of behaviour we would expect to find evidence of NPD staff using this knowledge to guide the improvements they make to the process (e.g. influencing decisions). Furthermore, the results of any changes to the NPD process would be monitored not only to see if the change was beneficial or otherwise, but also to ascertain the impact it may have had on NPD goals and objectives.

*Proposition*

NPD staff direct their improvement activity towards company or departmental goals and objectives, and monitor the results of such activity and the impact it has. To do this they need to have a clear understanding of what the strategy, goals and objectives are.
The Cl system is continually monitored and developed

NPD and the implementation of Cl are both processes. Like other business processes their performance should be monitored and actions taken as and when necessary to develop the process further and improve its performance. This implies a degree of flexibility, one of the features of NPD good practice. In the NPD context such flexibility might take the form of modifying the NPD process to cope with different types of new product. In the case of Cl it might become clear from monitoring the Cl process that existing enablers are inadequate (if, for example, only a small proportion of the company is actively engaged in Cl) and that a new form of enabler is needed.

This behaviour highlights the need for appropriate performance measures. In their study of TQM in R&D, May and Pearson (1993) found that companies had difficulties in attempting to measure the overall quality of research, rather than separate processes. Seven R&D sites were trying to measure the effectiveness of TQM overall, but were abandoning Cost of Quality in favour of qualitative measures and measurement of specific parameters which might be indicators of overall improvement.

The 'Cl system' in a company comprises all the processes, procedures and enabling mechanisms put in place to encourage adoption of the key behaviours. The wording used for this behaviour should be modified to read 'the Cl system as it operates within NPD is continually monitored and developed'. As in the general Cl model, the behaviours we would expect include measuring the incidence and results of Cl activities, reviewing the Cl system regularly and adjusting it as necessary, and providing resources to support development of the Cl system.

Proposition

Within NPD the incidence and results of Cl activities are monitored. The Cl system as it operates within NPD is reviewed and adjusted as necessary, and resources are provided to support its further development.

Ongoing assessment ensures that the organisation's structure and infrastructure and the Cl system consistently support and reinforce each other

Here again the overlap between the Cl behaviour and NPD 'good practice' is concerned with flexibility. In this case, the flexibility takes the form of being aware of, and responsive to, changes in the wider environments in which the NPD process or the Cl system operate. In the context of NPD, the wider environment refers to both systems and structures within the organisation as well as to the external environment (the market, industrial sector, etc.).

Pay and promotion systems are frequently cited by employees as being at odds with Cl. Wheelwright and Clark (1992) point out that one of the prerequisites for effective problem solving
and cross-functional integration within NPD is a promotion and compensation system that supports cross-functional integration. They illustrate the difficulties caused by the lack of supporting systems with examples from two companies. In the first case, a promotion system which favoured sales people over staff with technical backgrounds led to a 'second class' status for the engineering organisation, and as a result efforts to integrate marketing and engineering ran into serious problems. In the other firm, manufacturing engineering jobs were rated several grades below jobs with an equivalent level of responsibility in design engineering, with all sorts of negative consequences. The company’s initial attempts to encourage more effective interaction between design engineering and manufacturing were not successful, a critical first step was to change the compensation structure.

Again, the wording of this behaviour should make it clear that the scope is limited to NPD:
‘Ongoing assessment ensures that the NPD structures and infrastructure, and the CI system as operationalised within NPD, consistently support and reinforce each other.’ However, many of the organisational systems and structures that prevail within NPD may be devised and implemented at a company level (e.g. by the personnel function). Thus an individual or group within NPD may not be in a position to demonstrate this behaviour. For example, they may not have the authority to review company processes and systems and take action, if necessary, to ensure their compatibility with the CI system.

Proposition
Steps are taken to ensure that the NPD structures and infrastructure, and the CI system as operationalised within NPD, support and reinforce each other. However, if systems and structures within NPD are devised and implemented at a company level, NPD personnel may not have the authority to alter them.

B4 Managers at all levels display active commitment to, and leadership of, CI
The overlap between this behaviour and NPD 'good practice' is particularly striking. To achieve their full potential, CI and NPD both require some form of involvement from senior managers. Moreover, the style of management advocated for NPD (democratic, supportive) is the same as that often considered to be most appropriate for nurturing CI.

CI is a form of innovation (i.e. small-scale) and Rothwell (1992) includes top management commitment to, and visible support of, innovation, together with top management acceptance of risk, among strategic factors involved in sustained corporate innovation. He also notes that an 'organic' style of management is better for this than a 'mechanistic' approach. The organic style is participative and informal; free from rigid rules; non-hierarchical; outward looking; and emphasises face-to-face communication, and creative interaction and aims. Krehbiel (1993) argues that management must support NPD teams by providing the resources necessary to continuously
improve the process, for example tools like CAD and CAE systems, 3D modelling and analysis software, electronic data interchange capabilities. Support of this kind would demonstrate management commitment to improving the process.

Wheelwright and Clark (1992, p.335) state that management leadership is critical for a programme of continuous improvement in development capability, and can take many forms. They describe the technical, organisational, and commercial skills crucial for building outstanding development capability. Some of the organisational skills are similar to the sub-behaviours of this key CI behaviour. For example, they expect senior corporate managers to recognise the importance of creating a rapid learning organisation, and to lead and provide vision. The role of business unit General Managers includes training and selecting leaders, and championing cross-functional teams. Wheelwright and Clark stress that if people see a mismatch between management words and actions (e.g. expressing the desirability of dealing with mistakes early to prevent them continuing down the development cycle, while in practice continuing to emphasise meeting short-term deadlines at all cost) they will not adopt the new behaviours.

According to Wheelwright and Clark (op. cit.), effective problem solving and cross-functional integration relies on, amongst other things, senior management support and action. Examples include how senior managers shape the development process; the personal example they set (e.g. how heads of functions communicate and work together); the extent to which they invest in education, training and experience to give staff the necessary skills and capabilities for effective integration; and investment in tools and methods that create a common language (e.g. CAD-CAM).

**Proposition**

Managers in NPD demonstrate commitment to CI and leadership of it by spending time on CI-related activities, by encouraging staff to engage in CI, and by using measurement and targets in a manner consistent with CI.

**B5 People participate proactively in incremental improvement**

The aspect of this behaviour that overlaps with 'good practice' NPD is the use of tools and methodologies by staff to improve the way in which they carry out their work.

May and Pearson's study referred to above found that, in all the R&D divisions which had adopted TQM, quality tools were used with success, and Statistical Process Control and flowcharts were especially useful (May and Pearson, 1993). These tools are enablers of systematic improvement. Funk (1993) describes another enabler of this behaviour, 'working groups', used in Mitsubishi's Semiconductor Equipment Department "to reduce development time, reduce installation problems, and increase standardization (e.g. software reuse)". For example, in 1989 several working groups were used to improve the process, concentrating on the software design process (as opposed to
the mechanical and electrical design processes). Each working group had a representative from each of the department's seven equipment groups (typically a mid-level member). Groups met once or twice a month, for about two hours. Output from these groups included procedures and implementation plans which were circulated between the equipment group leaders and section managers for approval. Working groups developed support for the new procedures and plans by summarising the activities of the working groups in their equipment group's daily stand-up meetings.

This key behaviour applies to NPD as much as to anywhere else in the organisation. So we would expect NPD staff at all levels to engage in systematic improvement on a continuous basis. However, since the NPD function is all about developing new products and improving existing ones — "continuous improvement is what my job is all about" is a typical response of an employee in development — it must be stressed that the practice of CI should apply not only to the products themselves but to the processes whereby they are developed. To ensure that this is done in a systematic, rigorous way, we would expect individuals and groups to follow some form of logical problem solving / improvement opportunity finding cycle and to use appropriate tools and techniques, including process measurement. The proactive element of this key behaviour indicates that ideally staff should be engaging in improvement activities on their own initiative, and seeing them through to completion wherever possible.

There are some typical characteristics associated with NPD personnel that might suggest that these forms of behaviour — i.e. improving, systematic problem solving, initiating activity — would be more likely to be found in the NPD organisation than in other areas of the company:

- Development work is all about producing new or improved products, and definitely not about maintaining the status quo.
- The engineering or scientific background of most development staff could be expected to encourage a logical, inquisitive approach. For example, the principles of testing alternative solutions to find the optimum and of anticipating potential future problems may be found in design-build-test cycles and techniques such as Failure Mode and Effect Analysis (FMEA) and Design of Experiments.
- A higher level of education and job status than in some parts of the company (e.g. manufacturing), and possibly a greater degree of autonomy in their job, may mean that NPD staff expect, and are expected, to be responsible for improving the way they work.

**Proposition**

NPD staff at all levels engage in systematic improvement on a continual basis, ideally acting on their own initiative. Use of some form of logical problem solving / improvement opportunity finding cycle, together with appropriate tools and techniques, would help ensure that this is done in a systematic and rigorous way.
B6  There is effective working by individuals and groups across internal divisions (vertical and lateral) and external boundaries, at all levels

This key CI behaviour is particularly relevant for product development and overlaps with several of the NPD 'good practices': horizontal co-operation (including close linkages with customers and suppliers); functional integration; and the use of multi-discipline development teams. Arguably, if these practices are firmly rooted in a company this CI behaviour would be evident at a relatively high level of maturity (possibly Level 4 or Level 5).

Much of the recent literature on 'good practice' NPD stresses the advantages to be gained from closer integration of functions within the company, involvement of customers and suppliers in the development process, collaborative ventures, and good links to external sources of knowledge and expertise. Some of the mechanisms and practices used to support effective integration and communication, which in terms of the model are enablers of this behaviour, are listed in Table 4.2.

Studies have shown that innovative culture is fostered by an openness and interchange between different units and functions at all levels of organisation (Johne and Snelson, 1988b). Wheelwright and Clark (1992) stress the importance of integration across the functions in order to achieve outstanding product development and that it must occur at the working level i.e. there is more to true integration than schemes for linking the activities of the functions, or activities to support cross-functional integration. In terms of the CI Capability Model, such schemes and activities are enablers that encourage the desired behaviour (i.e. effective integrative working) but are not a substitute for it. Wheelwright and Clark propose a framework for cross-functional integration in which the involvement of all the functions in the different development phases is reinforced by integrated milestones which look at progress from the standpoint of the emerging system, with people from each function participating in the decision making.

Adler et al. (1989) urge top management to focus particular attention on managing the boundaries or interfaces between key functional areas. The interface between R&D and Marketing is the subject of a number of research studies. For example, Pearson and Ball (1993) concluded that the needs of the R&D/Marketing interface are likely to depend on the type of project and its information requirements at a particular point in time. They found that the type and quality of information seemed more important than the amount of communication. This fits with the contingent nature of the CI model, suggesting that firms need to be flexible when thinking about enablers for cross-boundary working within NPD, and to have a variety of enablers that can be activated as and when most appropriate.

Also specific to the NPD context is the use of prototypes. They can be an enabler of effective communication, for example, to convey emerging ideas from the development team to others within the company, or to elicit information from potential users (Leonard-Barton, 1995).
Table 4.2 Examples of enablers of cross-boundary working within the NPD context found in the literature

Turning now to working across external boundaries, Leonard-Barton (1995) argues that to build a company's absorptive capacity (i.e. its ability to identify, access and use technology from a wide variety of sources) managers have to, amongst other things, create porous boundaries. This is done by scanning broadly (e.g. conferences, posting employees in universities), continuously monitoring information sources, fighting the 'not-invented-here' attitude, and nurturing technological
gatekeepers and boundary spanners. Boundary spanners in particular are relevant to this CI behavior. They are the interface between the source of information and the receiver, in other words they translate as well as disseminate knowledge.

Proposition
NPD staff have a shared, holistic view of the organisation. They naturally co-operate with others and they work effectively across internal boundaries and with external agencies.

B7 People learn from their own and others' experiences, both positive and negative
There is considerable overlap between this CI behaviour (and the next one) and the emphasis on learning which is found in good practice NPD.

The behaviour is about individuals learning from their work experiences. Ideally people should not only learn when things happen to them, i.e. passively, but should be proactive in seeking out opportunities for learning. This behaviour also includes the sharing of their learning by individuals and groups at all levels, which itself can enhance the learning process – trying to explain an insight can help to clarify it in one's own mind. This might be done informally by passing on tips to colleagues, or more formally using channels provided for the purpose e.g. by participating in development project reviews.

Some enablers of this behaviour which are mentioned in the NPD literature are shown in Table 4.3.

An important part of the work of the special team set up by Ford in 1985 to develop new concepts, guidelines and milestones for product development teams, was learning by assessing projects. Each time a project ended, the Concept to Customer team reviewed it. However, they involved the members of the project's core team in the review process, thereby teaching people how to learn from their experience (Bowen, Clark et al., 1994a). Leonard-Barton (1995) describes what managers can do to create an organisational climate that encourages experimentation. Some of her suggestions are general and might apply to any part of the organisation, others are more specific to NPD. Examples of the latter are the use of rapid prototyping and internal wrecking crews, though both of these encourage innovation to the product rather than the process. Shortening the feedback loops involved in prototyping enables team members to learn quickly. Internal wrecking crews are employees who simulate the customer in their use of the product under development, in other words the company is able to prototype the conditions the product will face when launched.

Proposition
Individuals working within NPD learn from their work experiences, not just passively but also by seeking out learning opportunities (e.g. experiments), and they share their learning with others.
Table 4.3 Examples of enablers to encourage individual and group learning within the NPD context found in the literature

<table>
<thead>
<tr>
<th>Enabler</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Involve project team members in post project review e.g. Ford Customer-to-Concept team</td>
<td>Bowen, Clark et al. (1994a)</td>
</tr>
<tr>
<td>Human Resource practices that foster multifunctional learning e.g. job rotation, long-term employment, group evaluation</td>
<td>Imai, Nonaka et al. (1985)</td>
</tr>
<tr>
<td>Development procedure based on continual process of trial and error ('learning by doing')</td>
<td>Takeuchi and Nonaka (1986)</td>
</tr>
<tr>
<td>Reward teams for improvements to best practice templates</td>
<td>Adler, Mandelbaum et al. (1996)</td>
</tr>
<tr>
<td>Climate that tolerates and encourages experimentation</td>
<td>Leonard-Barton (1995)</td>
</tr>
<tr>
<td>Recognition of the role of failure in building knowledge</td>
<td>Leonard-Barton (1995); Maidique and Zirger (1985)</td>
</tr>
<tr>
<td>Internal wrecking crews</td>
<td>Leonard-Barton (1995)</td>
</tr>
<tr>
<td>Objectives for each development project include development of new technical know-how and new organisational capabilities</td>
<td>Adler, Riggs et al. (1989)</td>
</tr>
<tr>
<td>Analysis of variances between planned decisions and actual results during the NPD project</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
</tbody>
</table>

B8 The learning of individuals and groups is captured and deployed

Again, this behaviour is closely aligned to 'good practice' NPD. The emphasis on learning now considered important for NPD arguably encompasses this CI behaviour which is about capturing, sharing and applying the learning taking place. However, as Wheelwright and Clark (1992, p.284) acknowledge "organizational learning is not a natural outcome of development projects, even in successful development efforts". They cite two fundamental problems. First, performance is often a result of complex interactions within the overall development system, so it may be difficult to make the connection between cause and effect. Second, the natural incentives in the organisation encourage people to press on to the next project.

According to the CI Capability Model, there should be evidence that individuals and teams ensure that their learning is shared with others and stored in such a way that it can be reused. Managers must be prepared to act on the learning that takes place, even if it implies criticism of a system or process for which they have responsibility.
However, it is not enough to record the learning that has taken place and leave it at that. Wheelwright and Clark again:

"Learning does not end with recognition of cause-and-effect relationships or with insight into the behavior of the organization. In order to be effective, it must also extend to the introduction of change into the organization – capturing the insight and incorporating it into behaviors (that is, into the way the organization does development)." (ibid. p.300)

It may be necessary to designate a person or team to make sure that the learning that is captured across the organisation is properly deployed, since this entails far more than merely communicating changes made by a team or individual. Bartezzaghi et al. (1997) have described how the inter-project learning process involves abstraction and generalisation, learning embodiment, learning dissemination, and learning application. Inevitably, a company will need to provide a range of enablers to assist in the capture and application of learning. Examples of the form such enablers might take within NPD are given in Table 4.4.

Takeuchi and Nonaka (1986) talk about transferring learning through 'osmosis', that is by assigning key individuals to subsequent projects; by converting project activities into standard practice (they give the example of Canon's Auto Boy project which produced a format for reviews that was used in later projects); and by trying to institutionalise the lessons learnt from their successes. However, they caution that institutionalisation can be a danger if carried too far since changes in the environment may make lessons learnt impractical. When this happens a core capability may turn into a core rigidity (Leonard-Barton, 1995). Leonard-Barton (1995) warns that the emphasis on speed to market has led in some cases to ignoring knowledge-gathering activities prior to the official start of a project, which should include the learning derived from previous failures.

Bartezzaghi et al. (1997) describe barriers to inter-project learning. As well as the same ones found in the parts of the organisation, such as production, where many processes are repetitive (e.g. lack of strategic vision of improvement objectives, the organisation does not promote trials, the organisation condemns errors) they identify barriers peculiar to the NPD environment:

- space and time separation of cause and effect within the past project;
- space and time disjunction between past experience and future application;
- inapplicable context specific experiences;
- not-invented-here syndrome.

The impact of these barriers varies according to the kind of knowledge to be improved: specialised knowledge (i.e. about a single part of the product or of the organisation) suffers a moderate impact from these barriers; systemic knowledge (i.e. about interactions among parts of the product and of the organisation) faces a more serious impact from such barriers. There is a need for articulated, cross-functional organisational mechanisms (i.e. enablers) to overcome these barriers. Bartezzaghi et al. (1997) describe various enablers used by the 20 Italian and Swedish companies in their research (see Table 4.4). They found that the analysis of variances between planned decisions and actual results, which took place in the Project Termination and Project Audit phases.
of NPD projects, appeared to be the most effective inter-project learning mechanism. Schemes for classifying projects were able to help in the identification and transfer of patterns of knowledge. However, reports and databases did not seem to be very effective at embodying and disseminating improvements.

<table>
<thead>
<tr>
<th>Enabler</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Reassignment of key change agents to transfer experience in managing product innovation</td>
<td>Takeuchi and Nonaka (1986)</td>
</tr>
<tr>
<td>Managerial style and structure that acts as a catalyst of internal and external communication</td>
<td>Maidique and Zirger (1985)</td>
</tr>
<tr>
<td>Oral diary</td>
<td>Kransdorff (1996)</td>
</tr>
<tr>
<td>Electronic product books</td>
<td>Bennett and Culverhouse (1994)</td>
</tr>
<tr>
<td>Periodic debriefings among product development teams</td>
<td>McKee (1992)</td>
</tr>
<tr>
<td>Best practice conferences</td>
<td>Duarte and Snyder (1997)</td>
</tr>
<tr>
<td>Use of pre-project teams – members provide continuity between past experiences and new projects</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
<tr>
<td>Team mentors</td>
<td>Duarte and Snyder (1997)</td>
</tr>
<tr>
<td>Reports and databases</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
<tr>
<td>Structured CAD/CAE libraries</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
<tr>
<td>Standard formula and design rules</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
<tr>
<td>Actual physical solutions of design problems (e.g. a product platform which embodies past learning experiences)</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
<tr>
<td>Project classification schemes</td>
<td>Wheelwright and Clark (1992)</td>
</tr>
<tr>
<td>Procedures – changes to the specific, detailed sequence of activities or rules that developers follow</td>
<td>Wheelwright and Clark (1992)</td>
</tr>
<tr>
<td>Tools and methods – teaching engineers and developers new skills in using specific tools and methods</td>
<td>Wheelwright and Clark (1992)</td>
</tr>
<tr>
<td>Process – changes to the broad sequence of activities and phases that structure development</td>
<td>Wheelwright and Clark (1992)</td>
</tr>
<tr>
<td>Structure – change the formal organisation, the locus of responsibility, and the geographic location of development activities</td>
<td>Wheelwright and Clark (1992)</td>
</tr>
<tr>
<td>Principles – add to the set of ideas and values used to guide development decisions</td>
<td>Wheelwright and Clark (1992)</td>
</tr>
<tr>
<td>Project audit</td>
<td>Wheelwright and Clark (1992)</td>
</tr>
<tr>
<td>Post project analysis</td>
<td>Bowen, Clark et al. (1994a)</td>
</tr>
<tr>
<td>Learning audit</td>
<td>Bowen, Clark et al. (1994a)</td>
</tr>
<tr>
<td>Analysis of key learnings</td>
<td>Duarte and Snyder (1997)</td>
</tr>
<tr>
<td>Rotation of teams of engineers and managers from existing products to new products (e.g. Xerox)</td>
<td>Anon. (1995)</td>
</tr>
<tr>
<td>Closer physical co-location of R&amp;D personnel</td>
<td>Moenaert and Caeldries (1996)</td>
</tr>
<tr>
<td>Systems dynamics tool for conducting a post-mortem diagnostic analysis of software development projects</td>
<td>Abdel-Hamid and Madnick (1990)</td>
</tr>
<tr>
<td>Analysis of variances between planned decisions and actual results in the Project Termination and Project Audit phases of the NPD project</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
<tr>
<td>Objectives of an individual development project include inter-project learning</td>
<td>Bartezzaghi, Corso et al. (1997)</td>
</tr>
</tbody>
</table>

Table 4.4 Examples of enablers for capturing, sharing and transferring learning within the NPD context found in the literature
Kransdorff (1996) cites work from Warwick University and from the Manufacturing Vision Group (in the U.S.) which suggests there is corporate 'amnesia' i.e. very few organisations seriously attempt to learn from their own past performance. When they do try to, concern not to hurt people's feelings gets in the way of learning constructively from experience. Moreover personal memory is highly selective, and under scrutiny an individual manager is likely to adopt defensive reasoning (Argyris, 1993). Kransdorff's solution to this problem is an 'oral diary'. Helped by an experienced researcher, key decision-makers record their actions on tape at regular intervals during an 'event' or project's life cycle. Afterwards the edited transcript provides unequivocal evidence of how and why decisions were made at the time. These are scrutinised by independent functional experts who jointly produce a learning audit for the company which identifies lessons that can be applied in the future.

Ward (1995) describes the 'engineering checksheets' used by Toyota in Japan which he calls 'lessons-learned books'. Each functional area has its own lessons-learned books which describe the current company capability, including feasibility ranges. For example, a book may list the 60 ranges of specifications for a fender which the company knows it can manufacture; stylists, body engineers, and production engineers refer to their own book to select options they know will be manufacturable. Deviations from the lessons-learned book are discussed and resolved or may result in a new technology or processes to make the design feasible, and the lessons-learned book will then be revised.

The enabler proposed by Bennett and Culverhouse (1994) is also influenced by Japanese practice. Specifically, the product design and product engineering support systems or infrastructures evolved by Japanese electronics firms to overcome the problems associated with current approaches to electronics design knowledge reuse. They claim that these infrastructures facilitate the organisational learning process, thus enabling the companies to continuously improve both the design of their products and the processes by which those products are manufactured. Bennett and Culverhouse's potential solution to the practical knowledge storage and retrieval problems faced by electronics designers is a design database which is structured in the same way as a book: with chapters, sections, headings, tables of contents and indices. They argue that such an 'electronic book' would be a more intuitive tool for human designers than many current design automation products because the users' mental model of the database would already have been formed by years of experience reading books. A series of three 'electronic' product books, each holding aspects of the developing product for current use and future reference, generated over a product's lifetime would form a Product Encyclopedia. Over time the Product Encyclopaedias would accumulate to form a Product Development Library. However, as noted above, Bartezzaghi et al. (1997) found that the effectiveness of databases for dissemination was marginal.
Co-location is another enabler of learning amongst NPD personnel. Moenaert and Caeldries (1996) report how one company found that locating R&D staff in closer proximity to one another significantly improved market learning and innovativeness but, interestingly, not technological learning. Duarte and Snyder (1997) describe several enablers implemented by a firm to facilitate learning after product development projects. Theses include best practice conferences, the use of team mentors to bring prior experience of product development to the team, and analysis of key learnings.

Bartezzaghi et al. (1997) found that post project analysis could be an effective inter-project learning mechanism, though the degree of effectiveness depended on how it was used e.g. which functions were involved. According to Leonard-Barton (1995 p.134) "Many companies conduct audits of new-product development projects. Most do so in name only." To be effective, post project audits must be systematic, that is, involve all team members; apply to all projects; and result in actions that can be implemented. For example, Hewlett-Packard studied its 'successful' and 'unsuccessful' projects in order to redesign its NPD process (ibid.). However, as Bowen et al. (1994a) point out, it does take extra time, effort and money to use development projects to learn and this is one reason why so few companies audit their projects. Some companies set up a kind of 'learning SWAT' team but this can cause employees to regard learning as that team's responsibility and not their own. Another shortcut senior managers take is to assign someone else to capture the learning from one project and apply it to another project, whereas in the companies that are most successful at using development projects to expand capabilities, senior managers "strive to be leaders in learning". An additional problem in many organisations is that the reward system does not encourage learning and project leadership. At Chaparral Steel, post project analysis of development projects is conducted to see if operations lessons (the way people actually worked best together) can be passed on to other projects (Bowen, Clark et al., 1994a). Wheelwright and Clark (1992 p.300) describe how a project audit can be carried out in such a way that it becomes "a learning project conducted by a project leader and involving individuals from the key functions represented in development".

Proposition

The learning that takes place within NPD is captured, shared and applied. This transfer of learning occurs not only within a development project (i.e. between different actors, stages or activities) but also between projects (i.e. between projects running concurrently and between projects that take place at different points in time). The nature of the development process and setting pose particular challenges to the reuse of learning, but it is possible to design enablers that are effective in the NPD context.

17 SWAT – Strengths, Weaknesses, Advantages, Threats
B9 People are guided by a shared set of values underpinning CI as they go about their everyday work

As discussed in Chapter 2, CI is underpinned by a number of core values including recognition of the value of small-scale improvements; belief in the ability of everyone in the organisation to make a contribution; and treating mistakes and failure as valuable opportunities for learning and improvement. There are of course many other values which support CI, and the NPD 'good practice' concerned with 'widespread acceptance of the need for change' is one of them.

The values identified by Leonard-Barton (1992b) in her model of 'the factory as a learning laboratory' can be regarded as 'CI values':

- egalitarianism and respect for the individual;
- shared knowledge;
- positive risk (no blame, freedom to make mistakes, do not single out for praise or blame; know when to call off a project);
- openness to knowledge from outside.

The activities Leonard-Barton describes as essential to the learning laboratory, and which are supported by these underlying values, reflect some of the key CI behaviours: independent problem solving (cf. B5); integrating internal knowledge (cf. B6); continuous experimentation (cf. B5); integrating external knowledge (cf. B6). In her more recent writings she shows how these four activities contribute to the development of core capabilities (Leonard-Barton, 1995). Each of the activities is supported by a 'managerial system'. These are, respectively, performance rewards; apprenticeships and education; hiring practices and career paths; and resources for alliances and networks. The managerial systems comprise a number of what the CI model would call enablers e.g. cross-training; using foremen as instructors; constant sending of mixed employee teams to customers, suppliers and competitors world-wide. Leonard-Barton's learning laboratory model refers to a company as a whole and is clearly applicable to the development part of the organisation.

According to Bowen et al. (1994a), one of seven key elements in optimised development is "pushing the envelope" i.e. constantly making improvements to a company's products, processes and capabilities on a broad front. This epitomises much of what CI is about.

There are many ways in which managers can show by their behaviour whether they are truly committed to CI values, for example, how they react under pressure (do the CI values slip?), or when subordinates make mistakes. Of course, this key behaviour applies to everyone, not just to managers. For example, NPD staff could demonstrate their belief in the CI values by themselves being actively involved in making and recognising incremental improvements, and when something goes wrong looking for reasons why rather than casting blame.
Proposition
NPD personnel are guided by a shared set of cultural values underpinning CI as they go about their everyday work. Such values include recognition of the value of small-scale improvements; belief in the ability of everyone in the organisation to make a contribution; and treating mistakes and failure as valuable opportunities for learning and improvement.

Summary
This subsection has demonstrated the extension of the behaviours in the CI Capability Model to the product development context. The similarities between the CI behaviours and ‘good practice’ NPD are particularly strong in the areas of management style and involvement; functional integration and cross-boundary working; and learning. Arguably, an organisation that emphasises these aspects of ‘good practice’ NPD would have a strong foundation on which to develop a process of continuous improvement.

The discussion focused on two elements central to the CI Capability Model, generic CI behaviours and contingent CI enablers. The appropriateness of the behaviours to the NPD context was supported by the writings of other researchers, and examples of mechanisms described in the literature which have the potential to be CI enablers were listed. Many of these are actually being used by firms, rather than representing academic suggestions. In addition, for each CI behaviour a proposition was made of how it might appear within the context of NPD processes.

So, in theory, it seems appropriate to adapt the concepts of CI behaviours and CI enablers to the NPD context. The other key aspect of the CI Capability Model is the evolution of the CI behaviours over time. Is the concept of different levels of maturity one that fits with the NPD environment? The following subsection will address this issue by looking at the use of maturity models within a product development setting.

4.3.2 Maturity models in NPD

An important feature of the CI Capability Model is the evolutionary approach it takes to the development of the key CI behaviours. As shown in Chapter 2, the model identifies a series of phases, or levels of maturity, that a firm passes through as the behaviours become more established. The concept of maturity or evolutionary models is not alien to the NPD context. Examples found in the literature include:

- A.D. Little model – three levels of research management: the intuitive mode, where the emphasis is on creativity and R&D is isolated from the wider business context; the systematic mode, in which there are closer links between business and R&D management and combined insights at the level of individual projects; and strategic and purposeful management of R&D, which provides a holistic strategic framework within
which R&D cooperate with other vital functions across the entire organisation (Roussel, Saad et al., 1991).

- Rothwell model – five levels through which the dominant form of the innovation process has moved over the years: technology push; market pull; coupling model; integrated model; systems integration and networking (Rothwell, 1992). (See Chapter 3 Sections 3.3 and 3.6 for details about these models.)

- Software Engineering Institute model – five levels of maturity of the management processes used in software development projects (see below) (Paulk, Curtis et al., 1993).

Miller (1994) refers to these 'staircase' models before presenting the findings from his own research into quality practices in R&D in terms of transitions between four hierarchical levels. His levels are: science frontier R&D; revenue-dependency R&D; cross-functionally integrated R&D; and strategic change R&D (see Chapter 3 Section 3.5.3). Management practices, quality metrics and conceptions of effectiveness differ between the levels. However, Miller then appears to be unhappy with the perspectives offered by maturity models which, he claims, "oversimplify complex realities" and are based on a number of assumptions, for example, that it is desirable to progress from lower to higher levels regardless of a firm's competitive situation. He believes that "a contingency interpretation is more plausible" and plots his four categories of R&D management against the different contingent situations arising from the rate of introduction of new products (few vs. continuous flow) and the type of innovation (radical vs. incremental). Indeed, a contingency interpretation of Miller's categories of R&D management does seem more appropriate than a maturity perspective. The aims and objectives pursued are different for the different categories of management. However, in the CI Capabil ity Model firms are trying to achieve the same ultimate objective as they pass through the different levels i.e. they are working towards widespread adoption of the key CI behaviours; the levels represent progress made. Also, as noted in Chapter 2, in applying the CI Capability Model it is recognised that it may be appropriate for some firms to remain at a lower level (e.g. Level 3 may be considered sufficient by a company in a mature mass production industry).

As seen in Chapter 2, the existence of other maturity models was one of many influences on the emerging CI Capability Model. The Software Engineering Institute's Capability Maturity Model (CMM) is particularly relevant in the present context as it is directed specifically at the development process.

Software process maturity is defined as "the extent to which a specific process is explicitly defined, managed, measured and improved" (Paulk, Curtis et al., 1993). The CMM identifies five levels of
process maturity (Institute of Software Engineering, 1992).

- **Level 1: Initial** — every project is handled differently
- **Level 2: Repeatable** — every similar project is handled similarly
- **Level 3: Defined** — a standard process is now well defined for all projects
- **Level 4: Managed** — a measurable basis for all improvements to the process
- **Level 5: Optimised** — emphasis on defect prevention

At Level 5 the whole organisation is focused on continuous process improvement and best practice is identified and transferred throughout the organisation (Paulk, Curtis et al., 1993).

Each of the five maturity levels is described by key process areas which comprise key practices and are grouped according to common features (Paulk, 1995). This structure is represented in Figure 4.2.

![Figure 4.2 The architecture of the Software Engineering Institute's Capability Maturity Model (Source: Paulk, 1995)](image-url)
CMM is a normative rather than prescriptive model. It does not tell an organisation how to improve but describes characteristics typical of the different levels in terms that are general enough not to constrain how the software process is implemented in a particular organisation. In this approach and in the elements of the CMM we can see much in common with the CI Capability Model. The CMM describes key practices (cf. CI key behaviours and subbehaviours), found at different levels of maturity, which contribute to satisfying the goals of each key process area or 'essential attribute' (cf. CI core abilities). Recognising the contingency issue, CMM does not attempt to prescribe specific means (cf. CI enablers) for achieving a maturity level.

Writing in 1993, Paulk et al. comment that there were too few examples of Level 4 and 5 software projects and organisations to draw general conclusions about the characteristics of firms at these levels; the creators of CMM looked to other industries and to the concepts of statistical process control to help define Level 4 and 5 characteristics (Paulk, Curtis et al., 1993). Similarly, the CIRCA research found relatively few examples of companies at Levels 4 and 5 of the CI Capability Model; details of how the CI behaviours would appear are drawn partly from theory (in particular ideas around the operation of learning organisations) and partly from the few companies worldwide who appear to have reached these heights.

CMM is a hierarchical model in which "each level builds a foundation for succeeding levels to leverage for implementing processes effectively and efficiently" (Paulk, Curtis et al., 1993). Although a firm can use processes described at a higher maturity level than it is at, such processes will be unable to reach their full potential until the proper foundation is laid ("skipping levels is counterproductive"). The same caveat applies to the CI Capability Model. For example, it would be possible, but probably not desirable, to encourage Level 4 forms of CI behaviour (autonomous decision making, self-direction of CI activity etc.) before establishing widespread acceptance and practice of systematic problem solving aligned to company aims and objectives (Level 3).

However, there is at least one respect in which the CMM represents a significant difference in approach to the CI Capability Model. CMM takes a 'staged' approach according to which the key processes areas reside at a single maturity level (Paulk, 1995). The approach of the CI Capability Model is one of continuous evolution whereby the same key CI behaviours are developed to higher degrees of maturity as the company progresses through the levels. There are two important reasons why a staged approach would not be appropriate for the CI model. First, the nine key CI behaviours are closely interrelated. For example, it would be unlikely that a firm could achieve a high level of maturity on B8 (the learning of individuals and groups is captured and shared) without having made any progress with B7 (people learn from their own and others' experiences, both positive and negative). The nine behaviours need to co-evolve, although not necessarily at exactly the same rate. Second, the continuous evolution approach reflects reality. People do not instantly
adopt new ways of behaving. The behaviours take time to nurture and cannot be 'acquired' by a firm at will.

Another maturity model is Trillium, created by Bell Canada, Bell-Northern Research and NORTEL (Coallier, McKenzie et al., 1995). Trillium has a telecommunications focus and provides a benchmark of the best industry practices for the development and support of software products. It can be used in various ways, including as a self-assessment tool to help identify improvement opportunities within product development, and to evaluate a supplier's product development and support capability. The Trillium model is based on the CMM v1.1 but is more wide ranging. It draws on other sources including ISO 9001 and ISO 9000-3, Malcolm Baldrige National Quality Award criteria, and IEEE Software Engineering Standards, and incorporates practices from ten other areas among which are quality management, business process engineering, and technological maturity. Although the Trillium model also has five maturity levels its architecture differs from the CMM and it takes a product, rather than software, perspective.

The application of other maturity models to the area of product development indicates that the evolutionary aspect of the CI Capability Model is not out of place in the NPD context. In particular, the many similarities between the CMM and the CI Capability Model suggest that the latter should be workable within NPD. The CMM also reinforces the view taken by this thesis that the NPD process is repeatable, though the product may change, and can be defined, managed, measured and improved.

4.4 INCIDE\textsuperscript{18} – a tool for investigating CI in NPD

The preceding sections have argued for the extension of the CI concept to NPD and suggested how elements of the CI Capability Model might appear specifically within the NPD context. This section will describe the development of INCIDE, the instrument designed to identify the presence or absence of the key CI behaviours, and of existing or potential CI enablers, in firms in practice. The logical starting point for developing this instrument was the CIRCA CI mapping tool, which co-evolved alongside the CIRCA models for continuous improvement. However, as we shall see, differences in the purpose and application of the tool required for this research resulted in a completely new instrument being designed.

4.4.1 The CIRCA mapping tool

The CI mapping tool initially reflected the 'five gear model' described in Chapter 2, and was incrementally refined (by the author) over a period of three years, going into four versions.\textsuperscript{19}

18 INCIDE – IINvestigating CI in new product DEvelopment processes

19 The CI mapping tool is not presented as part of this thesis and so the process whereby it was developed will not be elaborated on here. A brief description of the CI mapping tool is given so that the reader may gain an insight into the researcher's previous experience of CI mapping tools, which influenced the design of INCIDE.
Version 4.0 of the tool took the form of a main schedule used to guide a semi-structured interview with the manager with overall responsibility for CI; additional checklists for gathering data on communication, 'vehicles' for CI, and use of CI tools; and a much shorter schedule for interviews with small groups of shop floor employees (Caffyn, Gilbert et al., 1995). The main schedule followed the structure of the gear model, with short sections on company background and history of CI followed by sections devoted to each of the 'gears' i.e. strategy, culture, infrastructure, process, and tools (Table 4.5).

<table>
<thead>
<tr>
<th>Sections/themes (number of questions)</th>
<th>CI mapping tool v4.0</th>
<th>CI mapping tool v5.0</th>
<th>INCIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company background (3)</td>
<td></td>
<td></td>
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<tr>
<td>History of CI (5)</td>
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<td></td>
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<tr>
<td>Strategy (13)</td>
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<tr>
<td>Culture (11)</td>
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<tr>
<td>Infrastructure (14)</td>
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<td>Process (9)</td>
<td></td>
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<td></td>
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<tr>
<td>Tools (4)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Company background (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of CI (5)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>CI at present time (3)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Strategy (12)</td>
<td></td>
<td></td>
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<tr>
<td>Managers &amp; CI (6)</td>
<td></td>
<td></td>
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<tr>
<td>Management of CI system (6)</td>
<td></td>
<td></td>
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<tr>
<td>CI system &amp; company structures (5)</td>
<td></td>
<td></td>
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<tr>
<td>Involvement in CI (9)</td>
<td></td>
<td></td>
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<tr>
<td>Cross-boundary working (7)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Learning of individuals &amp; groups (6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capturing &amp; sharing learning (3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI values (7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of questions</td>
<td>58</td>
<td>73</td>
<td>21</td>
</tr>
</tbody>
</table>

Table 4.5 Comparison of the main interview schedules used for CIRCA mapping tool v4.0 and v5.0 and the INCIDE tool

During the development of the CI Capability Model the author produced a major revision of the mapping tool, version 5, which reflected the capability model. Many of the questions remained similar to before, though organised differently, but additional questions were included to take in aspects not previously covered (e.g. the congruity issue flagged by key behaviour 3). This version of the tool comprised a main interview schedule for use with the person responsible for CI in the company, and three shorter schedules for use with senior managers, middle managers, supervisors, and non-managerial employees. The main schedule comprised three preliminary sections (company background; history of CI; CI at the present time) before asking a series of questions about each of the nine key CI behaviours in turn (Table 4.5). This schedule alone contained 73 questions (ignoring supplementary or follow-up questions) and inevitably took several hours to work through.
4.4.2 Considerations governing the design of INCIDE, a tool to investigate CI within NPD processes

The CI Capability Model argues that the nine key CI behaviours are generic and equally applicable to the NPD area of a company as to other areas. It follows that the tool which has been used to assess CI in manufacturing divisions and in entire firms, the CIRCA mapping tool, could also be used to investigate CI within NPD. However, several factors, relating to the purpose and scope of this investigation into CI in NPD, the unit of analysis, and the interviewees, suggested that it might not be appropriate to use the same tool to conduct the research for this thesis.

**Purpose**
The CI mapping tool was used in a form of consultancy. The mapping process resulted in a written report giving the company an objective view of its CI and offering guidance on further development. The mapping process took a full day (longer in some cases) and it was in the company's interest to provide staff time and access to employees because it had paid for the exercise. Firms involved in the present research would not be paying for the visit and would not receive formal consultancy in return – the purpose was research only. The tool therefore needed to be more concise, as a company may not be prepared to give so much time if it is not going to gain any tangible benefit from it (in the event both case companies did give a fair amount of time).

**Scope**
Whereas the CI mapping tool looks at the entire CI programme the new instrument would be concerned only with CI within the NPD area. There was less need for a comprehensive picture of CI in the company in general, but the instrument would have to generate sufficient data to build a picture of the NPD context in the company.

**Unit of analysis**
The CI mapping tool was designed to investigate the company and its CI system as a whole, with interviewees selected to be representative, as much as was possible (e.g. some from office-based departments, others from shop floor areas). The main interview covered all aspects of the CI system, while the additional interviews asked employees in small groups about their experience and involvement in CI; non-managerial staff were also asked questions about their job role and work processes which would indirectly shed light on CI practices. As already noted, the new tool would be limited in scope to look at the NPD area only. Within this there was an issue of whether the focus of the interviews should be the interviewee's job/department or the development project. For some organisations, e.g. those with a strong functional orientation and 'lightweight' development teams, it may be more appropriate to examine CI at the level of the department. In others, where a development project encapsulates the whole NPD process, it may be more useful to direct the enquiry at the level of the project. In the event, because of the nature of the
companies involved, the first case used the department and the second case used the project. It was possible to do this using the same tool with only minor modifications.

**Interviewees**

The CI mapping process involved a cross-section of members of the organisation, from senior management to shop floor. The new tool would be limited to personnel involved with NPD and therefore likely to have a fairly high level of education and, possibly, responsibility. This might mean that some questions in the additional schedule should be phrased differently.

These considerations led to the conclusion that it would not be appropriate to use version 5.0 of the CI mapping tool, even if modified. The research required a new instrument capable of generating the necessary data while taking up less time of individual interviewees.

**4.4.3 INCIDE**

The challenge was to develop a concise instrument which would generate data that could lead to an understanding of the implementation of CI within NPD. The tool had to be applicable regardless of the way in which the NPD process under investigation was organised and carried out.

Several themes emerged from an analysis of the CI Capability Model and comments in the literature:

- organisation and operation of product development in the company;
- changes to the NPD process;
- involvement of staff in changing the process;
- capturing and sharing learning;
- enablers and disablers.

Questions were devised covering each of these areas (Table 4.5). The answers to the questions would shed light on the presence or absence of the key CI behaviours, with the exception of B2 (CI system monitored and developed) and B3 (congruity between company structure and infrastructure and CI system) which at that time were felt to relate to the CI system on a company-wide basis and therefore be beyond the scope of the research. However, during the course of using the tool, some information was gleaned which addressed these behaviours as modified in Section 4.3.1 of this chapter (i.e. with the addition of the proviso 'within NPD'). Figure 4.3 indicates which of the key behaviours the questions primarily relate to; the questions appear in full against the behaviours in Appendix 4. It should be noted that although the questions are designed to give an interview some structure, they are sufficiently open to encourage interviewees to talk around the issues they are being asked about. Thus in practice data about a particular behaviour may be forthcoming at any point in an interview. The questions are contained in three different schedules for use with different
interviewees: the person in charge of NPD; other functional managers involved in NPD; and people working on NPD.

<table>
<thead>
<tr>
<th>Question number §</th>
<th>Theme of question</th>
<th>Key CI Behaviours*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A8, B2, C2</td>
<td>NPD process in practice: cross-boundary working</td>
<td>B1</td>
</tr>
<tr>
<td>A9, C3</td>
<td>Measurement of NPD process</td>
<td>B2</td>
</tr>
<tr>
<td>A10, B3</td>
<td>Identifying ways to improve process</td>
<td>B3</td>
</tr>
<tr>
<td>A12, C4</td>
<td>Encouraging people to have ideas</td>
<td>B4</td>
</tr>
<tr>
<td>A11, B4</td>
<td>Acting on an improvement idea (in theory)</td>
<td>B5</td>
</tr>
<tr>
<td>A13, B5, C5</td>
<td>Suggesting/implementing ideas for process improvement (in reality)</td>
<td>B6</td>
</tr>
<tr>
<td>A14, B6, C6</td>
<td>Impact of changes on department/company objectives</td>
<td>B7</td>
</tr>
<tr>
<td>A15, B7, C6</td>
<td>Nature of changes: proactive vs. reactive</td>
<td>B8</td>
</tr>
<tr>
<td>A16, B8, C5</td>
<td>Implementing an improvement idea</td>
<td>B9</td>
</tr>
<tr>
<td>A17, B9, C6</td>
<td>Monitoring changes/improvements to NPD process</td>
<td></td>
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<tr>
<td>C7</td>
<td>Learning from experience</td>
<td></td>
</tr>
<tr>
<td>A18, A19, B10, B11, C7</td>
<td>Capturing and sharing learning</td>
<td></td>
</tr>
<tr>
<td>A20, B12, C8</td>
<td>Disablers, barriers to CI in NPD</td>
<td></td>
</tr>
<tr>
<td>A21, B13, C9</td>
<td>Possible enablers of CI in NPD</td>
<td></td>
</tr>
</tbody>
</table>

*Key Behaviours
B1 Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities.
B2 The CI system as it operates within NPD is continually monitored and developed.
B3 Ongoing assessment ensures that the NPD structure's and infrastructure, and the CI system as operationalised within NPD, consistently support and reinforce each other.
B4 Managers at all levels display active commitment to, and leadership of, CI.
B5 People participate proactively in incremental improvement.
B6 Effective working by individuals and groups across internal divisions and external boundaries at all levels.
B7 People learn from their own and others' experiences, both positive and negative.
B8 The learning of individuals and groups is captured and deployed.
B9 People are guided by a shared set of values underpinning CI as they go about their everyday work.

¥ Letters refer to the three schedules that make up INCIDE, for the person in charge of NPD (A); other functional managers involved in NPD (B); and people working on NPD (C).

Figure 4.3 Questions in INCIDE and the CI behaviours to which they primarily relate (Questions to elicit background information about the interviewee and the firm's NPD are not included in this figure.)
A copy of the resulting tool, called INCIDE because it investigates CI within new product development processes, is given in Appendix 1.

INCIDE is designed to guide a researcher in carrying out semi-structured interviews with company personnel working within the area of new product development. It is not a questionnaire to be completed by respondents on their own. Although some of the questions are straightforward ('What are the company's main products?'), others require more effort on the part of the interviewee ('If people have made changes to the NPD process, do the changes reflect departmental or company objectives?'), while several are quite subjective ('Are you or your colleagues encouraged to improve the NPD process?'). Moreover, the interviewee may not be familiar with, or readily understand, some of the issues and ideas asked about (e.g. mechanisms for converting learning into the organisation's memory). For these reasons it may be necessary for the researcher to offer additional explanations or examples, or to ask supplementary questions in order to verify responses. The open nature of most of the questions gives interviewees scope to talk around the issues being investigated. Such discussions often reveal additional relevant information and valuable insights. In short, INCIDE is an interview tool to be used by researchers gathering data on CI within NPD; the researcher may need to elaborate on certain of the questions, depending on particular interviewees and their responses. It would not be appropriate to use INCIDE in its present form as a stand-alone questionnaire.

INCIDE carries over from the CI mapping tool the use of different interview schedules according to the interviewee's role. However, in many other respects INCIDE is very different from the CI mapping tool, most noticeably in length (a total of 43 questions over the three interview schedules compared to the 132 questions in the mapping tool's main and additional schedules) and structure (it starts from a wide view of NPD and then focuses down on improvement activity rather than going through behaviour by behaviour). INCIDE is also more even in the amount of time (and questions) allocated to the different categories of interviewee.

4.5 Conclusion

This chapter has argued for the extension of CI to NPD. It has reinterpreted the CI Capability Model in terms of the NPD context, and in doing so has generated a series of propositions that are grounded to some extent in the literature and in the CIRCA work. The instrument described in the previous section, INCIDE, provides a means of seeking evidence to test these propositions based on the practical experience of companies. The degree of commonality between 'good practice' NPD and the CI behaviours, particularly in the areas of management leadership, cross-functional integration and learning, suggests that an organisation pursuing the former should have a strong foundation from which to develop CI.
In short, this chapter has shown that in theory it is valid to extend the concept of CI to the NPD context. The next two chapters will describe the research carried out to investigate the application of CI to NPD processes in practice.
Chapter 5  Research Methodology

5.1 Introduction

This chapter begins with an explanation of the research philosophy underlying the investigation. It then outlines the strategy followed, describing the original methodological design and explaining how this evolved with the adoption of a multi-methods approach. Section 5.3 also provides an overview of the research methods used, covering their objectives, sequencing and timing. The practical details of each method and the main research tools are given in Section 5.4. This is followed by a critical review of the methodologies applied.

The steps taken to test and validate the research conclusions are described in Chapter 8, after the research findings have been presented and discussed in Chapters 6 and 7. This reflects the sequencing of the validation process, which was designed and implemented after the research findings had been analysed.

5.2 Research philosophy

The main aim of this research was to explore the scope for the application of continuous improvement to the process of new product development. To address this 'problem' the researcher adopted an inductive approach based on the development of grounded theory, for the following reasons:

1) The focus of the research in this thesis is largely exploratory and hypothesis generating. It is possible to apply a rigorous approach to the formulation and testing of a series of small hypotheses. The outcome of this is grounded theory, that is, theory which is grounded in what is observed in specific cases. It is pieced together step-by-step and tested on an on-going basis, as part of an iterative process (Strauss and Corbin, 1994).

2) The researcher has previous experience with these methods; they were successful in developing the CIRCA CI Capability Model described in Chapter 2.

3) The deductive approach of Scientific Methods and positivism are not suitable for this type of research because:
   • there are so many possible variables that the 'experiment' cannot be controlled.
   • this thesis does not start with a well developed conceptual theory to test (there is no covering law to impose).
It can be seen from this that a major influence on the approach adopted is whether the researcher starts with a fully developed conceptual theory or with a blank sheet of paper, or somewhere in between, as was the case with this research. This thesis starts with some half-formed theories or proposals as described in Chapter 4 i.e. how we might expect Cl to appear in NPD. The researcher did not start with a fully formed hypothesis because at the time of embarking on the research this was an unexplored area so it would not be possible to build up a hypothesis based on the reported research of others. The researcher did not start with a blank sheet of paper because there were already cases and a model on CI, though not related to NPD, from the CIRCA work. Recent literature on NPD suggested some similarity with aspects of the CI work. Chapter 4 showed how some themes seem to stretch across from CI theory into NPD. It was possible to use this as a starting point for proposals, in order to give a framework for the investigation. The decision to start with proposals, together with the researcher's belief in the suitability of induction for research of this nature, guided the choice of methodologies used, as described below.

5.3 Research strategy

This section describes the original methodological design and explains how, and why, this evolved with the adoption of a multi-methods approach. It then provides an overview of the research methods used covering their objectives, sequencing and timing.

5.3.1 Original plan

NPD processes vary significantly between (and even within) companies, and aspects of both the process of NPD and the CI process can at times appear somewhat fuzzy. These factors, together with the exploratory nature of the study, suggested that qualitative research methods would be more likely to produce a valid understanding of the issues being investigated. Case studies were particularly appropriate for the type of investigation and the researcher had gained experience of their use during previous work.

The original methodological design had been to follow the literature review with a short exploratory phase which would help shape the interview schedule and identify potential problems with the methodology. This was to involve organisations that differed in terms of size, complexity of project, and experience of CI. The exploratory phase was to be followed by a series of semi-structured interviews, with a range of personnel associated with NPD and CI, in approximately 20 companies. Companies were to be selected which had either recognised expertise in the area of NPD and / or were considered to follow 'good practice' in terms of CI. The purpose of these interviews was to establish:

- a map of the product development process in the company;
- the extent to which CI is or is not applied to the NPD process;
the extent to which Cl could or could not be applied to the NPD process;
how the company measures the NPD process, and how it monitors the impact of any changes or improvements to the process.

Data collection was to be followed by a period of analysis, preliminary verification and writing up.

Before starting the research several methodological concerns were identified: the intangible nature of the concept of Cl within NPD; access to the target population; and problems associated with the size of the companies involved. Small companies may not have a clearly defined process for NPD, making it more difficult for the researcher to understand what happens and for interviewees to relate to the questions being asked. Large organisations may produce extremely complex products, with different parts developed around the world, making the NPD process very difficult to track. For these reasons it was decided to target (a) medium-sized companies and (b) particular, carefully selected NPD projects in larger companies.

5.3.2 Adoption of multi-methods approach

Early on in the research process two developments took place which led to a re-evaluation of the research strategy. First, it became increasingly clear, from the literature and from the preliminary interviews, that although there was interest in the topic so little was known about it that the area needed to be opened up as broadly as possible. No single method, case studies included, is perfect. There was a strong argument for adopting a variety of methods which would approach the research problem from different directions and help to create a consolidated picture of the issues involved. Second, several opportunities arose which enabled the researcher to adopt a multi-methods approach and, in doing so, to strengthen the research. The researcher was able to organise two hypothesis generating workshops, and to gather some quantitative data by including relevant questions in a Cl survey she organised as part of a wider European investigation (Berger, Boer et al., 1999 (forthcoming); Caffyn, 1998a).

To take account of these extra activities, and to balance the sources more evenly, the number of company studies was reduced to two. Two potential drawbacks immediately arise: qualitative data from fewer firms will reduce the ability to draw general conclusions; and with only two firms the ability to explore contingent issues stemming from different company settings is greatly diminished.

The first of these possible drawbacks should be more than offset by the use of additional methods, including the quantitative data provided by the survey. Moreover, two cases will allow analytic, as opposed to statistical, generalisation. Analytic generalisation occurs when:

"... a previously developed theory is used as a template with which to compare the empirical results of the case study. If two or more cases are shown to support the same theory, replication may be claimed." (Yin, 1994)
In this research the starting point for the case work was the analytical framework and investigation tool based on the proposals described in Chapter 4. The data generated by the two cases should allow this theory to be expanded and generalised.

The second potential drawback should not be a problem either, for two reasons. First, the two companies to be studied in detail represent very different organisations in all respects: size, ownership, product complexity, technologies, etc. What they have in common is realisation of the need to improve their NPD processes and recognition that CI could help them achieve this. It should therefore be possible to find out whether CI is being, or could be, applied in two very different settings. Second, the first requirement is to establish whether there is any scope for CI to be applied to NPD processes, rather than assuming that there is and straight away narrowing the focus by comparing different company situations to see how this might affect the scope of CI application. Indeed, in hindsight perhaps the case only approach originally proposed would be better suited to a subsequent project – once the basic questions have been explored (e.g. is there any scope for CI in NPD, what are the potential limits etc.) there will be a sound platform from which to develop a hypothesis and launch a more focused study.

A further advantage of reducing the number of case studies is that it is possible to go into more depth in the companies. It soon became apparent that the topic is quite complex and that to build an accurate picture of CI in NPD requires more time in each firm than originally envisaged. The extremely exploratory nature of the research means that the ability to do this is of greater value than being able to carry out a more superficial examination in a larger number of firms.

5.3.3 Overview of methods used

The main methods used fall into four categories: preliminary interviews; workshops; postal survey; and case studies developed on the basis of detailed interviews. A summary of these methods is given in Table 5.1. In addition to an overall purpose (e.g. to explore the issue, to generate hypotheses) each method had distinct objectives:

Preliminary interviews
- to learn about some actual NPD processes
- to start to explore the potential for CI in NPD processes
- to help shape the research instrument to be used in case studies

Workshops
- to find out if industrialists believe that CI can/should be implemented in NPD
- to elicit details of how industrialists have attempted to generate CI within NPD processes, or how they might do so in future
- to identify actual or potential barriers to implementing CI in NPD
• to identify actual or potential enablers of CI in NPD

Survey
• to establish how widespread the application of CI to NPD processes is amongst companies
• to discover if firms have benefited from implementing CI within NPD
• to see if a particular type of firm is more likely to apply CI to NPD processes

Company cases
• to test whether the main concepts of the CI Capability Model (i.e. generic behaviours, contingent enablers, evolving maturity) hold up within the NPD context
• to discover whether the actual experience of companies negates, supports, or extends the mini-hypotheses described in Chapter 4 concerning the form CI might take in an NPD environment
• to evaluate INCIDE, the instrument designed to investigate CI within NPD

<table>
<thead>
<tr>
<th>Main purpose</th>
<th>Data collection method</th>
<th>Number of interviewees/respondents/workshop participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary interviews</td>
<td>exploratory</td>
<td>semi-structured interviews unstructured interview 4 1</td>
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<tr>
<td>Crendon</td>
<td></td>
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<td>IBM</td>
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<td>Workshop sessions</td>
<td>hypothesis generating</td>
<td>structured discussion structured discussion 6 20</td>
</tr>
<tr>
<td>June 1995</td>
<td></td>
<td></td>
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<tr>
<td>March 1996</td>
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<td>Survey</td>
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<td>hypothesis testing</td>
<td>semi-structured interviews &amp; documentation 4</td>
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<tr>
<td>TM Products</td>
<td>testing instrument</td>
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<td>Ericsson</td>
<td></td>
<td>semi-structured interviews &amp; documentation 7</td>
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Table 5.1 Summary of methods used in the research
<table>
<thead>
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<th>Year</th>
<th>Jan</th>
<th>Feb</th>
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<td>1998</td>
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</tbody>
</table>

- **Literature review**
- **Prelim. interviews**
- **Workshops**
- **Survey**
- **Company case 1**
- **Company case 2**
- **Analysis**
- **Validation activities**
- **Analysis**
- **Writing up**

**Figure 5.1** The main research activities carried out during the project
The timing and sequencing of the key research activities is shown in Figure 5.1. The preliminary interviews were carried out at the start of the research period, in line with the original schedule. The timing of remaining methods is a consequence of the opportunities arising when they did. Since the research was designed to be exploratory, rather than building a hypothesis to test in a detailed company situation, the order in which the research activities were carried out was less important. However, knowing more about the issues under investigation helps a researcher to conduct better interviews and glean more information. So it is appropriate that the company cases were developed during the middle stages of the project.

It should be noted that although interviews were carried out in six firms during the course of this research the company studies differ in purpose and importance. The preliminary interviews carried out in two firms were an initial exploratory activity and were not intended to provide material for detailed case studies. Towards the end of the project interviews were carried out in a further two companies in order to validate certain of the research conclusions (see Chapter 8, Section 8.3 and Section 8.4). The purpose of these validation cases meant that, although the interview work was quite extensive (e.g. in terms of number of interviews and the amount of data gathered), the data analysis and subsequent reporting of the results in this dissertation focused on evidence related to the conclusions being validated, rather than building additional broader case studies.

Two in-depth case studies are presented in this thesis. They were developed from interview data and other materials gathered from TM Products Ltd and from a division of Ericsson Ltd. Ericsson is the most significant case presented here. The predominance of the Ericsson case stems not only from the larger amount of material gathered but, more importantly, from the richness of the data which provide many examples of the CI behaviours and enablers being investigated. Although the same research techniques were used in both firms, the work carried out in Ericsson was more extensive (e.g. 7 interviews and 34 pages of interview notes, compared to 4 interviews and 19 pages of notes in TM Products).

5.4 Practical details of the methods used

This section gives details of each of the methods used to explore the application of CI concepts within NPD processes. The information is practical and descriptive, and a critical evaluation of the methodologies is provided in the following section. The methods used to test and validate the research conclusions are reported in Chapter 8.

5.4.1 Preliminary interviews

Preliminary interviews were carried out in two very different companies, Crendon Group Ltd and IBM. These firms were selected because the researcher was offered access to them just as she
was embarking on this project, at a time when she needed to increase her understanding of the NPD context and start to explore the whole issue of applying CI to product development processes.

_Crendon Group Ltd_

Crendon was a medium-sized company manufacturing pre-cast concrete near Aylesbury in Buckinghamshire. In June 1994 the company had around 100 employees and a turnover of £6.3M (1994/5). The researcher had had previous contact with the company through the CIRCA project, though business problems had severely curtailed Crendon's involvement in that research. However, a change in company strategy had led to the development of a new product: tunnel rings. The first tunnel order was received in January 1994, production started in March, and completion on site was scheduled for August. In May 1994 the researcher was asked to talk to participants in the tunnel project in order to extract their different perspectives of the development process, and any learning points that could be of use in the development of another new product then under consideration.

The unit of analysis was the tunnel project, from its conception in early 1993 to June 1994 when the interviews took place. Semi-structured interviews were carried out over two days with four people key to the project: Managing Director; Works Manager; Technical Development person (formerly Overseas Technical Director); and the Sales & Quality Manager (formerly Works Manager).

An interview schedule (see Appendix 5) was used to give focus and structure to the interviews, but interviewees were allowed to elaborate and give additional information when they wished. The interview schedule is unrelated to INCIDE, the tool described in Chapter 4. It was compiled nearly a year before the concepts of CI behaviours and enablers started to evolve, and was focused on one particular development project. All interviewees were asked about the Tunnel Project; the MD was also asked about the company's strategy for NPD, and more generally about the company's recent restructuring and attempts at continuous improvement. Each interview lasted between one and one and a half hours and, with the consent of the interviewees, was tape recorded.

_IBM_

International Business Machines (IBM) is the world's leading provider of computer hardware, software, and services. The company makes a wide range of computers, including desktop, midrange, and mainframe computers and servers. Its peripheral products include printers and devices for networking, storage, and telecommunications. IBM also provides information technology services such as consulting and systems integration.

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20 Crendon Group Ltd ceased trading in 1995.
21 The information in this paragraph is taken from the Internet.
One unstructured interview was held with the individual who designed IBM's End-To-End Design Method. The purpose was to find out about the End-To-End (E2E) Design Method and the scope it offered for CI. The interview covered the history of the development of the End-To-End Design Method, the E2E Design Method, and improving the E2E Design Method. The meeting took place at IBM's Basingstoke site and lasted approximately two hours.

5.4.2 Workshops

The researcher organised two workshop sessions during which industry practitioners shared their experiences and views of the application of CI to NPD. The first took place in March 1995 during a CIRCA workshop examining the application of CI beyond the manufacturing function. During the session a group of six senior and middle managers from five organisations in the UK considered the issues involved (Caffyn, 1995). Specifically, they addressed three questions:

- What are the key differences, if any, between implementing CI on the shop floor and applying it to the process of NPD?

- What are the inhibitors and the facilitators to implementing and sustaining CI within NPD?

- What practical steps have you taken, or do you think could be taken, to generate CI within the NPD process?

A similar exercise took place in March 1996 during a workshop following the R&D Management Conference at the University of Twente in the Netherlands. Around 20 delegates from a variety of European countries took part in the discussions, about half of whom were from industry and half from academia. Working in three groups, participants were asked to debate aids and barriers to the introduction of CI in NPD, and to recommend enabling mechanisms that could be put in place to help reinforce CI behaviours. Delegates were briefed on the outcomes of the earlier workshop before they addressed the issues, in an attempt to build on the outcomes of the UK workshop and avoid 'reinventing the wheel'. As a result, many points were raised which had not been made during the earlier workshop and there was relatively little overlap between the two.

5.4.3 Survey

In 1995 the researcher carried out a survey of UK manufacturing companies in conjunction with Findlay Publications, publisher of Works Management magazine, as part of a wider study
coordinated by EuroClNet. The purpose of the survey was to build a picture of Cl experience and practice, and highlight issues for more thorough investigation. It provided the researcher with a good opportunity to generate some quantitative data on the issue of applying Cl to the NPD process at little extra effort and no extra cost.

The survey instrument comprised an eight page questionnaire (Appendix 6). It was designed by the participating EuroClNet researchers and where appropriate drew on the experiences of the CIRCA Cl mapping tool and the International Manufacturing Strategy (IMS) survey. In particular, this researcher was able to contribute insights gained from developing the CIRCA mapping questionnaire over several years (See Chapter 4, Section 4.4) and from having used it to carry out 15 Cl mapping visits. For example, the researcher circulated copies of the Cl mapping tool and a paper describing its practical application (Caffyn, Gilbert et al., 1995), and presented a seminar to the group on the tool's content and use. To enable inter-country comparisons to be made a set of core questions was agreed, but individual countries were able to add further questions if they wished. This enabled the UK researcher to include choices relating to NPD, in a questionnaire that was directed largely at production operations.

The UK questionnaire comprised five sections covering company background; general characteristics of the organisation of the business unit and experience of Cl; the organisation and operation of Cl; support for Cl, and tools used in the process; the effects of Cl. There were a total of 31 structured questions plus an open ended question at the end. The researcher added several questions in the UK version to elicit data related to the emerging Cl Capability Model (e.g. strategy, and management leadership of Cl) and to particular interests (e.g. enablers to encourage individuals to engage in Cl activity). To generate some data that could contribute to this thesis, the UK questionnaire asked about the frequency with which Cl is applied to the NPD process (Question 16) and the extent to which Cl had contributed to a change in NPD cycle time over the previous two years (Question 30).

A company which had been engaged in Cl for several years was used to pilot the UK questionnaire. Following minor modifications the questionnaire was mailed to 1,000 companies selected from the Findlay Publications database according to size of site (between 100 - 1000 employees) and industrial sector (manufacture of metal products, electrical and optical equipment, transport equipment, and machinery and equipment not elsewhere classified). These criteria had been agreed by the EuroClNet group to aid international comparisons. To increase the likelihood of response the selection included readers who had responded during 1995 to editorial features (not advertising) on TQM, Lean Manufacturing, and Teamworking. The questionnaire was

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EuroClNet is a Europe-wide network of researchers working in the field of continuous improvement. Details of activities carried out by EuroClNet, including the survey, are given in (Caffyn, 1998a).
addressed to a named individual known to be in charge of the business unit, who was asked to pass it to a colleague best able to complete it. The initial response was slow so a follow-up letter, with another copy of the questionnaire, was sent to non-respondents urging them to participate in the survey. This boosted the response rate and a total of 142 usable questionnaires were returned.

The data was entered onto an Excel spreadsheet by a colleague, using a common coding scheme agreed by the EuroCI Net group. With the exception of inputting the data and producing tables and graphics from the spreadsheet, the researcher carried out all the work for the UK survey including developing the UK version of the questionnaire, conducting the pilot test, negotiating the mailing arrangements with Findlay, analysing the results, and writing an initial report (Caffyn and Silano, 1996).

5.4.4 Company cases

Detailed interviews were carried out in two organisations: TM Products Ltd and the Cellular Systems & Special Network Division of Ericsson Ltd, referred to as ETL/R. As noted earlier (Section 5.3.3), although the same research techniques were used in both firms, the work carried out in Ericsson was more extensive (e.g. in terms of number of interviews and the amount of data gathered and analysed) and Ericsson is the more significant of the two cases. Factors influencing selection of the case firms included convenience (both geographically and in terms of access already gained by the researcher for other work) and the significant differences between the two organisations which would enhance the usefulness of the data in addressing the research question (Table 5.2).

<table>
<thead>
<tr>
<th>Ownership</th>
<th>TM Products Ltd</th>
<th>ETL/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years established</td>
<td>UK plc (former utility company)</td>
<td>Swedish multi-national</td>
</tr>
<tr>
<td>Number of employees</td>
<td>92</td>
<td>6</td>
</tr>
<tr>
<td>Number of staff engaged in design/development</td>
<td>150</td>
<td>560</td>
</tr>
<tr>
<td>Main products</td>
<td>water pipeline products</td>
<td>cellular telecommunications systems</td>
</tr>
<tr>
<td>Product complexity</td>
<td>low-medium</td>
<td>high</td>
</tr>
<tr>
<td>Technical expertise</td>
<td>mechanics, hydraulics</td>
<td>software design</td>
</tr>
<tr>
<td>Main customer base</td>
<td>water companies world-wide</td>
<td>large cellular operators e.g. Vodafone, Mercury</td>
</tr>
</tbody>
</table>

* Includes one product manager and one marketing manager who spend a significant amount of time on development work, but excludes those from other functions (e.g. Purchasing, Planning) who may be involved to a lesser extent.

¥ Includes staff providing administrative support within the design organisation.

Table 5.2 Comparison of the organisations in which detailed interviews were conducted
In both firms semi-structured interviews were carried out using a version of INCIDE, the research tool described in Chapter 4. In brief, the research instrument comprised three schedules designed to guide interviews with the person with overall responsibility for NPD, with managers working in NPD, and with other staff engaged in product development activities (see Appendix 1). The questions, which embodied certain propositions concerning how CI might look in the NPD context (see Chapter 4), covered the following areas:

- background to product development in the firm;
- strategy for NPD;
- changes to the NPD process;
- organisation, management and operation of NPD
- involvement of staff in changing the process;
- nature of changes made to the NPD process;
- capturing and sharing learning;
- CI enablers and disablers.

The tool was adapted slightly for the Ericsson case which was carried out as the UK contribution to an investigation by EuroCI Net involving seven Ericsson sites around Europe (see below).

To augment the interview data, relevant company documentation was also collected in both firms. These documents include: organisation charts; Engineering Manual; Quality Manual; relevant sections of business plan, policy deployment performance plan, and employee survey report; summary review of development projects; report and agenda for new products meeting; internal quarterly bulletin.

**TM Products**

TM Products is a medium-sized company owned by Thames Water plc, engaged in the design, production and marketing of pipe-line products for use world-wide. The researcher had had previous contact with the company, having carried out CI 'mapping' visits (a sort of 'CI audit') in 1993 and 1995. This provided useful background for the present research, particularly in terms of the company's experience of continuous improvement, and of the reorganisation resulting from merging with several smaller businesses during 1994. The following staff, who all work on the company's main brand (Talbot), were interviewed: Engineering Manager; Design & Development Engineer; Marketing Manager; Product Manager. The interviews took place in January and March 1996, and lasted between 50 minutes and two hours. The interviews were tape recorded. A list of the questions to be covered was supplied to the Marketing Manager in advance, on request. A preliminary analysis of the data in terms of the CI Capability Model was confirmed by interviewees, and by a company Director, to be an accurate reflection of the situation.
Ericsson Ltd

Ericsson Ltd is part of the Swedish multinational telecommunications company LM Ericsson. At the time of the research Ericsson Ltd (hereafter referred to as ETL) was organised into four divisions according to product and type of customer. The research was carried out in the Cellular Systems & Special Network Division, ETL/R, located at Guildford, Surrey. It was conducted as part of a project undertaken by EuroCI Net to investigate continuous improvement at Ericsson sites in seven European countries. An initial meeting with the Sector Manager in charge of Product Management and Design took place in May 1996 to scope the project and gather background information. It was agreed that of the three design areas at ETL/R the research should focus on TAS because it had the longest history at Guildford. TAS is one of the four main parts of a base station controller (BSC) which itself is a component of the GSM (Group System Mobile) system used in cellular telephone communications. At the time of the interviews there were 4 TAS projects running (in addition to a pilot project working on introducing a totally new methodology, Shlaer Mellor, into the design process):

- R5 'in service', i.e. staff were involved with maintenance activities
- R6 just about to go to First Office Application (FOA) in Italy
- R6.1 the main design project ongoing, at that time getting ready for testing
- R7 in the prestudy stage

Seven interviews took place over two days in June 1996, each lasting about one and a half hours. A copy of the interview schedule was supplied in advance to the Design Sector Manager who, on his own initiative, circulated it to the interviewees. The job titles of those interviewed were: Design Sector Manager, Design Manager, Design Supervisor, Senior Software Development Engineer, Test Manager, Senior Tester, Project Manager. All interviewees except the Design Sector Manager worked in the TAS sector (the TAS Sector Manager was unavailable but the Design Sector Manager has extensive knowledge of the area). All interviewees had worked at ETL/R for at least 3.5 years with one exception; he was 9 months into a two year contract with ETUR, having previously worked for Ericsson in Sweden for almost 7 years. A Danish doctoral student with an interest in the EuroCI Net project attended the interviews, which were not tape recorded. The researcher used the data gathered during the interviews to write a case description, which was circulated to all interviewees for validation and clarification of a number of points.

To ensure consistency between the seven EuroCI Net Ericsson case studies a common research instrument was used. The EuroCI Net group adopted the INCIDE tool designed for this thesis and at the request of the group the researcher added several more questions and subquestions e.g. about 'company culture' in different Ericsson locations (see Appendix 1).
5.5 Critical review of the methodology

Here we will review the main methods used in the research, namely the workshop sessions, the survey by postal questionnaire, and the detailed interviews using INCIDE which generated the case data. Each of these will be considered in terms of the following criteria, as defined by Gill & Johnson (1991):

- Internal validity – extent to which conclusions regarding cause and effect are warranted.
- External validity – extent to which conclusions might be generalised to other people (population validity) and to social contexts other than those in which data has been collected (ecological validity).
- Reliability – consistency of the results obtained in the research.

5.5.1 Workshop discussions

Participants came from a variety of manufacturing sectors, which would lend some external validity i.e. their comments might apply to manufacturing in general. A proportion of the comments were probably based on personal theories derived from participants’ own beliefs, readings, and observations rather than on established facts. This would reduce internal validity. In other words a comment, for example, that "x is a barrier to CI in NPD" might be that person's perception and a 'scientific' investigation might show that there was not a direct cause and effect relationship. However, internal validity is not a major issue here because the primary role of the workshop sessions was hypothesis generating. They contributed an industrial perspective to emerging hypotheses, which otherwise drew on literature and academic research. The strong similarities between the outcomes of the workshop sessions and reported research in a similar area (i.e. TQM in R&D, see May and Pearson, 1993) indicate that the workshops might be considered to have a degree of reliability.

5.5.2 Survey

Surveys enable researchers to reach a large number of companies for relatively little expenditure in terms of cost and time. However, this advantage is gained at the expense of the quality of the data collected.

*Internal validity*

To what extent did the questions generate valid data on what they were intended to measure? The aim was to build up a picture of the practices and experience of CI in the companies surveyed. The questions were framed based on what other research has revealed about the motivations for CI, practices, support mechanisms, etc. (for example Bessant, Caffyn et al., 1994; Hart and Berger, 1993; Imai, 1987; Lillrank and Kano, 1989). To avoid confusion over what might be meant by
'continuous improvement' a definition appeared prominently at the start of the questionnaire, and definitions and examples were given to help ensure that respondents understood the questions. Despite this, some respondents may have misunderstood some of the questions. For example, as many as 11% of respondents claimed to have two or fewer levels in the business unit hierarchy 'between, and including, the head of the unit and operators' which is somewhat surprising given the size of the businesses involved. In response to a question (Q.24) which asked about the tools and techniques used to support Cl, 20 respondents indicated the use or partial use of a 'red herring'23 ('Komashure Analysis'). The question which asked about the impact of Cl on certain performance indicators (Q.30) was also problematic, in that some respondents appear to have misunderstood the instruction for reporting the direction of any change.24 In these cases responses were interpreted on the basis of other data supplied; if in doing so the researcher made an incorrect assumption the number of instances in which Cl made a positive contribution to one or more performance indicators would have been over estimated.

Some of the questions used ordinal scales (1 - 5) to attempt to measure, for example, the frequency with which Cl is applied to a particular area, or the importance of a particular factor. The instructions indicated the extremes in terms of, for example, 1 = not frequent, 5 = very frequent (rather than, say, 1 = once a year or less, 2 = 2 or 3 times a year, etc.). Clearly, how people respond to this type of question will be influenced by their own experience and expectations of what is meant by 'frequent'.

External validity
Descriptive surveys like this one need to involve a representative sample of the relevant population in order to ensure population validity (Gill and Johnson, 1991 p.78). The sample was not representative of the whole of UK manufacturing; it was targeted at companies of 100 - 1000 people and in certain SIC categories. In 1995, 3.7% of UK manufacturing enterprises had 100 - 1000 employees, rising to 12.6% when enterprises employing less than 10 people are excluded (Central Statistical Office, 1995). By contrast, 83% of the responding units employed 100 - 1000 people. The SIC codes targeted accounted for 41.5% of the UK's manufacturing output in 1994

23 A 'red herring' is a spurious piece of information included in a questionnaire to help assess the accuracy with which the questionnaire is completed. In this case 'Komashure Analysis' was a fictitious term concocted by the researcher. The fact that 11% of respondents claimed that it was used in their organisation puts a question mark over the veracity of some of the data generated by the survey.

24 Respondents were asked to give the % change in the performance indicators over the previous two years, and to use a plus sign (+) to indicate a change for the better and a minus sign (-) to indicate a change for the worse. However, while for some of the indicators an increase in the measure would correspond to a change for the better (e.g. productivity and manufacturing quality), for others an increase would imply a change for the worse (e.g. lead time, product cost, and new product development time). Some respondents appear to have put a minus sign against changes in the latter indicators in error i.e. they may have intended to report a reduction in, say, lead time (which is a change for the better) but have used the minus sign (which indicates a change for the worse). The possibility that the minus sign has been used incorrectly, rather than that these respondents intended to report a deterioration in the performance indicator, is suggested from their other responses.
(National Manufacturing Council, 1995) and for 66% of the responding business units in the survey. The discrepancy between some of the responding units and the selection criteria may reflect a change in the business unit since the database was last updated, and a variability in how the company is categorised. The deliberate inclusion of readers who had responded during 1995 to features on TQM, Lean Manufacturing, and Teamworking may have introduced bias in the sample towards companies with experience of, or an interest in, issues often closely allied to CI.

The response rate was 14.2%. Non-respondents were not followed-up (due to time and cost restrictions) and so it is not possible to say whether those who did respond differed significantly from those who did not in a way which might reduce the external validity of the data. For example, in manufacturing companies in general, are people working in firms which have adopted CI more likely to complete a questionnaire on the topic than those working in organisations which do not have any CI activity?

Another problem with validity, specific to this thesis, relates to the fact that the issue of the application of CI with NPD was only incidental to the survey and was not taken into account during sample selection. There are manufacturing business units which are not engaged in product development, but the questionnaire did not identify if any responding business units fell into this category. Thus conclusions regarding the general extent of CI application to NPD based on the whole sample would, if anything, underestimate the level of activity, because it assumes that all firms in the sample do NPD and therefore have the possibility of applying CI to product development processes.

**Reliability**

The issue here is the degree to which the results are consistent and would have been replicated if the survey had been repeated. There are several factors which potentially may have an adverse affect on reliability. First, the questionnaire was sent to the individual responsible for the business unit who was asked to pass it to the person most able to complete it. In most cases, therefore, the questionnaire is likely to have been completed by a single individual within the business unit. The accuracy of the responses will depend on that individual's knowledge and understanding of the issues asked about. It is possible that someone else in the same organisation may give different responses to the same questions. Second, as noted above, some of the questions used ordinal scales to attempt to measure, for example, the frequency with which CI is applied to a particular area, while Q.30 asked respondents to indicate the contribution CI had made to changes in selected performance indicators. The responses to these questions may be quite subjective.

In some of the countries where the survey was carried out follow-up telephone calls were made to a random sample of respondents in order to verify responses (this was not done in the UK because of insufficient resource). For example, in Sweden telephone interviews with first-line managers
confirmed the general picture given by the production managers who had completed the questionnaire, in 6 out of 8 cases (Berger, 1996a).

5.5.3 Company cases based on detailed interviews

Interviewees in both companies confirmed analyses derived from the data and felt them to be accurate, suggesting that INCIDE has a reasonable degree of internal validity. However, the external validity of the findings must be low since only two companies were studied. Even so, given the exploratory nature of the research a detailed examination of two firms is arguably preferable to a more cursory look at a larger number of firms. This view is supported by Mintzberg (1979) who feels small samples should be encouraged rather than "less valid data that were statistically significant". Gill and others took a similar line when resource constraints forced a choice between a survey across the whole population under investigation or use of a limited number of in-depth cases:

".... we felt we would be more likely to produce valid findings in a relatively under-researched area if data was taken in depth from a few cases. It was not possible, given the level of resourcing, to pursue an ideal strategy and do both." (Gill and Johnson, 1991 p.150).

Finally, INCIDE seems quite reliable. It was used in seven countries by researchers of seven different nationalities who were able to come up with comparable data.

5.5.4 Triangulation

Each of the main methods used in this research has its strengths and weaknesses, as detailed above. An advantage of using multiple methods is that the particular limitation of one method may be compensated for by a strength of another of the methods used. For example, while there may be doubts about the accuracy of some of the survey responses, the data generated by the interviews in the case firms appear to have high internal validity. The relative strengths and weaknesses of the methods reviewed above are summarised in Table 5.3.

<table>
<thead>
<tr>
<th></th>
<th>Internal Validity</th>
<th>External Validity</th>
<th>Reliability</th>
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<tbody>
<tr>
<td>Workshops</td>
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<tr>
<td>Survey</td>
<td>-</td>
<td>(+)</td>
<td></td>
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<tr>
<td>Company cases</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Table 5.3 Relative strengths (+) and weaknesses (-) of the methods used in the research
5.6 Conclusion

This chapter has explained the research philosophy underlying this thesis which caused the researcher to take an inductive approach based on the development of grounded theory. It has described the research strategy and shown how, following the preliminary investigation, pragmatism and opportunism led to the application of multiple methods: hypothesis generating workshops; a descriptive postal survey; and detailed case studies to test both the propositions previously generated and the research instrument, INCIDE. It has been argued that a reduction in the number of company studies to two was more than offset by the ability to conduct the case research in greater depth and by the use of additional methods. A critical review of the methodology has shown that although all the methods have certain limitations, their degree of validity and reliability is such that, taken together, it should be possible to build a valid picture of the scope for applying CI to the NPD process. The results of using these methods are reported in the next chapter.
Chapter 6  Research Findings

6.1 Introduction

Chapter 5 described the research strategy followed for this thesis and explained the reasons for adopting a multi-methods approach which included workshops, a postal survey, and detailed company studies. It gave practical details of how each of the research activities was carried out and critically reviewed the main methods used in terms of validity and reliability. This chapter reports the findings of each research activity in turn. Presentation is in the form of a straightforward commentary and each section concludes by highlighting the implications the research activity had for (a) the research process, and (b) the research content. The results of these research activities, together with the contribution made by the literature, will be consolidated, analysed and discussed in Chapter 7 in order to address the research question and related themes. The steps taken to validate the conclusions reached are reported in Chapter 8. Finally, the implications that the findings and their interpretation have for future research will be discussed in Chapter 9 (Figure 6.1).

6.2 Preliminary interviews

The nature of this research activity was exploratory, with the specific objectives of:

- learning about some actual NPD processes;
- starting to explore the potential for CI in NPD processes;
- helping to shape the research instrument to be used for the case studies.

Two very different organisations were involved in the preliminary interviews: Crendon, a medium-sized producer of pre-cast concrete; and IBM, the world's leading provider of computer hardware, software, and services. In the case of Crendon, four semi-structured interviews were conducted with staff who had played leading roles in developing the company's first new product in 50 years: tunnels. At IBM one unstructured interview was held with the person who had initiated and subsequently coordinated development of the company's End-To-End Design Method.

6.2.1 Crendon

Tunnels represented a totally new product for Crendon, the company's first new product in 50 years. Since the 1940s Crendon had made variations on their 'core' product, concrete buildings. Originally these had been for the agricultural market, then the industrial market and more recently for supermarkets and sports stadia. Although the different structures used different frames, they were basically variations on the same theme. The company decided to leave the 'supply and erect' structures market, which was highly competitive and where funding was problematic, and to focus
on manufacturing. Within manufacturing the company needed to find a fairly consistent product to make. Tunnels appeared to meet this requirement, and to be a profitable area (there were only three tunnel makers in the UK at that time).

The decision to investigate tunnels was taken in early 1993, and from June of that year the Sales & Quality manager worked full-time on developing the new product concept. This included collecting market intelligence and approaching potential customers. Crendon developed a close relationship with a tunnelling contractor, Miller Civil Engineering, and put in two tenders with Miller which came to nothing. Miller subsequently succeeded in winning the contract for a new baggage tunnel at Heathrow airport, and in January 1994 placed an order with Crendon.
The next few months were spent developing the product for Miller. This involved ordering the moulds; testing materials; designing and ordering the special equipment which would be needed; and production trials. Production started at the end of March and was followed by the first in a series of buildability tests and by quality assurance audits on procedures and production methods; the latter were carried out by both Miller and their customer Bovis, who were managing the contract for the British Airports Authority. Production of the tunnel rings, which accounted for half of Crendon's weekly output, was due to be finished by mid August. The two measures for monitoring the development work were progress against the time budget and against the development budget.

During the concept development period the project was very much in the hands of one person, the Sales & Quality Manager, who worked on it full-time but consulted with others. When the order came in the job was "handed down" and become more of a team effort, involving primarily the Works Director and the Technical Development person with input from the Sales & Quality Manager, the MD, and later the Commercial Manager. They made decisions in their own areas of competence.

Internal communication was mostly good. The Works Director and the Technical Development person worked well together, but sometimes had problems getting the right information from the Sales & Quality Manager. The latter found it difficult to hand over the project and for a while continued to make many of the external contacts so that the Works Director and the Technical Development person were getting information second hand. This contributed to a lack of continuity from the selling phase to the doing phase. For example, the Sales & Quality Manager had given the customer a "guestimate" rather than a quotation, so when the firm order was received Crendon had only a short period of time in which they had to not only decide what sort of equipment to use, but also to source and purchase it.

External communications had some initial shortcomings but improved. Early on in the project the customer took a long time to answer any queries, and delays in receiving the firm order and final drawings were compounded during the development process (sample moulds, trial test, final moulds) causing production to start a month behind schedule, which lead to a lot of costly weekend working. However, later on communication became "very good". The companies solved problems together and developed a mutual respect, with staff from Miller visiting Crendon regularly in the pre-production stage with offers of help and ideas. The mould supplier, 160 miles from Crendon, was very co-operative but very slow at answering faxes, returning telephone calls, "and terrible at telling an honest story". Crendon overcame this by making frequent visits, and at one point the Technical Development person was spending three days a week in the firm.

There were many technical differences between the development process for the tunnel and for a 'normal' job, including the mix, tolerances, moulds, techniques, and the way the mould makers
were monitored. It was the first time Dramix fibres (used to strengthen the concrete) had been used in pre-cast concrete in the UK. Crendon had never worked to such tight tolerances before and had to buy new computer measuring equipment and develop testing procedures. The measuring machine they bought proved inaccurate, probably because the surfaces of the segments it was measuring were too small, but they continued to use it because the Quality Manual required an inspection (allowances were made for the machine’s tolerances when deciding if a segment was within tolerance). Another major investment was made in poker vibrators which were drawn out of the concrete slowly to give a better finish and compaction.

On several occasions during the project staff in the factory and workshops came up with ideas for low level innovations to overcome technical problems. For example, the rig for the poker vibrators prevented the mould being filled in the usual way because the overhead skip could not be brought over the top of the mould. First the shopfloor suggested using a metal conveyor to take the concrete to the top of the mould. However, the metal fibre and the dryness of the concrete prevented the concrete from dropping in properly. Eventually the factory came up with a solution which was adopted: to put metal chutes at the side of the mould into which the skip dropped the concrete which then slid in. There were also problems with how to do the moulds up tightly enough and, again, the method used to fasten the plates was suggested by the factory.

The tunnel project was considered "a great success". Crendon had developed a new product and had shown that it worked. They had achieved difficult dates and, at the time of the interviews, were running slightly below budget. By then 50 meters of tunnel rings were in the ground and there had been no complaints; indeed, Miller were asking Crendon to quote for more work. Feedback received by the Sales & Quality Manager led him to conclude that Crendon was producing "a better segment than the market is currently supplying".

The Technical Development person had enjoyed working on the project; there was a lot of pressure, which he thrived on, and he felt a great sense of achievement. The Works Manager, by contrast, had not enjoyed working on the project; he was not able to give it enough time (the factory took up 75% of his time) and achieving the daily production requirement was a great worry in the early days. The Sales & Quality Manager had “got a considerable amount of satisfaction” out of the project, although he had been somewhat disillusioned when it moved out of his hands (though in retrospect he realised that this was inevitable and the right thing to do).

Crendon recognised that the way it had developed the tunnel product could be improved on. In the words of the Works Manager, "We've learnt a lot from it that we would do differently." The main learning points about the process are:
• The need for a longer lead-in to get organised. On the next job they will start to prepare the final drawings once they are confident of getting the order but before it is awarded. They will also do mould sketches and get factual quotations for the moulds so that they can order them within a week of being awarded the job. In order to start this advance preparation the "doing side" must be involved earlier in the process.

• Need to start the process as a team. This point was made by the Sales & Quality Manager who had already started investigating the company's next new product (prison cells). Although he had carried out the initial investigation, this time he had involved the others in the process early on by circulating information and raising questions for discussion.

• The importance of making sure records and information are readily available to everyone.

• Need to improve control over the supply of moulds by insisting that the supplier produces proper mould drawings and improves mould delivery. More frequent contact with the mould supplier was also considered desirable.

• In future they would spend more time and money on finishing the moulds, for example by using steel rather than rubber chamfers. Although steel is more expensive and tunnel moulds often are not used more than once, on this project a large amount of time was spent repairing the rubber chamfers each day.

There was also evidence of technical learning. For example, the Works Manager and the Sales & Quality Manager learnt from their trip to France and Germany to look at tunnel production that it was not necessary to shrink wrap the units in polythene to assist curing, as the customer had originally requested. Crendon suffered a great deal of anxiety over meeting the very tight tolerances. Although they believed the tolerances were unnecessarily tight they lacked the experience to challenge them, though their view later proved to have been correct.

6.2.2 IBM

IBM's End-to-End Infrastructure Design Method is a methodology for designing systems developed during the late 1980s. The individual who produced the first sub-versions was driven to do so as a result of his investigation into why so many of the systems built by companies in the UK had proved unsuccessful – he found that the people designing these systems had not followed a method. The E2E method has 5 stages, from Requirements Analysis through to Detailed Design, with formal checkpoints and reviews (Booth, 1994). The method can be used in a range of situations, from relatively small systems to large, complex enterprise systems and networks. The first version was
entirely paper-based but in response to user requests it was turned into a computer tool. The tool is a large programme which includes the method (all versions), documentation, and process information (i.e. how to actually do this).

The method is improved in distinct releases every one to one and a half years, using feedback from people using it. However, because it is a fast changing industry, each stage has an adjunct containing useful amendments, experience etc. which is added to on an on-going basis. Within each stage there are various questions and activities. Each question has a theme and users are able to add their experience and comments about the particular theme to a 'Guidance bucket'. These buckets are checked by the Architectural Review Board before the method is revised, and any really good suggestions are incorporated into the next version. Feedback on how well the design method works is also sought from clients on delivery of a system.

The Architectural Review Board is responsible for improving the Method. It is a group of nine people from different countries, all practitioners apart from one E2E educator, which meets every few months. The Review Board keeps representatives from each country informed, and a member of the Board is usually present at the review that takes place at the end of each stage. Occasionally the Review Board has identified a centre of competence and has held meetings with practitioners there to gather good practice that can be incorporated into future versions of the Method. During the version 2 upgrade a large meeting was held in the US to generate feedback which was subsequently incorporated into the Method; although cost implications prevented the holding of a similar meeting for version 3, various people were asked to comment via the e-mail network. Everyone who has been taught the Method has access to an e-mail forum.

The E2E Infrastructure relates only to design and is used alongside two other methods, Solution/2000 for application development, and Managing Implementation of the Total Project (MiTP) for project management. Work had begun in 1994 to put the three methods into a single 'overall solution' method. In 1994 it was estimated that the E2E Method was used by around 1,500 designers world-wide, of whom about 120 were UK based.

6.2.3 Implications for the research

The preliminary interviews had a bearing on the later research in terms of both methodology and content. In particular, the Crendon case highlighted methodological issues relevant not only to the present research but which also influenced the recommendations for future research put forward in Chapter 9.
Implications for research process

As noted in Chapter 5, one of the methodological concerns noted in the original research proposal was related to the size of company, and lead to the conclusion that it would be best to study either medium-sized companies or particular projects within larger firms. Although Crendon fitted the size criteria there were other factors which made it less easy to look at CI within its NPD process. First, tunnels was the company's first really new product in many years. There was no set process for taking a new product concept and developing it, making it impossible to uncover changes between iterations of the process. Second, Crendon operates in a project-based rather than mass production industry. The new product concept was developed in the company's own time-frame, but the new product itself was not developed until an order had been received. This resulted in a bespoke product which went into production for a relatively short space of time i.e. only to fulfil the single order.

During the interviews more than 38 different players (companies and people) in the project were referred to, including 9 named individuals within Crendon; 6 companies on the customer side (including consultant firms brought in by Miller and by BAA); 6 supply companies; and various other outside agencies and individuals, such as the Building Research Establishment, a structural engineer who helped Crendon develop the concept, and the man who had directed the tunnelling work carried out on the Channel Tunnel (brought in by Miller). At a practical level, it takes up time for the interviewer to gain an understanding of the links and relationships between so many different parties involved. This, together with time taken to build up the company background and NPD context, suggested that the original plan may not have allowed sufficient time for the detailed company cases.

Implications for research content

In terms of content, the Crendon tunnel story highlighted the importance of several issues already flagged in the literature as having a significant impact on the NPD process, notably communication, handovers, and relationships with customers and suppliers. It suggested that these would be areas worth considering in any future investigation concerned with understanding a company’s NPD process and how it might be improved.

IBM’s End-to-End Infrastructure Design Method provided an early example of how companies could build into a development process procedures to trigger CI type behaviours (e.g. reflecting on how a process could be improved, sharing a better way of doing a particular task).

6.3 Workshop sessions

The primary purpose of the workshops was hypothesis generation. It was hoped that these interactive sessions with people working in industry would:
• establish whether industrialists believe that CI can and should be implemented in NPD;
• elicit details of how industrialists have attempted to generate CI within NPD processes, or how they might do so in future;
• identify actual or potential barriers to implementing CI in NPD;
• identify actual or potential enablers of CI in NPD.

At the first workshop the participants, all UK based, discussed three questions:

• What are the key differences, if any, between implementing CI on the shop floor and applying it to the process of NPD?
• What are the inhibitors and the facilitators to implementing and sustaining CI within NPD?
• What practical steps have you taken, or do you think could be taken, to generate CI within the NPD process?

Delegates to the second workshop, held one year later in the Netherlands, were informed of the outcome of the UK discussion and asked to add to the knowledge base by debating aids and barriers to the introduction of CI in NPD, and to recommend enabling mechanisms that could be put in place to help reinforce CI behaviours.

6.3.1 Workshop findings

The points that emerged from both workshops have been combined and are given in Tables 6.1 to 6.3.

<table>
<thead>
<tr>
<th>Tangibility</th>
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<tbody>
<tr>
<td>• NPD is a more intangible process than manufacturing processes</td>
</tr>
<tr>
<td>• on the shop floor creativity is about improving something that is already there</td>
</tr>
<tr>
<td>• it is more difficult to define what the deliverable is</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Process characteristics</th>
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<tbody>
<tr>
<td>• longer time-scales in NPD</td>
</tr>
<tr>
<td>• NPD is an iterative process</td>
</tr>
<tr>
<td>• culture in NPD is different from shop floor culture; has two aspects: creative vs. structured</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluative frameworks</th>
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<tbody>
<tr>
<td>• difficult to measure 'quality' of the process</td>
</tr>
<tr>
<td>• tendency to measure things that are easy to measure (e.g. time) which may not necessarily lead to the desired result</td>
</tr>
<tr>
<td>• problem in deciding what is the 'right' value to aim for with measurement</td>
</tr>
</tbody>
</table>

Table 6.1 Implementing CI within the NPD process: differences in the NPD context compared to a shop floor environment  (Source: CIRCA Workshop 12, June 1995, UK)
<table>
<thead>
<tr>
<th>Facilitating factors</th>
<th>Inhibiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• a moderate level of turnover in development teams</td>
<td>• the differences listed in Table 6.1</td>
</tr>
<tr>
<td>• focus on post project evaluation</td>
<td>• conflict between the need for restriction/control vs. the need for experimentation and creativity</td>
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<tr>
<td>• customer awareness and links to the customer</td>
<td>• lack of measure points and performance indicators</td>
</tr>
<tr>
<td>• communication of threats resulting from increased pace of change and global competition</td>
<td>• lack of parameters to prove the benefit of improvements</td>
</tr>
<tr>
<td>• bonuses (if based on the 'right' criteria)</td>
<td>• lack of leading measures as opposed to lagging measures</td>
</tr>
<tr>
<td>• NPD staff are technically competent people, so if they can be convinced that CI will help beat the competition they may accept it</td>
<td>• lack of formal planning system</td>
</tr>
<tr>
<td>• once convinced, engineers may be strongly for CI</td>
<td>• existing formal procedures, especially when used in R&amp;D facilities world-wide</td>
</tr>
<tr>
<td>• highly motivated staff</td>
<td>• existing standards (may also serve as an aid)</td>
</tr>
<tr>
<td>• open-minded staff</td>
<td>• legal and safety implications</td>
</tr>
<tr>
<td>• high levels of numeracy and other skills amongst NPD personnel</td>
<td>• existing contracts, employment legislation</td>
</tr>
<tr>
<td></td>
<td>• people being bothered with 'old problems' from previous generations of products</td>
</tr>
<tr>
<td></td>
<td>• team composition</td>
</tr>
<tr>
<td></td>
<td>• too much turnover in development teams</td>
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<tr>
<td></td>
<td>• intellectual snobbery – suggesting that there is scope for improvement is taken as implied criticism</td>
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<tr>
<td></td>
<td>• professional pride, the 'not invented here' syndrome</td>
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<tr>
<td></td>
<td>• people's dislike of being measured</td>
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<tr>
<td></td>
<td>• use of technology for its own sake</td>
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<tr>
<td></td>
<td>• NPD culture – engineers are paid to be sceptical</td>
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<tr>
<td></td>
<td>• company culture</td>
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<td></td>
<td>• lack of common language</td>
</tr>
<tr>
<td></td>
<td>• fear of being made redundant</td>
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<tr>
<td></td>
<td>• lack of training in quality management</td>
</tr>
<tr>
<td></td>
<td>• lack of time to work on CI</td>
</tr>
</tbody>
</table>

Table 6.2 Implementing CI within the NPD process: facilitating factors (aids) and inhibiting factors (barriers)  
(Source: CIRCA Workshop 12, June 1995, UK; R&D Management Conference workshop, March 1996, The Netherlands)
Implementation tactics
- get a champion
- look for small, easy to get successes (avoid early failures)
- improve communication in all directions
- organise CI as a project
- hold a start-up workshop
- explain the need for CI
- start by giving a written agreement that no one will lose their job as a result of CI
- provide training in improvement techniques and tools
- organise informal communication

Winning over NPD staff
- increase understanding amongst NPD staff of the whole business (multi-discipline teams help achieve this)
- get engineers to talk to peers in companies successfully practising CI in NPD
- make NPD staff more aware of the competition e.g. through competitive benchmarking
- cast CI in a way to appeal to NPD staff – logical
- show engineers that they can benefit from CI (e.g. share savings made, provide incentives)
- focus on the 80% of the people who want to cooperate, fire the remainder (manager level only)
- let people set their own standards

Increasing participation
- use process modelling – get engineers to model the process as they actually work it (i.e. not the documented process), and then identify how it could be improved
- encourage use of simple quality tools
- use simple internal measures that everyone understands, and display them
- provide a suggestion box with a facilitator
- recognise and reward people for their efforts
- develop concept of customer-supplier amongst NPD staff
- define and communicate common goals and objectives
- provide time and resources for CI
- adopt ISO 9000 ‘the open way’
- Company B has set up a new suggestion scheme which asks for product innovation ideas; this appeals to engineers
- Company R has an innovation fund to help people progress their ideas about a product or process

Structural changes to the NPD process
- introduce rapid closed-loop feedback system (where the issue raiser not the designer signs it off as solved); log and deal with smaller and smaller problems
- combine Non-Conformance Reports with suggestions
- use multi-discipline teams which include marketing staff
- use dynamically constituted teams
- ‘empower’ project leaders
- adapt the management system so that it supports CI
- set up an experience database to capture best practice

Table 6.3 Strategies for generating CI within the NPD process (Source: CIRCA Workshop 12, June 1995, UK; R&D Management Conference workshop, March 1996, The Netherlands)

6.3.2 Implications for the research

Implications for research process

The workshops informed the company studies to the extent that they provided the researcher with examples and ideas that could be used to help explain the concepts involved to interviewees, e.g. when asking if there was anything in their company which might get in the way of people improving the NPD process. Also, it became apparent that some of the characteristics of NPD which posed challenges for the researcher (e.g. the intangible nature of the process, the relatively long process cycle times) were also perceived as potential obstacles to CI by people working within NPD. This
steered the researcher towards gathering certain data during the company studies, for example, relating to official (documented) NPD processes vs. what happens in reality, and to the frequency and duration of development projects.

Implications for research content
In terms of research content, the workshops demonstrated acceptance by industrialists of the appropriateness of attempting to apply CI to the process of NPD. They generated examples of possible or actual barriers and enablers to CI in NPD, including some enablers which had the potential to institutionalise the CI behaviours. The first session also raised the challenge posed by the contradiction between encouraging creativity and experimentation while keeping the process under control. These observations discussed in detail in Chapter 7.

6.4 Survey

The survey was designed to build a picture of general CI experience and practice in manufacturing companies. However, the researcher used the opportunity it presented to generate descriptive data from which it might be possible to:

- determine how widespread the application of CI to NPD processes is amongst companies;
- discover if firms have benefited from implementing CI within NPD;
- see if a particular type of firm is more likely to apply CI to NPD processes.

The survey questionnaire comprised five sections covering company background; organisation of the business unit and experience of CI; organisation and operation of CI; support for CI; and the effects of CI. It was mailed in the latter part of 1995 to 1,000 named individuals on a database managed by Findlay Publications, and achieved a response rate of 14.2%. The survey formed part of a wider study coordinated by EuroCINet; as a consequence the researcher was involved in discussions to agree a core set of questions and the sample selection criteria (sites of between 100 - 1000 employees in specified industrial sectors), to aid international comparisons.

6.4.1 Survey results

Out of the 142 usable questionnaires returned, 92 respondents (65%) said that their business unit had either "initiated a systematic application of CI" or had a "widespread and sustained process of CI".

In the companies surveyed CI is focused primarily on manufacturing costs and manufacturing quality with less emphasis on the NPD process. When asked to indicate the frequency with which CI is applied to particular areas, on a scale from 1 "not frequent" to 5 "very frequent", respondents
awarded a total of 502 points to manufacturing costs (ranked 1, n=129) and 489 to manufacturing quality (ranked 2, n=128), compared with 372 for the NPD process (ranked 11, n=122) followed by 363 for product design (ranked 12, n=123).

The average scores (i.e. total points divided by the number of respondents giving at least one point to the area) are: 3.89 for manufacturing costs; 3.82 for manufacturing quality; 3.05 for NPD process; and 2.95 for product design. However, when averages are calculated using only responses indicating average or above frequency (i.e. scores 3 or 4 or 5) the gap between the averages narrows. The average score for the NPD process as a focus for CI activity becomes 4.08 (n=73) compared with 4.26 (n=112) for manufacturing costs and 4.17 (n=111) for manufacturing quality. And when only the above average frequency scores are used (i.e. scores 4 or 5) the position is reversed: 4.61 for NPD process (n=49); 4.60 for manufacturing costs (n=88); and 4.46 for manufacturing quality (n=89). This suggests that although fewer companies are making a determined effort to apply CI to the NPD process, among those that do there is a high level of activity in this area, an impression reinforced by the fact that the mode score for the frequency with which CI is applied to the NPD process was 5 (30 respondents).

A comparison of the 49 companies where CI is applied frequently to the NPD process (scoring 4 or 5) with the rest of the sample shows that they are on average larger in terms of number of employees but with lower turnover, and have been practising CI for slightly longer (Table 6.4).

<table>
<thead>
<tr>
<th>Companies in which CI is frequently applied to NPD process (n. = 40-49)</th>
<th>Remaining companies (n. = 70-92)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average duration of CI (years)</td>
<td>3.15 2.68</td>
</tr>
<tr>
<td>Average number of employees</td>
<td>617 457</td>
</tr>
<tr>
<td>Average turnover (£ million)</td>
<td>42 49</td>
</tr>
<tr>
<td>Industrial sector (most common)</td>
<td></td>
</tr>
<tr>
<td>Chemicals &amp; chemical products manufacture</td>
<td>3 6% 6% 7%</td>
</tr>
<tr>
<td>Basic metals &amp; fabricated metal products manufacture</td>
<td>3 6% 6% 7%</td>
</tr>
<tr>
<td>Machinery &amp; equipment man.</td>
<td>9 18% 14 15%</td>
</tr>
<tr>
<td>Electrical &amp; optical equipment man.</td>
<td>19 39% 21 23%</td>
</tr>
<tr>
<td>Transport equipment man.</td>
<td>5 10% 18 20%</td>
</tr>
<tr>
<td>Not elsewhere classified</td>
<td>3 6% 6 7%</td>
</tr>
</tbody>
</table>

Table 6.4 Profile of companies where CI is focused on the NPD process

CI does appear to have an impact on the NPD process. In all, 71 respondents said that CI had contributed to a change in development time over the previous two years, and of these 13 (18%) described the contribution made by CI to the change as large (more than 30%*). The proportion of
companies reporting that CI has had a large impact on NPD time increases among companies who have had longer experience of CI (Figure 6.2).

![Figure 6.2](https://example.com/figure6.2)

**Figure 6.2** Experience of CI vs. the impact CI has had on NPD time

Some of the differences between the 13 companies reporting that CI has had a large impact on NPD time, referred to as Group A, and the other companies in the sample (Group B) are as follows.

- Group A firms are more likely to produce standardised products, rather than modularised or totally unique products. Standardised products account for more than half the production volume (in turnover) in 69% of Group A companies compared to 30% of Group B firms.

- 77% of Group A had "initiated a systematic application of CI" or had a "widespread and sustained process of CI" compared to 64% of the other companies.

- 25% of companies in Group A had been practising CI for less than 2 years and 42% for more than 4 years, compared with Group B's rates of 55% and 17%.

- CI is regarded as being of strategic importance (as opposed to of operational or of minor importance) in 75% of Group A companies against 64% of group B companies. Group A companies have made further progress with adopting and deploying a strategic approach to CI. Respondents were asked to indicate the extent to which certain statements applied to their business unit. Table 6.5 shows how the proportions of Group A allocating the highest score (5 "to a large extent") compares with the other respondents.
• CI is focused on the NPD process to a greater extent in Group A companies than in the rest of the sample. For Group A companies the NPD process has an average score for application frequency of 4.45 and ranks second in a list of areas to which CI is applied, compared with being in eleventh place, with an average score of 2.91, for Group B.

• CI is more widely spread in Group A companies. In 83% of them CI extends across the entire business unit, compared with 62% for Group B companies.

• There is higher use of CI tools amongst Group A, especially the "seven new management and planning tools" which are used by 77% of these companies compared with 33% of Group B. All the Group A companies use creativity/idea generation tools and display tools, compared with 78% and 81% respectively of Group B companies. In nearly half (46%) of firms in Group A more than three quarters of employees have received training in problem-solving tools; only 14 (13%) of the companies in Group B who answered this question have provided training to this extent.

<table>
<thead>
<tr>
<th>Proportion of companies giving the highest score (&quot;to a large extent&quot;) to the statement</th>
<th>Group A (n = 13)</th>
<th>Group B (n = 129)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The role of CI within the company's strategy is clearly stated.</td>
<td>62</td>
<td>33</td>
</tr>
<tr>
<td>There is effective communication of the CI strategy to everyone within the unit.</td>
<td>31</td>
<td>11</td>
</tr>
<tr>
<td>People use the organisation's strategic goals and objectives to focus and prioritise their improvement activities.</td>
<td>23</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 6.5 Strategic approach to CI: Comparison of companies in which CI has had a large in impact on NPD time (Group A) with the other companies in the survey (Group B)

6.4.2 Implications for the research

Implications for research process

The survey results had little impact on the other research methods. However, the fact that some firms claimed to apply CI to the NPD process, and to have benefited from doing so, emphasised the desirability of using the company studies to find illustrative examples of the practice of CI (e.g. particular improvements suggested and/or implemented by 'ordinary' staff) and of the outcomes of applying CI to the NPD process.
Implications for research content

The survey data are much more significant in terms of the research content. Just over a third (35%) of respondents reported that CI is applied frequently to the NPD process, a higher proportion than the researcher had expected. The finding that half the firms in the total sample attribute some change in development time to CI is also important, supporting the theoretical assumption that CI can bring benefits to NPD. It is also worth noting that there is a clear difference between those companies claiming CI has had a large impact on development cycle times and the rest of the sample. The former are more than twice as likely to be engaged predominantly in the production of standardised products as opposed to modularised or unique products than are the other firms.

6.5 Company cases

The main purpose of the company studies was to test both the theoretical framework proposed for the application of CI to NPD and the instrument designed to build a picture of CI within a company's development organisation. Specifically, the objectives of this phase of the research can be summarised as:

- to test whether the main concepts of the CI Capability Model hold up within the NPD context;
- to discover whether the actual experience of companies negates, supports, or extends the propositions put forward in Chapter 4 concerning the form CI might take in an NPD environment;
- to evaluate INCIDE, the instrument designed to investigate CI within NPD.

The CI Capability Model, described in detail in Chapter 2, argues that CI is essentially about developing a new set of behaviours. It identifies nine key CI behaviours which it claims are generic and therefore applicable in all organisations. A distinction is made between the behaviours and the many different enablers – processes, mechanisms, procedures and other supporting actions – a firm may introduce in order to encourage them. The enablers are contingent and which ones are most appropriate will depend on a particular company and its own situation. The third concept is that of evolving maturity. The model argues that the CI behaviours develop over time, moving from a superficial, conscious level to, eventually, a point where they have become deeply ingrained and are enacted automatically. The researcher was a key architect of this model which is taken in this thesis and applied to the context of the new product development process.

The two companies studied in detail for this research are very different in terms of size, product, and technologies applied. However, the same research instrument (see Appendix 1), with only minor modifications, was used in both cases to conduct semi-structured interviews with a range of personnel working in product development. The observations from both firms are presented in a
common format covering company background; the organisation and operation of the NPD process; improvement of the NPD process; and an analysis of the research data against the framework suggested by the CI Capability Model. The companies' organisation and structures are described as they were at the time the interviews took place; both firms have since experienced some changes.

6.5.1 TM Products

The researcher had had previous contact with TM Products, having assessed the company's CI programme in 1993 and 1995. Four staff members took part in the interviews for this research, two from Engineering and two from Marketing. The findings are presented in four parts. The first three sections give background to the company and the NPD organisation, the final section presents a detailed analysis of the data.

Background

TM Products Ltd has around 150 employees engaged in the design, production and marketing of equipment for providers of water around the world. The original business, F W Talbot & Co Ltd, was founded in 1904 and purchased by a conglomerate in 1964, which in turn was acquired by Thames Water plc in 1989. As the result of a merger with other businesses owned by Thames Water in December 1994, the company now comprises four business streams or brands relating to different groups of products. The largest of these, Talbot, accounts for approximately 63% of total turnover and was the focus of the interviews.

Talbot products include a wide range of service fittings, general pipe fittings, tapping machines, and a limited range of mains fittings. The main customer base is water companies around the world, but agriculture and construction are significant sectors for growth. Another Talbot product is the Talflo valve, a stand-post tap for use in developing countries, which is typically sold to aid agencies. The Talbot brand is market-driven, being driven more by customer needs and expectations than by technology.

As a separate company before the merger, Talbot had adopted a 'Total Quality philosophy' to introduce a more people-oriented approach that would complement the planning and implementation of MRPII (Manufacturing Resource Planning). In May 1993 the company cut over to the new computer system, and two years later achieved MRPII Class A status (Souza, 1993). To gain Class A the company had to demonstrate that the business planning process was fully integrated with the operating system; this included the integration of new product introduction. Talbot also had to show that it was committed to CI.
The company has ISO 9001 accreditation.

**NPD process and organisation**

There are seven engineering staff working on Talbot product development (PD). The Marketing Manager spends around a third of her time on Talbot PD, while up to two thirds of the product manager's time is given over to new product work. At any one time there are around 15 live PD projects, of which five would be major projects at various stages. The typical time-scale for a PD project is two years.

Recently there has been a shift in emphasis to make more use of PD project teams. These are headed by a Project Manager (usually the Engineering or Marketing Manager) and, in addition to the engineer assigned (part-time) to the development work, usually include the purchasing director, a planner, and often a member of the quality department; the production supervisor is involved in some projects when they get close to production. The teams usually meet monthly or fortnightly, to discuss progress and agree actions. The function heads report aspects of PD projects that relate to their departments to the monthly Business Review Meeting. This meeting, attended by the Managing Director, Executive Team and the Commercial and Product Manager, reviews progress and sets priorities.

The Talbot Engineering Manual includes a flowchart of the key activities in a typical development project, as shown in Figure 6.3. The process is flexible and it is recognised that the activities will not always occur in the same order. For example, an FMEA 25 may take place at a different point in design, or field trials may take place at different stages. Interviewees generally felt that the process worked quite well, and had improved since the introduction of project teams. However, it appears that sometimes parts of the process may not be carried out properly. For example, on one recent project an FMEA was done and written up but no attention was paid to the results; this led to many problems later on which delayed the product launch.

At the time of the interviews, there was little measurement of the Talbot PD process. The number of engineering changes was not monitored, though the reasons for the changes were noted and examined on a monthly basis. The only measure used to evaluate a product was internal rate of return, or payback. However, NPD staff had just begun to record, at the start of a new project, the expected launch date, dates of key milestones, cost targets, and market share, to enable comparison of actual performance against forecast.

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25 FMEA – Failure Mode & Effect Analysis, a systematic examination of the ways in which a product could fail, and the effect of such failures.
IDEA

First Look:
New Products Meeting

Research: Marketing and Technical

Performance Spec: Marketing

Concepts

Design Specification

FMEA

Detail Design and Development

Supplier Discussions

Design Review

Cost/Finalise
Marketing
Justification

Production Tooling and Samples

Approve
Dimensions & Performance

Field Trial

Review Trial
Results

Manufacture Launch Quantities

LAUNCH

Figure 6.3 Key activities in the development of Talbot products
Source: Talbot Engineering Manual ENGW 003 Issue A 15.9.95
Improvement of the NPD process

The implementation of MRPII led to some change in the NPD process, but this was not as radical as in other areas of the company. The change was concerned with integrating information into the company at large, rather than altering the process whereby new products are developed. A procedure to integrate information about new product introduction into the MRPII system was developed by a business improvement team, BIT20, made up of the Product Engineering Manager, the Marketing Manager and a Planner. As a result there is now an emphasis on making visible the dates on which products will be available, hitting those dates, and keeping the information on the system up-to-date. However, one year on there were doubts over the effectiveness of the new procedure, the Engineering Manager being of the opinion that it was not working because individual engineers had not been involved in designing it.

A major improvement to the NPD process which was planned but not yet implemented involved the use of modern computer techniques in order to design tools 'right first time' and thus reduce the large amount of work currently done at the production tooling stage. The recent availability of increased computer power, together with more sophisticated and usable software, meant that computer modelling and analysis could now be carried out in-house (the high cost of sub-contracting such work had deterred the company from adopting 3D modelling before). This approach would increase the time spent at the Detail Design & Development stage but save time (and cost) later in the process.

Analysis

This section will present the research observations in terms of the core abilities and key behaviours in the CI Capability Model (see Table 2.3 in Chapter 2), with reference to the propositions put forward in Chapter 4 (Section 4.3).

A. The ability to link CI activity at all levels to company strategy

B1 Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities

Proposition

NPD staff direct their improvement activity towards company or departmental goals and objectives, and monitor the results of such activity and the impact it has. To do this they need to have a clear understanding of what the strategy, goals and objectives are.
Evidence

A form of policy deployment operates within TM Products. The company's overall strategy has been broken down into departmental objectives and strategies which are linked into the business plan. Each department also has an action plan derived from its strategy and objectives, and staff have annual job goals and targets which reflect projects within these action plans. For example, one engineer has as a personal objective to learn how to operate CAD. This directly addresses the action plan items 'introduce use of 3D CAD for plastic mouldings to assist links to toolmakers' and 'introduce use of computer modelling for stress and mould flow analysis', which in turn address two points in the department's strategy. Thus the strategy for NPD, the actions required to achieve it, and a time-scale for these actions are set out in the company's three year plan, some of which are then deployed via personal objectives set annually through the job appraisal process. Strategy deployment can be an enabler of this key CI behaviour but in this case the effect appears to be lessened by the lack of measurement. So although an objective is to reduce development time by 20%, time-scales of the process stages are not being measured, making it difficult to identify where time could be saved or the extent to which the objective is being met.

Although the three year plan was deliberately written in language that everyone would understand it has not been communicated formally, and those at lower levels in the company have not seen the document. Despite this some of the people working in NPD should have some awareness of the content, or at least the part relating to their own department. Before writing down her department's objectives the Marketing Manager discussed them with her staff, and the Engineering Manager gave his Product Engineering Manager an opportunity to comment on the first draft and to view the final draft. In addition, the Engineering strategy is discussed at departmental meetings.

There was no evidence of people using company or departmental goals to consciously focus or prioritise CI activities. However, one marketing objective is to integrate the marketing system with the company quality systems. To achieve this individuals will write down what they currently do and this will be examined by the department as a whole. If they find that the work can be carried out in a better way, the improved method will be recorded in the written procedure. So process improvements may be made while working to achieve this departmental objective.

People do not monitor implemented changes or assess the impact of such changes on company or local objectives, although it was claimed that the monitoring of changes to gauge their effect was "just starting to happen". In the absence of process measures the impact of any improvements or changes to the process is seen subjectively and indirectly, for example, "a particular engineer's projects always seem to happen more quickly than someone else's". Although the PD process is reviewed, the question of whether the company is better at NPD than it used to be is never addressed.
B. The ability to strategically manage the development of the CI system within the organisation's structures

B2 The CI system is continually monitored and developed

Proposition
Within NPD the incidence and results of CI activities are monitored. The CI system as it operates within NPD is reviewed and adjusted as necessary, and resources are provided to support its further development.

Evidence
This key behaviour was not covered in the interviews carried out for this thesis since the 'CI system' in TM Products is managed on a company-wide rather than a local basis. However, data relating to this aspect of CI was gathered during a CI mapping visit carried out shortly before. The company's CI is managed by a Support Group, which feeds into a Steering Committee (the latter equates with the Executive team and therefore includes both the Engineering Manager and the Marketing Manager). The Support Group demonstrates this key behaviour to an extent by, for example, informally reviewing elements of the CI system and by postponing a planned addition to the system because there was too much else going on. Despite this, there is no formal process for reviewing the CI system in its entirety and no strategy for evolving the CI. Measurement of the CI system and the incidence and results of CI activity is also weak. The number of ideas is logged but it is recognised that this is not a good measure because many ideas go unrecorded. Sufficient budgetary resources are made available for supporting the CI in terms of training, but shortage of personnel and time is slowing the ongoing development of the CI system.

B3 Ongoing assessment ensures that the organisation's structure and infrastructure and the CI system consistently support and reinforce each other

Proposition
Steps are taken to ensure that the NPD structures and infrastructure, and the CI system as operationalised within NPD, support and reinforce each other. However, if systems and structures within NPD are devised and implemented at a company level, NPD personnel may not have the authority to alter them.

Evidence
The most significant change to take place in recent years in the NPD structures and processes seems to be the introduction of project teams, three years before the interviews took place. It took about 18 months before the project teams worked effectively, but now this change in the NPD organisation can be seen to have supported development of the 'CI culture' in several ways:
• It has led to increased co-operation and cross-boundary working.
• It has led to devolution of responsibility for progressing product development projects. The project teams review progress and decide what will happen next, previously this would have been done by senior managers at the New Product Meeting.
• The multi-functional membership of project teams facilitates the spread of learning across departments.

The 'Cl system' as operationalised within NPD comprises general encouragement of people to come up with improvement ideas and implement them. The concept of 'Cl vehicles' has been introduced throughout the company to stress the importance of ideas of all sizes and to provide guidelines on how an idea can be taken forward. For example, a 'bike' is for an idea which only requires the involvement of one or two people; a suggestion needing a team input implies a procedure on the 'car' scale; and so on, up to 'buses' and down to 'skateboards'. Department managers log the number of suggestions raised on monthly activity sheets. Although general encouragement of Cl activity and the concept of Cl vehicles does not contradict anything in NPD, the logging of tiny ideas may not be an appropriate form of measure of Cl activity amongst the highly educated and professional personnel working in development. The interviews revealed that some staff here are embarrassed to record such small improvements.

C. The ability to generate sustained involvement in incremental innovation

B4 Managers at all levels display active commitment to, and leadership of, Cl

Proposition
Managers in NPD demonstrate commitment to Cl and leadership of it by spending time on Cl-related activities, by encouraging staff to engage in Cl, and by using measurement and targets in a manner consistent with Cl.

Evidence
Certain elements of this behaviour are apparent in some parts of the NPD organisation, notably the Marketing Department where the manager expects everyone to make improvements. It is clear from the interviews that this manager is very open to the ideas of subordinates and readily accepts their improvements, even when these involve changes to the way the manager has done things in the past. The manager's approach to work in hand on the marketing database also demonstrates a 'Cl style' of management. The market analyst and the administrator have started to work together on the database, at each other's pace. The manager is encouraging them to improve the system and to let her know what they do, but has decided not to get involved herself, even though that would get the job done more quickly, in order to give the analyst and administrator a greater sense
of 'ownership'. The same manager held the first post-project review, is overseeing the review and improvement of marketing processes, and is aware of the need to monitor the effects of changes.

There was no evidence of active leadership of CI in other parts of the immediate NPD organisation, though the Engineering Manager sets an example of cross-boundary co-operation and has collaborated on improving part of the process (see below under B6). One engineer pointed out that no time is allocated for dealing with CI-related improvements, and was of the opinion that staff were not consciously encouraged to improve. However, others acknowledge the support for CI and encouragement of ideas and change coming from senior management. In particular the Manufacturing Director, to whom the department managers in NPD report, is an enthusiastic champion of CI.

There were no examples of measurements and targets being used by local managers to drive or focus CI activities.

**B5 People participate proactively in incremental improvement**

*Proposition*

NPD staff at all levels engage in systematic improvement on a continual basis, ideally acting on their own initiative. Use of some form of logical problem solving / improvement opportunity finding cycle, together with appropriate tools and techniques, would help ensure that this is done in a systematic and rigorous way.

*Evidence*

The interviews suggest that people do come up with ideas but not nearly as much as they could, and these ideas are implemented randomly rather than as part of a systematic process of improvement. An attempt to be more systematic was about to start in Marketing with an evaluation of all the department's procedures, with a view to improving them before they are integrated with the company's quality systems.

*Responsibility*

Although the Marketing Manager believes that everyone is responsible for identifying ways to improve the PD process, she thinks that most people would say it is the responsibility of the Engineering Manager or the Marketing Manager or the Executive. According to the Engineering Manager, many of his engineers argue that their job is about improvement anyway, and that it is not repetitive and so not as suited to CI as the assembly process. The confusion between product and process improvement and the role of CI surfaced during the interviews. In the words of one engineer: "It's very difficult to distinguish what's part of your job and what's continuous improvement when you're an engineer and you're developing the product .... the main function of
the job is to improve products." However, this same person went on to agree that part of his function is to improve the NPD process "because it benefits me. If I improve the way we do things and we don't have so many problems it causes me a lot less stress."

Level of activity
The chart of CI ideas logged since May 1994 shows that up to and including October 1995 the Marketing and Engineering Departments had reported 17 and 13 ideas respectively. The Engineering Manager attributes the low figure for his area to the nature of the process in NPD and the attitudes of his staff towards CI i.e. as being something more relevant for assembly or the sales office than their own area. However, staff in both Engineering and Marketing claim that they have implemented improvements without recording them on the CI forms, so the chart of ideas logged must represent a minimum level of activity.

Although there has not been a systematic application of CI to the core NPD process and procedures, the NPD process flowchart does change from time to time as the result of improvements, and all interviewees were able to give examples of small improvements to the process that staff have made relating to their everyday work, some of which are presented in Figure 6.4. Nevertheless, the consensus was that such improvements are fairly rare and that people could come up with more ideas.

- A Design & Development Engineer revised the form for instructing staff in the internal Laboratory so that it gave more information (e.g. when the samples are due, when test results are required). Previously the two laboratory technicians would have problems if several projects suddenly required a lot of testing at the same time, a situation made worse because they did not know what the priorities were. By improving the information given by engineers to the laboratory the technicians would be able to schedule their work better.

- A Product Manager devised a form for the sales people to fill in during field trials which asked the questions marketing wanted answered. This replaced the old field trials register which they had had to use because it was in the company manuals but which did not generate the necessary information.

- The Engineering Manager reduced dead time in the process by sending a fax to a supplier requesting the tooling and saying an order would follow.

- The Engineering Manager and a Product Manager improved the accuracy of the forecasts they submit to the sales forecasting system by instituting a meeting five days before the deadline.

Figure 6.4 Examples of process improvements at TM Products

Some of the changes made are proactive, made as a result of reviewing what has happened or of asking if something can be done better, before there is a problem. An example of the latter is the current attempt to improve the field trial stage in order to reduce delays. Other changes are more
reactive or the result of 'fire-fighting'. As one engineer said, he does not go looking for problems but if he knows something is not working he will sort it out.

People do not appear to be following a documented problem-solving process, though some tools commonly associated with CI are occasionally used. These include brainstorming (at the concept stage or if someone is really stuck with a problem or if there is a recurring problem), flowcharts and graphs.

*Implementing improvements*

There do not appear to be major barriers to implementing ideas to improve the process. Staff are able to implement smaller changes without reference to anyone else, for example improvements relating to the new CAD system set up (short cuts, customising it, programming in standard settings used everyday). Larger changes are discussed with the department manager but before being implemented the rest of the project team would need to be convinced of its benefit. However, even if an improvement is implemented it may not always be acted out. For example, the improved laboratory form (see Figure 6.4) was not used properly in the months following its introduction. Instead of supplying the additional information on the form, designed to help the laboratory technicians plan and prioritise their work and thus avoid bottlenecks, engineers continued to give inadequate details, verbally. This did not have bad consequences immediately because the level of work had declined since the major problems which inspired the change; however, it would become more important to use the new procedure when the work load increased again.

*Enablers and disablers*

A summary of CI enablers and disablers found within the development organisation at TM Products is given in Table 6.6. In terms of formal enablers, Business Improvement Team (BIT) 20 stands out in several respects. Since the MRP II implementation, membership of BIT 20 has expanded to about 8 or 9 members and although it meets less frequently it remains a channel for people's ideas about improving the process. Specifically, the Marketing Manager was about to use BIT 20 to review the processes which had been in operation for the previous six months to see if they could be streamlined and improved before being documented in the ISO 9000 manuals. Another proposed task for the BIT was to examine and improve the way in which projects are appraised. The 'vehicle' framework described above is another potential enabler of CI. This emphasises the value of ideas of all sizes and shows people how they can take forward their suggestions. Less tangible enablers include the discretion given to engineers on how they interpret the process, for example whether to do an FMEA earlier or later in the process, and encouragement at the Marketing Department's monthly meetings to come up with ideas which could relate to NPD or to simpler, house-keeping matters. Outside the NPD organisation, but affecting the 'idea' stage of the process, the company has encouraged production staff to attend exhibitions where it is has been exhibiting and this has led to several ideas for new products.
The main barrier to CI, in both the Engineering and Marketing departments, appears to be lack of time. In Engineering there is also an attitude block as noted above, with many staff believing that CI is not relevant for them. It was also suggested, by an engineer, that involvement in CI might be higher if there was greater awareness of the overall process and the benefits to be gained from improving it and keeping it in control.

<table>
<thead>
<tr>
<th>CI Enablers</th>
<th>CI Disablers</th>
</tr>
</thead>
<tbody>
<tr>
<td>• BIT 20 – a Business Improvement Team focusing on NPD procedures</td>
<td>• Lack of time</td>
</tr>
<tr>
<td>• Framework of ‘CI vehicles’</td>
<td>• Attitude of some staff that process improvement is not relevant to their work</td>
</tr>
<tr>
<td>• Encouragement at department meetings</td>
<td>• ‘Empowerment’ in the form of engineers having discretion to adapt the process</td>
</tr>
</tbody>
</table>

Table 6.6 Enablers and disablers of participation in CI within the NPD process at TM Products

E. The ability to work effectively across internal divisions and external boundaries

B6 There is effective working by individuals and groups across internal divisions (vertical and lateral) and external boundaries, at all levels

Proposition

NPD staff have a shared, holistic view of the organisation. They naturally co-operate with others and they work effectively across internal boundaries and with external agencies.

Evidence

Cross-functional working has greatly improved with the use of Product Development teams, and the increasing involvement of purchasing, planning and production personnel, as described above. Although there is usually someone from each department on a PD team, time pressures mean that they cannot all attend every meeting; it is up to the team leader to involve the right mix of people depending on what issues will be discussed at the meeting. It took about 18 months for people to learn how to work effectively in the teams: at first people felt it was just a way of being communicated to, now they realise they have to get actively involved. They take a team approach to solving specific problems, with members agreeing what should be done and then each doing their bit to solve the problem. Those involved with product development meet fairly frequently. For example, the Product Manager might take part in from 2 to 6 meetings a week on PD issues, relating to different projects. The involvement of people across the company in the PD process has encouraged informal communication outside of meetings between people who have met on a project. On at least one occasion such contact led a production person, who had felt a bit intimidated in the project meetings, to suggest an idea to another member of the team. However,
although there is consensus that cross-boundary working has improved greatly in the last 18 months, there is recognition that it could be better still, for example by somehow involving areas like sales and operations who continue to feel left out.

Communication and co-operation between the Engineering and Marketing departments is particularly strong. The Engineering Manager regards the Marketing Manager as almost his closest working colleague – "in some respects closer than the engineers who work for me" – and both managers actively encourage their people to work closely with colleagues in other functions, and with contacts in other organisations. The collaboration between Marketing and Engineering is helped by the close physical location of the two departments in the same building so that, for example, most days the Product Manager can "pop down and informally pick up on what's going on".

An example of the close co-operation between Marketing and Engineering relates to an improvement in the forecasting process for the Talbot brand. In the past year there had been so many projects under development it was difficult to keep up with the progress of all of them and to provide accurate information for the sales forecasting system by the date it was required. The Engineering Manager and the Product Manager agreed to meet five days before the forecast had to be submitted, in order to update each other on what they were putting forward and to enable them to make more accurate forecasts. They discussed this idea informally and went ahead with it, intending to raise it at the next BIT 20 meeting so that the procedure could be formalised.

Communications with Sales are not so good. Marketing try to involve sales staff in NPD and keep them informed of new product developments (e.g. via quarterly sales meetings, and by the product manager's monthly report), but because the sales force is based in the field this can be difficult.

Suppliers are involved "quite early in the process". Occasionally they participate in development project meetings, though more typically the project team's deliberations are taken to the monthly Partnership meetings. There were also plans to involve suppliers in brainstorm discussions at the start of new projects. The company is very open with its customers and has involved them heavily in product development (e.g. in field trials).

The company works with other outside agencies and the following example shows how NPD staff improved their way of working with a regulatory body. TM Products requires approval from an industry research centre for all its products. The research centre can be very inefficient and the situation is not helped by the fact that after testing a product goes before a committee, which only meets once a month, for ratification. A particular product launched late in 1994 finally received approval six months after the launch date. A year later another product got the go-ahead four weeks in advance of launch. Two factors contributed to this improvement. First, the company
initiated the process earlier. Second, the engineers kept in much closer contact with the research centre throughout the testing phase. The Product Manager and Development Engineer built up a rapport with the research centre contact who consequently wrote to tell them that the product had passed the tests, even though the committee would not be meeting for a few weeks.

F. The ability to enable learning to take place, be captured and shared, at all levels

B7 People learn from their own and others' experiences, both positive and negative

Proposition
Individuals working within NPD learn from their work experiences, not just passively but also by seeking out learning opportunities (e.g. experiments), and they share their learning with others.

Evidence
There was no evidence of people seeking out learning opportunities. There was one example of an individual learning from a work experience and intending to apply that learning in future. This was provided by an engineer working on a project which was considerably behind schedule. In the three weeks preceding the interview he had started to work in a different way, much more organised and with everything planned, and had found that he was able to accomplish a great deal more, far quicker. He intended to apply this improved way of working to the next project he worked on.

There are several forums in which people are able to share their learning with others, including department and project meetings, and they are used. The last few years has seen competitiveness and jealousy in the Engineering department replaced by greater openness and cooperation, leading to a lot of informal discussion and bouncing around of ideas. It appears that some at least of those working in NPD do pass on improvements and learning when they think it will be of benefit to others.

B8 The learning of individuals and groups is captured and deployed

Proposition
The learning that takes place within NPD is captured, shared and applied. This transfer of learning occurs not only within a development project (i.e. between different actors, stages or activities) but also between projects (i.e. between projects running concurrently and between projects that take place at different points in time). The nature of the development process and setting pose particular challenges to the reuse of learning, but it is possible to design enablers that are effective in the NPD context.
Evidence

Individuals are willing to share their learning, as noted above, but it is hit and miss whether this happens. Mechanisms that have potential to capture learning are post project reviews; technology review meetings; the CI Activity Log; BIT 20; and ISO manuals.

At the time of the interviews, one post project review had taken place involving the first project managed by a PD team to reach launch. Team members were asked to consider, amongst other things, how the process could be done differently next time, and some changes were made as a result. However, post project reviews are not written into the NPD procedure, the first review took place because the project manager (who was the Marketing Manager) thought it would be a good thing to do. There have been two Technology Review meetings across the whole company but they were not effective. People are asked to record their CI ideas in writing but, as noted earlier, many people do not bother to do so, especially for very small changes. Proposals for larger changes to the process would be brought to the attention of BIT 20 and then captured by changing the documented procedures. The most formalised way of capturing learning is by incorporating the results of the learning (i.e. changes which have been shown to work) into updated procedures in the company's ISO manuals.

There are several ways in which learning is, or could be, shared. Intra-departmental learning is facilitated potentially by the departmental meetings, though there had not been any such meetings in Engineering during the six months prior to the interviews. Learning across departments takes place largely via the project team. However, it is notable that although the comments arising from the first review were documented they were not shared outside the team. Common membership between project teams results in informal cross-fertilisation of ideas and improvements between projects. One interviewee believed that project meetings were a good mechanism for sharing learning because most of the people heavily involved in PD would be present and so if someone came up with a good idea they would hear it immediately. Other ways used by the Marketing Manager to share learning and ideas across the company are raising the idea at a New Products meeting and, in the case of a major process change, giving a short presentation to everyone with a nominal interest in the change.

The most effective means for ensuring that the learning that is captured is deployed seems to be incorporation into updated procedures and manuals, which then become the operating standard. There has been a conscious effort to transfer to the other brands the benefits that have come out of the work put into designing the Talbot process, varying it where necessary to take account of the different products and markets. Another example of the application of learning relates to the first post project review. One of the issues which emerged from this was communication, and the operation of project teams changed partly as a result of this. Specifically, the Engineering Manager
now seeks to make project meetings more frequent and shorter, so that people see them as a more natural routine and less onerous part of their work.

G. The ability to articulate, demonstrate and communicate the CI values

B9 People are guided by a shared set of values underpinning CI as they go about their everyday work

Proposition
NPD personnel are guided by a shared set of cultural values underpinning CI as they go about their everyday work. Such values include recognition of the value of small-scale improvements; belief in the ability of everyone in the organisation to make a contribution; and treating mistakes and failure as valuable opportunities for learning and improvement.

Evidence
The company appears to support CI cultural values in theory, by encouraging everyone to make small-scale improvements and building improvement into the Quality Policy and Manual. All those interviewed expressed support for such values and provided examples of them in practice, but it is impossible to tell how widespread within NPD these beliefs are, and the true extent to which such beliefs are enacted (as opposed to espoused). One view was that "a Talbot characteristic, which covers engineering, is that people will whinge about something but not be prepared to do anything about it".

Summary
The propositions concerning management commitment and leadership of CI (B4) and effective cross-boundary working (B6) are reflected in the data for TM Products. The Marketing Manager in particular seems to behave in a way consistent with the proposition under B4, and the data show how the natural cooperation between engineering and marketing has led to process improvements. There are glimpses of one or two of the other propositions but they are a long way from being fully realised. For example, some staff within NPD have made improvements to the NPD process, but they do not do so systematically or on a continual basis (B5).

Alongside the examples of the CI behaviours, there is evidence of CI enablers (e.g. BIT20) or potential enablers (e.g. policy deployment). Taken together, the evidence of the behaviours and the enablers is indicative of a CI implementation still in its infancy. In terms of CI maturity, the company, including the part engaged in product development, is striving to attain Level 2 (formal CI). When certain individuals, such as the Marketing Manager, show more mature forms of CI behaviour these are the exception rather than the rule.
6.5.2 Ericsson

The second detailed study was carried out in the Cellular Systems and Special Networks Division (ETL/R) of Ericsson Ltd. The research focused on the TAS Sector and at the time four TAS projects (R5, R6, R6.1, and R7), all at different stages, were running. The seven interviews were conducted as the UK contribution to a project undertaken by EuroCI Net to investigate continuous improvement within the NPD process at Ericsson sites in seven European countries. However, for the EuroCI Net project the data were analysed against a different framework to that used in this thesis.

Here the findings are presented in four sections, the first three providing the context for the analysis in the fourth. The first section gives a little background to the TAS Sector and locates it in the wider organisation. Then there is a description of the development process and the TAS Sector's involvement in it. This is followed by a brief comment on some of the most significant changes to the process and the main drivers of improvement. The final section analyses the data gathered against the CI Capability Model.

Background

The Cellular Systems and Special Networks Division of ETL was set up in Guildford in the south of England in 1990. There are about 560 people in ETL/R26 of which approximately 150 people work in the Design function. There are two design sectors, one covers SSF, TACS and MTACS products, the other is solely concerned with TAS.

The TAS sector was the focus for the current research. Within the TAS sector there are a Design Department; Function Test & Product Support Department; BSC System Design group; Design Support group; and Project Management group. Around 53 people work in this sector.

TAS is one of the four main parts of a base station controller (BSC) which itself is a component of the GSM (Group System Mobile) system used in cellular telephone communications. The TAS sector is thus part of Ericsson's BSC organisation and the customer for the sector's products is Ericsson Radio in Linkoping, Sweden, who are the 'node owners' of BSC. Guildford has subsystem responsibility for TAS and is therefore responsible for documenting the subsystem and supporting the markets and Product Management areas with technical expertise.

26 In September 1996 ETL/R was reorganised into ETL/G and ETL/N, with the Design function located within ETL/G. The description in this thesis refers to the situation before the reorganisation.
NPD processes and organisation

An overview of the development process showing the key tollgates (TG) and milestones (MS) is given in Figure 6.5. There is approximately one new TAS product (project) a year. A complete project, from TG0 to TG5/GA, takes about two years. However, involvement of TAS Sector staff at Guildford usually starts between TG1 and TG2 and finishes at MS8, so on average a TAS sub project takes one year, or a bit longer, to complete. The areas of the TAS Sector directly involved are Design, Function Test, and Project Management. Design personnel are involved in the process from TG1 until the hand over to Function Test. In addition, a member of the Design Department may sometimes participate in the pre-study phase run from Stockholm. For Function Test, excluding early activity of the Test Leader during the feasibility study, a project lasts from TG2 to First Office Application (FOA). The Project Manager's involvement usually starts between TG1 and TG2 and finishes soon after MS8.

Figure 6.5 The development process at ETUR in theory. In practice, a far greater proportion of the development time is taken up by the prestudy and the feasibility study, and FOA takes place midway between MS8 and TG5.

As the node owner, Linkoping divides a BSC development project into sub projects which it allocates to different parts of the BSC organisation in the UK, Ireland, and Sweden. Guildford appoint a project manager to lead their sub project through Design and Function Test. All the sub projects within the main project are brought together by the overall project manager in Linkoping who oversees the industrialisation process and First Office Application. The new development is then made available to local companies who configure it for their customers and introduce it.

The TAS Sector uses a methodology common to all the design offices in Ericsson who work with BSC development. This is based on Ericsson's PROPS methodology, which has standard headings and corporate defined tollgates and milestones. In practice PROPS is a high level guideline that says what needs to be done, not how to do it; it can be interpreted and adapted locally. Guildford have their own local process descriptions, which provide more detail, and can tailor them so long as they fit in with the high level corporate processes (e.g. PROPS). The BSC organisation has its own milestone criteria set by Linkoping, the node owner. All the design
processes and checklists are on the Ericsson web site pages on the Internet, accessible from all the Ericsson sites.

At the beginning of a project the methodology to be followed is decided by line managers, project managers, the quality co-ordinator, and the methodology specialist, in agreement with the other countries they are working with. Although it will be very similar in each area, it is adapted to meet actual needs. The project manager states in the project's quality plan exactly which processes and methodologies should be followed. The processes will have been written by the line organisation and the line can update them. However, project members are not permitted to use revised versions until the project manager has authorised this, either by amending the quality plan or by completing an exemption request. Every phase (e.g. feasibility, high level design etc.) has a process description (flowchart) with standard input and output documents. Before starting a phase the project team considers the process and, if there is a good reason, they can use formal procedures to request changes to the process; these have to be cleared further up.

The success of a project is considered in terms of quality and how well time goals are met. The most visible measurement are trouble reports, which record faults found either during Function Test or when products are in service. For example, the target for R6.1 was to reduce the number of faults in operation (i.e. faults found by the customer) during the first six months to 0.14 per 1,000 lines of code (roughly one or two faults). There is no real measure of quality in Design but there are inspections of code. The design teams inspect all the documents, in batches, recording the number of major and minor faults per document.

**Improvement of the NPD process**

There have been a number of changes to the NPD process and way of working over the last few years. In particular, project management has been strengthened with the introduction of the role of project manager to take on activities which were previously carried out by line managers. Another significant change is the recent introduction of a more team-oriented approach to design, with teams rather than individuals having responsibility for tasks. Other improvements in the Design Department include better planning in terms of time and resource allocation; the introduction of the role of Team Technical Co-ordinator (TTC) in each group; more powerful computers which enable staff to multi-task; improved and more reliable software tools; and a better working environment. Function Test has adopted a new approach for test objects and has taken steps to improve the inspection process, for example by inspecting documents earlier to prevent mistakes being repeated. The R6 project saw co-location of designers and testers during the test specification phase, and a change in the nature of the target set to encourage Design and Test to work together, not in competition.
There are two main corporate drivers of improvement, ESSI (Ericsson Software Systems Improvement) and CMM (Capability Maturity Model). Through these, actions are deployed down to the department managers who in turn deploy them amongst their staff.

ESSI focuses on reducing the number of faults in the first 6 months of operation. It is more directed from the top than CMM, with ESSI Policy Deployment Performance Plans at Sector Manager level being deployed into lower level plans which tell people what they must do to improve. CMM allows more for local input, providing a framework within which areas (e.g. the Guildford Design function) decide for themselves what they need to improve and how to go about it. A number of teams have been set up to look at certain issues in connection with CMM.

Another corporate initiative, the Compass survey of employee attitudes, may drive improvement by revealing weaknesses. For example, a major change that has come from this was the adoption of teamworking.

**Analysis**

This section will present the research observations in terms of the core abilities and key behaviours in the CI Capability Model (see Table 2.3 in Chapter 2), with reference to the propositions put forward in Chapter 4 (Section 4.3).

**A. The ability to link CI activity at all levels to company strategy**

**B1 Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise improvement their activities**

*Proposition*

NPD staff direct their improvement activity towards company or departmental goals and objectives, and monitor the results of such activity and the impact it has. To do this they need to have a clear understanding of what the strategy, goals and objectives are.

*Evidence*

A range of objectives and targets, deriving from different sources, apply to the TAS Sector. The ESSI objective for ETUR Design is "to improve the quality of system software as experienced by the customer". The target is a 50% reduction of fault density measured in the first six months in operation. To achieve this, five 'Vital Few Actions' have been identified:

- Increase the effective use of inspections throughout the development process.

27 See Chapter 4, Section 4.3.2, for a description of the Capability Maturity Model.
• Improve function testing to prevent faults slipping through.
• Implementation of a learning culture.
• Eliminate stinkers,²⁸ by implementing stinker prevention process in codes of practice and by redesigning blocks identified.
• Introduction of fast track training.

Responsibility for each of these actions has been allocated to one or more managers, who have broken them down into further sets of Vital Few Actions which are again allocated to one or more responsible person (mostly at manager level). These are then deployed amongst department members.

Every department has annual objectives, some come from the sector manager, others are originated by the department manager. There is also a BSC goal in the BSC quality plan of improving lead time per project by 20% from TG2 to FOA. In addition, ETL/R Design has objectives in nine areas for 1996, but only some would be relevant for the TAS Sector, for example, improving customer satisfaction, cost control, and full deployment of the ESSI vital few actions.

Details of these objectives and associated targets are communicated to staff via the ETL/R Design Quarterly Bulletin (first issue was in Quarter 1 1996) and at Sector meetings.

There appears to be universal awareness of the ESSI target for faults in the first six months of operation and of other objectives related to lead time reduction. After an "atrocious record with milestones" on R6, designers have become much more aware of the need to meet project milestones and understand the impact of not meeting them. There was no evidence either way of whether people consciously assessed proposed changes against departmental objectives to ensure consistency, though with such a high awareness of the time and quality (faults) targets this may have happened subconsciously.

Changes made as a result of ESSI are monitored, and are reviewed at the fortnightly Quality Review Group meeting of line managers. However, the impact of changes made by teams as a result of resolving problems with the NPD process is not directly monitored, though it may be reflected in the number of faults found in blocks which is monitored at various stages of the process. The nature of the product and process can make it difficult to measure the impact of changes. For example, a Continuous Improvement Project (CIP) was set up in Function Test to try and reduce the amount of rework – 20% of the time spent writing the test instruction document was being used for updating. The impact of the different approach adopted for new test objects as a

²⁸ A 'stinker' is a particularly problematic piece of software (in general 80%–90% of faults come from 5% of the software). The 'stinker analysis process' involves evaluating pieces of software before they are created so that potential stinkers can be identified and action taken to reduce the risk of errors. Analysis at later stages in the design/test process checks whether the problems remain, or if the risk has been reduced or eliminated.
result of the CIP was considered by one interviewee as “nearly impossible to measure” – the nature of projects had changed – though the department manager intended to hold a wash up meeting for R6 which would examine the statistics in order to gauge the effectiveness of the change made.

In short, changes resulting from deployed objectives would clearly reflect department objectives. It also appears that many of the smaller changes which people handle themselves would impact on objectives, since these often have the effect of improving quality or reducing the time taken to do a particular task. However, it appears that the loop is not necessarily closed i.e. the impact of changes, particularly smaller ones implemented by individuals, is not necessarily monitored. In terms of the CI Capability Model, ESSI can be seen as an enabler which helps link improvement activity to corporate objectives.

B. The ability to strategically manage the development of the CI system within the organisation’s structures

B2 The CI system is continually monitored and developed

Proposition
Within NPD the incidence and results of CI activities are monitored. The CI system as it operates within NPD is reviewed and adjusted as necessary, and resources are provided to support its further development.

Evidence
Improvement activities triggered by formal drivers, i.e. ESSI and CMM, are monitored, but there does not currently seem to be any monitoring or recording of the smaller improvements initiated by individuals.

It is not clear whether the CI system is reviewed regularly. However, some review and adjustment have taken place. When ETL/R started working with TQM and CI, Continuous Improvement Projects (CIPs) were set up. Guildford level CIPs led to lower level CIPs, especially in technical areas, and in the TAS Sector a Function Test CIP was initiated in May 1994. In general, however, CIPs were not very successful. The projects were management inspired and people ended up working on things that were not really a problem and not gaining enough for themselves to become really engaged in the task. In an attempt to improve this situation, later improvement projects were run in line with the PROPS methodology, with a business case made for the project and measurements put in at the start. Subsequently, in a move to make CI more integrated, the emphasis is now on ESSI, CMM and developing a learning culture. Instead of constantly forming teams to deal with management selected problems, an attempt has been made to break down
ESSI and CMM to people on the ground who can find the best ways to achieve the desired improvements.

An example of the provision of resources to support development of the CI system came to light during the interviews. A student was about to be employed, on a one year industrial placement from a University, to look after the web pages. As part of his or her job, this person would be asked to create what in effect would be an enabler of CI: a tool which, when someone picks up skeletons (templates) for a particular document, allows them to send their comments on how they use it. The comments would be reviewed periodically and put on the web as a 'tip of the day' which people could view when they access the skeleton documents, thus helping to spread good practice and learning.

B3 Ongoing assessment ensures that the organisation's structures and infrastructure and the CI system consistently support and reinforce each other

Proposition
Steps are taken to ensure that the NPD structures and infrastructure, and the CI system as operationalised within NPD, support and reinforce each other. However, if systems and structures within NPD are devised and implemented at a company level, NPD personnel may not have the authority to alter them.

Evidence
There is evidence that elements of the 'CI system' within ET/R are considered in their wider context. For example, a recognition scheme was prepared for Guildford, and almost ready to be launched – thank you cards had been printed, a list of awards was agreed, and the booklets were at proof stage. However, at the last minute the scheme was dropped, partly because it did not fit entirely with the culture, and partly from a fear of being swamped with ideas and unable to meet people's expectations.

There have been changes to the work organisation in the TAS Sector that reinforce the development of a CI culture by encouraging co-operation, participation and improvement. These are the move to team working; increased involvement in planning; the introduction of the Team Technical Co-ordinator (TTC) role; and a change in how faults are measured.

The three design groups in the TAS Sector had recently started to work as teams, with collective responsibility for tasks. They have a Team Agreement which lists the outputs they are responsible for and the delivery date to Test. All the team members signed this and have a copy of it. The teams now have a weekly team meeting, and each time they go through one person's function and discuss it so that team members have greater awareness of what colleagues are doing. There is
more team spirit – for example, people cover for each other, and everyone looks at each other's work (before only a few experts would). Teamworking has improved communication and morale among designers. The Function Test Department has subscribed to some of the teamwork activities, but because of time pressure on the current project had not been able to participate as much as they had promised.

The design teams had been given the opportunity, for the first time, to participate in the planning of the current project. They reviewed the time plans drawn up by their supervisors and suggested changes, for example altering the order in which they did things; and if there are changes in a plan the team are involved in reviewing them. This approach gives team members an opportunity to draw on their experience and apply it, and results in a high level of buy-in and commitment. Again, this change in work organisation had not yet been implemented in Function Test.

The introduction of a Team Technical Co-ordinator (TTC) in each design group has removed bottlenecks by sharing technical tasks between the TTC and the supervisor – previously the supervisor would also be the technical person who ran all the inspections, all the updates, said yes or no to technical things. The TTC role also involves a lot of coaching and support for team members, including passing on experience and good practice.

Another recent change has been in the nature of the target set, in order to encourage Design and Test to work together, not in competition. For R4 and R5 targets were set for the number of faults found during testing. However, this caused friction between the function testers and designers: testers found faults but the designers would not accept them as faults (the pay scheme in Dublin was linked to faults). From R6 the targets have been to reduce the number of faults found after testing, with the result that Design and Test work together to produce a quality product.

C. The ability to generate sustained involvement in incremental innovation

B4 Managers at all levels display active commitment to, and leadership of, CI

Proposition
Managers in NPD demonstrate commitment to CI and leadership of it by spending time on CI-related activities, by encouraging staff to engage in CI, and by using measurement and targets in a manner consistent with CI.

Evidence
Managers clearly spend time on ESSI – drawing up the plans, deploying them, and actioning the Vital Few Actions. On two occasions they have used brainstorming and root cause analysis to see what they could do to improve.
There are two examples of the Design Manager using his resources (time and money) in a way that demonstrates commitment to CI. He hired a subcontractor to develop an idea for a tool proposed by someone who did not have time to do it himself. The Design Manager also acted on suggestions from people to improve the working environment by rearranging the furniture into a better layout, making it more open plan with spare desks and designated rooms for meetings.

Generally there is a lot of encouragement from managers and supervisors to make improvements. CIP and ESSI are talked about a lot. One department manager "actively encourages us to come up with ideas and improvements and to let him know." Another, however, admits that although he may have asked for ideas at department meetings he has not plugged it because "we're too busy to think about it". Several managers (both junior and senior), while encouraging CI, are concerned not to impose more demands on people or to pressure them into having ideas. One supervisor supports a team member's idea by establishing if it is worth pursuing and, if it is, taking it to the weekly department meeting or to the department manager. However, he deliberately tries to avoid getting too involved with a person's idea, letting the proposer deal with it, as they are better at describing their own idea and should take the credit for it. On a less positive note, a project manager was described as being not very receptive to ideas, "he doesn't care as long as work is done on time".

There are examples of managers showing awareness of the role of measurement and target setting in CI. One manager started doing his own measurement because the statistics on the IBM computer were in such a mess. His measurements include faults found in different phases of the project, progress made, number of hours expended, and number of tests written, and he uses this as input to discussions on how to improve. A supervisor sees one of his missions as promoting a better understanding of what projects are about and the importance of milestones among designers. He explained the impact of not meeting milestones, he prepared statistics to show them how good they really were, and he told them that this is the type of data that goes onto the database used by corporate Ericsson to measure them.

However, an opportunity to use data gathered during the inspections of code to spur systematic CI is not being taken. The design teams inspect all the documents, in batches, recording the number of major and minor faults per document. This metric is passed on but does not appear to be acted on in any systematic fashion – if there were a lot of major faults the team would investigate but there is no process or guideline to follow, no systematic acting on the data.
There has not been much in the way of specific CI training for managers. Two or three years ago when CIP (Continuous Improvement Projects) was introduced the managers and a few staff had training in it. However, one interviewee reported having received a lot of management training which always includes discussion of topics such as participation. The continual development scheme, which all project managers and supervisors go on, covers motivation in the sense of getting people to do what you want them to do, but does not deal with how to get people to come up with improvement ideas.

B5 People participate proactively in incremental improvement

Proposition
NPD staff at all levels engage in systematic improvement on a continual basis, ideally acting on their own initiative. Use of some form of logical problem solving / improvement opportunity finding cycle, together with appropriate tools and techniques, would help ensure that this is done in a systematic and rigorous way.

Evidence
The impression given by the interviewees is that people do make improvements to their way of working and do come up with suggestions for improving the process, but that team members could bring forward many more ideas. It is hard to gauge the level of CI activity since people may not tell anyone else about the improvements they have made. An estimate was that about half the members of the Function Test and Product Support Department would have put forward ideas on how processes or tools could be changed to improve testing and maintenance. Another estimate was that a design group of seven people might have one idea a month that can be used. Certain individuals are particularly prolific with ideas while others may not contribute any. Several interviewees commented that, in general, if there is a problem people have the view "there must be a better way of doing this", and there is now more awareness of the importance of sorting out problems earlier in the process.

Interviewees described a number of improvements made by team members, including some excellent examples of simple ideas which epitomise the nature of CI (see Figure 6.6).

- A tool to check that a document does not exceed the correct length.
- Stamp 'new' or 'modified' on test specification to indicate whether or not it needs to be read.
- Put hard copies of project documents on the web in a 'virtual binder' so that everyone has access.
- A tester wrote shell script which automatically checks a document to make sure all the references are correct.
- Programs which automatically generate tables and structures into Plex code.
- A tool to co-ordinate signals and interface information.

Figure 6.6 Examples of ideas implemented by staff at ETL/R
People just get on and implement simple, small changes, but changes which impact on the wider BSC organisation may take a very long time to implement. Often, though, ideas are not applied immediately “because of project pressure” but are documented for use in the next project. Proactive ideas may be worked on in the lull between projects. Suggestions for improving software tools can be harder to implement because the tool is owned jointly with other companies (e.g. Hewlett Packard, other Ericsson companies). Aside from time pressures, it may not always be appropriate to implement a process change immediately, for example, if the project team is in the middle of some work which would be affected by the change. If the Project Manager had an idea for improving project management he would write an intermediate report, because by the time the final report is completed the next project would have started and it would be too late to incorporate the change.

Changes made to the NPD process are sometimes proactive and sometimes reactive. Changes driven from above are reactive. For example, teamwork came out of the Compass survey; improvement to document inspections, making sure people are trained, and stinker analysis came out of ESSI; peer group meetings of project managers, supervisors, and testers came out of CMM and appear in the ESSI plan as one of the ‘Vital Few Actions’. Ideas from people are proactive, for example, use made of the Internet by the maintenance group, and the Shlaer Mellor methodology being worked on by the BSC Systems Design group.

In the past designers did not consciously engage in resolving problems with the NPD process, or seek to systematically improve it. If they did fix things they did so individually, for one’s own sake without telling anybody. Now they are starting to address these problems and, with the introduction of teamwork, the approach has become more collective. Such activity is instigated by the TTC or Group Supervisor.

There are development tools (e.g. FTP in design, emulator) and project management tools (e.g. DocStat) but the only ‘CI tools’ mentioned by interviewees were brainstorming, root cause analysis and checklists. A cyclic process is followed for problem solving and looking at faults, and for inspection.

**Enablers and disablers**

Although everyone is encouraged and able to identify ways to improve the NPD process, there is no universal, formal requirement to do so. The Design Manager is responsible for making sure things are improved in his department, but wants to promote the idea that everyone is able to make improvements. The Project Manager is expected to come up with improvements to project management, and the project team is responsible for including in the final report any improvements they have made, comments or suggestions. The Team Technical Co-ordinator’s role includes coming up with improvement ideas.
Ideas result from discussions, irritation, and interest. Team members are motivated to seek to improve the NPD process because such improvements make it easier to work and develop products in future projects; give more time to test the product; and make the work less labour intensive, with fewer manual tasks where errors might be introduced. Table 6.7 lists a variety of enablers which stimulate improvement activity amongst TAS Sector personnel, and some of the barriers or disablers that impede it.

<table>
<thead>
<tr>
<th>CI Enablers</th>
<th>CI Disablers</th>
</tr>
</thead>
<tbody>
<tr>
<td>• ESSI</td>
<td>• Lack of time.</td>
</tr>
<tr>
<td>• CMM</td>
<td>• No opportunity to stand back and look at what you're doing (but now project managers have to).</td>
</tr>
<tr>
<td>• Encouragement by managers and supervisors.</td>
<td>• Some managers too busy to push CI.</td>
</tr>
<tr>
<td>• Team working practices</td>
<td>• Bureaucracy. It may take a long time for an idea to be implemented.</td>
</tr>
<tr>
<td>• Regular meetings of different peer groups (project managers, supervisors, testers) to discuss problems and improvements.</td>
<td>• The need to match what is going on in the BSC organisation.</td>
</tr>
<tr>
<td>• Methods meetings to examine and improve work methods and processes.</td>
<td>• The need to convince others of the value of the idea (especially if it involves Sweden).</td>
</tr>
<tr>
<td>• Product Line Maintenance meeting to analyse faults found in the market.</td>
<td>• Cost (if an improvement would cost a lot to implement).</td>
</tr>
<tr>
<td>• Tools group solves problems and suggests improvements relating to tools.</td>
<td>• Too many new initiatives – this has been recognised and there is now less emphasis on CIP teams.</td>
</tr>
<tr>
<td>• Requirement that project managers present improvement proposals to Quality Reference Group.</td>
<td>• People being &quot;volunteered&quot; to participate in an improvement of no benefit to themselves – this happens less now.</td>
</tr>
<tr>
<td>• Requirement that all documents (standards, processes etc.) are reviewed annually.</td>
<td></td>
</tr>
<tr>
<td>• Web page on which people can post ideas about methods.</td>
<td></td>
</tr>
<tr>
<td>• Web page run by technical specialist in BSC Systems Design on which people can put ideas and improvements.</td>
<td></td>
</tr>
<tr>
<td>• Dedicated Methods person and Tools person to improve methods and tools and act as conduit for ideas of other employees.</td>
<td></td>
</tr>
<tr>
<td>• Two-day off-site session to discuss teamwork generated many ideas.</td>
<td></td>
</tr>
<tr>
<td>• Continuous Improvement Projects (not used much now)</td>
<td></td>
</tr>
<tr>
<td>• Staff picking up a skeleton document on the web are invited to send comments on how they use it; the best tips will be shared (to be implemented).</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.7 Enablers and disablers of participation in CI found in ETL/R
One enabler used elsewhere in ETU/R Design but not in the TAS Sector relates to the performance appraisal scheme. This includes a follow-up of objectives after three months, which staff are asked to prepare for by completing a form. In some areas this form includes an item on "changes I have made to my job without telling anybody", the purpose of which is to encourage people to recognise small improvements.

Lack of time was the most frequently cited obstacle to CI. Several other 'disablers' are a consequence being part of a wider organisation, for example, the need to match what is going on in the BSC organisation (e.g. Guildford cannot unilaterally do away with a phase in the process, though it has almost done so). One view was that too many people have to be involved in changes, there are too many procedures, too much form filling, too much politics, the Swedish company is slow to act, and some long-standing staff members are too set in old ways. As a result it may take a very long time for an idea to be implemented, and when it is it may not be recognisable.

E. The ability to work effectively across internal divisions and external boundaries

B6 There is effective working by individuals and groups across internal divisions (vertical and lateral) and external boundaries, at all levels

Proposition
NPD staff have a shared, holistic view of the organisation. They naturally co-operate with others and they work effectively across internal boundaries and with external agencies.

Evidence
The project managers and line managers work together quite closely, and there is no conflict between them. Communication and co-operation within work groups or teams, between groups, and between the Design and Test Departments is generally considered to be good or excellent. For example, design teams help each other if one falls behind schedule. In earlier years Design and Test were located on different sides of another building, now they are separated only by a partition. Physical closeness increased during the test specification phase of R6, with the person testing a function moving to sit with the people designing that function. The R6 project also saw a change in the nature of the target set, from faults found during testing to faults found in service, which has encouraged Design and Test to work together rather than in competition.

All the sub project managers, from different locations, work together in the main Project Team and meet in Sweden. However, in general communication between Ericsson sites is not as good as it is internally. Although designers try to inform colleagues in other companies about changes "we probably don't communicate as much as we should". The Team Technical Coordinators meetings,
which started with R6, now provide a forum for exchanging information between sites, via the TAS sector's technical specialist who deals with much of the high level technical issues between sites. When communication does take place with other Ericsson organisations, their co-operation is good; the example was given of a manager asking his counterparts in other locations what they are doing for ESSI.

Table 6.8 lists some of the enablers that facilitate cross-boundary working.

<table>
<thead>
<tr>
<th>Internal to Guildford</th>
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</thead>
<tbody>
<tr>
<td>Meetings of work groups and of peer groups (supervisors, project managers, testers).</td>
</tr>
<tr>
<td>Regular reviews and inspections of documents.</td>
</tr>
<tr>
<td>Methodology Meeting attended by a representative from each team.</td>
</tr>
<tr>
<td>E-mail and web pages on the Internet.</td>
</tr>
<tr>
<td>Ability to involve people from other teams, groups and departments in meetings.</td>
</tr>
<tr>
<td>Co-location of testers and designers during certain phases of the project.</td>
</tr>
<tr>
<td>Targets that encourage co-operation between departments.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External to Guildford</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Technical Co-ordinators' meeting with technical specialist who acts as a conduit for exchanging information between sites.</td>
</tr>
<tr>
<td>TAS Product Committee meeting, held every fortnight, attended by up to a dozen people, including some from Sweden.</td>
</tr>
</tbody>
</table>

Table 6.8 Enablers of effective communication and cross-boundary working at ETL/R

F. The ability to enable learning to take place, be captured and shared, at all levels

B7 People learn from their own and others' experiences, both positive and negative

Proposition
Individuals working within NPD learn from their work experiences, not just passively but also by seeking out learning opportunities (e.g. experiments), and they share their learning with others.

Evidence
The various changes made to the running and operation of projects since R4 show that learning taking place at the project level is acted on to a greater or lesser degree. There is evidence of
collective learning from the experience of R6, a project which was very tight in terms of time and quite difficult to handle. As a result of that bad experience, the designers recognised the importance of not cutting corners and subsequently worked in a much more organised manner. Members of the design teams drew on their experience and applied it during their involvement in the planning for R6.1, for example by suggesting alterations to the sequence in which tasks would be carried out.

Individuals appear to share their learning and the improvements they make with immediate work colleagues fairly often, though not always. They tell colleagues verbally and by e-mail, raise the issue at meetings, prepare reports for their supervisor or manager, and put their ideas and improvements on the server (web). People are able to share their experience by raising local documents and putting them on the Delta system, which is accessible to everyone at Guilford. For example, the emulator tool is not easy to use and designers share their experience on how to build it, in local Help documents. Even so, there is still a lot of learning going on that is not shared. In particular, although there is quite a lot of sharing of ideas within Design and within Test, relatively little takes place across the two departments.

B8 The learning of individuals and groups is captured and deployed

Proposition
The learning that takes place within NPD is captured, shared and applied. This transfer of learning occurs not only within a development project (i.e. between different actors, stages or activities) but also between projects (i.e. between projects running concurrently and between projects that take place at different points in time). The nature of the development process and setting pose particular challenges to the reuse of learning, but it is possible to design enablers that are effective in the NPD context.

Evidence
Interviewees claimed that there is no formal way of spreading knowledge, that learning is spread "through the jungle drums". Despite this prevailing view there seems to be a wide range of enablers through which experience and learning are, or could be, captured and shared (see Table 6.9). Some of these are quite formal (in the sense that there is a requirement that they happen, or they require some organising); others are very informal (e.g. e-mail, web pages) and it is up to the individuals concerned whether to use them or not.

Some of these enablers are very recent introductions. Notably, the 1996 ESSI plan includes the establishment of enablers with the potential to encourage the capturing and sharing of learning. They derive from one of the objectives for ETL/R Design at Sector Manager level which was 'Implementation of learning culture'. The performance indicator used to monitor progress towards
this was "% improvement proposals implemented", and the target was to achieve 30% by 96Q4, compared with 10% in 95Q4. The objective was broken down into four lower level actions. The first was a formal requirement for all project managers to present improvement proposals to the Quality Reference Group (QRG) and for the QRG to follow up implementation. The remaining three actions were for separate meetings of Testers, Project Managers, and Supervisors to take place at least once every two months to share experiences.

- Regular get togethers, about every 6 weeks, of Project Managers, of supervisors, and of testers to share experiences. The information would get back to team members, but there is no formal feedback process. The meetings are minuted and points arising go to the Quality Reference Group (QRG) and might then be institutionalised.

- Project managers are required to give a verbal end-of-phase report to the QRG describing what has happened in the previous phase, the problems and improvements. Bringing this to the QRG ensures that changes made in one department are made available to the rest of the organisation.

- Seminars and presentations to, say, a different team or a different department. For example, designers who have worked on a functionality give a presentation to the maintenance staff about the changes.

- Wash-up meeting after the end of a project to feedback learning about the causes of faults.

- Team Technical Co-ordinators' meeting at which TTCs share information which will get passed to others.

- Verification Group meeting. This is a meeting within a project of the Test Leader from each site plus the overall Test Co-ordinator at which they discuss testing and share testing ideas.

- Corporate Ericsson are compiling a list of best practices to share between organisations.

- Project final reports should include improvements made, comments and suggestions. However, there is no formal mechanism whereby these would be incorporated into the next project and there does not appear to be any written requirement on project managers to look back at previous project reports.

Table 6.9 Formal mechanisms for sharing learning and improvements at ETL/R

Transferring learning from one project to the next is not formalised (although some of the formal mechanisms recently introduced may help to close this gap). For example, the ideas about project management which emerged from R6 were not readily accessible, so the project manager for R6.1 could not look at them.

Sharing learning between Ericsson companies is particularly poor. Most of the interviewees felt that there was no real co-ordination between companies and that they "rarely share with others outside Guildford". There used to be a MethNet meeting for the BSC companies but it was stopped because it was getting bogged down in detail. However, the project manager interviewed claimed that they had "every possibility" to share a good improvement idea with other Ericsson companies.
either via the project manager or direct. Perhaps the channels for sharing externally exist but are just not used.

G. The ability to articulate, demonstrate and communicate the CI values

B9 People are guided by a shared set of cultural values underpinning CI as they go about their everyday work

*Proposition*
NPD personnel are guided by a shared set of cultural values underpinning CI as they go about their everyday work. Such values include recognition of the value of small-scale improvements; belief in the ability of everyone in the organisation to make a contribution; and treating mistakes and failure as valuable opportunities for learning and improvement.

*Evidence*
Interviewees perceive ETUR Design as having more of an “Ericsson culture” and a more “Scandinavian management style”, than what might be regarded as typically English: it is people-oriented, open, young, and quite informal. There are some indications that the ‘management style’ reflects commitment to CI values. Most of the managers encourage new ideas and are receptive to change. The atmosphere is one of ‘we’re here to help’ and there is clearly an assumption that everyone is capable of making a contribution and that small improvements are worthwhile.

TAS Sector personnel are very aware of continuous improvement, and there is now greater understanding of the importance of working better and fixing problems earlier in the process. Managers, supervisors and staff are receptive to change and new forms of working. One supervisor is of the opinion that although some people express “mock cynicism” about CI they are getting on and doing it: "... generally at the end of the day, everyone believes in doing a good job and wants to do a better job". Some people demonstrate their belief in the value of small steps and that everyone can contribute, by themselves making incremental improvements. However, others commented that although everyone is aware of CI and suggestions for improvement are encouraged, people may not have time to think about it and develop their ideas.

A measure of the extent to which CI values are embedded in the culture is how people act under pressure or when things go wrong i.e. do they stick to CI principles or revert to more ‘traditional’ ways of behaving in a crisis (fire-fighting, passing the buck, etc.). It is difficult to ascertain this from interviews. However, it was noted that when Guildford staff came under intense pressure during the Text Execution phase of R6, relations between Design and Test deteriorated and morale hit rock bottom.
Summary

The Ericsson data contain examples of people acting in a way which lends support to all of the propositions, at least in part. For example, there are some good illustrations of ensuring congruity between NPD structures and the CI system (B3), and management commitment to and leadership of CI (B4). However, the proposition concerned with cross-boundary working (B6) is only partially supported. Although there have been improvements in working across internal divisions (e.g. the increased co-operation between staff in Design and Test), working with other Ericsson companies is impeded by poor communication. At the time of the interviews, the capture, sharing and application of learning (B8) was not as advanced as might be expected considering the number of enablers in place to facilitate it (admittedly some of these enablers had only recently been introduced). The Ericsson case yields many examples of CI enablers as well as CI behaviours, supporting the use of the behavioural framework to describe and explain the situation. The analysis against this framework indicates that in terms of CI maturity Ericsson is spanning Levels 2 (formal CI) and 3 (goal-directed CI).

6.5.3 Implications for the research

The company cases generated an enormous amount of data, particularly in terms of the research content. However, the experience of using the research instrument also led to conclusions about its use in future research.

Implications for research process

The detailed interviews were the last research activity to be carried out for this thesis, and so did not impact on any of the other methods used. However, one of the objectives was to evaluate the research instrument, INCIDE, as a tool for investigating CI within NPD, and the conclusions drawn in this respect may influence future research. A detailed evaluation of the tool is provided in Chapter 7. Key points that emerge from the case work include:

- the tool is valid and reliable;
- using the tool is time consuming but it does generate a large amount of relevant data;
- although the tool is easy to use it can sometimes be hard to interpret the data it generates in terms of the key CI behaviours;
- in its present form the tool generates data which allows the researcher to describe CI within the NPD environment and to discriminate in general terms between different levels of CI maturity, but not to produce an accurate assessment of progress made (e.g. how deep or how widespread a particular CI behaviour may be);
before beginning work in a company consideration should be given as to what the most appropriate unit of analysis will be (e.g. the development project or the department) and use of the tool tailored accordingly.

Implications for research content
The discussion in Chapter 7 draws heavily on the evidence provided by these cases. An important implication for the research content is that the interviewees appeared to accept the appropriateness of trying to apply the concept of CI to the NPD process. In terms of the CI Capability Model, the data supports the concepts of CI behaviours and CI enablers, providing examples of how these may appear in practice. The cases also support the generic/contingent distinction made by the Model: we see similar behaviours (e.g. management leadership of CI) developing in two very different organisations which have adopted different approaches to CI implementation, involving different types and forms of enabler. The data also reinforce the evolutionary nature of the development of the key CI behaviours, with individuals in each company exhibiting varying levels of 'CI maturity'.

The interview data have implications for the practice of CI within the NPD context, which in turn may influence the direction of future research. For example, they confirm some of the blocks to CI identified by the workshop delegates, and the need to design enablers appropriate for the NPD context which take account of the personnel involved and process characteristics. Indeed, the cases raise some important question about enablers. For example, is there a link between the higher level of CI maturity in Ericsson compared to TM Products, and the much larger number of enablers that were identified in the former company? Or can progress within Ericsson be attributed to a few particularly powerful enablers (e.g. ESSI)? The power of any enabler will depend on the company setting in which it is used, and the setting will vary according to the prevailing level of CI maturity as well as to the wider context (industrial setting etc.). These questions fall beyond the remit of the present study but are incorporated into the research programme outlined in Chapter 9.

6.6 Conclusion

The activities carried out for this research generated a mass of data and information relevant to the research questions. This chapter has taken each activity in turn – preliminary interviews, workshops, survey, company cases – and presented the observations and conclusions that can be drawn from it. The individual methods have all contributed to the research process and research content to a greater or lesser extent. A strength of the multi-methods approach is that by looking at the same issue from different directions some of the weaknesses inherent in any research method can be mitigated, allowing construction of a more complete and robust picture of the issue under investigation. This is what will be done in the next chapter, which will synthesise the findings presented here and interpret them in terms of the main research questions and related themes.
Chapter 7  The Application of CI to the Process of NPD

7.1 Introduction

The aim of this thesis is to explore the scope for the application of CI to the NPD process. Chapters 2 and 3 explained in detail a behavioural model for CI and reviewed the state-of-the-art in the field of NPD. Chapter 4 described how that CI model might look in theory if applied to the area of NPD; speculation was reinforced with examples from the literature. Chapters 5 and 6 reported the original research carried out to investigate the research question; a multi-methods approach was followed including workshops, a postal survey, and detailed interviews in two companies. This chapter will draw on all these sources to discuss the application of CI to the NPD process.

In order to explore the issues involved in the application of CI to the NPD process we will consider the five interconnected questions introduced in Chapter 1, together with a sixth question relating to the research tool, INCIDE:

- Q1  Is CI an appropriate concept for NPD?
- Q2  Is it practicable to apply CI to the process of NPD?
- Q3  How wide is the scope for CI within the NPD context?
- Q4  Are there any factors peculiar to NPD which facilitate or impede the implementation of CI?
- Q5  To what extent might it be possible to institutionalise the practice of CI to the NPD process?
- Q6  How appropriate is INCIDE for investigating the application of CI in NPD?

The starting point is whether CI is an appropriate concept for NPD. In other words, are there theoretical grounds for establishing that CI is relevant and applicable to NPD? It will be argued that this is indeed the case. Given this the next question has to be, is it practicable to apply CI to the process of NPD? Managers need to know not only if it is possible to implement CI within NPD but also whether this is viable i.e. whether the benefits arising from applying CI to NPD justify the effort involved in its implementation. The third question leads on from this, going in to greater depth by asking how wide the scope is for CI in NPD. In particular, how might variations in the NPD context (in terms of, for example, type of organisation, industry, process or product) affect the applicability and practicability of implementing CI in NPD? Moreover, are there any bounds beyond which it is not feasible to extend the concept into practice, or any constraints which companies may come up against? The issues of context and limitations are further explored in the discussion generated by the fourth question. This examines characteristics inherent in the NPD process which may
facilitate or hinder the implementation of CI in this part of the organisation. The next question asks if it might be possible to institutionalise the practice of CI within NPD so that the company continues to benefit in the long term. Finally, the method used to gather the case data for the thesis, the INCIDE tool, is examined – to what extent has it helped to explicate what was observed in the case companies? This is assessed in terms of how effective, efficient, usable, and useful the tool proved to be.

These questions reflect the balance in this thesis between theory and speculation on the one hand, and practical experience on the other (Figure 7.1). The first question is solely concerned with theory while the second is bedded in company experience. Questions 3, 4 and 5 span both domains, drawing on theory to generate substance and ideas for what is a relatively new application and field of research, and on practice to disprove, reinforce or build on the emerging constructs. INCIDE, examined by the final question, encompasses the two domains and represents their integration. The tool was derived from both theory and practice and is used to develop theory by reference to practice.

![Figure 7.1 The role of theory and practice in the questions addressed to explore the scope for the application of CI to the NPD process](image)

The following sections will consider each question in turn, drawing on the sources reported in earlier chapters to discuss the issues and reach conclusions. The key insights from each source are given in Table 7.1.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Method</th>
<th>Appropriateness</th>
<th>Practicability</th>
<th>Scope</th>
<th>Implementation</th>
<th>Institutionnalisation</th>
<th>INCIDE tool</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Literature</td>
<td>• e.g.s of possible CI enablers and behaviours</td>
<td>• reports of companies taking systematic, participative approach to improvement</td>
<td>• large potential for CI at interfaces within NPD</td>
<td>• factors aiding and hindering TQM implementation in R&amp;D</td>
<td>• many features of good practice NPD encourage CI behaviours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preliminary interviews</td>
<td>• similarity between good practice NPD and good practice CI</td>
<td>• TQM considered a success by firms implementing it in R&amp;D</td>
<td>• presence of barriers to interproject learning stemming from nature of NPD environment</td>
<td>• TQM more likely to succeed in R&amp;D if a bespoke system is used</td>
<td>• e.g.s of enablers to trigger a CI response e.g. post project analysis</td>
<td>e.g. of NPD process with built in procedures to trigger CI</td>
</tr>
<tr>
<td></td>
<td>Workshops</td>
<td>• potential for CI in NPD</td>
<td>• potential for CI with customers &amp; suppliers</td>
<td>• need to put bounds on creativity / experimentation</td>
<td>• challenges posed by intangible nature of process, long time-scales, measurement</td>
<td>• aids and barriers to CI in NPD relate to NPD practices and to people</td>
<td>• e.g.s of enablers to institutionalise CI</td>
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Table 7.1 Key insights from each source on the issues covered in the discussion (continued on next page)
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<thead>
<tr>
<th>Issue Method</th>
<th>Appropriateness</th>
<th>Practicability</th>
<th>Scope</th>
<th>Implementation</th>
<th>Institutionalisation</th>
<th>INCIDE tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey</td>
<td>• 35% of the firms apply CI to NPD process 'frequently'</td>
<td>• firms where CI has large impact on NPD more likely to make standardised products than modular or unique products</td>
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<td></td>
<td></td>
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<tr>
<td>Cases</td>
<td>• interviewees accept concept of CI in NPD</td>
<td>• different approaches to application</td>
<td>• CI is applicable regardless of firm size, industry, product, etc.</td>
<td>• problems for CI in NPD include: lack of time, identifying appropriate measures, need to conform to company procedures</td>
<td>• e.g.s of enablers to institutionalise CI in NPD</td>
<td>• tool is valid and reliable</td>
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<tr>
<td></td>
<td>• importance of management leadership of CI</td>
<td>• CI is relevant for all levels of staff, for individuals and groups</td>
<td></td>
<td></td>
<td></td>
<td>• contingency approach to using tool and unit of analysis may be appropriate</td>
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<td></td>
<td>• e.g.s of CI behaviours and enablers</td>
<td>• CI applies on four dimensions: product, process, intraproject, interproject</td>
<td></td>
<td></td>
<td></td>
<td>• time consuming but generates relevant data</td>
</tr>
<tr>
<td></td>
<td>• potential for CI at interfaces in NPD</td>
<td>• process constraint: time lag in implementing improvements</td>
<td></td>
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<td></td>
<td>• usable but can be hard to interpret some data in terms of behaviour</td>
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<td>• process descriptive constraint: rather than evaluative</td>
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<td>• tool descriptive rather than evaluative</td>
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<td></td>
<td>• possibly convert to self-assessment tool for NPD managers</td>
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Table 7.1 continued Key insights from each source on the issues covered in the discussion
For clarification, it should be noted that here we are concerned with ongoing improvement to the processes within NPD, and to any other aspect of work in that part of the organisation, but not directly with improvement to the products being developed. Also, the thesis is deliberately broad in that it is not aimed at a specific scale of development (e.g. incremental, or platform, or breakthrough) nor is it confined to a particular stage of the development process.

7.2 Is CI an appropriate concept for NPD?

In this thesis NPD refers to the process by which new products are developed in companies, from the generation of an idea until the product is launched onto the market. This process encompasses many activities and decisions, which typically move from initial screening and preliminary market and technical assessments, through detailed market research and business analysis to design; the later part of the process usually then involves some form of product testing, market testing, trial production and production start-up leading up to the market launch. Within this general description of the NPD process there are different contexts, in particular related to the scale of the development project. Projects may range from derivatives (e.g. product enhancements or cost-reduced versions of existing products), through next-generation platforms which provide the base for a new product family, to breakthrough projects which establish a new core product (Wheelwright and Clark, 1992).

CI is defined as an organisation-wide process of focused and sustained incremental innovation. The CI Capability Model describes CI in terms of a set of key behaviours which can be encouraged and reinforced by a wide range of enablers. This thesis has taken this pre-existing model for CI, which hitherto has been directed largely at manufacturing operations, and imposed it on a different context: NPD.

The question 'Is CI an appropriate concept for NPD?' is asking whether there are theoretical grounds for establishing that CI (here represented in the form of the CI Capability Model) is relevant and applicable to NPD. The answer to the question is: yes, in theory there is scope for CI in NPD.

The research carried out for this thesis suggests that many industrialists accept that in theory CI is applicable to the NPD process. Managers within NPD are being required to streamline, manage and improve the performance of their processes. In the manufacturing area CI has helped managers meet similar needs and realise commercial and other benefits. Increasingly their colleagues in NPD are recognising that the same concepts may help them meet the challenges they face. Workshop participants and interviewees in the two case companies had no difficulty with the concept (and desirability) of applying CI to NPD processes. What they did have a problem with was how to make it happen in reality. The survey is not a source for establishing the
appropriateness of the Cl concept to NPD, as it was concerned with what was actually happening in companies i.e. with practice.

Individuals arguing against the suitability of Cl in NPD often invoke the nature of the process itself, saying that it is not repetitive, and is not suited to the measurement and problem solving techniques found in shop floor applications of Cl. This is precisely the point made by some of the engineers at TM Products to their manager (see Chapter 6, Section 6.5.1). Certainly such characteristics might make it more difficult to implement Cl. They are among the factors identified by May and Pearson as hindering implementation of TQM in R&D (see Table 4.1). They were also identified as possible barriers to Cl in NPD by managers at the workshops (see Table 6.2).

However, it can be argued that NPD is indeed a repetitive process: although the product under development may be different each time, the basic activities required to develop it are usually the same. We would expect product developments representing projects of different scale (derivative, platform, breakthrough) to follow different processes, appropriate for the scale of change involved. But here again, every time a platform product is developed, for example, the project will go through a certain set of activities common to all platform projects in the firm. Also, within a particular project the development process is often iterative (e.g. there may be repeated design-build-test cycles) thus providing opportunities for process improvements with feedback loops operating within relatively short time frames.

The earlier chapters of this dissertation show academics, industrialists and industry bodies supporting the appropriateness of Cl for NPD in theory, either directly or indirectly. The increasing emphasis placed on the Product Introduction Process by practitioners of Business Process Reengineering and by researchers further demonstrates the perceived importance of NPD and the need to improve the process. Moreover, as we have seen in Chapter 1, various industry bodies are encouraging firms to apply continuous improvement throughout their organisations by encapsulating the concept in the requirements for certain standards and awards including, for example, the EFQM's Business Excellence model and associated award, and the Capability Maturity Model (CMM) developed by the Software Engineering Institute. The latter is a particularly relevant example because it specifically relates to the development process, albeit confined to software development. It recognises the need to follow a process in order to develop high quality software products efficiently and, at the higher levels of maturity, for such a process to be iteratively improved. The CMM was one of the drivers of Cl in the Ericsson case reported in Chapter 6.

Much of the 'good practice' NPD reported in the literature (see Chapter 3, Section 3.4) is closely aligned with 'good practice' Cl, in particular the adoption of a process view, taking an integrative

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29 Anecdotal evidence reported to the researcher.
approach, a supportive, participative management style, and recognition of the importance of learning. This suggests that there is common ground between the two concepts and reinforces the appropriateness of imposing the CI concept on the NPD context. There was no shortage of literature to reinforce a theoretical picture of how the CI Capability Model might look when applied within a development organisation, in terms of providing examples of possible enablers and appropriate behaviours (see Chapter 4).

The academic discussion on organisational style and control is interesting. Companies are recommended to shift between 'loose' and 'tight' forms of co-ordination and control during the NPD process, as the innovation moves from the early, creative part of process towards better definition and more routine activities. At first sight the organic style as described by Rothwell (1992), associated with 'loose' forms of control, appears to have much in common with what is widely regarded as an appropriate style for CI e.g. participative, non-hierarchical, flexible. The mechanistic organisation, by contrast, is characterised by formal reporting, rigid demarcation and little freedom for individuals. But this should not lead to the automatic assumption that CI is not an appropriate concept for the latter part of the process. There has been some debate in the CI literature on how different forms of organisational style and control affect the application of CI on the factory floor. Adler and Cole, comparing the experiences of NUMMI and Volvo's Udevalla plant, challenge the view that hierarchy, standardisation, time-and-motion etc. prevent CI, learning and creativity (Adler, 1993; Adler and Cole, 1993). This supports the contingency view of CI encapsulated in the CI Capability Model i.e. there are many different ways (enablers) of encouraging the key CI behaviours and which one is most appropriate will depend on the particular circumstances of the organisation in question. As argued in Chapter 4, the logical extension of the generic nature of the capability model is that it should apply to NPD, but that the enablers most appropriate may differ from those elsewhere in the firm. Taking this internal contingency argument one stage further would suggest that differing circumstances within NPD (e.g. between the early and late phases) may require different forms of enabler. However, this does not contradict the appropriateness of the CI concept to the whole NPD process – it can still be argued that, in theory, the same generic key behaviours are applicable to all phases of the process.

May & Pearson's review of the literature on TQM in R&D led them to conclude that "TQM is relevant to R&D and produces results, particularly in reducing product development time" and their own research subsequently confirmed this (May and Pearson, 1993). Others studies, reviewed in Chapter 3, have reached similar conclusions (Miller, 1995; Fisher, Kirk et al., 1995). In each case the research involved gathering the views of industrialists by interviews and / or postal questionnaires.
To conclude, the theoretical evidence presented in this dissertation suggests that CI is indeed a suitable concept for improvement of NPD processes. This view is supported by the literature, by industrialists, and by industry bodies.

Having established that, in theory, CI is applicable to NPD we need to explore how the concept appears in practice. This exploration forms the bulk of the research carried out in support of this thesis and to aid the investigation the INCIDE tool was developed. INCIDE comprises a set of three interview schedules with questions directed to the person with overall responsibility for NPD; managers involved in the NPD process; and staff working on the NPD process. The schedules are designed to elicit data which will indicate the presence or lack of the key CI behaviours and on any enablers, or potential enablers, within NPD, as well as background information on the organisation and operation of the development organisation. The tool was described in detail in Chapter 4 and will be evaluated later in this chapter, in Section 7.7. Now we will move on to consider whether the evidence suggests that CI is appropriate for NPD in practice.

7.3 Is it practicable to apply CI to the process of NPD?

There are two dimensions to this question. Managers need to know not only if it is possible to implement CI within NPD but also whether this is viable — whether the benefits arising from applying CI to NPD justify the effort involved in its implementation.

Improvements can be observed in firms which have not consciously adopted the CI concept. For instance, the rapid improvement in process performance following the introduction into manufacturing of a new product or piece of machinery, which is often attributed to the so-called 'learning curve'; or improvements to operations introduced by a manager or functional specialist. However, such improvements do not reflect the systematic nature of CI as defined in this thesis. For example, a typical S-shaped learning curve flattens out after the obvious problems associated with the new product or machine have been overcome; ad hoc improvements and innovations by managers or others within a firm depend on the individuals concerned and are often largely confined to those higher in the organisation or in specialist roles (e.g. production engineers, scientists). CI as an organisation-wide process of focused and sustained incremental innovation implies something quite different: a systematic approach to improvement in which staff throughout the firm (all levels, all areas) are engaged in an on-going effort to implement changes which, though often small-scale, cumulatively will impact on the goals and objectives of the business.

With this picture of CI in mind, it is helpful to break down the question of the practicability of applying CI within NPD in line with the two dimensions referred to above i.e. to consider first if it is possible to apply CI to NPD in practice, and then whether doing so is viable. We will consider these issues in terms of the following questions:
• Do we see evidence of companies applying CI to the NPD process?
• If firms are applying CI to NPD, do they benefit from doing so?

As we shall see, the research suggests that CI can be applied to the NPD process in practice, but the evidence on the tangible benefits of doing so is inconclusive.

7.3.1 Do we see evidence of companies applying CI to the NPD process?

The survey found that in the majority of responding companies CI is applied less frequently to the process of NPD than to other aspects of the business. However, there is a sizeable minority of firms which claim to have a high level of activity in this area. A comparison of the 49 (35%) companies where CI is applied frequently to the NPD process with the rest of the sample shows that they have been practising CI for slightly longer. This may reflect a tendency for CI to start in operations areas and move out to other parts of the organisation later.

The two case companies provide a close up view of firms which recognise the value of CI to NPD but have adopted very different approaches to its application. TM Products is in the very early days of attempting to generate CI within the NPD process and this is not being done systematically. Although the company has attempted a company-wide implementation (e.g. the monthly reporting of ideas relates to all departments) and has had to demonstrate commitment to CI to achieve MRPII Class A status, the degree to which CI concepts are being applied seems to depend very much on the lead set by local management and the receptiveness of staff. There appears to be more evidence of elements of CI in the Marketing Department where there is particularly strong leadership of CI values and behaviours from the manager, than in Engineering. Nevertheless, as we saw in Chapter 6, there are examples of some of the CI behaviours in both departments and also in the collaboration between the two departments.

In the Ericsson case there appears to be more onus on the senior managers to develop a process of continuous improvement, with challenging quality targets and the implementation of a learning culture included in the Vital Few Actions deployed via the ESSI process. The company's commitment to the CMM is also helping to drive process improvement. In this part of Ericsson a conscious decision has now been taken to make CI integral to 'normal' work. This is reflected in various changes to the organisation and operation of NPD which can be seen to support the CI behaviours, for example, the move towards teamworking and the change in the nature of the target set to encourage co-operation between Design and Test staff. The research found examples of CI behaviours and enablers, though the general impression is one of a minority of individuals making improvements and doing so in a somewhat ad hoc fashion, rather than as part of a systematic and sustained process. Even so, the case is an excellent example of a firm making positive steps towards developing CI within NPD, and it provides examples of most of the behaviours in the CI
Capability Model. These behaviours may become more widespread as some of the recently introduced enablers start to have an effect.

IBM's End-to-End Infrastructure Design Method, and the procedures around its operation and upgrading, provide a good example of CI practice within the development context. The 'Guidance buckets' can be seen as CI enablers, which collect users' experience of using the procedure and suggestions for improving it, the best of which are incorporated into future issues. The e-mail forum stimulates the sharing of learning about the design process.

The workshops do not provide much evidence on this issue. Only one of the companies represented appeared to have made significant progress in applying CI to NPD.

There are a few cases reported in the literature of companies applying CI to the NPD process e.g. Mitsubishi's Semiconductor Equipment Division (Funk, 1993), and other instances of firms reporting their progress in this area at conferences. Examples of the latter include Philips Electronics (Olthuis, 1996), Siemens (Jahn, 1996) and British Aerospace Defence (Caffyn, 1995) which were described in Chapter 1. Although these four firms have adopted different methodologies for streamlining and improving their development processes, what they have in common is a systematic approach which extends involvement in improvement to 'ordinary' people working in product development, and which is seen as the start of a never-ending effort. It is probable that if these companies were investigated using INCIDE, in each case there would be evidence of the key CI behaviours and various supporting enablers.

As noted in the previous section, various awards and standards promoted by industry bodies, including the EFQM's Business Excellence model and the CMM, encourage the adoption of CI throughout a firm including its development organisation. The fact that some companies have attained these awards implies that they have successfully implemented CI processes within NPD. For example, in 1996 it was reported that some Siemens departments had reached level 4 on the CMM (Jahn, 1996) which, as seen in Chapter 1, includes several questions related to systematic improvement of the software engineering process. However, the assessment of CI in these awards may or may not be as rigorous as that enabled by INCIDE. While not detracting from TM Products' achievement in gaining MRPII Class A it is clear from the findings reported in Chapter 6 that the application of CI, as defined in this thesis, is still in its infancy.

So, although in some cases the application of CI to the process of NPD may be less systematic than in examples reported in the literature, there is evidence that attempts are being made to apply CI to NPD processes in practice.
7.3.2 If firms applying CI to NPD, do they benefit from doing so?

The next question, then, is whether applying CI to NPD brings significant benefits to the firm.

The responses to the survey suggest that companies can benefit from applying CI to NPD. Exactly half of the 142 companies in the sample reported that CI had contributed to a change in development time over the previous two years, and of these 13 (18%) described the contribution made by CI to the change as large ("more than 30%"). Those firms attributing a significant part of the change in development time to CI tend to have been practising CI for longer; are more likely to have CI company-wide and to take a strategic approach to CI; and make more use of CI tools, with a higher proportion of personnel trained in their use.

In neither of the companies studied for this research is it possible to put quantitative values (e.g. time or financial savings made) on the impact of the CI activities that have taken place. However, in both cases there appears to be a link between encouragement of CI (by managers and by enablers) and increased employee motivation. It could be argued that this, together with the effect of individual improvements which might make the work easier or quicker, must have some influence on development performance. A comment made by the Ericsson designer stands out. He emphasised how the move to teamwork and giving team members a chance to contribute to the planning process had greatly increased morale: "people are happier now, they can see something happening, they have meaning in the project".

Since the application of CI to NPD is a relatively recent field of research the literature sheds little light on this question. In terms of TQM, in which CI is regarded as an essential part, May and Pearson's study found that in all 11 firms which had initiated TQM within R&D the TQM was considered to be a success (May and Pearson, 1993). However, this judgement of success "was made on qualitative perceptions of culture change, the specific successes of quality teams and examples of improvements"; no quantitative measures or metrics relating to specific parameters were reported.

A useful area of future research would be to attempt to measure the impact of applying CI within NPD. This might be done via a carefully constructed longitudinal study involving firms implementing CI within NPD and, if possible, other similar companies who are not. Ideally a participating company would have a steady stream of development projects of similar scope with a relatively short development cycle time (so that the researcher can observe the same development process being repeated). Relevant performance and process measures, and other aspects

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30 The companies reporting that CI had contributed to a change in development time must include some firms in which CI was not applied 'frequently' (score 4 or 5 out of 5) to NPD, since they out number by 22 those where CI is frequently applied to NPD.
important to the firm (this might include 'soft' areas like staff motivation) would be identified and monitored. At the same time the progress of CI would be recorded, including specific improvements made by individuals and groups and their outcomes as well as levels of involvement. The data generated should allow the researcher to demonstrate the presence or absence of a link between CI and improved performance, providing the study is not disrupted by events beyond the researcher's control (e.g. organisational restructuring, downsizing) which might distort the results.

7.3.3 Conclusion

Evidence from various sources suggests that CI concepts can be applied to the NPD process in practice. The research reveals the practice of CI in terms of, for example, attempts at company-wide implementation, cross-functional collaboration, and the important role of managers in giving leadership to CI. However, there is a lack of firm quantified data to illustrate the tangible benefits of applying CI, though many of the survey respondents believe that CI has helped to reduce development time. There is also anecdotal evidence of the advantages of particular improvements and of intangible effects such as enhanced motivation. There may be a link between the lack of examples of the benefits of applying CI to NPD and the relatively low take up at this point in time. This would be in line with the adoption of innovation theory according to which the rate of take up of an innovation is affected by, amongst other things, observability. Thus publicising examples of the benefits to be gained from implementing CI within NPD may trigger a rapid increase in the number of firms adopting this approach.

One factor which may affect the impact of CI on NPD is how much scope there is for CI within this part of the organisation and this is the subject of the next section.

7.4 How wide is the scope for CI within the NPD context?

Again, there are two aspects to this question. Clearly it is directed at uncovering the opportunities for CI within NPD, but this needs to be balanced by considering whether there are any actual or potential constraints. To structure the discussion we will treat these as separate questions:

- What is the possible range of application for CI within NPD?
- Are there any limits to the application of CI within NPD?

7.4.1 What is the possible range of application for CI within NPD?

In other words, what are the possibilities for CI in NPD in terms of the many different contexts that may prevail, including type of organisation, industry or process; different stages of the NPD
process; personnel involved; within and between projects? Before looking at what the research found we will examine some of the ideas behind these contexts.

In Chapter 4 it was argued that since the CI Capability Model is generic it should apply to all business processes, including NPD. By the same reasoning the model should apply to all organisations regardless of size, ownership, sector or industry. This leads to the hypothesis that CI should apply to the NPD process in any organisation that undertakes development work. As seen in Section 7.2 above, internal contingency allows for variation in the methodologies used to generate CI at different phases of the NPD process, while standing by one of the fundamental concepts of the CI Capability Model: the same generic key behaviours are applicable to all phases of the process. The interpretation of CI used in this thesis by definition ("company-wide") requires that people of all levels and areas are involved in CI, staff and managers within NPD being no exception.

The application of CI within NPD can be considered in at least two dimensions: product vs. process; and inter vs. intra project. These dimensions emerged from a group analysis of the combined data produced by the EuroCI Net Ericsson project, for which the Ericsson case described in this dissertation was the UK contribution. While this thesis is primarily concerned with CI as applied to processes, it accepts that incremental product innovation is in many cases an integral part of the work of NPD personnel and may be a defined development strategy. The fact that in many senses NPD is synonymous with product improvement can make it harder for NPD personnel to grasp the concept of process improvement. As an engineer at TM Products said, "It's very difficult to distinguish what's part of your job and what's continuous improvement when you're an engineer and you're developing the product... the main function of the job is to improve products."

Distinguishing between product, process, inter-project and intra-project CI may help people understand that CI can play a wider role in NPD than is often thought. It also suggests one possible structured route into CI within NPD, as illustrated in Figure 7.2. This shows the process starting with incremental improvement to a particular product within a project, followed by the transfer of product improvements between different projects. Both types of activity are fairly common in development organisations, depending on the nature of the firm's products (for example, these stages may be less usual in developers of complex product systems, such as telecommunications networks or flight simulators, which are developed and built on a one-off basis). The next stage is to generate sustainable process improvement, first within the development projects and then between projects.

31 The group comprised researchers from seven European countries who had carried out interviews in Ericsson companies. The author participated in the discussion and facilitated one of the break-out sessions.
Figure 7.2 Possible spread of CI within NPD. Improvement activity is initially focused exclusively on products, starting with an individual product and then being transferred to other products. Process improvement begins on a within-project basis, later extending to improvements between projects.

The evidence suggests that the answer to the question above is that the potential range of application of CI within NPD is wide.

The survey sheds a little light on the issue of context, though the usefulness of the data is limited since the survey was targeted at particular industrial sectors. As shown in Table 6.5, the firms in which CI is most frequently applied to NPD are more likely to be engaged in the manufacture of electrical and optical equipment than companies where CI is not applied to NPD to the same extent, and less likely to be involved with the manufacture of transport equipment. However, it is impossible to conclude from this whether the difference derives from the different industry context or from the type of product. Barclay (1992b) found that mechanically based companies developed fewer new products than electrical and electronic firms. It might be inferred from this that the latter would have greater vested interest in applying CI to their NPD processes. The survey data do reveal that the 13 firms reporting that CI has had a large impact on NPD (i.e. CI accounts for more than 30% of the change in development time over the previous two years) are far more likely to manufacture standardised products than modularised or totally unique products.

The cases contribute to the discussion in several respects. First, they support the argument that the generic nature of CI means that it is applicable in all firms regardless of industry, size, product, etc. Ericsson and TM Products are clearly very different companies in many respects. Ericsson has hundreds of staff in several countries working on highly complex products using sophisticated software technology, while in TM Products seven engineers and technicians do all the development work required for the much simpler Talbot products. Despite the differences, the
research shows that it would be possible to implement CI within the NPD part of both organisations and that attempts are already being made to do so.

The case data also show that there need be no limit on involvement in CI amongst NPD personnel in terms of job status or preference for working individually or with others. In both companies examples of CI behaviours were demonstrated (though on an ad hoc basis rather than systematically) by all levels of staff, and by both individuals and groups.

The Ericsson case provides examples of enablers of both product improvement (e.g. Product Line Maintenance meetings to analyse faults found in the market) and process improvement (e.g. Methods meetings to examine and improve work methods and processes). The group analysis of the combined Ericsson data also found that it is possible to distinguish between improvement activity and learning which takes place within a project and that which take place between projects. Again, there are different enablers to support these activities. Tables 6.7, 6.8 and 6.9 list many of the enablers found in the UK Ericsson case. Some of these would facilitate intra-project CI (e.g. co-location of testers and designers at certain phases of the project) while others enhance inter-project CI (e.g. project manager's end-of-phase report which includes problems faced and improvements).

Both cases demonstrate the potential for CI at the interfaces within NPD. TM Products provides several examples of improvements that are directly attributable to the very high levels of co-operation and collaboration between Engineering and Marketing. In the Ericsson case, improvements at the interfaces between Ericsson companies would enhance the transfer of knowledge and learning around the global organisation. The preliminary interviews carried out at Crendon also highlighted the scope for improvement across internal divisions and external boundaries, particularly in relation to internal communication, handovers, and dealings with customers and suppliers.

The conclusion that there is particular scope for CI at interfaces within NPD is supported by the literature. An often reported benefit of the early days of CI implementation is the breaking down of internal barriers, particularly between departments and functions, and improved communications. Due to the nature of the NPD process, effective cross-boundary working is very important and is reflected in many of the 'good practice' prescriptions shown in Table 3.2, including cross-functional, multi-discipline teams; intensive two-way information processing; concurrent engineering; functional integration; and techniques such as Quality Function Deployment and Design For Manufacturability. In particular, attention has focused on the R&D/Marketing interface (for example, Pearson and Ball, 1993)
So, the NPD environment offers a wide range of potential application for CI. We will now consider whether this environment at the same time may present any inherent limits to the application of CI.

7.4.2 Are there any limits to the application of CI within NPD?

The issue here is whether there are any bounds beyond which it is not feasible to extend the concept into practice, or any constraints which companies may come up against.

The evidence suggests that there may indeed be some areas where limits might occur. In addition, data from the workshops and the cases, and research reported in the literature, suggest that there may be particular challenges in implementing CI within NPD, as discussed in Section 7.5 below, though in themselves these need not necessarily imply limits.

Delegates to the first workshop raised the issue of creativity versus control. They were concerned that within NPD there is a conflict between the need for restriction and control and the need for experimentation and creativity. They felt that the latter qualities, which are associated with CI, needed to have some bounds. The degree of control necessary may vary according to the stage the development project is at. The whole issue of the applicability of CI to different phases of the NPD process requires further research and is discussed below.

A potential limitation on CI within NPD was raised during the Ericsson field work and is concerned with the timing of implementing improvements and when to draw the line regarding further improvements. In the case of product improvement, especially where software is concerned, it is possible to go on making improvements for ever; without a cut-off point after which no further changes are permitted no product would ever get finished. This suggests the need for an enabler to capture proposed product improvements and ensure that they are incorporated into the next product version or generation. The problem of the timing of implementing improvements also relates to process improvement. Again in Ericsson, it was pointed out that it is not always desirable to implement an improvement immediately because if, for example, the project is midway the change may have negative repercussions for people working on other parts of the project. So the process improvement may have to be deferred until the next project. However, the overlapping nature of the projects (e.g. the Testers were still working on R6 while the Designers had already started on R6.1) means that occasionally such an improvement may have to wait until the next but one project.

As reported in Chapter 4, Bartezzaghi et al. (1997) have identified barriers to inter-project learning (which is one aspect of CI) which are peculiar to the NPD environment. These include the time that elapses between the development work and feedback received from the market, making it harder to understand cause and effect; the fact that the feedback may not even reach the NPD
people concerned; and the possibility that the experience and learning gained during a particular project may not have immediate relevance for another project but will be needed at some point in the future, and possibly in a different location from where the learning occurred (e.g. in the case of companies such as Ericsson who carry out product development around the world).

7.4.3 Further research

This research has demonstrated the theoretical grounds for applying CI to NPD processes and has shown that it is possible to apply CI to NPD in practice. However, it is clear from the discussion surrounding the 'scope' question that this is an area requiring further study. In particular, research is needed into whether the applicability of CI may vary between different stages of the NPD process and, if so, what form this variation might take. In theory the CI behaviours are generic and therefore would apply at all stages of the process, though they may be manifested in different ways. Certainly the enablers may well differ between phases of the process which are significantly different, for example, the upfront highly creative concept generation stage compared to more routine downstream activities like prototyping and pre-production work. The changing nature of the NPD process as it unfolds has led writers to advocate a flexible 'loose-tight' approach to control and management style. As noted above, research into CI on the factory floor suggests that neither of these very different forms of control and style necessarily precludes CI. While on the one hand the 'loose-tight' recommendation suggests that a management style close to that advocated for CI is better suited to the earlier stages of NPD, the creativity vs. control concern of the workshop delegates points to a possible need to restrict the experimentation and creativity associated with CI thus making it more suited to the more routine later stages.

CI is essentially adaptive – it is about continuous incremental improvement rather than sporadic breakthroughs. Michael Kirton (1980) has shown that individuals differ in creative style, being either 'adopters' or 'innovators'. While adopters solve problems within existing paradigms, innovators take a more radical approach, detaching the problem from the accepted thinking surrounding it and reconstructing both the problem and the paradigm while seeking a solution. The nature of the NPD process might suggest that innovators are more at home in the upstream, creative phases while adopters would flourish in the downstream phases. Thus a hypothesis which could be usefully tested is that the more routine, downstream phases of the NPD process are more suited to CI.

An investigation of the applicability of CI at different phases of the NPD process might take the form of an in-depth, longitudinal study in several firms which are actively attempting to implement CI within NPD. Individuals or work groups at each stage in the process could be identified and interviewed regularly to monitor their involvement in CI, with an emphasis on factors which motivate or facilitate their engagement in CI and factors which obstruct it (by discussing, for
example, changes they make to their work processes, improvements they would like to make but feel unable to action, constraints they feel, etc.). A study lasting one to two years would be more valuable than one-off interviews, since the researcher would be more likely to uncover the less obvious constraints and would be less reliant on the memory of the interviewees.

Other variables which produce different NPD contexts and thus may affect the scope for CI include:

- product complexity;
- frequency of new products;
- development cycle time;
- organisational structure e.g. project based vs. function based;
- size of development organisation.

These could be investigated by carrying out case research in a pool of companies which differ on one or more of the variables, including a detailed examination of the firms' CI using INCIDE. In order to get insight into why a particular company may be doing well, or not so well, with an aspect of CI, its context and CI achievement would be compared with others in the pool. This would not necessarily reveal a simple cause and effect relationship (e.g. complex products = less scope/more limits to CI) because of the interrelationships between the variables (if a product is complex, say, then it is likely that the cycle time taken to develop it will be longer). However, it may be possible to identify tendencies which in turn would inform companies of what they may reasonably expect from CI, given their particular situation.

7.4.4 Conclusion

In short, there seems to be much potential for CI within NPD in terms of applying the CI concept to all types of firm regardless of sector, to work carried out by all levels of personnel whether as individuals or groups, to both process and product, and to improvement activity both within and between projects. However, the research has highlighted other contextual issues which would repay further investigation, in particular the applicability of CI at different stages of the NPD process, and possible limits to CI stemming from the nature of the process.

The issues of context and limitations are further explored in the next section, which examines characteristics inherent in the NPD process that may facilitate or hinder the implementation of CI in this part of the organisation.
7.5 Are there any factors peculiar to NPD which facilitate or impede the implementation of CI?

This question also picks up the issue of contingency, but rather than singling out contingent situations within NPD it steps back to look at the NPD environment as a whole, to see if the process has any attributes which stand out as actual or potential barriers or aids to CI.

Chapter 4 speculated that some of the typical characteristics associated with NPD personnel may suggest that proactive involvement in improvement and systematic problem solving might be more likely to be found in the NPD organisation than in other areas of the company. Such characteristics included the fact that development work is about producing new or improved products, not maintaining the status quo; that the engineering or scientific background of most NPD staff might predispose them towards a logical, inquisitive approach; and that the higher level of education, job status and possibly autonomy of NPD staff, compared to employees in other areas of the business, suggests they are more likely to be expected to improve the way they work as a matter of course. In line with the CI Capability Model, it may be argued that although we would expect the same basic ‘CI behaviours’ the form these behaviours take and the enablers suitable for encouraging them are likely to be very different to those found on the shop floor.

It would also be reasonable to expect that the nature of the NPD process itself may prove in some ways more conducive to CI but in others less so. For example, work on CI within manufacturing production areas demonstrates the important role played by measurement. Yet finding appropriate and meaningful measures within NPD can be difficult for firms and there is relatively little advice available, though recent research attempts to remedy this (see, for example, Griffin, 1993). A 1990 study of NPD practice in US firms which looked at, amongst other things, obstacles to successful NPD found that problems were more varied and less uniform than they had been in 1982 (Page, 1993). In 1990 the most common obstacle, cited by 39% of respondents, was insufficient resources (be it people, time, or other resources such as market research or design). It might be surmised from this that time pressures are a feature of NPD which may impede the application of CI (though of course, ultimately CI could mitigate this problem by leading to process improvements which reduce the time taken to do particular tasks).

As we shall see, the research carried out for this thesis supports the view that, while the nature of the NPD process imposes particular challenges to implementing CI within NPD, other aspects of the development setting have the potential to facilitate the adoption of CI.

While the survey data do not shed any light on this question the workshops provide some rich details. The delegates considered the facilitating factors (aids) and inhibiting factors (barriers) to
implementing CI within the NPD process, having first discussed the differences between production processes and NPD processes. The results of their deliberations were given in Tables 6.1 and 6.2.

Most of the differences delegates identified between implementing CI in NPD compared to manufacturing relate to the nature of the NPD process and the difficulty of identifying appropriate measures. The NPD process is less tangible and involves longer time-scales than manufacturing processes, and it can be more difficult to define what the deliverable is. These factors, together with the problems associated with measurement (including how to measure 'quality' of the process and what the measures and targets should be), pose particular challenges for the implementation of CI within NPD. Cultural differences and the iterative nature of the NPD process may not make it harder to implement CI in this part of the business but suggest that a different approach would need to be taken. It is worth noting that although at first sight the concept of 'right first time' does not appear transferable to the NPD process due to its iterative nature (e.g. repeated design-build-test cycles) some companies, including BAe Defence, have been able to reduce the number of iterations as part their efforts to improve and streamline the NPD process (Caffyn, 1995).

Some of the factors identified as helping and hindering the implementation of CI within NPD could be classed as enablers or disablers in the terminology of the CI Capability Model. For example, post project evaluation and a policy of moderate turnover of staff on development teams are types of enabler. Existing formal procedures, standards and contracts may act as disablers if they prevent or discourage people from instigating change and improvement.

The factors within the NPD area that could be mobilised to support CI fall into two groupings. First, delegates suggested a number of practices which take place, or could be instituted fairly easily, including ensuring an appropriate level of staff turnover in development teams, emphasising the importance of post project evaluation, and motivating an interest in improvement by increasing awareness of customer and competitive pressures, or possibly through the use of bonuses. The second group of facilitating factors relate to the people involved in the development process. It was claimed that many NPD personnel are highly motivated, open-minded, technically competent and have high levels of numeracy and other relevant skills; as a result such staff might be receptive to CI and, once convinced of its merits, able to achieve a lot with it.

Similarly, obstacles to the implementation of CI within NPD stem from the development process itself and from the reaction of the people involved. The former include tension caused by the conflicting needs of control and creativity; restrictions imposed by formal procedures and standards; inappropriate composition of development teams; and too high a level of turnover of team members. The measurement issue was also raised, notably the lack of metrics to stimulate proactive improvement, as opposed to measurement which reports what has already happened and leads to reactive improvement. The potential barriers attributed to NPD staff, intellectual
snobertry and a belief that it is not appropriate to measure their work, may perhaps be common to other 'professional' occupations. In the NPD context it was noted that engineers are paid to be sceptical and constantly question, and so were likely to challenge CI. A third group of inhibitors is not specific to NPD but might also apply elsewhere in the organisation, for example lack of training in quality management, a fear of being made redundant, and not enough time to work on CI.

Some of the issues raised by the workshop delegates are illustrated in the cases. For example, the problem of identifying appropriate measures in the NPD process manifested itself in TM Products in the absence of measures of any sort. In both TM Products and Ericsson lack of time for CI was the most frequently cited obstacle. Several of the Ericsson interviewees echoed the problem delegates raised concerning the need to conform to existing formal procedures, especially when they are used in R&D facilities world-wide.

The speculation that typical characteristics associated with NPD personnel might make them particularly responsive to the CI concept compared to staff in other areas of the company, particularly the shop floor which has been the traditional area of application for CI, is borne out to a certain extent by the experience of TM Products. At about the same time that the interviews for this research took place the author did a CI diagnostic of the company as a whole. It was very apparent that the office staff interviewed (from Information Technology, Customer Service, and Accounts) felt that improving the way they carried out their work was an ingrained part of their job, whereas although some production staff had made small improvements they tended to feel that they were being asked for something extra, beyond the call of duty. The attitude of the office interviewees was reflected by the marketing personnel interviewed for this research, and to a certain extent by the engineers.

TM Products also provides evidence to illustrate the potential need, suggested above, for enablers designed to suit staff engaged in NPD. As part of the attempt to promote involvement in CI, people are asked to log the improvements they make; this information is collated by the department managers who pass it to the Quality Manager every month. However, the marketing staff interviewed admitted that many of the improvements they made went unrecorded because they were embarrassed to record such tiny improvements. Clearly, what may work as an enabler (to encourage involvement by ensuring some form of recognition and to monitor CI activity) in some parts of the company is inappropriate in other areas.

The present research confirms the findings of other researchers in a number of respects. In particular, there are strong similarities between the points raised during the workshops and the factors identified by May and Pearson (1993) as making the implementation of TQM in R&D easier than in other functions, and the factors making it harder (see Table 4.1). Among the factors found by the earlier research to aid implementation of TQM in R&D were: the higher level of education of
personnel; an analytical approach; existing levels of motivation, control over processes and openness which reduce the culture change required; and less diversity between departmental functions. Factors identified as hindering implementation included the conceptual nature of activities; non-repetitive processes; difficulty in assessing the 'product', which is information; and the inappropriateness of the Cost of Quality as a measure due to the difficulty of assigning a value to the price of non-conformance. The literature also supports the concept of internal contingency, with Taylor and Pearson (1994) concluding that TQM in R&D is more likely to be successful if a bespoke system designed after organisational analysis is introduced, rather than adapting a system used in other parts of the company.

To conclude, the research shows that while the nature of the NPD process imposes particular challenges to implementing CI within NPD (for the researcher as well as for the industrialist) there are also potential advantages which could facilitate the development of CI in this part of the organisation. The multi-methods approach was particularly useful here in helping to identify some of the more important factors. Potential obstacles to CI within NPD which recur in the sources include the less tangible nature of development activities, the perception that the process is non-repetitive (but see the counter argument to this in Section 7.2 above), the need to conform to company-wide standards, and difficulties in finding appropriate measurements. On a more positive note, the sources highlight the potential support for CI within NPD arising from comparatively high levels of skill and education among staff, and their tendency to adopt a logical, analytical approach to problems. The discussion has also demonstrated the importance of the concept of internal contingency, particularly in terms of CI enablers within NPD.

A number of interesting issues have been raised here which would repay further investigation, in particular:

- differences between CI on the shop floor and CI amongst a group of professionals;
- internal contingency within an organisation and how this affects CI enablers;
- how to overcome some of the key barriers to CI within NPD.

Having discussed the factors which may help or hinder the implementation of CI within NPD, we will now look at how it may be possible to establish the key CI behaviours to such an extent that they become embedded routines.

7.6 To what extent might it be possible to institutionalise the practice of CI to the NPD process?

The research has demonstrated the role that enablers have in helping to encourage and reinforce the CI behaviours. This raises the question of whether any of the enablers are so effective that they can be said to help to institutionalise the application of CI within NPD. In other words, can we
identify one or more enablers which, if used consistently, lead to the CI concepts and behaviours becoming embedded into the 'normal' way of working.

It is proposed here that such enablers are feasible and may fall into one of several categories:

1. Enablers which integrate CI as an in-line activity.
2. Enablers built into NPD processes that trigger a CI response from individuals and groups.
3. External enablers of CI adopted by the organisation.

The cases provide examples of all three types of enabler. An example of an enabler in the first category is a corporate policy which promotes CI and is deployed in the line. In Ericsson the ESSI process fulfills such a role (see Chapter 6, Section 6.5.2). Indeed, some form of policy deployment with measures and targets is considered a critical enabler to achieve Level 3 (goal-oriented CI) on the CI Capability Model.

The second category of enablers are devices and procedures which are deliberately built into the NPD processes to trigger CI. For example, IBM's E2E Method has built-in mechanisms for encouraging users to suggest how the process might be improved and to share their experience. In Ericsson project managers are now required to give a verbal report to the Quality Reference Group at the end of each project phase which describes not only what happened during the previous phase but also problems faced and how they were overcome, and improvements implemented or identified.

The third category of enablers covers external standards and awards which, if they are to be achieved, require explicitly or implicitly that a process of CI is established. An example from the research is the adoption of the CMM at Ericsson.

During their discussion on strategies for generating CI within the NPD process, the workshop delegates mentioned one or two enablers that might fall into the first two categories. They are found under the 'structural changes to the NPD process' heading in Table 6.2 and include feedback systems for making sure problems are dealt with rapidly and completely; use of multi-discipline development teams, membership of which is fluid over time; and increasing the decision-making authority of project leaders.

These findings add to what may be found in the literature, and are more explicit in linking use of the enabler to a CI outcome. For example, an enabler which helps to integrate CI as an in-line activity is a formal NPD process designed in such a way that the process itself stimulates the CI behaviours. Characteristics of such a process would include many of the 'good practice' features described in the literature (see Chapter 3) including, for example, concurrent engineering,
integrated milestones, cross-functional teams, and methods which require input from several functions (e.g. DFM, QFD); all these features encourage the key CI behaviour concerned with effective cross-boundary working. The literature also mentions mechanisms that potentially represent the second type of enabler, including post project analysis and learning audits (Bowen, Clark et al., 1994a).

So the research indicates that there may indeed be certain enablers which could help to institutionalise the concept and practices of CI within NPD, and it provides evidence of some; but this provisional conclusion requires more extensive investigation. It should be remembered that although some enablers appear to be particularly powerful for helping to make CI an underlying cultural norm, all enablers are contingent and that what works for one firm may not succeed in another. As we saw in Chapter 3, current 'best practice' regarding organisational structures for NPD is having the ability to apply the most appropriate form of structure on a project by project basis. This suggests that either enablers need to be sufficiently generic or high level to apply equally whatever type of process or structure is being used, or that each possible process (e.g. for derivative products, for platform developments) has appropriate enablers built into it.

It is possible that if INCIDE, which is generic in style and takes a holistic view of the NPD process, were modified into a more manager-friendly tool it might become an enabler to help institutionalise CI within NPD. This possibility will be considered in the next section (see Section 7.7.4), after an evaluation of INCIDE as a research instrument.

7.7 How appropriate is INCIDE for investigating the application of CI in NPD?

INCIDE is based on the CI Capability Model. The tool is designed to extract data which will indicate the presence or lack of the key CI behaviours and of any enablers, or potential enablers, within NPD, as well as background information on the structure and operation of the development organisation. In this section we will evaluate INCIDE, examining it in terms of its effectiveness, efficiency, usability, and usefulness. Since it was designed as a research tool we will examine these four aspects against a research perspective. However, as noted in the previous section, it is possible that INCIDE could form the basis of a management tool and this potential application will also be considered briefly. A further test of INCIDE is reported in Chapter 8.

7.7.1 Effectiveness

The effectiveness of a tool can be gauged in terms of whether it performs relative to its objective. In the case of INCIDE the objective was to explore the presence or absence of CI behaviours and enablers. The findings from the two case companies reported in Chapter 6 show clearly that the
tool met this objective. In a research context, there are two dimensions of 'effectiveness' which should be considered separately during any evaluation of a tool, validity and reliability.

*Is the tool valid?*

The answer is yes, we see what we should see. As argued in Chapter 5, INCIDE appears to have internal validity, in that the analyses based on the data generated by the tool were confirmed as accurate by the interviewees. In other words, there is a match between what the questions are seeking to find out (i.e. whether certain behaviours exist in the organisation) and what they do in fact find out.

*Is the tool reliable?*

Again the answer is yes, INCIDE successfully maps over different situations and contexts. The two cases reported in this thesis demonstrate the generic nature of the tool and that it can be used in a variety of situations regardless of organisational context (company size, industrial sector, technologies used in product development, etc.). Moreover, as noted in Chapter 5, the tool's reliability was demonstrated by the fact that seven researchers of different nationalities working in seven countries were able to use it to come up with comparable data.

INCIDE is effective as it stands, but there is potential to further improve its performance. Using the key behaviours as the sole unit of analysis may cause the user of this tool to miss some of the bigger picture concerning process improvement. For the work on the combined Ericsson data the unit of analysis used was the development project. This enabled the researcher to build up a picture of the main process improvements over a period of time. It is then possible to go down into more detail and find out, for example, who had suggested the improvement and how it had been implemented, which in turn shed light on some of the key CI behaviours. This suggests that it may be appropriate to adopt a contingent approach to using INCIDE, depending on the type of organisation. In a large, project-based company such as Ericsson the emphasis could be on the project as the unit of analysis, with interviewees asked about changes between successive projects. In a medium-sized, department based firm like TM Products, where an individual may be working on several projects at one time, the tool could be directed at the NPD process in general.

### 7.7.2 Efficiency

Efficiency can be considered in terms of output relative to input (effort, time and other resources). For the researcher, using the tool takes a large amount of time, not only to conduct the interviews but to process and analyse the large amount of data generated. However, the experience of the two cases in this thesis is that a high proportion of the data produced is relevant.

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32 This refers to the Ericsson project co-ordinated by EuroCIrNet.
The nature of the subject of investigation – behaviour, what people actually do – and the need to assess this without living in the company for months at a time, makes it necessary to generate enough data from which it is possible to make an informed interpretation of the situation. To avoid accepting at face value everything one is told the interviewer needs supporting evidence, from within a single interview or from different interviewees, or from other sources such as company documentation. Inevitably, this will lengthen the data collection process and produce more data which then have to be processed and analysed, than if the investigation was, say, solely concerned with opinions or with assessing an item of 'hard' technology. The low levels of redundancy among the data collected for the cases (this is hard to measure, but more data was used than was discarded) indicates a degree of efficiency.

The companies involved with the research also provided significant inputs to the process, largely in terms of staff time. The Ericsson case involved a preliminary two hour meeting with a senior manager, also attended by a second manager with corporate responsibilities, to scope and agree the project. Apart from this, little advance preparation was required by either company, other than setting up the interviews, though in both cases a list of issues to be covered in the interviews was circulated to some or all of the interviewees in advance. However, the interviews took up approximately 5 hours of staff time in TM Products and up to 11 hours in Ericsson. Both firms also validated the findings by commenting on written descriptions of the analyses. In return, they received an outside perspective of their attempts at CI within NPD.

7.7.3 Usability

Can INCIDE be used by a researcher other than the author? Yes, this has been demonstrated by the use made of the tool by researchers elsewhere in Europe. However, during the course of this research there were some instances when it was quite hard to interpret the interview data in terms of behaviours. It is much easier to generate and interpret data relating to the enablers. Care must be taken to avoid over emphasising the enablers at the expense of the behaviours. Arguably, the heavy focus on what we would here describe as enablers (e.g. training, tools for quality, a problem solving process, teams) with little, if any, attention to the underlying behaviours in a company contributed to the failure of so many of the TQM efforts of the 1980s.

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33 See note 32.
34 Another factor contributing to the high failure rate of TQM implementations was that the enablers promoted were often regarded as universally applicable, with little account taken of different organisational contexts.
7.7.4 Usefulness

How useful is the tool – does it yield anything of value? Again, the answer is yes, on the grounds that it generated data which substantiated the extension of CI (and the CI Capability Model) into the area of NPD.

The data INCIDE generates allows the researcher to uncover the presence or absence of particular behaviours, and to discriminate in general terms between different levels of CI maturity, by interpreting how the interviewees describe their own actions and those of colleagues. However, perhaps the strongest limitation of INCIDE is that it does not measure the extent to which these behaviours reflect organisational 'norms'. Interviewing everyone, or a high proportion of people who work in NPD, may help establish a more accurate picture in this respect, but it is still overly dependent on what people say they do or have done, rather than on direct observation of how people actually behave as they go about their everyday work. One way to make the tool more evaluative might be to include a further section aimed at generating quantitative data which would allow the researcher to estimate the extent to which the key CI behaviours are typical. This could take the form of a short questionnaire, focused on some key areas, completed by everyone within NPD. The questions would have to be very clear and unambiguous, to avoid capturing opinion as opposed to what really happens.

So, INCIDE is useful for researchers but does it have the potential to become a manager-friendly tool and enabler of CI? The most immediately obvious management application would be as some form of self-assessment tool which could be used in a diagnostic exercise. Instigating such an assessment, and then repeating it at regular intervals, might lead to:

- a shared understanding of the need to develop new ways of behaving in order to establish a ‘CI culture’;
- wider awareness of CI amongst NPD personnel;
- acceptance amongst staff that management are serious about their wish to develop CI.

As the tool stands, it may not be clear to a manager what lies behind the questions (unless he or she is familiar with the CI Capability Model) and how to interpret responses. To develop INCIDE into a manager-friendly assessment tool would require making explicit what it is trying to find out and why, designing a format appropriate for self-assessment, and ensuring that the language used is appropriate. This process has already been applied by the author to the CI Capability Model and general 'CI mapping exercise' in order to develop the CIRCA Continuous Improvement Self-Assessment Tool (Caffyn, 1998b). Indeed the CIRCA tool, claiming as it does to be generic, could in theory be applied to the NPD area as it stands. However, it may be more useful for NPD managers if the data and knowledge generated by this research were used to tailor the CIRCA tool
to the NPD environment, for example by substituting examples relating to an NPD environment and explaining the possibility of different contexts within a firm’s NPD organisation.

### 7.7.5 Conclusion

On the whole INCIDE worked well. Its use for the two cases shows it to be reasonably effective, efficient, usable and useful. The tool provided a framework for generating the data necessary to build up a descriptive picture of CI in NPD. However, certain limitations make it less effective as an evaluative tool. If INCIDE were used as part of a diagnostic or assessment exercise it would also be necessary to gather corroborating evidence to establish more accurately the extent to which the CI behaviours are or are not present.

### 7.8 Conclusions

The discussion in this chapter leads to the conclusion that the application of CI to NPD is appropriate both in theory and in practice. The scope for applying CI within NPD appears to be broad, in that CI can be applied to development processes in a wide variety of firms, regardless of size, industry sector, technology, and type of product. The research clearly supports the generic aspect of the CI capability model, although it did not go as far as exploring possible differences in applicability between different stages of the NPD process. At a practical level, this thesis has identified certain enablers that not only encourage CI behaviour but could help to institutionalise it. There do appear to be factors or characteristics which work in favour of CI in NPD and others which work against it. In this respect the research presented here supports other work reported in the literature. Finally, INCIDE is a useful instrument for collecting data to be analysed against the framework of the CI Capability Model, although it has some limitations as an assessment or evaluative tool.

These conclusions may be summarised as follows:

- **In theory** there is scope for CI in NPD.
- CI can be applied to the NPD process in practice but firm evidence of tangible benefits of doing so is, as yet, inconclusive.
- The potential range of application of CI within NPD is wide, but there may be some areas where limits are found.
- There are factors or characteristics which work in favour of CI in NPD and others which work against it.
- There may be certain enablers which can help to institutionalise the concept and practices of CI within NPD.
- The INCIDE tool is reasonably effective, efficient, usable and useful.
These conclusions are based on the findings from the various research activities undertaken to develop this thesis. However, in common with all research methodologies, the workshops, survey and cases have their limitations, and latent threats to validity. The next chapter will describe steps taken to validate and test the research conclusions by addressing these threats to validity.
Chapter 8 Validation

8.1 Introduction

This thesis makes two contributions to knowledge. First, it explores the application of CI to the process of NPD, a combination which is relatively uncharted. Second, the thesis provides an analytical model to support the implementation of CI in NPD. Any type of study has potential threats to validity and the purpose of this chapter is to report the steps taken to test the validity of the conclusions made about CI in NPD, and of the analytical model.

The preceding chapter contained a discussion of the application of CI to NPD processes, centred around six related questions. Using evidence from the research carried out for this thesis the following conclusions were reached:

- C.1 In theory there is scope for CI in NPD.
- C.2 CI can be applied to the NPD process in practice but firm evidence of tangible benefits of doing so is, as yet, inconclusive.
- C.3 The potential range of application of CI within NPD is wide, but there may be some areas where limits are found.
- C.4 There are factors or characteristics which work in favour of CI in NPD and others which work against it.
- C.5 There may be certain enablers which can help to institutionalise the concept and practices of CI within NPD.
- C.6 The INCIDE tool is reasonably effective, efficient, usable and useful.

The analytical model for looking at CI in NPD was detailed in Chapter 4. This model builds on the concepts of the CI Capability Model (i.e. generic CI behaviours which evolve over time and are supported and encouraged by a wide range of enablers) to describe and explain the application of CI within the context of NPD processes. The INCIDE tool was developed to gather data which could be analysed against the framework of the model, in order to build a picture of CI within the NPD organisation of a firm.

This chapter will explain the steps taken to test and validate the conclusions drawn about the application of CI within NPD, and the analytical model. It begins with a discussion of validity and the threats to validity latent in this research. Section 8.3 describes the validation methodology, and the results of each of the two methods employed are reported in Section 8.4. This is followed by a review of the implications the validation test has for the thesis.
8.2 Validity

All research studies face threats to validity. These threats have many different sources, but the aspects of a study which they have the potential to damage can be grouped into four categories:

- statistical conclusion validity;
- internal validity;
- construct validity;
- external validity.

This section begins by defining these different types of validity and indicating the sort of threats posed to them. It argues that construct validity and external validity are especially critical for the present research, which is exploratory in nature, while aspects of internal validity are relevant, but to a lesser degree. These three dimensions of validity are then examined in more detail, in terms of the threats they face and how these threats may be mitigated. This is followed by a discussion of the threats to validity latent in this research and how they have been, or will be, addressed.

8.2.1 Definitions of validity

The following definitions draw on several sources (Cook and Campbell, 1979; Gill and Johnson, 1991; Kidder, Judd et al., 1987). It should be noted that Cook and Campbell regard statistical conclusion validity as part of internal validity, and construct validity as part of external validity.

**Statistical conclusion validity** is concerned with the extent to which inferences about whether two variables covary are valid. It is threatened by features that might lead the researcher to draw false conclusions about covariation including, for example, low statistical power, the reliability of measures, and the reliability of treatment implementation.

**Internal validity** is concerned with the extent to which conclusions about the cause and effect relationship between two variables are warranted. Among the many threats to internal validity are history (the effect is caused by an event, that is not part of the research treatment, which takes place during the study); maturation (the effect is due to the respondent growing older, more experienced etc. during the course of the study); testing (the effect might be caused by the number of times particular responses are measured); and instrumentation (the effect might be due to a change in the measuring instrument used at different times in the study).

**Construct validity** is concerned with the extent to which the constructs of theoretical interest are successfully operationalised in the research. The threats to construct validity, if unchecked, will result in either failure to incorporate all the dimensions of the concept into the operations, or to the operations containing dimensions that are irrelevant to the construct under investigation.
External validity is concerned with the extent to which conclusions may be generalised from the sample and setting used in the research, to the populations, settings and times specified in the research hypothesis. The threats to external validity stem from the selection of participants; the setting in which the study is carried out; and from ‘history’, in the sense that the circumstances prevailing when the research is conducted may differ from those in the past and the future.

Since the purpose of the present research is to explore the scope for CI within NPD processes, the accuracy with which the concept of CI is operationalised is critical. The issue of construct validity is therefore particularly significant. However, the extent to which the study has external validity is also very relevant, since the thesis attempts to extend the generalisability of the CI Capability Model by imposing it onto the NPD context. Guided by the framework of the CI Capability Model, the research looked for the presence of CI enablers and CI behaviours in the context of NPD. Although there is an associative relationship between enablers and behaviours, the thesis does not attempt to establish a causal link between these variables. Thus issues of internal validity, while still important, carry less weight for this study. Statistical conclusion validity is not relevant for this thesis and will not be referred to again.

8.2.2 Threats to construct validity, external validity and internal validity

Construct validity
Construct validity is about establishing correct operational measures for the concepts being studied (Yin, 1994). This involves selecting variables, which are partial representations of the construct and are measurable, and measuring them in the manner specified by an operational definition. The problem is that variables never measure only the construct of interest, they also measure things outside the research issue ('constructs of disinterest') and they contain random errors (Kidder, Judd et al., 1987). Cook and Campbell (1979) identify as many as ten different threats to construct validity. These are listed in Table 8.1, together with what can be done to reduce the threat. This list of threats serves as a useful checklist against which to examine the construct validity of the present research (see Section 8.2.3). Perhaps the single most important action to maximise construct validity is to use multiple ways of measuring the construct (Kidder, Judd et al., 1987).
Inadequate preoperational explication of constructs | Carry out a conceptual analysis of the essential features of a construct before deciding how it will be operationalised.

Mono-operation bias | Have more than one operational representation for each construct.

Mono-method bias | Use more than one method to present the manipulations and to record responses.

Hypothesis-guessing within experimental conditions | Make hypotheses hard to guess.

Evaluation apprehension | -

Experimenter expectancies | Employ experimenters who have no expectations or have false expectations, or analyse the data separately for persons who deliver the treatments and have different expectancies.

Confounding constructs and levels of constructs | Conduct parametric research in which the independent variable is at many different levels, and many levels of the dependent variable are measured.

Interaction of different treatments | Give only one treatment to respondents, or conduct separate analyses of the different treatments respondents received.

Interaction of testing [i.e. of the pretest, or of repeated posttests] and treatment | Use a control group which only has the posttest. Use independent control groups at each delayed test session.

Restricted generalisability across constructs | Explore with others how the treatment might influence constructs not immediately apparent in the original formulation of the research question.

<table>
<thead>
<tr>
<th>Threat</th>
<th>Action to reduce threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate preoperational explication of constructs</td>
<td>Carry out a conceptual analysis of the essential features of a construct before deciding how it will be operationalised.</td>
</tr>
<tr>
<td>Mono-operation bias</td>
<td>Have more than one operational representation for each construct.</td>
</tr>
<tr>
<td>Mono-method bias</td>
<td>Use more than one method to present the manipulations and to record responses.</td>
</tr>
<tr>
<td>Hypothesis-guessing within experimental conditions</td>
<td>Make hypotheses hard to guess.</td>
</tr>
<tr>
<td>Evaluation apprehension</td>
<td>-</td>
</tr>
<tr>
<td>Experimenter expectancies</td>
<td>Employ experimenters who have no expectations or have false expectations, or analyse the data separately for persons who deliver the treatments and have different expectancies.</td>
</tr>
<tr>
<td>Confounding constructs and levels of constructs</td>
<td>Conduct parametric research in which the independent variable is at many different levels, and many levels of the dependent variable are measured.</td>
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</tr>
<tr>
<td>Restricted generalisability across constructs</td>
<td>Explore with others how the treatment might influence constructs not immediately apparent in the original formulation of the research question.</td>
</tr>
</tbody>
</table>

Table 8.1 Threats to construct validity and actions that can be taken to reduce them (Source: Cook and Campbell, 1979)

**External validity**

External validity involves establishing the domain to which a study's findings can be generalised. (Yin, 1994). As noted above, the threats to external validity relate to participant selection, the research setting, and the circumstances prevailing at the time the investigation took place. Cook and Campbell (1979) describe three models which can help to increase external validity. Under the 'random sampling for representativeness model' the sample is chosen randomly from the population. The problem with this is that it requires considerable resources and is probably only feasible if the target to be sampled is persons, rather than settings or historical times. The 'model of deliberate sampling for heterogeneity' requires that target classes of person, settings, and times are defined, and a wide range of instances from within each class is included in the design.
However, because there is no random sampling the researcher should not, strictly speaking, generalise the findings to the populations from which the participants were drawn. A researcher following the 'impressionistic modal instance model' first makes explicit the kinds of persons, settings, or times to which he or she most wants to generalise, and then selects at least one example from each class that appears to be similar to the class mode. In situations where the target is specified, the third model is not as powerful as the second model, which in turn is less powerful than the first. However, the 'impressionistic modal instance model' has the advantage of being applicable when no targets are specified and the researcher's main concern is not to be limited in his or her generalisations.

So, the method of sample selection that gives the highest level of external validity is also the one that will often be impracticable to adopt. This means that in many cases generalisation will have to be at a theoretical level (i.e. it will take the form of speculation). However, the external validity of the research may subsequently be maximised by replicating the study in other settings and with other samples (Kidder, Judd et al., 1987).

**Internal validity**

Internal validity is primarily about establishing causal relationships, whereby certain conditions are shown to lead to other conditions. In this sense, internal validity is relevant for explanatory or causal studies only, and not for descriptive or exploratory studies; for the latter, concerns of internal validity extend to the problems of making inferences (Yin, 1994).

### 8.2.3 Threats to validity faced by this research

The design of the present research was described and critically reviewed in Chapter 5. Briefly, preliminary exploratory interviews were followed by hypothesis generating workshops, a descriptive postal survey, and two company cases to test both the hypotheses generated by translating the Cl Capability Model into the NPD context, and the research instrument. The strengths and weaknesses of each method (workshops, survey, cases based on detailed interviews) were discussed in terms of internal validity, external validity and reliability (see Section 5.5). The findings of these research activities were discussed in Chapter 7 and conclusions were drawn concerning a number of issues related to the main research question (see Section 8.1 above). Now we will consider the research design as a whole and examine how the methods taken together stand up to the threats to validity outlined above.

**Construct validity**

The purpose of this research was to explore the scope for Cl within NPD processes. In Chapter 1 Cl was defined as "an organisation-wide process of focused and sustained incremental innovation". NPD was described as the process by which new products are developed in companies, from the
generation of an idea until the product is launched onto the market. The investigation was not confined to a specific type of NPD process, or to certain stages within the process, or to a particular scale of product development (incremental, breakthrough, etc.). 'Scope' for CI has been interpreted in terms of the opportunities for CI, either realised or potential.

To move from an abstract concept of CI to something more tangible the research used the nine CI behaviours of the CI Capability Model and adapted them to the NPD context (Chapter 4). The behaviours provided a framework against which data could be gathered and analysed. They were investigated using INCIDE, the operational definitions of the variables (behaviours) being implicit in the tool and its use.

The research is exploratory, rather than looking for effects caused by the application of a 'treatment', and so not all the threats to construct validity listed in Table 8.1 apply. However, six potential threats remain in the research.

(1) Inadequate preoperational explication of constructs
In fact, a lot of work had been done on explicating the construct 'continuous improvement'. Chapter 2 describes the process of model development which resulted in the CI Capability Model. This model came from grounded theory which the researcher was deeply involved in evolving. At the start of this research, the NPD context was explored in detail, in terms of different processes and of good practice (Chapter 3). Subsequently, a detailed examination of CI within the NPD context created a framework for conducting the case work (Chapter 4).

(2) Mono-operation bias
Although there was much analysis of the concept of CI, there was less on how it could be operationalised, though experience from earlier work mapping the CI behaviours in a general context was carried over into this research and informed development of the investigation tool, INCIDE (see Chapter 4, Section 4.4).

The largest strand of this research was the case work, involving detailed interviews in two firms. For this work CI was operationalised in terms of the nine key behaviours via INCIDE. However within the research, though not within the case work, other representations of CI were used. In the case of the workshops, delegates were given a verbal description of CI based on the definition above ("an organisation-wide process..."). The survey defined CI in writing as "a systematic attempt to involve all employees in incremental improvement".

(3) Mono-method bias
The adoption of a multi-methods approach, involving detailed company cases, a survey and workshops, counters this potential threat.
(4) Hypothesis-guessing within experimental conditions
Although the research was exploratory and not experimental this threat was latent, in particular in the case work. It was probably very obvious to interviewees what the researcher was looking for and this may have influenced their responses, either consciously or subconsciously. However, conducting multiple interviews within each firm, and obtaining supporting documentary evidence where possible, should have reduced the likelihood of including inaccurate data in the analysis.

(5) Evaluation apprehension
This threat was latent in the research design, in both the company cases and the survey. However, survey respondents were able to remain anonymous, thus reducing the motivation to report more progress etc. with CI than had in fact been achieved. During the case work, it was made very clear to each interviewee that the interviews were not part of an evaluation process; the researcher stressed the need for honest replies and confirmed that no one other than the interviewee would see the notes of his or her interview. Despite this, it is possible that some people may have wanted to create a good impression to the 'outsider', particularly if they had responsibility for CI, employee involvement, or other of the issues covered by the interviews. Again, the use of multiple interviews within each firm would have helped to highlight misleading responses.

(6) Experimenter expectancies
Although this research was not experimental, and did not involve delivering a 'treatment' to respondents, researcher expectancy was a potential threat to validity of the case work. The researcher was hoping to find evidence that would shed light on the research question, and this may have influenced the data provided by interviewees, or the way in which it was analysed. However, confirmation of the case analyses by the companies involved suggests that researcher expectancy did not distort the findings.

The research design mitigates against these six threats to construct validity. However, since construct validity is particularly important for exploratory research the researcher decided to check the way in which the concept of CI was operationalised. In other words, to ask 'Is the use of the behavioural framework appropriate to investigate CI within the NPD context?' This question was addressed by conducting a test of face validity, in which industrialists with experience of NPD were asked to review and critique the framework. The test is described in Sections 8.3.2 and 8.5 below.

External validity
This research set out to explore the application of CI within NPD processes. The only limit put on the context, 'NPD processes', was that the development takes place 'in firms'. There were no restrictions in terms of industrial sector, type of product, scale of development, etc. The area under investigation was left wide open deliberately, for two reasons. First, the topic of CI within NPD was
relatively uncharted and this research intended to open up the whole area. Second, the conceptual framework guiding the research indicated that CI was applicable in any development organisation.

The threats to external validity relate to participant selection, the research setting, and the circumstances prevailing at the time the investigation took place. Each of these threats is a concern in the present research: the case work took place in two firms only and at a single period in time, and neither the survey or workshops selected participants in a manner to allow generalisability. Moreover, the companies and individuals involved were all predisposed to participate. However, the exploratory nature of the work make these shortcomings less critical than would otherwise be the case.

Three models to increase external validity were described above. The third of these, the 'impressionistic modal instance model', most closely describes the approach taken by the present research. The framework guiding the research suggested that CI was applicable in all firms doing NPD regardless of size, type of product, ownership etc. In setting up the case work, the researcher did not attempt to focus on any one of these dimensions and select a firm representative of each possible variation. Instead, two companies which differed in many aspects were chosen. The workshop delegates and survey respondents also represented different company settings, but were not selected in a deliberate manner.

As noted above, replication can be used to increase the external validity of research conclusions that are based on generalisation at a theoretical level. This approach was adopted as part of the validation process for this thesis. A further two firms, which differed from the original case companies in many respects, were investigated to examine whether CI is, or could be, applied within their NPD processes. This validation test is described in Sections 8.3.1 and 8.4 below.

Internal validity
Although the thesis identifies potential aids and barriers to the implementation of CI within NPD processes, and suggests that there may be certain enablers which can help to institutionalise the concept and practices of CI within NPD, it does not attempt to prove causal relationships. The present research describes an associative, rather than causal, relationship between CI enablers (and disablers) and CI behaviours. In other words, within the framework of the CI Capability Model, the researcher looked for the presence or absence of CI enablers and CI behaviours, but did not seek to establish whether the latter were dependent on the former. From this it follows that the main threat to internal validity latent in the study is the drawing of incorrect inferences from the data gathered. This could lead the researcher to conclude, for example, that enablers or behaviours existed when in fact they did not, or to fail to identify the presence of enablers or behaviours. This threat does not appear to have materialised. The analyses of the case data in terms of CI behaviours and enablers, which were presented in Chapter 6, were sent to the companies involved
for validation. In neither case were any modifications required to statements made about the presence or absence of behaviours or enablers.

The two workshops contributed data on enablers and disablers of CI within NPD processes. In terms of threats to validity, the integrity of these data may be affected by the accuracy of the delegates' comments and the extent to which they were based on experience or on unfounded assumptions. However, the validity of the workshop outcomes concerning factors helping or hindering CI within NPD is supported by their similarity to the findings of other researchers (see Chapter 7, Section 7.5).

Throughout this section the exploratory, descriptive nature of the research has been stressed. However, one of the research sub questions implies a causal relationship: If firms are applying CI to NPD, do they benefit from doing so? This question was addressed most directly in the survey, with respondents being asked about the impact of CI performance on NPD cycle time. However, as the critique in Chapter 5, Section 5.5.2 indicated, the question was poorly framed and the responses need to be treated with caution. The impact of applying CI within NPD processes would repay further investigation.

8.2.4 Conclusion

This section has highlighted the threats to validity latent in the research and shown how most of them were dealt with by the original research design. Of the remaining threats, the two of most concern are the threat to construct validity posed by the way in which the concept of CI was operationalised, and the limits to external validity arising from the low number of companies involved in the research. The rest of this chapter will describe the steps taken to test for these threats.

The preceding discussion has also flagged two areas worth investigating in future research, namely, the causal relationships between CI enablers and CI behaviours, and the impact of applying CI within NPD processes.

8.3 Validation methodology

Two methods were used in the validation process. First, interviews were carried out in two more companies in order to test, in particular, the external validity of the conclusions made regarding the practicability, scope and institutionalisation of CI in NPD (C.2, C.3 and C.5), and to further test the usability etc. of INCIDE (C.6). Second, in a test of construct validity, a workshop was held at which the opinions of 'experts' in the field were sought on the model (C.7), and on all the conclusions
except C.6, which relates to INCIDE. The conclusions that the interviews and the workshop were primarily intended to validate are indicated in Table 8.2.

<table>
<thead>
<tr>
<th>Research conclusion</th>
<th>Validation method</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.1 In theory there is scope for CI in NPD.</td>
<td>Interviews</td>
</tr>
<tr>
<td>C.2 CI can be applied to the NPD process in practice but firm evidence of tangible benefits of doing so is, as yet, inconclusive.</td>
<td>•</td>
</tr>
<tr>
<td>C.3 The potential range of application of CI within NPD is wide, but there may be some areas where limits are found.</td>
<td>•</td>
</tr>
<tr>
<td>C.4 There are factors or characteristics which work in favour of CI in NPD and others which work against it.</td>
<td></td>
</tr>
<tr>
<td>C.5 There may be certain enablers which can help to institutionalise the concept and practices of CI within NPD.</td>
<td>•</td>
</tr>
<tr>
<td>C.6 The INCIDE tool is reasonably effective, efficient, usable and useful.</td>
<td>•</td>
</tr>
<tr>
<td>C.7 The analytical model for CI in NPD is useful in describing and explaining the application of CI within the context of NPD processes.</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.2 The methods used to validate the research conclusions

8.3.1 Company interviews

Interviews were carried out in two companies to validate certain of the conclusions, as shown in Table 8.2. The companies selected for this work, Concord Lighting Ltd and Hosiden Besson Ltd, were already known to the researcher. Both firms had experience of implementing CI, and both had overhauled their NPD process within the previous two years. However, the companies differed from each other, and from the two case companies, in many other respects, including industry, size, and ownership. A profile of the companies is given in Table 8.3. (In return for their cooperation, both companies requested reports on CI within their NPD processes.)

The interviews were carried out using INCIDE. Although the data gathered would not be analysed against the model, behaviour by behaviour, as had been done for the case studies, using the tool would provide an opportunity for further testing its usability etc., and would also generate sufficient data to write reports for the companies. When it came to analysing the data the focus would be on evidence which supported or contradicted the conclusions being validated i.e. C2, C3 and C5.
<table>
<thead>
<tr>
<th></th>
<th>Concord Lighting</th>
<th>Hosiden Besson</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership</td>
<td>US (Swiss up to August 1997)</td>
<td>Japanese</td>
</tr>
<tr>
<td>Number of employees</td>
<td>280</td>
<td>700</td>
</tr>
<tr>
<td>Number of staff engaged in design/development</td>
<td>16*</td>
<td>74¥</td>
</tr>
<tr>
<td>Main products</td>
<td>luminaires (for 'accent lighting')</td>
<td>telecoms equipment, mobile telephone products, alarm systems</td>
</tr>
<tr>
<td>Technical expertise</td>
<td>electro-mechanical</td>
<td>electro-acoustic</td>
</tr>
<tr>
<td>Main customer base</td>
<td>distributors world-wide</td>
<td>Original Equipment Manufacturers in telecommunications; distributors of fire alarms</td>
</tr>
<tr>
<td>Main driver of new products</td>
<td>replacement of existing products and filling gaps in product range</td>
<td>customers</td>
</tr>
<tr>
<td>Number of new products per year</td>
<td>8-9 (1997)</td>
<td>approx. 25</td>
</tr>
<tr>
<td></td>
<td>4-5 (budget for 1998)</td>
<td>(of which 3-4 are brand new products and 20+ are major changes/minor variants to existing products)</td>
</tr>
<tr>
<td>Average development time</td>
<td>1 year</td>
<td>6-8 months</td>
</tr>
<tr>
<td></td>
<td>(target is 9 months)</td>
<td>(range is 6 weeks - 18 months)</td>
</tr>
</tbody>
</table>

* Includes 2 Purchasing staff; the rest are different functions within Engineering. Of the 16, 11 serve as members of NPD teams. In addition, some Marketing staff are involved in NPD.

¥ Includes staff from sales, technical, quality assurance, manufacturing, engineering, and materials functions who are involved in NPD.

Table 8.3 Profile of the companies involved in the validation interviews

All the interviews were carried out during November 1997. At Concord, seven members of staff were involved, representing the main functions involved in NPD: Engineering (Design; Test & Development; Production Engineering), Marketing, Purchasing, and Quality Assurance. Nine employees at Hosiden Besson were interviewed drawn from the following departments: Development (2), Marketing, Project Engineering (2), Test Development, Estimating, Production, and Production Engineering. In both companies, some interviewees, but not all, had served as leaders and/or members of development teams.

The interviews were tape recorded. Each interviewee was sent the notes from his or her interview and asked to verify their accuracy and, in some cases, to clarify specific points.
8.3.2 Workshop

The second validation activity was designed as a one day workshop at which people working in NPD would be invited to discuss and comment on the research conclusions. To test construct validity, delegates' views would be sought on the appropriateness of the behavioural model within the NPD context. The occasion would also be used to see if the other conclusions stand up to 'experts' in the field. As Miles and Huberman (1994 p.278) note in their discussion of validity, a researcher needs to ask "Do the findings of the study make sense? Are they credible to the people we study and to our readers?". The data gathered during case interviews had already been checked for accuracy by interviewees. The workshop participants would be asked to comment not on individual cases but on the higher level conclusions drawn from an analysis of all the research activities undertaken in the course of developing this thesis.

Invitations were sent to the two case companies and to the companies in which the validation interviews had been held, as well as to approximately 50 members of a continuous improvement network, who might be expected to have interest and expertise in this area. The response was low and several last minute cancellations left only 3 delegates. Both the companies used for validation work were represented. The profile of the delegates in Table 8.4 shows that only two of the delegates had sufficient relevant experience to be considered 'experts' for the purpose of the validation exercise.

<table>
<thead>
<tr>
<th>Position</th>
<th>Experience of NPD (working in NPD in current company)</th>
<th>Length of time company has attempted to apply CI to NPD</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Director</td>
<td>26 years (8 years)</td>
<td>2 years</td>
<td>Led recent effort to streamline NPD process</td>
</tr>
<tr>
<td>Project Engineer</td>
<td>5.5 years (1.5 years)</td>
<td>1.5 years</td>
<td>Job includes responsibility for ensuring NPD process is adhered to</td>
</tr>
<tr>
<td>Production Planner</td>
<td>None</td>
<td>3 months</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.4 Delegates to the validation workshop

As a result of low attendance, the plan for delegates to work in two groups to discuss the issues and prepare arguments for and against the research conclusions (in order to encourage them to think about the research conclusions in depth and not to agree out of hand), had to be abandoned. Delegates were sent a copy of a paper on the subject (Caffyn, 1997) to read in advance, to help
reduce the time that would be needed during the workshop to explain the background and the concepts, and to start them thinking about their own experiences in this area.

The design was to present the analytical model and research conclusions, allow plenty of time for debate, and then ask the delegates for their verdicts. Several means were used to record delegates' views: note-taking of the points raised, back-up tapes (in case any details needed to be checked), a live 'vote' on each of the research conclusions, and a questionnaire. A copy of the questionnaire is given in Appendix 7. It is split into 3 parts which were given to delegates at different times in the day: Part A – experience of working in NPD; Part B – views of the analytical model; Part C – opinions on the research findings.

The researcher's role was to present the content, chair discussions and make sure the time-table was kept to. The delegates' role was to give their considered opinion on the research conclusions. A colleague of the researcher noted points raised during the discussions.

The workshop began with an introduction. This included brief résumés from delegates on their experience in NPD and CI, a short presentation on background to the research, a summary of key points from the paper distributed for pre-reading, and clarification of definitions of NPD and CI. The rest of the morning was given over to the analytical model for CI in NPD. The researcher explained the CI Capability Model, making sure delegates had a full understanding of the concepts used. She then elaborated on the model as it applies to the NPD context, suggesting how each of the behaviours might appear in practice, describing enablers to support the behaviour, and giving examples taken from the Ericsson case. The process was interactive, with delegates contributing to the discussion with comments and examples of their own experiences. In doing so they demonstrated an understanding of the concepts being discussed. At the end of the session, delegates were given parts A and B of the questionnaire to complete.

The afternoon session began with reiteration of the concept of CI maturity and a short activity which involved delegates plotting the maturity level they think their company is at.

The bulk of the afternoon was spent debating the research conclusions. First, the researcher explained what was meant by each of the research questions (as described in Chapter 7 Section 7.1). Then delegates debated each question in turn, and before moving on to the next question a 'show of hands' vote was taken on whether delegates answered Yes or No to the question. Next the researcher presented her answers to the questions, explaining why she reached the conclusions she did. Presentation of the researcher's conclusions was deliberately left until after the delegates had had a chance to discuss and present their own views. Delegates were then asked to complete section C of the questionnaire.
Finally, there was a brief discussion on future research in this area and the issues delegates would like to see investigated.

### 8.4 Results of validation cases

The interview data was examined for evidence that might support or contradict conclusions 2, 3 and 5. The conclusions were rewritten as questions to help focus this analysis. The questions and sub questions are shown in Figure 8.1.

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.2 Cl can be applied to the NPD process in practice but firm evidence of tangible benefits of doing so is, as yet, inconclusive.</td>
</tr>
<tr>
<td>Q2.1 Is there evidence that Cl is being applied to/is present in the NPD process in this firm?</td>
</tr>
<tr>
<td>Q2.1.1 Is there evidence of the presence of Cl behaviours?</td>
</tr>
<tr>
<td>Q2.1.2 Is there evidence of Cl enablers?</td>
</tr>
<tr>
<td>Q2.2 Is there evidence of benefits of applying Cl to the NPD process in this firm?</td>
</tr>
<tr>
<td>C.3 The potential range of application of Cl within NPD is wide, but there may be some areas where limits are found.</td>
</tr>
<tr>
<td>Q3.1 What evidence does the case provide about the scope of application of Cl in terms of:</td>
</tr>
<tr>
<td>• organisation size and industry;</td>
</tr>
<tr>
<td>• interfaces;</td>
</tr>
<tr>
<td>• level and function of personnel;</td>
</tr>
<tr>
<td>• individuals and groups.</td>
</tr>
<tr>
<td>Q3.2 Is there evidence of any limits (actual or potential) to the application of Cl within NPD in this firm?</td>
</tr>
<tr>
<td>C.5 There may be certain enablers which can help to institutionalise the concept and practices of Cl within NPD.</td>
</tr>
<tr>
<td>Q5.1 Does the case suggest any enablers which might support institutionalisation of Cl within NPD?</td>
</tr>
<tr>
<td>C.6 The INCIDE tool is reasonably effective, efficient, usable and useful.</td>
</tr>
<tr>
<td>Q6.1 Does the use of the tool in this case shed any further light on the degree to which it is effective, efficient, usable or useful?</td>
</tr>
</tbody>
</table>

Figure 8.1 Questions used to structure analysis of the interview data

#### 8.4.1 Concord Lighting

The NPD process in its present form is the result of a reform carried out about two years before this research took place, which streamlined the process and cut development times. The process now consists of three main phases: feasibility (up to the first development review); design and test (up to the second development review); tooling and trial production (up to manufacturing). More recently the company has started to use what are regarded as better tool makers. This change was triggered by the adoption of CAD technology, together with a realisation that cheapest is not always best. Other attempted improvements to the operationalisation of the NPD process, tried out
on a recent project, include involving the toolmakers and suppliers right at the start; and using a 'managed tool programme' whereby the supplier plans and manages the tooling programme. The development of teamworking is seen to have brought a number of benefits including increased cooperation, a lessening of the 'blame culture', and a wider understanding of what others are trying to achieve.

Q2.1 Is there evidence that CI is being applied to/is present in the NPD process in this firm?
There is no formal attempt to apply the concept and practice of continuous improvement, as defined in this thesis, within the development organisation in Concord. To date the main focus of CI activity in the company have been the assembly areas on the factory floor. The reform of the NPD process, which was largely forced by a reduction in staff numbers, resulted in the amount of time staff actually spent on NPD increasing from 30% to 70%. This was achieved by focusing on core activities and cutting out waste. The major change has not been consolidated by implementing CI. Although improvements continue to be made, they appear to be somewhat random and reactive. Senior management "hope" that people are having improvement ideas and are implementing them, but do not know if this is happening. During the interviews opinion was divided on whether people are encouraged to improve the NPD process, although the negative response was stronger.

Q2.1.1 Is there evidence of the presence of CI behaviours?
Although there is no formal attempt to apply CI, improvements are being implemented. The interview data reveals some activity in two areas represented by key CI behaviours in the analytical model: participation in incremental improvement, and cross-boundary working.

Despite the lack of formal encouragement to improve the processes they work with, people do appear to be making some improvements, both to the way they operationalise the NPD process and to particular work tasks undertaken to support that process: five interviewees described improvements they have made. However, it was generally felt that there is not as much process improvement as there could be, and it does not appear to be done systematically and continuously. The process tends to be changed only when it is seen not to work (rather than making a conscious effort to improve the process before a problem occurs).

Inter-functional working has improved with the greater use of multi-discipline development teams, though in some cases there is still a gap between engineering and marketing. Most striking is the close involvement with suppliers. The aim is to get the design right first time, and now suppliers' comments lead to changes in the design before it is released. Some of the recent process improvements concern the way Concord works with suppliers, and suppliers' requests to rationalise materials have prompted several ideas concerning the use of colours in designs.
As already noted, improvements tend to be in response to problems. However, everyone is aware of the development target of 39 weeks, and trying to meet it has led to improvements, for example, the earlier involvement of suppliers. There is no active leadership of improvement activity and while management is regarded as accessible and trying to move away from a blame culture, it is also accused of not always listening, or providing feedback to suggestions, or giving enough support to individuals and teams with ideas. Although there are no formal mechanisms for capturing the learning that is taking place, or for sharing it, it was claimed that quite a lot of informal (verbal) sharing of learning takes place within people's immediate workplace. In terms of attitudes amongst staff, there appears to be a mixture, with some people being open to change and wanting to do things better, while others are apparently unwilling to accept change or get involved in anything outside a very tight definition of their job.

Q2.1.2 Is there evidence of CI enablers?
There are no specific mechanisms or structures to encourage improvement to the NPD process, though several respondents referred to situations which might indirectly lead to process improvement. These include: encouragement to improve development lead time (which suggests that some process improvement will take place); letting team leaders change the process as they want, provided the product is there at the end; reduction in the number of staff working on NPD, which has forced streamlining of the process; and in the case of a Sourcing Agent, being responsible as part of his job for improving selection of suppliers. Two mechanisms with the potential to facilitate learning about the NPD process were mentioned: end-of-project reviews, and 'features' FMEA. For one product, an end-of-project review involving marketing, design and engineering staff, examined specific problems experienced during the project and led to process improvements for subsequent projects. A features FMEA involves examining the features described in the product brief and asking what is already known about them, for example, if a particular feature has given trouble in the past. It is then possible to share the work more evenly, start work earlier on features that are likely to be problematic, and identify an engineer who has particular expertise on a certain feature. However, both project reviews and features FMEAs are rare in practice.

Q2.2 Is there evidence of benefits of applying CI to the NPD process in this firm?
Improvements to the NPD process have led to a reduction in development time from three years, two and a half years previously, to one year. However, this cannot be attributed to CI. The improvement is the result of the one-off streamlining effort, and subsequent ad hoc changes. The

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35 FMEA – Failure Mode & Effect Analysis, a technique which involves the systematic examination of the ways in which a product could fail and the effect that such failures would have.

36 There are similarities between the features FMEA used in Concord and the stinker analysis process used in Ericsson (see Chapter 6, Section 6.5.2).
reduction in the number of design modifications is attributed to the much closer involvement with suppliers.

Q3.1 What evidence does the case provide about the scope of application of CI?

- organisation size and industry

Although Concord does not have a process of CI within NPD there are examples of process improvements, and potential enablers of improvement, that suggest CI could work in the Concord context i.e. a medium-sized firm working with electro-mechanical technology.

- interfaces

In Concord the engineering/marketing interface again emerged as a source of problems with scope for process improvements. For example, potential improvements mentioned by interviewees, but not yet implemented, included: making sure the team leader reports relevant outcomes of a team meeting to the marketing team member, if he or she was unable to attend; ensuring that marketing pass to engineering the results of their research so that engineering do not have to repeat the research at a later stage in the process.

The Concord case also demonstrates the scope for CI at the supplier interface, both in terms of actual improvements made and also the potential for further improvement. The Concord context is particularly relevant here. The company's production operation is an assembly shop, making it heavily dependent on the expertise of its suppliers. Several of the recent process improvements involve the suppliers. These include the implementation of 'Pentamode', which involves bringing in toolmakers and suppliers at the start of a project; and use of a 'managed tool programme'. The latter was suggested by the toolmakers and meant that the supplier would plan the tooling, manage the various aspects of the tooling programme, and provide regular updates of how it was progressing.

- level and function of personnel

The improvement ideas related by interviewees came from all functions involved in NPD, and from managerial as well as ordinary staff.

- individuals and groups

Many of the ideas appear to have been thought up by individuals, though some resulted from group activity, such as the end-of-project review into how the process could be improved.

Q3.2 Is there evidence of any limits (actual or potential) to the application of CI within NPD in this firm?

There was no evidence of potential limits to the application of CI within NPD in Concord. When interviewees were asked about possible barriers to improvement many of the usual items were
raised: lack of time to reflect on improvement; lack of feedback or action to suggestions; lack of motivation; reluctance of people to admit to mistakes; conflicting targets; entrenched attitudes; politics and personalities of senior managers. Although these obstacles can make it hard or impossible to establish a process of CI, they are not insurmountable, and they cannot be attributed to the context of the NPD process, or of this particular firm or industry.

Q5.1 Does the case suggest any enablers which might support institutionalisation of CI within NPD?
The case does not provide any evidence about enablers that might help institutionalise the concept or practices of CI within NPD.

Q6.1 Does the use of the INCIDE tool in this case shed any further light on the degree to which it is effective, efficient, usable or useful?
The tool is designed for carrying out semi-structured interviews. In some cases the interviewer had to use a number of sub questions to tease out the information required. This has the potential to reduce reliability (repeatability), if the tool was used by someone else.

8.4.2 Hosiden Besson

Hosiden Besson's current NPD process was formally launched in March 1996 after an organisational development intervention facilitated by external consultants. A deliberate attempt was made to involve staff in the design of this new process, and around 35 people from across the organisation, representing different levels and functions within NPD, took part a series of brainstorming sessions, discussion workshops, and small group activities (Bessant and Francis, 1997). The resulting process encompasses 7 stages, each culminating in a decision point or 'gate'. The procedure has since been modified a little in several areas, including changes to the paperwork in order to reduce the bureaucracy, and reorganisation of the project files. Although the new process is widely believed to be a good thing to have in theory, in practice there are many ways in which it does not live up to expectations, and much of the initial enthusiasm with which it was greeted has evaporated.

Q2.1 Is there evidence that CI is being applied to/is present in the NPD process in this firm?
The short answer to this question is – no. Several years previously Hosiden Besson had identified CI as having the potential to enhance business performance and help achieve its goal of creating sustainable profitable growth (Gallagher, Austin et al., 1997). A formal CI implementation programme began in 1994, a major plank of which was the introduction of teamworking. Despite this, it is clear from the interview data that CI, as defined in this thesis, is not being applied within the NPD process. Process improvements are made, but they appear to be ad hoc and largely the work of a few keen individuals, or the result of the 'process owners' (the Technical Manager and a
Project Engineer, the latter having specific responsibility for making sure the NPD process is adhered to) responding to complaints. There is nothing that resembles an ongoing, focused process of incremental improvement throughout the development organisation.

2.1.1 Is there evidence of the presence of CI behaviours?
None of the key CI behaviours is present to any degree, though there are examples of some in a rudimentary form, in the areas of making improvements, cross-boundary working, and learning from experience.

Although interviewees were very clear on the point that they are not encouraged to improve the NPD process, some described improvements they had suggested or implemented. For example, an engineer wrote a program which could measure the distortion problems on a particular product and collate the information, enabling the team to find out what was going on and solve the problems; the program is now used on other product developments. Another engineer estimated that there is at least one process improvement on every project. One interviewee claimed that he does consciously try to improve any problem he comes across, but that while there are others like this in the company, they are a minority. In general, it appears that people complain about the NPD process and leave it to the Technical Manager or Project Engineer to find and implement solutions.

There is one example of typical 'CI behaviour' which stands out as an exception. This is a project leader who has been systematically improving the process himself for his own projects, in order to achieve his personal goal of getting the product introduced into the market on time, to a cost and quality. He believes that there is a lot of scope for improvement and described several ideas he himself has implemented. However, this stands out as the only example of systematic process improvement.

In terms of working across company boundaries, some interviewees described the close cooperation and communication with certain key customers and suppliers. Internal communication appears variable, however, and while some suggest it is quite effective others express an opposite view.

Staff admit that not everything is shared ("there is a bit of parochialism"), though informally improvements and new ways of doing things may be passed on to colleagues, especially within the same department, by means of electronic mail, meetings and casual conversations. Learning is sometimes spread across departments verbally via members of development teams who may pass on things they have learnt while working on other projects. The learning and experience from previous projects is starting to be fed into subsequent projects early on. Several interviewees claim
that there is now more discussion of processes and problems, and one suggested that this might be the result of the introduction of CI four years previously.

On the other hand, there appear to be behaviours that work strongly against CI. For example, management has taken a deliberate decision not to measure the NPD process, so there is no quantitative feedback on how the process is performing and where it might be improved. Comments from two interviewees indicate discouragement to improve, claiming that if they question the process, or say something is not working, they are met with the response that they helped design the process, this is the process the company has adopted, and they must run with it and put up with the problems. Further, there is still a tendency to look for someone to blame for a mistake, rather than trying to learn from it and improve the process. Since people "do not like to name names" departments are blamed, which reinforces inter-departmental animosity. A fear of being "the one to rock the boat", amongst staff of all levels, right up to senior management, deters people from offering suggestions.

Q2.1.2 Is there evidence of CI enablers?
There are several potential enablers of CI but they are ineffective. The company's documented procedure for NPD includes learning and feedback loops, but these loops do not happen in practice. A mechanism was introduced to the NPD process to facilitate learning about the process: the Stage 6 Review. The idea was to encourage team members to reflect on the process they had just followed in order to develop the product, and identify learning points. Several interviewees commented that some quite good points came out of the Reviews that were held, and some of them were incorporated into the paperwork modifications. However, very few Stage 6 Reviews have in fact taken place, and there had not been any during 1997.

The Project Review form, which is supposed to be filled in by team leaders and given to the monthly NPD Executive Meeting, includes a comments section and invites project leaders to comment on the NPD process. However, the form had not been used in the six months prior to the interviews, and even when it had been completed people did not put forward suggestions or comments.

Q2.2 Is there evidence of benefits of applying CI to the NPD process in this firm?
As CI is not being applied to Hosiden Besson's NPD process, the case does not shed any light on this question.
Q3.1 What evidence does the case provide about the scope of application of CI?

• organisation size and industry

CI is not being applied within the development organisation at Hosiden Besson. However, as in the Concord case, the interviews reveal plenty of scope for systematic process improvement which suggests that the organisation's context need not be a bar to CI.

• interfaces

The nature of Original Equipment Manufacturer (OEM) business demands close liaison with customers, suggesting that the customer interface may provide particular scope for CI in firms which develop products for OEMs. At Hosiden Besson a number of improvements have been made to the process whereby products for a major OEM customer are developed, including setting up regular meetings between the Hosiden team and the customer.

• level and function of personnel

During the interviews various grades of engineering staff, as well as junior and middle managers, referred to improvements they had implemented or would like to make, suggesting that, given the right encouragement, there is scope for all levels of NPD personnel to become involved in CI. When the Technical Manager, acting in response to complaints, asked staff for ideas on how the NPD forms and checklists could be improved, suggestions were made by most functions including sales, marketing, quality and test.

• individuals and groups

Of the implemented improvements described by interviewees, a few were group efforts but most were the work of individuals.

Q3.2 Is there evidence of any limits (actual or potential) to the application of CI within NPD in this firm?

One interviewee commented that the "fluid nature" of Hosiden Besson's NPD procedure enabled him to be flexible in how he operationalises – and improves – the process. This highlights a potential limit on the application of CI within any firm seeking certification to internationally recognised standards (such as ISO9000). If the process is too rigidly defined in the controlled documentation it may be difficult (troublesome or bureaucratic) for staff to improve it incrementally without risking non-compliance.

Q5.1 Does the case suggest any enablers which might support institutionalisation of CI within NPD?

A Senior Development Engineer explained that part of his role is to enhance the way work is carried out, and to find what he thinks is the best way of doing a particular job. Inevitably this leads to improvements in the way development work is performed in his department. This example
suggests that writing process improvement into job descriptions as a recognised activity of the employee may be effective in helping to make CI an integral part of working life.

Q6.1 Does the use of the INCIDE tool in this case shed any further light on the degree to which it is effective, efficient, usable or useful?

It became clear at times that some interviewees thought the phrase 'improvements to the NPD process' referred solely to changes in the document detailing the NPD process. Care had to be taken to make them aware that the interviewer was concerned with improvements to any of the activities undertaken in the course of developing a product. A misunderstanding of this sort could potentially reduce internal validity, as data that is being sought may not be forthcoming. This in turn would lead to incorrect analysis of the situation. To avoid this pitfall, a revised version of the tool should include an introductory statement to remind the interviewer to explain very clearly at the start of each interview what is meant by the phrase 'NPD process'.

8.4.3 Conclusion

Neither Concord nor Hosiden Besson have CI within their development organisations, though both have made some progress implementing CI within production areas. Although certain individuals have made process improvements, neither firm has any effective CI enablers which might build on these early seeds. It follows that the cases cannot shed light on the benefits of applying CI to NPD. The evidence suggests that, within both companies, the NPD environment has the potential to support and benefit from a systematic process of CI. This reinforces the conclusion that CI may be applied to all types of firm, regardless of size, industry, and so on. These cases suggest that the nature of the business operation and what drives the development of new products may offer particular scope for CI. For Concord, a firm which designs, assembles and markets products, the relationship with, and service provided by, suppliers is extremely important. Hosiden Besson's development efforts are driven by large OEM customers, making effective working at the customer interface an important aspect of the NPD process. One potential limit on the application of CI within NPD is having too detailed a description of the NPD process in controlled documentation, making it harder for people to implement process improvements without the risk of non-compliance (of course, this would apply to any business process, not just NPD). The Hosiden Besson case also illustrates an enabler with the potential to help institutionalise CI: writing process improvement into job descriptions.

Finally, INCIDE again proved to be effective at generating data that can describe and explain CI within the NPD context. However, two potential problems were found which might affect reliability and internal validity. These could be addressed in a revised version, by including a definition of 'NPD processes' which the interviewer should discuss at the start of each interview, and by documenting the sub questions used to probe beneath the main questions.
8.5 Results of validation workshop

The intention of the workshop was to elicit the views of 'experts' on the research findings. As noted above in Table 8.4, one of the delegates had no experience of working in NPD and so cannot be considered an 'expert'. This section will therefore report the views of the other two delegates only (though in fact the views of the 'non-expert' delegate were very similar). It should be noted that these two delegates represent two companies involved in validation interviews. While they both have experience of NPD, and one of them worked for two years as a 'Cl Engineer', in neither of the firms is Cl being successfully applied within NPD.

8.5.1 Delegates' verdict on analytical framework

Both delegates agreed that the Cl capability theory, with the concepts of Cl behaviours and enablers, is feasible and makes sense. They were able to cite examples of behaviours and enablers in their own companies. The delegates also agreed that eight of the nine 'key Cl behaviours' are appropriate and relevant for the NPD context. One delegate was not sure about the behaviour 'People are guided by a shared set of values underpinning Cl as they go about their everyday work'; though the other delegate felt that this, too, was relevant. Delegates were asked if they felt that there were any other key Cl behaviours: one said no, the other did not answer this question. Both delegates agreed that the examples of Cl enablers for the NPD context seemed appropriate and workable, one commenting that some enablers require significant effort to realise, and commitment from everyone. They also agreed that the concept of companies moving through different levels of Cl maturity made sense. During the early afternoon exercise delegates were able to place their firm's progress with Cl at a certain stage of the maturity model, and made unprompted comments which acknowledged the developmental approach inherent in the model.

8.5.2 Delegates' verdicts on research conclusions

Both 'experts' indicated on the questionnaire their agreement with each of the research conclusions. They made the following additional comments, either on the questionnaire or during the discussion.

(1) The application of 'continuous improvement' to the process of NPD is appropriate in theory.
   • Yes, especially if it is used to support departmental or company objectives.
   • A lot of the thinking behind Cl applies to NPD, but Cling [sic] the NPD process is very difficult, in theory and in practice.
   • Cl enablers can strongly affect NPD behaviours. However there are other ways of triggering those behaviours.
• In theory people see the value of combining CI and NPD but in reality there is a conflict between speed to market and capturing learning. In the short term people have to get things out quickly. Asking them to use tools, discuss, capture learning, etc., takes time.
• CI can be a disabler in NPD. On one side, you're trying to speed up the NPD process, and your objectives are the short-term delivery of projects and targets, whereas CI is based on developing more long-term, ingrained behaviours.
• An argument for a 'No' answer would be, concurrent engineering will probably get you the benefits the company is looking for.

(2a) CI can be applied to the process of NPD in practice.
• Yes, just because it's difficult it doesn't mean it's not possible or not right.
• You must be careful you aren't taking resource away from developing product, which is your core activity. You must invest some time with a view to saving time in the long term.
• Co-location or working in cross-functional teams can start the [CI] process. As a result of using cross-functional teams in the company, sales became involved in the process and are more aware of internal problems caused by customer demands.
• An argument for a 'No' answer would be, you have to cut across such a range of processes and boundaries, and engage the support of so many people.

(2b) Firms probably benefit from applying CI to the process of NPD.
• Measurement is key here. Without a measurement system, how do you know if you've improved or that the company will see any benefit.
• If you use it to meet some of the company's objectives there is a benefit, or if it makes work easier which leads to happier people. But if you spend more time on the process than on the product, the benefit is lost.
• This delegate believes he has gained some benefits in time-to-market and product reliability, and has highlighted areas that need more work, such as early supplier involvement – but he has done this without applying CI.

(3a) The scope for applying CI to the process of NPD is broad, in that CI can be applied to development processes in a wide variety of firms, regardless of size, industry sector, technology and type of product.
• National boundaries, languages and cultural differences can influence the scope of applying CI in the NPD process.
• If the product development is split across different countries it might be more difficult.
• CI applies across the board unless you are a one-man band.
(3b) There may be some limits to the application of CI within NPD.

- Timing of projects. The sporadic nature of learning, and therefore the capture of that learning, may limit the scope of CI within NPD.
- There are resource limits.
- Is the limit where you have to force someone to do something?

(4) Certain factors or characteristics of the NPD process work in favour of CI in NPD and others work against it.

- Cross-functional teams work for it, whilst [the need for] speed and [lack of] time work against it, in people's minds rather than in fact.
- Needs majority acceptance or else could be negative. Improvement environment should assist with motivation.
- Measurement is difficult – there are outside influences [e.g. customer decisions or actions] which might change the goal posts.
- Measurement [of development time] is problematic when you are a 'middle' part of a process, and very dependent on functions and customers outside the immediate work organisation.

(5) There are some 'enablers' which could help to institutionalise the concept and practices of CI within NPD.

No relevant comments

Most of these comments are supportive of the research conclusions. In several instances a delegate proposed what a counter argument might be, showing that the participants were thinking the issues through and not simply acquiescing with everything put to them. The comment (under (1) above) that "CI enablers can strongly affect NPD behaviours" supports internal validity, and goes beyond acceptance of an associative relationship between enablers and behaviours by suggesting a causal link. The delegates' unanimous agreement with the research conclusions, reinforced by these comments, strengthens the validity of the thesis.

8.5.3 Future research

Delegates proposed the following topics for further investigation.

- Enablers to help communication.
- The cost (in time) vs. benefits of applying CI.
- Measurement systems which are suitable for the NPD context and also facilitate CI.
- Template of how to implement CI (to avoid reinventing the wheel).
- How to give CI new impetus if it is going into decline.
8.5.4 Conclusion

The two 'expert' delegates support both the usefulness of the analytical model, and the conclusions this thesis makes about the application of CI within the NPD context. This allays some of the concerns raised in Section 8.2 concerning construct validity and internal validity. However, it would be improper to claim that the thesis is now validated, because of the low numbers involved. Further testing of the research conclusions against the opinions of 'experts' in the field would need to take place in the future.

8.6 Discussion

These validation activities go a little way towards testing the arguments this thesis makes. The 'experts' at the workshop support the research conclusions, but the small number of delegates limit the weight that can be given to this. The interviews shed less light than hoped for on the research conclusions, largely because neither company had established what this thesis would define as a process of CI within its NPD organisation. That they had not achieved this, despite both trying for several years, does not necessarily mean CI cannot be applied to NPD. Their lack of success implementing CI appears to stem from the same causes that are often found in a manufacturing context, such as lack of leadership and insufficient emphasis on learning. Nevertheless, the interviews do give rise to some interesting points.

Although CI, as defined in this thesis, is not present within the development organisation at Concord, interviewees were able to report a number of process improvements made by themselves or colleagues. Also, as noted above, cross-boundary working is improving, both within the firm and externally. The changes made, although seemingly ad hoc and reactive, have contributed to the reduction in development times and to better design quality. On the one hand, this could be seen to challenge the view of CI presented in this thesis, which argues that a wider range of key CI behaviours must be developed in order to generate and sustain a process of focused improvements. Perhaps it is possible to achieve ongoing process improvements without all nine key behaviours. On the other hand, however, it could be argued that the lack of key CI behaviours is a weakness, holding back the rate of improvement. If CI were consciously encouraged (formally or informally), and targeted on specific objectives (such as the nine months target for development), then greater benefits might be achieved, and sooner. In the present climate, whether improvements are suggested and implemented depends on individual employees, some of whom display a natural tendency towards improving the processes they work with, while others are content to leave things unchanged. The lack of enablers to encourage and structure widespread, systematic reflection, learning and improvement may be leading to many lost opportunities.
Hosiden Besson has attempted to extend CI from production, where it was first implemented, into NPD. It has put in place at least two enablers to try to stimulate CI, the Stage 6 reviews and the project review forms. However, neither of these has been used much. Although some of the interviewees expressed strong support for the concept of CI applied to NPD processes, there are clear obstacles which are deterring the practice of CI. The lack of success implementing CI within NPD may be caused partly by the lack of effective enablers, and partly by the effect of powerful disablers, including the lack of management backing for CI. The relationships between enablers and disablers, and the influence they have on each other and on CI, is an issue worth investigating further.

In both Concord and Hosiden Besson, the interviews reveal some low level activity in the areas of making improvements and cross-boundary working. The fact that in both firms the same two CI behaviours have some presence, however weak, may suggest something about the sequencing of the CI behaviours. The analytical model states that there are nine key behaviours which all develop over time. It does not attempt to sequence them or suggest interdependencies. Perhaps these two behaviours are the most 'natural' i.e. close to the 'usual' way of working in a development organisation. Also, they are less dependent on active management support or involvement than some of the other behaviours. Thus perhaps generating involvement and improving cross-boundary working might be areas to focus on at the start of CI implementation, building on what may be occurring already. However, companies should pay particular attention to Behaviour 4 ‘Managers at all levels display active commitment to, and leadership of, CI’ before encouraging some of the other behaviours which imply more management involvement, such as focusing improvement on strategic objectives, and promoting the spread of learning.

Although both Concord and Hosiden Besson have made some progress implementing CI within their production areas, neither has repeated this within the development organisation. There are various possible explanations. First, both firms have been focusing on CI in production areas for longer. Second, most of the examples of successful CI implementation within manufacturing that have been written about concentrate on production. When more is reported about CI within the context of development processes, the firms may be able to learn from other companies' experiences, and senior managers might offer more support to extending CI within NPD. A third possible reason is, of course, the NPD context. The discussion in Chapter 7 highlighted characteristics of the NPD process which pose particular challenges to implementing CI in this part of the firm, though it also noted other features that might aid implementation. It is clear from these cases, and from the comments of workshop delegates, that while the application of CI to the NPD process is seen as desirable, the big issue is how to move from theory to practice.
8.7 Conclusion

The activities described in this chapter were designed to test and validate the analytical model for CI within NPD described in Chapter 4, and the research conclusions discussed in Chapter 7. The workshop results give support to both the model and the conclusions though, as noted above, the number of 'experts' who participated was disappointing. The outcome of the case work is a lot less clear, and opens up further avenues of debate rather than providing firm evidence in support or contradiction of the conclusions.

The lack of a systematic application of CI within NPD processes in either of the validation case companies appears to undermine the conclusion C2 'CI can be applied to the NPD process in practice...'. Interestingly both the 'experts' at the validation workshop, who came from these companies, agreed with the conclusion. Moreover, as we saw in Chapter 6, over a third (34.5%) of the survey companies claim to apply CI frequently to the process of NPD. The situation is unclear. This confusion may in part be caused by a difference between espoused theory - what people claim they do, and theory in action - what they actually do. The evidence from the Ericsson case supports the conclusion, as do, to a lesser extent, the findings from the TM Products case. However, some companies may assert that they encourage and have a process of CI, and believe that they do, but they may not back up this intention with appropriate enablers / actions and the removal of disablers. So when they are subjected to the scrutiny enabled by the INCIDE tool, and compared against a very specific analytical model and a quite challenging definition of continuous improvement, we see little evidence of the CI behaviours. In short, it would be fair to conclude that in practice there is scope to apply CI to NPD, although firms may experience difficulties achieving this.

For the reasons just given, the second conclusion, C2, is revised to read:

C2 There is scope to apply CI to the process of NPD in practice, though companies may find it hard to achieve a thorough implementation and firm evidence of tangible benefits of doing so is, as yet, inconclusive.

The model will not be modified as a result of the validation activities. However, some of the points raised in the discussion should be noted for future work in this area, including:

- The definition of CI: Is it too rigid, implying a formality that may not always be necessary for successful CI?
- The explicit inclusion of disablers in the model.
- The sequencing of behaviours and their inter-dependencies.
- The relationships between the behaviours and various enablers and disablers.
The validation test has shown that some of the potential threats to validity described earlier do not appear to be present in the research. In particular, the way in which the concept of Cl was operationalised has not damaged construct validity. The test also suggests that the inferences drawn regarding the associative relationship between enablers and behaviours were correct, thus strengthening the internal validity of the thesis. Even so, further testing of the model and research conclusions is desirable. The threats to external validity were only partially addressed by the test, limiting the confidence with which generalisations may be made about the research findings. Future work could include a second consultation of 'experts', either via a workshop or a postal survey, and more company research. In order to generate evidence that more strongly either reinforces or contradicts the thesis, the firms chosen for this work should have a record of successful Cl implementation (in production and/or NPD).
Chapter 9 Conclusion

9.1 Introduction

This thesis set out to explore the scope for the application of continuous improvement to the process of new product development. In doing so it brought together the fields of CI and NPD which both have their own literature and research activity, but which had previously remained somewhat separated from each other.

The dissertation began by setting the scene for the investigation. The current context for NPD was discussed in terms of the need for firms to improve their NPD processes, with examples of how some organisations are attempting this, and the need for research into the area. Chapter 2 introduced the concept of CI, and examined in detail the CI Capability Model. This model presents CI as a set of generic behaviours which evolve over time and may be encouraged and supported by a wide range of contingent enablers. The third chapter reviewed the most significant NPD process models presented over the years and described what are currently considered ‘good practice’ approaches to organising and managing product development activities. This review demonstrated the multi-faceted nature of NPD, which would need to be taken into account by the present investigation. It also showed how both theory and practice have started to recognise the importance of applying learning and ongoing improvement to the process of NPD. Chapter 4 highlighted the areas of commonality between ‘good practice’ NPD and the CI behaviours, and reinterpreted the CI Capability Model in terms of the NPD context. Having argued for the extension of the CI concept to NPD in theory, the chapter described INCIDE, the tool developed to investigate CI within NPD in firms in practice.

Chapter 5 began by stating the rationale for following an inductive approach for this research. It then described the research strategy and showed how, following the preliminary investigation, pragmatism and opportunism led to the application of multiple methods: hypothesis generating workshops; a descriptive postal survey; and detailed case studies. A critical review of the methodology concluded that although the methods all had certain limitations, their degree of validity and reliability was such that, taken together, it should be possible to build a fairly accurate picture of the application of CI to the NPD process. The findings from each of the research activities were reported in Chapter 6, which also highlighted the implications each activity had for both the research process and the research content. Chapter 7 drew on all the sources used in the research to examine the application of CI to the NPD process. The discussion centred around six interconnected questions which addressed the appropriateness of the CI concept for NPD; issues of practicability, scope, implementation, and institutionalisation; and the suitability of the INCIDE
tool for this investigation. Finally, Chapter 8 discussed the threats to validity latent in this research and described two activities carried out to test for these threats, in order to validate the research conclusions and analytical model for CI within NPD. The validation cases and workshop indicated that some of the potential threats to construct validity and internal validity were not present in the research, but they only partially addressed the threats to external validity.

9.2 Summary of findings

The arguments and evidence presented in this thesis lead to the following conclusions:

- The application of CI to NPD is appropriate both in theory and in practice, though firms may find it hard to move from theory to practice.
- The scope for applying CI within NPD appears to be broad, in that CI has potential to be applied to development processes in a wide variety of firms, regardless of size, industry sector, technology, and type of product. However, there may be some areas where limits are found.
- Certain enablers may not only encourage CI behaviour but could help to institutionalise it.
- There do appear to be factors or characteristics which work in favour of CI in NPD and others which work against it and this supports other research reported in the literature.
- The analytical model for CI in NPD is useful in describing and explaining the application of CI within the context of NPD processes.
- The INCIDE tool is an appropriate instrument for collecting data to be analysed against the framework of this model, although it has some limitations as an assessment or evaluative tool.

The validation test was largely supportive of these conclusions. However, it only partially addressed the threats to external validity, thus restricting the generalisability of the research findings. It also opened up further avenues of debate and suggested areas which would benefit from more work, for example, to increase understanding of the essence of CI. There needs to be greater awareness within firms of what CI is and its place in the NPD process. However, the view of CI presented in this thesis is open to challenge – perhaps it is possible to achieve ongoing process improvements without all nine CI behaviours.

The model for CI in NPD and the INCIDE tool, taken together, provide the means to describe and explain CI within a company's development organisation. However, they do not have predictive power. Although the data generated by INCIDE allowed the researcher to describe the situation in each case company in terms of CI behaviours and enablers, and to understand the associative relationship between these variables, the tool design does not allow inferences to be made regarding causality. Further research is required to explore the relationship between CI behaviours.
and enablers, in particular to investigate the effect that certain enablers have on the behaviour of staff working within NPD.

9.3 Future research

During the course of the research and writing this thesis a number of areas which would merit further investigation became apparent. These were flagged in earlier chapters and are summarised in Table 9.1.

An outline for a research programme that would address most of these questions is depicted in Figure 9.1. The programme would begin with a survey, by postal questionnaire, of firms active in product development. The questionnaire would first establish whether the responding company has a recognisable process of Cl and, if the company does, it would be asked questions relating to measurement of Cl, benefits of applying Cl to NPD processes, characteristics of personnel groupings, and the relationship between enablers, behaviours and disablers. The findings of the survey would be used to help shape later in-depth case work. A selection of responding firms could be approached for follow-up interviews. These interviews would seek to verify responses given in the postal survey, and to probe certain issues further, in particular to uncover enablers with the potential to institutionalise the practice of Cl. Some of the companies taking part in these interviews might be willing to become involved in more detailed research.

The detailed, longitudinal case work could take two forms: observation and action research. For the former, case studies would be developed over a sustained period by researchers in regular contact with the firm. Data would be gathered by interview, observation, and documentation. The focus would be on the behaviours necessary for successful Cl within NPD, the applicability of Cl to different stages in the NPD process, and the impact of applying Cl to NPD processes. At the same time, action research could be carried out in other firms which are experiencing difficulties implementing Cl within NPD. The researchers would work with the firms to help them overcome the barriers to Cl within NPD and introduce effective enablers. The impact of implemented enablers could be monitored in such a way as to shed light on the relationship between enablers and behaviours, and the possibilities some enablers have for institutionalising the practice of Cl within NPD. In parallel with the longitudinal studies, and drawing on the learning emerging from them, spot cases could be carried out within a pool of companies to investigate Cl in different NPD contexts and issues of internal contingencies.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Research question</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Impact of applying CI within NPD</td>
<td>Does the application of CI bring measurable benefits?</td>
<td>Longitudinal study of cases plus survey</td>
</tr>
<tr>
<td>2. Applicability of CI to different stages of the NPD process</td>
<td>Are certain phases of the NPD process more or less suited to CI?</td>
<td>In-depth (2 or 3 year) study of several firms implementing CI within NPD</td>
</tr>
<tr>
<td>3. CI in different NPD contexts</td>
<td>To what extent is the potential and actual practice of CI within NPD affected by variables such as product complexity, frequency of new products, development cycle time, organisational structure, size of development organisation?</td>
<td>Case research among a pool of companies</td>
</tr>
<tr>
<td>4. Internal contingency at the level of the firm</td>
<td>How do different contexts and sub-cultures within a company affect the implementation of CI (e.g. NPD compared to production or administrative, functions)?</td>
<td>Case studies</td>
</tr>
<tr>
<td>5. The impact of personnel characteristics on implementation of CI</td>
<td>What differences (in style, approach, etc.) are there in implementing CI amongst a group of professionals compared with on the shop floor?</td>
<td>Survey followed by cases</td>
</tr>
<tr>
<td>6. Barriers to CI within NPD</td>
<td>What are the practical solutions companies can adopt to overcome barriers to CI within NPD?</td>
<td>Action Research</td>
</tr>
<tr>
<td>7. Relationship between enablers and behaviours</td>
<td>What is the nature of the relationship between CI enablers and CI behaviours?</td>
<td>Survey, Action Research</td>
</tr>
<tr>
<td>8. Enablers capable of institutionalising the practice of CI within NPD</td>
<td>Is it possible to design and implement enablers which lead to the CI concepts and behaviours becoming embedded in the NPD organisation?</td>
<td>Survey (by interview) followed by Action Research</td>
</tr>
<tr>
<td>9. Nature of CI</td>
<td>Is it possible to achieve a sustained process of CI without all 9 behaviours identified in the CI Capability Model? Are there any additional behaviours necessary for successful CI within NPD?</td>
<td>Case studies</td>
</tr>
</tbody>
</table>

Table 9.1 Issues for further research
This programme would rely on the careful selection of companies for study. The present research, and the Crendon case in particular, has highlighted a number of factors that should be taken into account when deciding which firms to approach. These include:

- rate at which a company develops new products;
- degree of customisation;
- development cycle time;
- department/project orientation;
- external involvement in development;
- product complexity.

For example, if new products are few and far between it might be harder to map the process and to identify changes and improvements between developments. Although there may be fewer opportunities to apply CI to the process in this situation, as the process is not operating all the time, some of the key CI behaviours become even more crucial, especially the capture and application of learning. The degree to which the process is routinised or fluid might also be
affected by whether the product being developed will go into mass production or whether it is a bespoke product designed for a particular customer.

Lengthy cycle times might make it harder to gather data on process improvements (for example, personnel may forget how they carried out the same type of activity several years earlier). In the case of action research, it might be more difficult to assess the impact of an intervention, especially if that intervention is designed to facilitate the transfer of learning and process improvement between successive projects. In such cases it might be better for the researcher to focus on particular phases of the development process.

The degree to which development activities are organised on a departmental or a project basis would influence the research method, for example, in deciding who to interview, what to monitor, and what to take as the unit of analysis. If, as in the Crendon case, there is a high degree of external involvement in development (e.g. customers, suppliers, sister companies, regulatory agencies) the researcher should allow sufficient time to understand the relationships and interview external players.

Finally, product complexity has a bearing on all the listed factors. For example, a highly complex product will usually take longer to develop than one of moderate complexity and it is unlikely that a firm will be developing large numbers of such products simultaneously. The development of complex products often, but not always, involves more external players and results in one-offs or small production numbers.

These factors relate to different aspects of the context in which product development activity takes place. In terms of research, they could affect:

- comparability between cases and the extent to which generalisations may be made;
- the suitability of a company for a particular strand of the research;
- the time required to allow the researcher to gain a full understanding of the development organisation in a particular firm.

Thus the companies to be studied would need to be carefully selected, and the implications of the selection taken into account during the planning of the research (for example, in the time that would be needed to set up and conduct the necessary interviews, or to monitor the impact of an intervention).

**9.4 Conclusion**

This thesis has contributed to knowledge in two respects. First, it has explored the application of CI to the process of NPD, a combination which was relatively uncharted. It draws a number of conclusions concerning the applicability and scope of CI within NPD, and identifies areas for future
research. Second, the thesis has provided an analytical model to support the implementation of CI within NPD. The concepts in this model can help researchers understand and explain the operation of CI within the development context, and have the potential to aid NPD managers who wish to instigate or strengthen a process of CI.
Appendix 1: INCIDE – A tool for investigating CI in new product development processes

PART A: FOR PERSON IN CHARGE OF NPD

1. What are the company's main products?

2. How many new products are there each year?

3. On average, how long does it take to develop a new product?

4. How many people are involved in NPD?
   • Which functions

5. What is the company's policy and/or strategy for NPD?
   • Policy statement

6. Have there been any recent changes to the NPD process?
   • Why?
   • What was the broad direction of the change (see following questions also)?

7. How is the NPD process organised/managed in theory?
   • Company procedure

8. How does the NPD process work in practice?
   • Extent of cross-boundary communication and co-operation

9. How is the NPD process monitored?
   • What measures are used?
   • Who looks at the measures?
   • Is any action ever taken as a result of the measurement?
   • Is there any local process measurement i.e. of parts of the process on an on-going basis, as opposed to global performance measures

10. Who is responsible for identifying ways to improve the NPD process?

11. How could people working on NPD improve the NPD process incrementally i.e. if someone had an idea for improving the process what would they do with the idea?
12. Are people encouraged to come up with ideas for improving the NPD process?
   • Who encourages them?
   • How are they encouraged?

13. To what extent, if any, do people working on the NPD process suggest or implement ideas for improving the process?
   • Who has suggested improvements?
   • What was the outcome of such improvement suggestions?
   • Examples of improvements to the process

14. If people have made changes to the NPD process, do the changes reflect departmental or company objectives?
   • Is there a conscious attempt to improve the process in line with company objectives?

15. Are changes to the NPD process reactive (responding to a problem) or proactive (taking advantage of an opportunity for improvement)?

16. Who is responsible for implementing new ideas and changes to the NPD process?

17. How is the impact of changes / improvements to the NPD process monitored?
   • Who by?

18. What mechanisms / means are there for converting the learning arising from an improvement to the NPD process into the organisation's memory (e.g. standardising it)?

19. What mechanisms / means are there for sharing / deploying the learning (a) within and (b) between NPD projects?
   • Who is involved?
   • Formal or informal?
   • Examples

20. What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?

21. What could help people get involved in improving the NPD process in this company (i.e. enablers)?
PART B: FOR OTHER FUNCTIONAL MANAGERS INVOLVED IN NPD PROCESS (E.G. MARKETING)

1. What is your involvement in the NPD process (role, frequency)?
   • You personally
   • Your staff

2. How well does the NPD process work?
   • Extent of cross-boundary communication and co-operation

3. Who is responsible for identifying ways to improve the NPD process?

4. How could people working on NPD improve the NPD process incrementally i.e. if someone had an idea for improving the process what would they do with the idea?

5. To what extent, if any, do people working on the NPD process suggest or implement ideas for improving the process?
   • Who has suggested improvements?
   • What was the outcome of such improvement suggestions?
   • Examples of improvements to the process

6. If people have made changes to the NPD process, do the changes reflect departmental or company objectives?
   • Is there a conscious attempt to improve the process in line with company objectives?

7. Are changes to the NPD process reactive (responding to a problem) or proactive (taking advantage of an opportunity for improvement)?

8. Who is responsible for implementing new ideas and changes to the NPD process?

9. How is the impact of changes / improvements to the NPD process monitored?
   • Who by?

10. What mechanisms / means are there for converting the learning arising from an improvement to the NPD process into the organisation's memory (e.g. standardising it)?

11. What mechanisms / means are there for sharing / deploying the learning (a) within and (b) between NPD projects?
   • Who is involved?
• Formal or informal?
• Examples

12. What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?

13. What could help people get involved in improving the NPD process in this company (i.e. enablers)?

PART C: FOR PEOPLE INVOLVED IN NPD

1. What is your job / role in NPD?
   • How long have you been doing this?

2. How well does the NPD process work?
   • Extent of cross-boundary communication and co-operation

3. How is the NPD process monitored?
   • Do you use any local measures yourself?

4. Are you or your colleagues encouraged to improve the NPD process?
   • Who by?
   • How?

5. Have you ever had an idea for improving the NPD process?
   • How often?
   • Examples
   • What do you do with your improvement ideas?
   • Who implements your suggestions?

6. Do you ever consciously engage in resolving problems/hiccups with the NPD process, or seek to improve it in some way?
   • As an individual or a group?
   • Who instigates such activity?
   • What is the motivation for it? Any link to departmental objectives?
   • Examples
   • Do you follow a problem-solving or improvement cycle?
   • Do you use any tools?
   • Do you monitor the impact of any changes resulting from this activity?
7. If you learn something about the NPD process (e.g. how to do something more efficiently), or if you have implemented an improvement, individually or as part of a group, do you tell anyone else about it?
   - How is the learning you have undergone passed on to others?
   - Is the learning captured in writing?
   - Do you hear about changes / improvements other people have made to the NPD process?

8. What, if anything, gets in the way of you or your colleagues improving the NPD process?

9. What do you think could be done to encourage/enable people to improve the NPD process?

QUESTIONS ADDED TO THE SCHEDULE FOR THE ERICSSON INTERVIEWS

PART A
Questions 5 and 6 in INCIDE were removed. The following questions were added to the schedule.

Q. Please place yourself in the organisation chart.
   - Job content.
   - How long in the company
   - How long in present job

Q. What kind of decisions do you take in your job?

Q. History of NPD organisation and experiences
   - Original driver of change in the NPD organisation i.e. if there has been a change, what was the reason for it and who or what drove it?
   - Overview to date
   - Cross-functionality
   - Key explanations of achieved performance (good or bad)
   - Describe key organisational features which drive learning and performance improvement. Give examples.

Q. Picture of learning in NPD (how do you learn within NPD?)
   - Organisation of learning
   - Operation of CI/learning
   - Level of activity
Q. Are the employees at Ericsson Guildford continuously conscious of CI?

Q. Have you received any Cl/TQ training courses at manager level?

Q. Do you have precisely defined CI goals?

Q. How do you learn from one project to the next, and from projects which are running concurrently?
   • What mechanisms are used to capture experiences and by doing that to generate learning (e.g. audits, project reviews)?

Q. Learning of individuals and groups
   • Company attitude to training and employee development (who gets what)
   • Learning/development objectives
   • Extent to which people learn from positive and negative experiences (do the same mistakes recur?)
   • Extent of, and encouragement of, experimentation
   • Sharing of learning arising in course of work experiences by individuals and teams
   • How individuals and groups share their learning (formally, informally)
   • Communication / deployment of learning
   • Examples of learning being transferred across the organisation
   • Reaction of managers to the learning/recommendations made by individuals/groups
   • Attitude (of managers, peers) to mistakes
   • Company policy with regard to repeated mistakes

Q. Are there any cultural differences between Ericsson companies world-wide?
   • How do you handle these?

Q. Are there any common values at this site?

Q. What is morale like at this site?

Q. How is Ericsson doing compared to its competitors?
   • How have you reached your current level of performance?

PART B

The following questions were added to the schedule.
Q. Please place yourself in the organisation chart.
   • Job content.
   • How long in the company
   • How long in present job

Q. What kind of decisions do you take in your job?

Q. Describe the professional structure of your staff i.e. who works for you and what is their role/function?

Q. What is your involvement in the NPD process (role, frequency)?
   • You personally
   • Your staff

Q. History of NPD organisation and experiences
   • Original driver of change in the NPD organisation i.e. if there has been a change, what was the reason for it and who or what drove it?
   • Overview to date
   • Cross-functionality
   • Key explanations of achieved performance (good or bad)
   • Describe key organisational features which drive learning and performance improvement. Give examples.

Q. Are employees here continuously aware of CI?

Q. Have you received any CI/TQ training at manager level?

Q. How do you learn from one project to the next, and from projects which are running concurrently?
   • What mechanisms are used to capture experiences and by doing that to generate learning (e.g. audits, project reviews)?
   • How do you ensure mistakes are not recurrent?

Q. Learning of individuals and groups
   • Company attitude to training and employee development (who gets what)
   • Learning/development objectives
   • Extent to which people learn from positive and negative experiences (do the same mistakes recur?)
   • Extent of, and encouragement of, experimentation
• Sharing of learning arising in course of work experiences by individuals and teams
• How individuals and groups share their learning (formally, informally)
• Communication / deployment of learning
• Examples of learning being transferred across the organisation
• Reaction of managers to the learning/recommendations made by individuals/groups
• Attitude (of managers, peers) to mistakes
• Company policy with regard to repeated mistakes

Q. Are there substantial differences between approaches to NPD and to learning in NPD depending on, for example:
- size of project
- newness / uncertainty (entirely new product vs. revisions of "old")
- time constraints
- strategic relevance

Q. Are there any cultural differences between Ericsson companies world-wide?
  • How do you handle these?

Q. Are there any common values at this site?

Q. What is morale like at this site?

Q. How is Ericsson doing compared to its competitors?
  • How have you reached your current level of performance?

PART C

The following questions were added to the schedule.

Q. What is your job / role in NPD?
  • How long have you been doing this?
  • How long have you worked for Ericsson?

Q. What kind of decisions do you take in your job?

Q. How do you perceive projects have evolved over time?
  • Have you improved the way of working?
  • How?
Q. What are the attitudes of your manager and peers to new forms of working and to new ideas and suggestions for improvement?

Q. Are there any cultural differences between Ericsson companies world-wide?
   • How do you handle these?

Q. Are there any common values at this site?

Q. What is morale like at this site?

Q. How is Ericsson doing compared to its competitors?
   • How have you reached your current level of performance?
Extending continuous improvement to the new product development process

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As the benefits of applying continuous improvement (CI) are reported and the pressure on companies to improve their processes for new product development (NPD) increases, there is growing interest in how these two developments can be brought together. This paper presents a model for CI and suggests how it may be used as framework for looking at CI within the context of NPD. The final section raises some of the issues and challenges companies face as they attempt to extend CI to the NPD process.

Introduction

This article sets out to stimulate discussion of the issues involved in applying continuous improvement (CI) to the process of new product development (NPD). It begins with a brief overview of the NPD literature, looking in particular at where it refers to process improvement, as well as considering the recent debate on the role of organizational capabilities. This is followed by a description of a 'good practice' model of continuous improvement developed during a five year research project to investigate the application of CI amongst UK companies. Examples taken from one company involved with the research are used to illustrate how this model may be interpreted within the context of NPD. Then the features of NPD identified by practitioners as helping or hindering the implementation of CI are considered, together with strategies for generating CI in this part of the organization. The paper concludes by combining the implications of the CI model with the issues raised by practical experience to suggest guidelines for implementing CI in NPD.

Continuous improvement can be defined as 'a company-wide process of focused and continuous incremental innovation' (Bessant et al., 1994). The potential of CI has been effectively demonstrated in the Japanese experience of kaizen, and in recent years it has received considerable attention in the USA and western Europe as part of Total Quality Management (TQM) programmes. For a detailed review of the history and practice of CI see (Bessant et al., 1993; Bessant et al., 1994; Imai, 1987; Melcher et al., 1990; Robinson, 1991; Schroeder and Robinson, 1991).

For some companies CI has grown out of a major crisis or restructuring; in others it has followed on from previous initiatives, in particular TQM programmes; some, with no crisis and no previous Quality programmes, have recognized the competitive advantages that CI can bring. However, much of the effort of implementation has been in the operations side of the business, whether in a manufacturing or service organization. This emphasis is reflected in the research which has tended to concentrate on production processes rather than other business processes. In companies which have tried to implement CI throughout the organization, the greatest success tends to be in operational areas, with a much lower take-up in sales, marketing, R&D, accounts and other support functions.

New product development (NPD) is now a crucial concern for a growing number of companies. In many organizations issues such as time-to-market and customization are high on the agenda (Clark and Fujimoto, 1989; Hart and Berger, 1993; Pine II et al., 1993; Sasaki, 1991). Some companies have responded to demands to bring products to market ever more quickly and to meet
increasingly specialized customer requirements by modifying or re-engineering their process for NPD. However, a one-off change in the NPD process will not be sufficient, because the competitive pressures continue to intensify. There is a need to continuously monitor the NPD process and improve it, to enable the organization to achieve its goals in this area. This may sound obvious but it is only relatively recently that the need for on-going changes to the NPD process has been given greater recognition by academics and industrialists. Barclay’s review of research into NPD, published in 1992, found that ‘little has been reported on practical evaluation and improvement methodologies. Most of the methodologies that have been suggested are specific and not comprehensive. ….. They are, in effect, “one off” solutions that are not continuous, not taking into account future changes affecting the NPDP’ (Barclay, 1992). His own study of 149 UK firms found little evidence of continuous improvement of NPD methodologies.

Much of the research into NPD over the last 20 years has been product oriented, e.g. what makes for a successful product (Cooper, 1992; Johne and Snelson, 1988a; Johne and Snelson, 1988b), or looks at innovation at the level of the organization (Pavitt, 1991). The literature on NPD processes mostly looks at templates or blueprints for NPD (Cooper, 1988; Thomas, 1993) while more recently there has been work on particular aspects of the process such as project management, communication, rapid prototyping and simultaneous engineering (Costanzo, 1993; Pawaar and Riedel, 1993; Pearson and Ball, 1993). In considering what will shape the next generation of new product processes, Cooper (1994) looks beyond structures to the implications these more flexible and complex processes have in terms of, for example, risk taking, wider participation in decision making, and learning.

Existing models for NPD tend to describe the stages in the process, but do not include feedback loops for process learning i.e. how learning about the process that could lead to an improvement in its future operation may be incorporated into the company’s official NPD process. There is relatively little on using incremental innovation to improve the process of NPD (as opposed to improving a product) on an on-going basis, though some researchers have started to address this (Barclay, 1992; McKee, 1992; Wheelwright and Clark, 1992). More recently there have been studies focusing on the application of TQM practices to R&D (May and Pearson, 1993; Miller, 1995).

Against this background there is increasing emphasis on the need for companies to grow ‘organizational capabilities’ in order to survive in today’s highly competitive, ever changing business environment. Such capabilities have been described in terms of ‘core competencies’ which are formed by consolidating corporate-wide technologies and production skills, for example Sony’s capacity in miniaturization (Prahalad and Hamel, 1990). Other writers argue that capabilities are ‘more broadly based, encompassing the entire value chain’ and derive from business processes and organizational practices relating to, for example, communication and cross boundary working (Stalk et al., 1992). This view attributes Honda’s success to capabilities in dealer management and product realisation without which, it is argued, the company could not have achieved so much from its engine competence.

A broader definition incorporates both these aspects, with capabilities comprising a combination of technical competencies and business processes and systems (Leonard-Barton, 1995; Wheelwright and Clark, 1992). Leonard-Barton (1995) believes that capabilities grow through the actions of members of the firm, and she shows how companies can nurture capabilities by encouraging staff to engage in shared problem solving, integration of new methodologies and process tools, constant formal and informal experimentation, and pulling in expertise from outside. There is a danger, however, that core capabilities may become core rigidities, ‘inappropriate sets of knowledge’, which inhibit progress (Leonard-Barton, 1992). This is why it is so important for companies to find a way to continually improve and develop their core technologies and the business processes and systems through which they are co-ordinated and applied. Several writers have suggested how development projects can be used to create
and expand distinctive capabilities (Adler et al., 1989; Bowen et al., 1994; Leonard-Barton et al., 1994; Wheelwright and Clark, 1992). Like other organizational capabilities, 'in order to be a source of sustainable advantage, development capability must be continually expanded, upgraded, and improved' (Wheelwright and Clark, 1992, p. 311).

Thus the concept of distinctive capabilities has been discussed and developed in the innovation management literature, and there is growing recognition of the importance of capability as a source of strategic advantage. However, the debate is somewhat obscured by the lack of a common definition of 'capability'. The concept of capability is central to the model presented in this paper. To avoid any confusion over terminology it should be made clear that 'capability' in innovation management is taken here to refer to how companies manage the process of innovation — examples of distinctive capabilities might include the ability to produce new products more quickly than competitors, or the ability to manage complex projects. The term 'technological competence' is held to represent the accumulated knowledge about a technological area available to the firm, embodied in products and processes as well as in tacit form. So two companies may have a similar level of technological knowledge but deploy the competence in different ways, reflecting their different capabilities. Learning processes are critical to both accumulating technological competence and building innovation management capability. This interpretation of organizational capabilities is described more fully in (Bessant et al., 1995).

At the same time as the demands on the development process have increased there are a growing number of cases where improvements in speed and flexibility have been made in manufacturing processes as a result of applying CI principles (Bessant, 1992; Bessant and Caffyn, 1997; Locke and Jain, 1995). The question then arises, can similar benefits be achieved by extending the application of CI to the process of NPD and, if so, how can CI be implemented successfully in this area. Despite the growing interest in capabilities and increased emphasis on organizational learning, in which CI practices (problem solving, experimentation etc.) play a key role (Garvin, 1993), the application of CI to the NPD process remains largely unexplored. This paper proposes a framework for looking at CI within the context of NPD, as a first step in this direction.

A model of continuous improvement capability

The CIRCA (Continuous Improvement Research for Competitive Advantage) team at the University of Brighton has developed a model for building strategic capability in CI (Bessant and Caffyn, 1997; Caffyn and Bessant, 1995). This model has emerged from work over the last five years during which time the researchers have studied a range of companies in the UK in order to gain an understanding of the issues around the implementation and maintenance of CI. The methodology used falls into the category of 'action research' (French and Bell, 1990). This has entailed working in collaboration with a set of industrial partners drawn from the manufacturing sector, and contact of varying degrees with over 70 companies, representing many different industries, who have joined a continuous improvement network.

CI capability is defined as 'the ability of a company to gain strategic advantage by extending involvement in innovation to a significant proportion of the organization'. The elements of the CI capability model are shown in Figure 1. The model identifies ten key behaviours or 'routines' considered essential if CI is to be developed to its full potential in a company, though further research may reveal others. These are behaviours displayed by individuals and groups but they are closely linked to core abilities pertaining to the organization. So for example, the presence of the behaviour 'throughout the organization people participate proactively in incremental improvement' reflects, and is the result of, the organization's ability to 'generate sustained involvement in CI'. The core abilities and associated key behaviours are summarized in Table 1.
Both the core abilities and the key behaviours are generic, i.e. applicable to all organizations, and the model assumes that they must be present in any company aspiring to CI capability. The abilities have been observed in companies, at different stages of development. It is clear that where they are present a lot of effort has gone into cultivating and sustaining them. People in positions of influence have to work consciously at developing the abilities, and the degree to which the key behaviours are present demonstrates how successful they have been at doing this. Developing the desired behaviours is not easy. It is a long-term activity which involves 'unlearning' the old behaviours and practising and reinforcing the new ones until they become routine. Moreover, there are often many barriers or 'disablers', including existing procedures, practices and cultural values, which impede adoption of the new behaviours. For example, one disabler cited by many practitioners as obstructing efforts to implement CI is a highly competitive reward system centred on individual performance. In many companies this has negated attempts to encourage joint problem solving, effective communication and co-operation, and the sharing of learning. However, despite the difficulties, there are still many actions a company can take to help create or reinforce the desired behaviour patterns.

The research has identified a range of enabling mechanisms the use of which supports development of each of the core abilities and encourages the appropriate key behaviours. These enablers are an important part of a company's 'CI system', the latter comprising all the processes, procedures, subsystems and other forms of support put in place to foster CI. Enablers are contingent and vary between organizations, depending on the company's history, structure, prevailing culture, commercial environment, etc. Examples of enablers include problem-solving methodologies, facilitators, role models, legitimization of time spent on improvement activity, measurement systems, movement of staff between different functional or product areas. Some of the enablers appear to be critical, while others are less significant 'nice to have'. However, even the critical enablers (e.g. policy deployment) take many different forms, depending on the organizational context. Although the research has linked enablers to different key behaviours they have not yet been studied in detail.
Table 1. CI core abilities and their associated behaviours.

<table>
<thead>
<tr>
<th>Core abilities</th>
<th>Key behaviours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A The ability to link CI activities to the strategic goals of the company</td>
<td>1 Employees demonstrate awareness and understanding of the organization's aims and objectives</td>
</tr>
<tr>
<td>B The ability to strategically manage the development of the CI system* within the organization’s structures</td>
<td>2 Individuals and groups use the organization's strategic goals and objectives to focus and prioritize their improvement activities</td>
</tr>
<tr>
<td>C The ability to generate sustained involvement in CI</td>
<td>3 The CI system* is continually monitored and developed</td>
</tr>
<tr>
<td>D The ability to move CI across organizational boundaries</td>
<td>4 Ongoing assessment ensures that the organization's structure/infrastructure and the CI system* consistently support and reinforce each other</td>
</tr>
<tr>
<td>E The ability to enable learning to take place and to be captured and shared at all levels</td>
<td>5 Managers at all levels display active commitment to, and leadership of, CI</td>
</tr>
<tr>
<td>F The ability to articulate and demonstrate the CI values</td>
<td>6 Throughout the organization people participate proactively in incremental improvement</td>
</tr>
<tr>
<td></td>
<td>7 There is effective working by individuals and groups across internal and external divisions at all levels</td>
</tr>
<tr>
<td></td>
<td>8 People learn from their own and others' experiences, both positive and negative</td>
</tr>
<tr>
<td></td>
<td>9 The learning of individuals and groups is captured and deployed</td>
</tr>
<tr>
<td></td>
<td>10 People are guided by a shared set of cultural values underpinning CI as they go about their everyday work</td>
</tr>
</tbody>
</table>

* The 'CI system' comprises all the processes, procedures and enabling mechanisms put in place to encourage adoption of the key behaviours.

(though other research projects have examined certain enablers in isolation) and there is no full classification of enablers. However, the concept is important and works in the way presented here.

When enablers are first used the resulting behaviours will be at a superficial level. By repeated use of the enablers the behaviours of individuals, and the organizational abilities they reflect, gradually become more deep-rooted with people starting to behave naturally in that way. For example, during the early stages of implementing CI an insurance company asked everyone to examine the processes they worked with and seek to improve them. The response was minimal. Work teams were under tremendous pressure to clear a massive backlog of paperwork, and people felt uncomfortable about interrupting their work to 'sit around talking about processes'. So the company introduced the concept of Quality Time. This made it official policy for work teams to stop what they were doing for half and hour each Tuesday morning in order to work together on process improvement. As a result many people became involved in improving work processes. Eventually Quality Time fell into disuse, but by then people no longer felt guilty about taking time out to work on process improvement, it had become an accepted behavioural norm. Full CI capability is attained only when the behaviours have become so ingrained that they are enacted automatically.

Companies appear to pass through several developmental stages, or 'levels of CI maturity' as they move towards CI capability (see...
Sarah Caffyn

for example Atkinson, 1995; Clark, 1994; Sirkin and Stalk, 1990). The CI capability model proposes five levels:

Level 1 'natural' or background CI
Level 2 structured CI
Level 3 goal oriented CI
Level 4 proactive, autonomous CI
Level 5 full CI capability.

Observation of companies suggests that they move through the levels by building the core abilities and developing the key behaviours.

At Level 1 the organization does not have any of the core abilities, and none of the key behaviours is present. Although there may be some 'naturally occurring' improvement the company typically operates in 'fire fighting' mode, innovation is the province of specialists and what problem-solving there is occurs randomly. A company at Level 2 has some enablers in place and there is evidence that aspects of some of the key behaviours are starting to be enacted consciously. Enablers commonly introduced at this level include a problem-solving process, simple CI tools and training in their use, some form of idea management system, and some vehicles to encourage involvement (e.g. CI teams, proposal scheme). The CI system often operates in parallel to other business operations. At Level 3 the organization has mastered certain of the abilities, and the behaviours supporting these abilities have become the norm. The problem-solving taking place is directed at helping the company achieve its goals and objectives, there is effective measurement and monitoring, and the CI system is now in-line i.e. an integral part of operations. Enablers at this level include policy deployment and training in monitoring and measurement. By the time Level 4 is reached the CI largely is self-driven, with individuals and groups instigating activities, and seeing them through to completion, whenever an opportunity arises. Enablers of this sort of behaviour include a policy of 'empowerment' or devolution of control to self-steering groups, and training in more advanced tools and techniques such as Design of Experiments. At Level 5 the organization has the full set of abilities, and all the key behaviours have become ingrained routines. Many of the characteristics attributed to the 'learning organization' are present (Luthans et al., 1995; Nevis et al., 1995). Enablers might include the facilitation of internal and external networking, learning laboratories, and meaningful evaluation interviews.

Moving between levels is not automatic. To progress to a higher level the company needs to engage in a process of double-loop learning, to review progress and ask what changes are required to move the CI forward. It is not possible to make this transition simply by doing more of the type of behaviour associated with the stage the company is currently at. Take, for example, key behaviour 7 'There is effective working by individuals and groups across internal and external divisions at all levels'. At Level 2 this behaviour may be displayed to a limited extent by, say, participation in multi-discipline CI teams. At Level 3, however, we would expect a cross-functional approach to be part of 'normal' working, even if largely management driven (e.g. scheduled meetings attended by representatives from several functions, such as product development meetings and quality reviews). A Level 4 company would be highly integrated, with co-operation across boundaries being self-driven by all organizational members as and when necessary.

This model of CI capability shows plainly what an organization needs to focus on if it is to move from superficial CI to CI as an integral part of the 'culture'. With a clear vision of the abilities it needs to develop and the behaviours that need to be encouraged, a company can decide which of the many enablers available are most appropriate in the circumstances.

Continuous improvement within the NPD process

An aspect of the CI capability model is that as CI develops over time it extends increasingly across the organization. To achieve a strategic capability in CI a significant proportion of the organization must be involved in innovation. The full potential of CI will not be realized until the key behaviours are the norm in all areas and at all levels of the

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organization. It follows that although the emphasize is often on the operations side of the business, the principles and practices of CI should also be applied to other business processes. Here we are concerned with how CI is, or could be, applied to the process of new product development.

As noted above, according to the model the abilities and behaviours are generic and should be developed by all organizations aspiring to CI capability. Similarly they are applicable to all areas within the organization. However, just as the enabling mechanisms will vary between companies, so there may well be internal variations which take account of the different personnel groupings, experiences and sub-cultures within the organization. The following section provides some examples of how these elements of the model may be interpreted within the context of NPD.

Applying the CI capability model to NPD — some examples

To illustrate how the CI behaviours and enablers might look in the NPD context, we will now consider some examples taken from a medium-sized company in the south of England, Company A. This firm is engaged in the design, production and marketing of products for use world-wide. In the early 1990s it adopted a 'Total Quality' philosophy to introduce a more people-oriented approach that would complement the planning and implementation of MRPII. There are seven engineering staff working on PD and at any one time there are around 15 live PD projects, of which five would be major projects at various stages. The typical time-scale for a PD project is two years. Recently there has been a shift in emphasis to make more use of PD Teams. These are headed by a Project Manager (usually the Engineering or Marketing Manager) and, in addition to the engineer assigned (part-time) to the development work, usually include the purchasing director, a planner, and often a member of the quality department; the production supervisor is involved in some projects when they get close to production.

The first examples relate to the organization's ability to generate sustained involvement in CI (Core Ability C), which is demonstrated by the extent to which people participate proactively in incremental improvement. As part of the MRPII implementation, Company A set up a Business Improvement Team (BIT 20) to look at the management of new product introduction and integrate information relating to this aspect of NPD into the company at large. The BIT originally comprised the Marketing Manager, the Planner and the Product Engineering Manager. BIT 20 led to a lot of change but there were problems making it work, perhaps because individual engineers were not involved in designing the new procedure. Since then BIT 20 has expanded to about 8 members and although it meets less frequently it remains a channel for people's ideas about improving the NPD process. Thus in terms of the Cl Capability Model it is a potential enabler for CI. Other enablers of involvement in CI present in this company include: the leadership (by example) and encouragement of the Engineering and Marketing Managers, and of their boss; and monthly department meetings at which staff are encouraged to put forward improvement suggestions. The company has also provided a structure which emphasizes the value of ideas of all sizes and shows how they can be taken forward. The structure uses the analogy of a number of 'vehicles', for example, a 'bike' is for an idea which only requires the involvement of one or two people; a suggestion needing a team input implies a procedure on the 'car' scale; and so on, up to 'juggernauts' and down to 'skateboards'.

So how effective are these enablers in terms of encouraging participation in incremental improvement? There has not been a systematic application of CI to the core NPD process and procedures, though the NPD process flowchart does change from time to time as the result of improvements. However, staff have made small improvements relating to their everyday work as the opportunity has arisen, for example, doing a CAD system back-up in a different way; improving the documentation used for field trials to ensure they generate the information required by Marketing.

An improvement made by a Design & Development Engineer, a graduate in his first job who had been in the company ten months, provides a good example of an
incremental change that enhanced an aspect of the process. The engineer revised the form for instructing staff in the internal Laboratory so that it gave more information (e.g. when the samples are due, when test results are required). Previously the two laboratory technicians would have problems if several projects suddenly required a lot of testing at the same time, a situation made worse because they did not know what the priorities were. By improving the information given by engineers to the laboratory, the technicians were able to schedule their work better. However, it is notable that the engineer was prompted to make the change by complaints from the technicians. If there had been widespread involvement in CI the people complaining would have resolved the problem for themselves. Moreover, the engineer concerned admitted that although he will sort out something if it is not working, he does not actively seek out problems i.e. he does not engage in CI systematically or proactively.

In short, people do come up with ideas but not nearly as much as they could, and these ideas are implemented randomly rather than as part of a systematic process of improvement. According to the Engineering Manager, many of his engineers argue that their job is about improvement anyway, and that it is not repetitive and so not as suited to CI as the assembly process.

The second area we will consider in more detail is the company’s ability to move CI across organizational boundaries (Core Ability D) which is manifested by the Key Behaviour: ‘effective working by individuals and groups across internal and external divisions at all levels’. Cross-functional working at Company A has greatly improved in the NPD area with the use of Product Development teams, and the increasing involvement of purchasing, planning and production personnel, as described above. Communication and co-operation between the Engineering and Marketing departments is particularly strong — the Engineering Manager regards the Marketing Manager as almost his closest working colleague ‘in some respects closer than the engineers who work for me’. Marketing try to involve sales staff in NPD and keep them informed of new product developments (e.g. via quarterly sales meetings), but because the sales force is based in the field this can be difficult. The company is very open with its customers and has involved them heavily in product development (e.g. in field trials). Suppliers are sometimes involved in development project meetings, though more typically the project team’s deliberations are taken to the monthly Partnership meetings; there are also plans to involve suppliers in brainstorm discussions at the start of new projects.

An example of the close co-operation between Marketing and Engineering relates to an improvement in the forecasting process for the main brand. In the past year there had been so many projects under development it was difficult to keep up with the progress of all of them and to provide accurate information for the sales forecasting system by the date it was required. The Engineering Manager and the Product Manager for the brand concerned agreed to meet five days before the forecast had to be submitted, in order to update each other on what they were putting forward and to enable them to make more accurate forecasts. They discussed this idea informally and went ahead with it, intending to raise it at the next BIT 20 meeting so that the procedure could be formalized.

Another example illustrates improved working across external boundaries. The company requires approval from an industry research centre for all its products. The research centre can be very inefficient and the situation is not helped by the fact that after testing a product goes before a committee, which only meets once a month, for ratification. A particular product launched late in 1994 finally received approval six months after the launch date. A year later another product got the go-ahead four weeks in advance of launch. Two factors contributed to this improvement. First, Company A initiated the process earlier. Second, the engineers kept in much closer contact with the research centre throughout the testing phase. The Product Manager and Development Engineer built up a rapport with the research centre contact who consequently wrote to tell them that the product had passed the tests, even though the committee would not meet for a few weeks.

In this company the Engineering and Marketing Managers actively encourage their
people to work closely with colleagues in other functions, and with contacts in other organizations. The collaboration between Marketing and Engineering is helped by the close physical location of the two departments in the same building so that, for example, most days the Product Manager can 'pop down and informally pick up on what's going on'. The monthly Partnership Meetings with suppliers are another enabler of effective cross-boundary working.

These examples give an indication of how the key behaviours and enablers of the CI Capability model might appear in practice within the context of NPD.

**Extent of application of CI to NPD**

The move towards applying CI to the development process is relatively recent and, as yet, there is little data available on the extent to which companies are attempting to do this. Single cases have been reported, usually concerning large organizations, which illustrate how some companies are adopting a more systematic approach to ongoing improvement of the NPD process. For example:

- At Philips Electronics the Product Creation Process improvement project developed an assessment tool which acts as a catalyst for process improvement, and a structure for sharing the learning between different product divisions (Olthuis, 1997).
- Siemens uses the Time Optimized Processes (TOP) programme to streamline and improve processes. Within this the innovation initiative involves mobilising five 'levers for innovation': product, process, management and employees, information systems, and structure (Jahn, 1996).
- Continuous improvement was one of three strands in the Total Quality process implemented in Texaco's R&D department during the late 1980s (Archer et al., 1993).

A survey of UK manufacturing companies carried out in 1995 to investigate their use of continuous improvement found that in the majority of firms CI is applied less frequently to the process of NPD than to other aspects of the business such as manufacturing costs, manufacturing quality, and work methods (Caffyn, 1996). Even so, just over a third of the respondents (48 out of 139) indicated that in their organization CI was focused to some extent on the development process.

Continuous improvement often, but not necessarily, forms part of a TQM implementation. Two recent pieces of research have investigated the applicability of TQM and quality practices to the R&D function. Miller's study of 45 large multinational companies from North America, Europe, and Japan concluded that although the penetration of quality practices in R&D was uneven among the firms, the quality approach made a valuable contribution to efficient R&D management (Miller, 1995). Another study involving the R&D departments of 14 companies in the UK and Canada found that TQM was considered to be highly applicable to the R&D function (May and Pearson, 1993). Moreover the TQM initiatives, although only in the early stages, were held to be successful. In both studies the focus was the R&D function, and in the latter, R&D functions with a known interest in TQM were selected.

Both these studies into TQM and R&D highlighted characteristics peculiar to R&D and commented on how these might affect the adoption of quality practices. Similarly, in terms of the CI capability model, in order to help companies devise appropriate enablers to facilitate the implementation of CI within the development process it is first necessary to consider the features of NPD that might help or hinder implementation. This will be the focus of the remainder of this article.

**Practical issues — facilitating change and overcoming barriers**

The CI capability model implies that it is not only possible but necessary to apply CI to the process of NPD. Responses to a recent CI survey suggest that this is happening, and to good effect, but in a limited number of companies (Caffyn, 1996). The discussion now turns to the problems faced by companies attempting to extend the concepts and prac-
tics of CI to the part of the organization engaged in product development.

In 1995, during a workshop examining the application of CI beyond the manufacturing function, a group of six senior and middle managers from five organizations in the UK considered the issues involved (Caffyn, 1995). Specifically, they addressed three questions:

- What are the key differences, if any, between implementing CI on the shop floor and applying it to the process of NPD?
- What are the inhibitors and the facilitators to implementing and sustaining CI within NPD?
- What practical steps have you taken, or do you think could be taken, to generate CI within the NPD process?

A similar exercise took place in March 1996 during a workshop following the R&D Management Conference at the University of Twente in the Netherlands. Around 20 delegates from a variety of European countries took part in the discussions, about half of whom were from industry and half from academia. Working in three groups, participants were asked to debate aids and barriers to the introduction of CI in NPD, and to recommend enabling mechanisms that could be put in place to help reinforce CI behaviours. Delegates were briefed on the outcomes of the earlier workshop before they addressed the issues, in an attempt to build on the outcomes of the UK workshop and avoid 'reinventing the wheel'. As a result, many points were raised which had not been made during the earlier workshop and there was relatively little overlap between the two.

The points that emerged from both workshops have been combined and are given in Tables 2 to 4. The facilitating and inhibiting factors identified in these workshops include many of those noted by May and Pearson regarding the implementation of Total Quality Management in R&D (May and Pearson, 1993).

Table 2 shows the differences identified between implementing CI in NPD compared to manufacturing. Most of these relate to the nature of the NPD process and the difficulty of identifying appropriate measures. The NPD process is less tangible and involves longer time-scales than manufacturing processes, and it can be more difficult to define what the deliverable is. These factors, together with the problems associated with measurement (including how to measure 'quality' of the process and what the measures and targets should be), pose particular challenges for the implementation of CI within NPD. Cultural differences and the iterative nature of the NPD process may not make it harder to implement CI in this part of the business but suggest that a different approach would need to be taken.

The factors identified by delegates as helping and hindering the implementation of CI within NPD are listed in Table 3. Some of

Table 2. Implementing CI within the NPD process: differences compared to a manufacturing implementation.

<table>
<thead>
<tr>
<th>Key differences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tangibility</strong></td>
</tr>
<tr>
<td>• NPD is a more intangible process than manufacturing processes</td>
</tr>
<tr>
<td>• on the shop floor creativity is about improving something that is already there</td>
</tr>
<tr>
<td>• it is more difficult to define what the deliverable is</td>
</tr>
<tr>
<td><strong>Process characteristics</strong></td>
</tr>
<tr>
<td>• longer time-scales in NPD</td>
</tr>
<tr>
<td>• NPD is an iterative process</td>
</tr>
<tr>
<td>• culture in NPD is different from shop floor culture; has two aspects: creative vs. structured</td>
</tr>
<tr>
<td><strong>Evalutive frameworks</strong></td>
</tr>
<tr>
<td>• difficult to measure 'quality' of the process</td>
</tr>
<tr>
<td>• tendency to measure things that are easy to measure (e.g. time) which may not necessarily lead to the desired result</td>
</tr>
<tr>
<td>• problem in deciding what is the 'right' value to aim for with measurement</td>
</tr>
</tbody>
</table>

Source: CIRCA Workshop No. 12, June 1995, UK.
these could be classed as 'enablers' or 'disablers' in the terminology of the CI capability model. For example, post project evaluation and a policy of moderate turnover of staff on development teams are types of enabler. Existing formal procedures, standards and contracts may act as disablers if they prevent or discourage people from instigating change and improvement. The factors within the NPD area that could be mobilized to support CI fall into two groupings. First, delegates suggested a number of practices which take place, or could be instituted fairly easily, including ensuring an appropriate level of staff turnover in development teams, emphasizing the importance of post project evaluation, and motivating an interest in improvement by increasing awareness of customer and competitive pressures or possibly through the use of bonuses. The second group of facilitating factors relate to the people involved in the development process. Workshop delegates claimed that many NPD personnel are highly motivated, open-minded, technically competent and have high levels of numeracy and other relevant skills; as a result such staff might be receptive to CI and, once convinced of its merits, able to achieve a lot with it. Similarly, delegates identified obstacles to the implementation of CI within NPD which stem from the development process itself and from the reaction of the people involved. The former include tension caused by the conflicting needs of control and creativity; restrictions imposed by formal procedures and standards; inappropriate composition of development teams; and too high a level of turnover of team members. The measurement issue was also raised, notably the lack of metrics to stimulate proactive improvement as opposed to measurement which reports what has already happened and leads to reactive improvement. The potential barriers attributed to NPD staff, intellectual snobbery and a belief that it is not appropriate to measure their work, may perhaps be common to other 'professional' occupations. In

### Extending CI to the NPD process

<table>
<thead>
<tr>
<th>Table 3. Implementing CI within the NPD process: facilitating factors (aids) and inhibiting factors (barriers).</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Facilitating factors</strong></td>
</tr>
<tr>
<td>• a moderate level of turnover in development teams</td>
</tr>
<tr>
<td>• focus on post project evaluation</td>
</tr>
<tr>
<td>• customer awareness and links to the customer</td>
</tr>
<tr>
<td>• communication of threats resulting from increased pace of change and global competition</td>
</tr>
<tr>
<td>• bonuses (if based on the 'right' criteria)</td>
</tr>
<tr>
<td>• NPD staff are technically competent people, so if they can be convinced that CI will help beat the competition they may accept it</td>
</tr>
<tr>
<td>• once convinced, engineers may be strongly for CI</td>
</tr>
<tr>
<td>• highly motivated staff</td>
</tr>
<tr>
<td>• open-minded staff</td>
</tr>
<tr>
<td>• high levels of numeracy and other skills amongst NPD personnel</td>
</tr>
<tr>
<td><strong>Inhibiting factors</strong></td>
</tr>
<tr>
<td>• the differences listed in Table 2</td>
</tr>
<tr>
<td>• conflict between the need for restriction/control vs. the need for experimentation and creativity</td>
</tr>
<tr>
<td>• lack of measure points and performance indicators</td>
</tr>
<tr>
<td>• lack of parameters to prove the benefit of improvements</td>
</tr>
<tr>
<td>• lack of leading measures as opposed to lagging measures</td>
</tr>
<tr>
<td>• lack of formal planning system</td>
</tr>
<tr>
<td>• existing formal procedures, especially when used in R&amp;D facilities world-wide</td>
</tr>
<tr>
<td>• existing standards (may also serve as an aid)</td>
</tr>
<tr>
<td>• legal and safety implications</td>
</tr>
<tr>
<td>• existing contracts, employment legislation</td>
</tr>
<tr>
<td>• people being bothered with 'old problems' from previous generations of products</td>
</tr>
<tr>
<td>• team composition</td>
</tr>
<tr>
<td>• too much turnover in development teams</td>
</tr>
<tr>
<td>• intellectual snobbery — suggesting that there is scope for improvement is taken as implied criticism</td>
</tr>
<tr>
<td>• professional pride, the 'not invented here' syndrome</td>
</tr>
<tr>
<td>• people's dislike of being measured</td>
</tr>
<tr>
<td>• use of technology for its own sake</td>
</tr>
<tr>
<td>• NPD culture — engineers are paid to be sceptical</td>
</tr>
<tr>
<td>• company culture</td>
</tr>
<tr>
<td>• lack of common language</td>
</tr>
<tr>
<td>• fear of being made redundant</td>
</tr>
<tr>
<td>• lack of training in quality management</td>
</tr>
<tr>
<td>• lack of time to work on CI</td>
</tr>
</tbody>
</table>

Sarah Caffyn

the NPD context it was noted that engineers are paid to be sceptical and constantly question, and so were likely to challenge CI. A third group of inhibitors are not specific to NPD but might also apply elsewhere in the organization, for example lack of training in quality management and a fear of being made redundant.

Table 4 lists the practical steps participants suggested for generating CI within NPD and reinforcing CI behaviours. They fall into four categories: tactics for introducing CI; ways of motivating and winning over NPD staff to the idea of CI; ways to increase participation in CI; and changes to the structure of the NPD process which would make it more conducive to CI and to learning.

The tactics proposed for implementing CI in NPD are not NPD-specific and most of them are nothing out of the ordinary. They reflect the sort of actions companies are taking, and are often included in the prescriptions of management gurus and consultants. The suggestion to organize informal communication stands out as being less obvious. An example of what this might mean in practice, taken from a firm not represented at the workshops, concerns the company 'grapevine'. In this company there was a very active grapevine, and most people learned what was going on in the business from casual conversations and social chit chat. However, often the information people picked up like this was distorted or incorrect, giving rise to ill-founded rumours. The Quality Manager, realising what was going on, asked the two or three individuals at the hub of the grapevine if they would be willing to act as a conduit for accurate information about the business. They agreed and from

Table 4. Strategies for generating CI within the NPD process.

<table>
<thead>
<tr>
<th>Implementation tactics</th>
<th>Winning over NPD staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>• get a champion</td>
<td>• increase understanding amongst NPD staff of the whole business (multi-discipline teams help achieve this)</td>
</tr>
<tr>
<td>• look for small, easy to get successes (avoid early failures)</td>
<td>• get engineers to talk to peers in companies successfully practising CI in NPD</td>
</tr>
<tr>
<td>• improve communication in all directions</td>
<td>• make NPD staff more aware of the competition e.g. through competitive benchmarking</td>
</tr>
<tr>
<td>• organize CI as a project</td>
<td>• cast CI in a way to appeal to NPD staff — logical</td>
</tr>
<tr>
<td>• hold a start-up workshop</td>
<td>• show engineers that they can benefit from CI (e.g. share savings made, provide incentives)</td>
</tr>
<tr>
<td>• explain the need for CI</td>
<td>• focus on the 80% of the people who want to cooperate, fire the remainder (manager level only)</td>
</tr>
<tr>
<td>• start by giving a written agreement that no one will lose their job as a result of CI</td>
<td>• let people set their own standards</td>
</tr>
<tr>
<td>• provide training in improvement techniques and tools</td>
<td>Structural changes to the NPD process</td>
</tr>
<tr>
<td>• organize informal communication</td>
<td>• introduce rapid closed-loop feedback system (where the issue raiser not the designer signs it off as solved); log and deal with smaller and smaller problems</td>
</tr>
</tbody>
</table>

Increasing participation

• use process modelling — get engineers to model the process as they actually work it (i.e. not the documented process), and then identify how it could be improved
• encourage use of simple quality tools
• use simple internal measures that everyone understands, and display them
• provide a suggestion box with a facilitator
• recognize and reward people for their efforts
• develop concept of customer-supplier amongst NPD staff
• define and communicate common goals and objectives
• provide time and resources for CI
• adopt ISO 9000 'the open way'
• Company B has set up a new suggestion scheme which asks for product innovation ideas; this appeals to engineers
• Company R has an innovation fund to help people progress their ideas about a product or process

then on were kept informed of key developments and business issues. As a result, any news spread rapidly throughout the workforce — the ‘official grapevine’ proved far more effective than formal briefings.

Many of the proposed strategies for winning over NPD staff to the idea of CI and increasing their level of participation are also generic in nature and could apply equally to other business areas, for example, the use of simple quality tools and the provision of time and resources for CI. A few, however, do try and tackle some of the specific characteristics of the NPD area. These include presenting CI in a logical (rather than emotive) way which is more likely to appeal to engineers and scientists; and widening the horizons of NPD staff, who may be more insular than, say, marketing personnel, to give them a wider understanding of the business and the environment it is operating in.

Finally, delegates suggested a number of changes to the way the NPD process was operationalized in order to make it more conducive to CI. These include feedback systems for making sure problems are dealt with rapidly and completely; use of multi-discipline development teams, membership of which is fluid over time; increasing the decision-making authority of project leaders; and (unspecified) changes to the management system to ensure that it supports rather than hinders the spread of CI.

Conclusion

The preceding discussions of the CI Capability model and the challenges faced by companies trying to extend CI to NPD suggest a number of points that managers seeking to apply CI to areas working on product development should take into account.

- To start with, managers must really understand what CI is about. This paper has argued that CI is best thought of in terms of a set of key behaviours. This perspective can help guide managers in their approach to implementation. Instead of asking which of the gurus they would do better to first identify a limited number of behaviours they need to focus on developing, and then generate the processes and tools capable of fostering these behaviours.

- Another step managers would be advised to take before tying to implement CI is to recognize the possible blocks and barriers, or disablers, that CI may face within their own NPD organization. Although each company is different, the experience of a variety of firms suggests that there may be difficulties with, for example, identifying appropriate measurements, in dealing with the conflicting needs of control and creativity, and in winning over professional staff to the cause of CI.

- Having decided exactly what they are trying to implement, and forewarned of the possible pitfalls, managers should then develop a range of enablers to support the implementation process within NPD (i.e. to nurture the key CI behaviours). Some of these enablers may be similar to those used elsewhere in the organization, others may be applicable only to the NPD area. There may already be processes and systems within NPD that have the potential to support CI (e.g. post project evaluation and learning reviews), provided they are used to this end.

Although the same key behaviours must become the norm amongst NPD personnel as on the shop floor, the way in which CI is introduced and practised in the NPD area will be different. The characteristics peculiar to the NPD process and the personnel involved need to be clearly understood so that potential obstacles to CI can be mitigated and factors already present which are likely to ease its implementation can be built on. The paper has highlighted some of the key issues relating to this which require further investigation, in particular:

- how to classify the large number of potential enablers of CI, and assess their effectiveness in different situations;

- how to implement CI amongst a group of professionals;

- how to identify and apply measures that are adapted to the special qualities of the NPD process;
Sarah Caffyn

- how to capture and build on the learning about the process which takes place.

Acknowledgements

The author is grateful to two anonymous reviewers, and to Dr Mike Hales of the University of Brighton, for their valuable comments on an earlier version of this paper.

References


Extending CI to the NPD process

Notes

1. Double-loop learning involves challenging underlying organization policies and objectives. It contrasts with single-loop or adaptive learning, which refers to action taken to correct a situation without changing existing policies or objectives (Argyris, 1977).

Appendix 3  Report to the Engineering and Physical Sciences Research Council describing the development of the CI Capability Model

Development and Testing of the Generic Model for Continuous Improvement

A report of the EPSRC sponsored CIRCA project

Sarah Caffyn, John Bessant and Maeve Gallagher

January 1997

University of Brighton

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Centre for Research in Innovation Management
University of Brighton
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UK
Report & Description of the Development and Testing of the Generic Model

This document describes:
• The CIRCA model for continuous improvement (at 31.1.97)
• The process whereby this model was developed and tested

Section 1 The CIRCA model of continuous improvement capability

The CIRCA model for CI proposes how CI may be developed to such a degree that it becomes a strategic capability. The elements of the CI capability model are shown in Figure 1.

Figure 1 Continuous improvement as a capability

CI capability is defined as the ability of a company to gain strategic advantage by extending involvement in innovation to a significant proportion of the organisation. The model identifies ten key behaviours or 'routines' considered essential if CI is to be developed to its full potential in an organisation. These are behaviours displayed by individuals and groups but they are closely linked to core abilities at the level of the organisation. So for example, the presence of the behaviour...
'throughout the organisation people engage proactively in incremental improvement' reflects, and is the result of, the organisation's ability to 'generate sustained involvement in Ci'. The terminology we have used is defined in Table 1.

**Table 1 Definition of terms used to describe Ci capability**

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl capability</td>
<td>The ability of a company to gain strategic advantage by extending involvement in innovation to a significant proportion of the organisation.</td>
</tr>
<tr>
<td>Core abilities</td>
<td>Abilities at the level of the organisation, all of which must be well established to achieve genuine capability in Cl.</td>
</tr>
<tr>
<td>Key behaviours</td>
<td>Behaviours displayed by individuals and groups which reflect, and are the result of, core organisational abilities.</td>
</tr>
<tr>
<td>Enablers</td>
<td>Mechanisms (processes, procedures and other forms of support) used by companies to encourage development of the key behaviours. Some enablers appear to be critical, while others are &quot;nice to haves&quot;. The enablers are contingent and take many different forms.</td>
</tr>
</tbody>
</table>

The research suggests that the core abilities and key behaviours are generic i.e. they apply to all organisations and must be present in any company aspiring to full Cl capability. The abilities have been observed in companies, at different stages of development. It is clear that where they are present much effort has gone into cultivating and sustaining them. The core abilities and associated key behaviours are summarised in Table 2.

The key behaviours can be broken down into lower level 'sub behaviours' to get a clearer understanding of what they involve. For example, the key behaviour 'Managers at all levels display active commitment to, and leadership of, Cl' comprises a number of constituent behaviours including:

- Managers support the Cl process through allocation of time, money, space and other resources.
- Managers recognise in formal (but not necessarily financial) ways the contribution of employees to Cl.
- Managers lead by example, becoming actively involved in design and implementation of Cl.
- Managers support experiment by not punishing mistakes but by encouraging learning from them.

A breakdown of all the key behaviours is given in Bessant and Caffyn (Bessant & Caffyn, 1997).
These key CI behaviours represent a new way of working, very different from the traditional 'Taylorist' paradigm that has dominated western practice for most of this century. Firms therefore need to break out of the old mindset and find ways to encourage their people to adopt the new behaviours. However, this is not easy. It is a long-term activity which involves 'unlearning' the old behaviours and practising and reinforcing the new ones until they become routine. Despite the difficulties, there are still many actions a company can take to help create or reinforce the desired behaviour patterns.

The research has identified a range of enabling mechanisms the use of which supports development of each of the core abilities and encourages the associated key behaviours. These enablers are an important part of a company's "CI system", the latter comprising all the processes, procedures, subsystems and other forms of support put in place to foster CI. Examples of enablers include a problem-solving methodology, facilitators, role models, legitimation of time spent on improvement activity, measurement systems, movement of staff between different functional or product areas. The enablers are contingent and vary between organisations depending on the company's history, structure, prevailing culture, commercial environment etc. Some of the enablers appear to be critical, while others are less significant "nice to haves". Even the critical enablers (e.g. policy deployment) take many different forms, depending on the organisational context.

New behavioural norms evolve gradually. At first people may enact a new behaviour self-consciously, practising it, reminding themselves what to do (in the same way that someone learning to drive a car needs to repeatedly practice changing gear, or overtaking another vehicle); it is only by repeating it over and over again that it becomes an ingrained, automatic way of behaving. Thus when CI enablers are first used the resulting behaviours are rather superficial. By repeated use of the enablers the behaviours of individuals, and the organisational abilities they reflect, gradually become more deep-rooted with people starting to behave naturally in that way. The enablers for CI are discussed more fully in the CIRCA project report Implementing Continuous Improvement.
Table 2 The core organisational abilities and key behaviours for continuous improvement

<table>
<thead>
<tr>
<th>Core Abilities</th>
<th>Key Behaviours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> The ability to link CI activities to the strategic goals of the company</td>
<td>1 Employees demonstrate awareness and understanding of the organisation's aims and objectives</td>
</tr>
<tr>
<td></td>
<td>2 Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities</td>
</tr>
<tr>
<td><strong>B</strong> The ability to strategically manage the development of CI</td>
<td>3 The enabling mechanisms (e.g. training, teamwork, methodologies) used to encourage involvement in CI are monitored and developed</td>
</tr>
<tr>
<td></td>
<td>4 Ongoing assessment ensures that the organisation's structure, systems and procedures, and the approach and mechanisms used to develop CI, consistently reinforce and support each other</td>
</tr>
<tr>
<td><strong>C</strong> The ability to generate sustained involvement in CI</td>
<td>5 Managers at all levels display active commitment to, and leadership of, CI</td>
</tr>
<tr>
<td></td>
<td>6 Throughout the organisation people engage proactively in incremental improvement</td>
</tr>
<tr>
<td><strong>D</strong> The ability to move CI across organisational boundaries</td>
<td>7 There is effective working across internal and external divisions at all levels</td>
</tr>
<tr>
<td><strong>E</strong> The ability to learn through CI activity</td>
<td>8 People learn from their own and others' experiences, both positive and negative</td>
</tr>
<tr>
<td></td>
<td>9 The learning of individuals and groups is captured and deployed</td>
</tr>
<tr>
<td><strong>F</strong> The ability to articulate and demonstrate CI values</td>
<td>10 People are guided by a shared set of cultural values underpinning CI as they go about their everyday work</td>
</tr>
</tbody>
</table>
Stages in the evolution of CI capability

Changing people's behaviour is not easy and it can take a long time. Observation and reported cases (e.g. Atkinson, 1995; Clark, 1994; Sirkin & Stalk, 1990) show companies passing through several developmental stages or 'levels of CI maturity' as they move towards CI capability. These are:

Level 1  'natural'/background CI
Level 2  structured CI
Level 3  goal oriented CI
Level 4  proactive/empowered CI
Level 5  CI capability

Firms appear to move through the levels by building the core abilities and developing the key behaviours. Characteristics typical of each level of CI maturity are given in Table 3.

Table 3  Stages in the evolution of CI capability

<table>
<thead>
<tr>
<th>Stage of development</th>
<th>Typical characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  'Natural'/background CI</td>
<td>Problem solving random&lt;br&gt;No formal efforts or structure&lt;br&gt;Occasional bursts punctuated by inactivity and non-participation&lt;br&gt;Dominant mode of problem solving is by specialists&lt;br&gt;Short-term benefits&lt;br&gt;No strategic impact</td>
</tr>
<tr>
<td>2  Structured CI</td>
<td>Formal attempts to create and sustain CI&lt;br&gt;Use of a formal problem-solving process&lt;br&gt;Use of participation&lt;br&gt;Training in basic CI tools&lt;br&gt;Structured idea-management system&lt;br&gt;Recognition system&lt;br&gt;Often parallel system to operations</td>
</tr>
<tr>
<td>3  Goal oriented CI</td>
<td>All of the above, plus formal deployment of strategic goals&lt;br&gt;Monitoring and measurement of CI against these goals&lt;br&gt;In-line system</td>
</tr>
<tr>
<td>4  Proactive/empowered CI</td>
<td>All of the above, plus responsibility for mechanisms, timing, etc.,&lt;br&gt;devolved to problem-solving unit&lt;br&gt;High levels of experimentation</td>
</tr>
<tr>
<td>5  Full CI capability – the Learning Organisation</td>
<td>CI as the dominant way of life&lt;br&gt;Automatic capture and sharing of learning&lt;br&gt;Everyone actively involved in innovation process&lt;br&gt;Incremental and radical innovation</td>
</tr>
</tbody>
</table>

The extent to which CI brings the organisation significant advantage increases as the company progresses through these levels. However, progression to the next level is not automatic, it
represents a major shift in the CI, which may require significant changes in organisational structures and practices. Moreover, natural atrophy will undermine the progress that is made and many companies report difficulties sustaining initial momentum.

Further reading
For the practical implementation of CI in accordance with this model, and details of enablers for CI, see the CIRCA project report Implementing Continuous Improvement.

Section 2 Development and testing of the CIRCA model for continuous improvement capability

2.1 STARTING POINT – THE CIRCA 'GEAR' MODEL

The early CIRCA model for generating and sustaining CI was developed during the first two years of the project (1992-94). It resulted from research activities carried out with a core group of collaborating companies and members of an industrial CI network, together with an analysis of cases in the literature. In this model the elements considered necessary for successful CI are grouped into five areas: strategy, culture, infrastructure, process and tools. A summary of some of the key components within each area is given in Table 4.

According to this model, a prerequisite for CI success is a clear strategic framework, with related targets and milestones, which is clearly communicated to all employees. CI programmes also need to be managed strategically. This implies guidance at the highest level together with regular planning, monitoring and, where necessary, intervention to ensure that CI can be sustained in the long term. To take root and flourish in an organisation, CI requires an underlying culture, or set of values and behavioural norms, that support it. This would include, for example, a widely held belief in the value of many small improvements and in the ability of everyone to contribute. Another cultural value associated with successful CI is the importance attached to learning, with failure being regarded as a learning opportunity rather than a trigger to apportion blame.
Table 4 Key components of the first CIRCA model for CI

<table>
<thead>
<tr>
<th>Area</th>
<th>Key components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy</td>
<td>• clear strategic framework for CI</td>
</tr>
<tr>
<td></td>
<td>• long-term goals and short-term targets</td>
</tr>
<tr>
<td></td>
<td>• communication of CI strategy to all employees</td>
</tr>
<tr>
<td></td>
<td>• top management commitment</td>
</tr>
<tr>
<td></td>
<td>• long-term, company-wide perspective</td>
</tr>
<tr>
<td>Culture</td>
<td>• shared belief in the value of small improvements</td>
</tr>
<tr>
<td></td>
<td>• belief that all employees have creative potential</td>
</tr>
<tr>
<td></td>
<td>• treating failure as a learning opportunity</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>• flattened hierarchy</td>
</tr>
<tr>
<td></td>
<td>• teamworking and flexibility</td>
</tr>
<tr>
<td></td>
<td>• devolution of decision making and empowerment</td>
</tr>
<tr>
<td></td>
<td>• effective communication channels</td>
</tr>
<tr>
<td></td>
<td>• commitment to training and personnel development</td>
</tr>
<tr>
<td></td>
<td>• CI facilitators</td>
</tr>
<tr>
<td></td>
<td>• CI “vehicles” such as problem solving groups or CI teams</td>
</tr>
<tr>
<td>Process</td>
<td>• formal CI/problem solving cycle</td>
</tr>
<tr>
<td></td>
<td>• capture and transfer of learning</td>
</tr>
<tr>
<td></td>
<td>• recognition and reward of CI activity</td>
</tr>
<tr>
<td>Tools</td>
<td>• company “toolbox” with a range of CI tools</td>
</tr>
<tr>
<td></td>
<td>• “toolbox manager”</td>
</tr>
</tbody>
</table>

CI also needs a supporting infrastructure. There are two components to this, a general context within which CI can thrive and develop and a specific CI-enabling infrastructure. Although there is no blueprint for the 'right' organisation form for CI – it is very much a matter of adapting both organisation and CI programme to suit each other – key areas appear to be the extent of devolution of autonomy, the communication and decision-making processes, the level of teamworking and, within teams, of flexible and multiskilled working, the degree of integration in inter-functional relations, and the approach to training and personal development. The CI infrastructure will include a fleet of CI vehicles to mobilise CI throughout the organisation, ranging from mechanisms that encourage individual proposals for small-scale local improvements, through team activities, to company-wide top management driven projects (Caffyn, Gilbert & Bessant, 1994).

At the heart of CI is a repeated problem-solving and learning cycle, moving from identification, through exploration and selection of improvement suggestions to implementation and review. Each
stage of the cycle needs to be supported with appropriate facilitation and tools. Important issues here are how to capture the learning arising from such activity and deploy it around the organisation; and how best to recognise participation in CI activity in order to motivate continued involvement. According to the model, a successful CI company would have a balanced range of CI tools and techniques in its toolbox to support teams and individuals in their improvement activities.

This model is described in more detail and illustrated with case examples in (Bessant, Caffyn, et al., 1994).

To aid communication and emphasise the interdependency between the areas, the model was depicted graphically as five meshing gear wheels representing the key areas, the teeth on the gears being the specific features (actions, attitudes, conditions etc.) that can enhance or damage CI in a company (Figure 2). The argument was that although incremental innovation may be found naturally occurring in an organisation, its potential will not be fully realised if it is sporadic and left to chance; to succeed, the organisation will have to work in each of the areas represented by the gears. According to this model, if any of the ‘gears’ is missing the CI will fail sooner or later; a gear without a full set of teeth will result in a bumpy ride.

**Figure 2** The first CIRCA model for CI: the ‘gear’ model

This model provided a simple way of representing what was in fact a complex situation. It seemed to work empirically, and was popular with firms. The "gear model" provided the research team with a good framework for looking at the CI system in any company, and formed the basis of the CIRCA...
diagnostic tool. The latter enabled a fairly accurate 'snapshot' of a company's CI to be constructed in a short space of time (Caffyn, Gilbert & Bessant, 1995). In using the model in this way to benchmark a company against a notional model of good practice there were similarities with the approach taken by, for example, the EFQA and the Baldrige award assessments, though in this case the focus was restricted to CI and factors affecting it.

**Phases in continuous improvement**

During the latter part of this phase of the CIRCA project it had become clear from the research that companies could be observed which were clearly in different development phases of CI; and that as they progressed to more advanced phases the impact on the business increased. These phases distinguished between firefighting; prevention; process improvement; and process innovation (see Figure 3).

**Figure 3 Phases in continuous improvement (January 1994)**

![Diagram showing phases of continuous improvement](image)

**2.2 LIMITATIONS OF THE GEAR MODEL**

However, during the early stages of the second phase of the CIRCA research (1994-97) the limitations of the gear model became increasingly apparent. There were several important issues that it did not address.

- **Generic and contingent factors in continuous improvement**
  First, the gear model was largely a generic model, making little distinction between generic and contingent factors. It assumed that to succeed at CI a company must have a whole range of specific features (the details represented by the gear 'teeth') whereas in reality the desirability and
necessity of some of these features will depend on the organisation in question and its particular circumstances. As the research activity widened out, taking in organisations ranging in size from 60 to over 20,000 people, and from diverse types of operation, it became clear that there were different ways of achieving a particular end in different situations. So that although many companies which appeared to have made progress with CI may have followed a similar path (e.g. flattening the organisational structures), there was no single "best" way.

• Moving from cosmetic to ingrained continuous improvement
A second weakness of this model is that it does not show how to move from superficial CI to CI as a deep-rooted, "automatic" way of behaving. For example, one company seemed to be doing very well with CI, attributing £1.3M of its £5.7M profit in 1992 to CI activities. In early 1993 it came out quite well when assessed using the mapping tool based on the model: there was a strong teamworking culture, high levels of involvement, genuine commitment to CI by top management, etc. Although the diagnostic exercise did find some weaker areas and identified a plateauing effect, with hindsight it did not highlight the full extent of the problem. Subsequently there was a big decline in CI activity, and the initial momentum tailed right off despite the company having in place many of the elements the model said it should have.

• Different structures for implementing continuous improvement — parallel vs. integral
There is another issue, spanning both the previous points, which the gear model did not address adequately. Namely, what form of structures are appropriate for initiating and sustaining a CI programme, and how might they change over time. The gear model did stress that CI should not be seen as an optional 'add on' to the rest of the business but should have a clear strategic framework (strategy gear). However, the model also emphasised, or appeared to through the language it used, some form of parallel structure (CI vehicles, CI tools, CI steering committees etc.), reflecting the most common form of practice at the time. Examples started to be reported of companies coming to adopt a more seamless approach, such as Honeywell where it was reported in early 1993 that the quality organisation had blended with the regular structure, the three Quality Councils in effect being the senior management team (Heller, 1993). This trend was also noticed in some of the companies CIRCA worked with. For example, one company which had started quality improvement by following Crosby approach found that this led to a hierarchy of councils and became rather bureaucratic. After several years it was decided that the high level Quality Improvement Team should in future be synonymous with the management team. This was the first step towards integrating quality improvement into the way the business operated, and it also meant that managers were unable to opt out of responsibility for quality improvement. From then on quality improvement was the first item on the agenda of the monthly management meeting, and the concepts of CI started to be integrated into the strategy and business planning process.
2.3 DEVELOPMENT OF THE MODEL FROM LATE 1994

The limitations described above, together with the problems that many companies were having sustaining CI, led us to re-evaluate our data. There followed a period during which the team went through a cycle of discussion, reflection, conceptualisation; while at the same time continuing to work with companies on the practical aspects of implementing CI. Inevitably, the practical experience informed the theory being developed concurrently, and vice versa. The team was also aware of the ongoing debate in the innovation management literature over core competencies and distinctive capabilities, and of the growing recognition of the importance of capability as a source of strategic advantage (see, for example, Bowen, Clark, et al., 1994; Leonard-Barton, 1992; Leonard-Barton, 1995; Prahalad & Hamel, 1990; Stalk, Evans & Shulman, 1992; Wheelwright & Clark, 1992).

A log has been kept of how the model evolved during this period. Table 5 indicates some of the phases the team's thinking went through.

2.4 TESTING THE CAPABILITY MODEL

The CI capability model was tested during the development process described above on a number of fronts. These include:

- Exposure to critical review from academic peers.
- Exposure to industrialists.
- The model was used as the basis for implementing CI within a local electronics company via the Teaching Company Scheme (1994-96, and 1996-98).
- The CI Self-Assessment tool which is derived from this model has been tested in a number of companies and was considered by users to provide an accurate reflection of the state of CI in the business unit assessed. (See CIRCA project report: Description of the Development and Testing of the CIRCA Continuous Improvement Self-Assessment Tool.)
- "People Winners" research conducted by CENTRIM with the DTI Innovation Unit and the DTI Best Practice Division.

This form of validation took place throughout the period of model development, as shown in Table 6. In addition to formal events the model was presented informally to industrialists and other academics on numerous occasions. In some instances, feedback led to modification or enhancement of the model.
<table>
<thead>
<tr>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 1994</td>
<td>Start thinking of CI in terms of &quot;a diffused capability for change&quot;. See improvement (PDCA) of the CI system as &quot;single loop learning&quot; while shifting to the next &quot;cloud&quot; or maturity level involved &quot;double loop learning&quot;. Use contingency to explain Adler &amp; Cole argument that CI can work in a hierarchical organisation (Adler &amp; Cole, 1993). Realise need to look for minimum structural requirements.</td>
</tr>
<tr>
<td>February 1995</td>
<td>Present CI as one aspect of innovation management capability (i.e. how to mobilise and deploy widespread incremental innovation) which is developed over time.</td>
</tr>
<tr>
<td>March 1995</td>
<td>Identify a hierarchy of elements that make up CI capability: CI capability — abilities — routines.</td>
</tr>
<tr>
<td>April 1995</td>
<td>Use research data to identify core generic abilities necessary for CI. Make contrast between superficial and deep routines (or behaviour patterns).</td>
</tr>
<tr>
<td>May 1995</td>
<td>Identify features associated with each ability (in retrospect, these features were a mixture of behavioural routines and enablers).</td>
</tr>
<tr>
<td>June 1995</td>
<td>Clarify distinction between routines (the desired outcome, how people behave) and abilities (what the company needs to do to develop the routines). Four components to the model: CI capability; abilities; behaviours; enablers. List behaviours attached to each of the abilities; refine list. Two dimensions of behaviours: how deeply ingrained, how widespread. Recognise that some enablers may be critical while others are &quot;nice to have&quot;.</td>
</tr>
<tr>
<td>August 1995</td>
<td>Draft working paper which describes current state of development of model. Introduce notion of six levels of &quot;CI maturity&quot;. Consider concept of &quot;internal contingency&quot;.</td>
</tr>
<tr>
<td>September 1995</td>
<td>Further refinement of levels of maturity model. Consider qualitative and quantitative shifts as a company moves between levels.</td>
</tr>
<tr>
<td>October 1995</td>
<td>Link development of abilities to the levels of maturity. Produce working matrix of behaviours/enablers at each level of maturity. Disaggregate each key behaviour into three &quot;subbehaviours&quot;. Reanalyse data gathered from two companies in 1993 in terms of the disaggregated behaviours (presented to EPSRC review panel 7.11.95). Reduce number of maturity levels to five. Survey of UK manufacturing companies provides more data on CI enablers.</td>
</tr>
<tr>
<td>November 1995</td>
<td>Revise mapping tool to enable collection of data about each behaviour / subbehaviour. Revised tool is used in three companies (November, December 1995 and March 1996).</td>
</tr>
<tr>
<td>January 1996</td>
<td>Discuss simple formula to give numeric measure for each behaviour: Performance = time x intensity x frequency but encounter problems in trying to apply it and so do not develop this further.</td>
</tr>
<tr>
<td>February 1996</td>
<td>Make minor revisions to capability model.</td>
</tr>
<tr>
<td>February - July 1996</td>
<td>Use Post-It exercise to extract examples of behaviours and enablers from the data and attribute these to a level of maturity.</td>
</tr>
<tr>
<td>June 1996</td>
<td>Draw up draft implementation methodology.</td>
</tr>
</tbody>
</table>
The model was exposed industrialists to check whether it made practical sense. There were several routes for doing this: one to one discussion during mapping visits; workshops and seminars; involvement of companies in the testing of the self-assessment model; and while helping companies to implement CI, via the Teaching Company Scheme and other consultancy work. The model provided an evolving framework for the series of CIRCA workshops and different aspects of it were focused on during the breakout group sessions which took place at these workshops. For example, the group work which took place at Workshop 12 in June 1995 (CI beyond the factory floor) was directed related to the contingency aspect of the model. Several companies have changed their framework for CI as a result of exposure to the CIRCA model.

Table 6 Selected events in the testing and validation of the model

<table>
<thead>
<tr>
<th>Date</th>
<th>Form*</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995 on</td>
<td>I</td>
<td>Implementation in local company via Teaching Company Scheme.</td>
</tr>
<tr>
<td>Sep 1995</td>
<td>A</td>
<td>National Manufacturing Research Conference, UK. Presentation of what was wrong with gear model; capability model.</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>IIR Conference, UK. Present model.</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td>Presentation of maturity concept to DTI &amp; IEE.</td>
</tr>
<tr>
<td>Nov 1995</td>
<td>I</td>
<td>Company assessed against model.</td>
</tr>
<tr>
<td>Dec 1995</td>
<td>A</td>
<td>EuroCINet Conference, UK. Presentation of model.</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>CIRCA Network Workshop, Gatwick. Presentation of model.</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>Company assessed against model.</td>
</tr>
<tr>
<td></td>
<td>I</td>
<td>Company assessed against model.</td>
</tr>
</tbody>
</table>

* I = industrial exposure, A = academic exposure, O = other
REFERENCES


Appendix 4  Questions in INCIDE and the CI behaviours to which they primarily relate

The CI behaviours are in bold. The letters prefixing the questions refer to the three schedules that make up INCIDE: for the person in charge of NPD (A); other functional managers involved in NPD (B); and people working on NPD (C).

B1  Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities

A14, B6  If people have made changes to the NPD process, do the changes reflect departmental or company objectives?
   • Is there a conscious attempt to improve the process in line with company objectives?

A17, B9  How is the impact of changes / improvements to the NPD process monitored?
   • Who by?

C6  Do you ever consciously engage in resolving problems/hiccups with the NPD process, or seek to improve it in some way? [The relevant sub questions are:]
   • What is the motivation for it? Any link to departmental objectives?
   • Examples
   • Do you monitor the impact of any changes resulting from this activity?

A20, B12, C8  What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?

A21, B13, C9  What could help people get involved in improving the NPD process in this company (i.e. enablers)?

B2  The CI system is continually monitored and developed

A20, B12, C8  What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?
A21, B13, C9  What could help people get involved in improving the NPD process in this company (i.e. enablers)?

B3  Ongoing assessment ensures that the organisation's structures and infrastructure and the Cl system consistently support and reinforce each other

A20, B12, C8  What could get in the way of applying Cl to the NPD process in this company (i.e. barriers)?

A21, B13, C9  What could help people get involved in improving the NPD process in this company (i.e. enablers)?

B4  Managers at all levels display active commitment to, and leadership of, Cl

A11, B4  How could people working on NPD improve the NPD process incrementally i.e. if someone had an idea for improving the process what would they do with the idea?

A12  Are people encouraged to come up with ideas for improving the NPD process?
   • Who encourages them?
   • How are they encouraged?

A16, B8  Who is responsible for implementing new ideas and changes to the NPD process?

A9  How is the NPD process monitored?
   • What measures are used?
   • Who looks at the measures?
   • Is any action ever taken as a result of the measurement?
   • Is there any local process measurement i.e. of parts of the process on an on-going basis, as opposed to global performance measures

C3  How is the NPD process monitored?
   • Do you use any local measures yourself?

C4  Are you or your colleagues encouraged to improve the NPD process?
   • Who by?
   • How?

C5  Have you ever had an idea for improving the NPD process? [relevant sub questions:]
• What do you do with your improvement ideas?
• Who implements your suggestions?

A20, B12, C8  What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?

A21, B13, C9  What could help people get involved in improving the NPD process in this company (i.e. enablers)?

**B5  People participate proactively in incremental improvement**

A9  How is the NPD process monitored?
    • What measures are used?
    • Who looks at the measures?
    • Is any action ever taken as a result of the measurement?
    • Is there any local process measurement i.e. of parts of the process on an on-going basis, as opposed to global performance measures

C3  How is the NPD process monitored?
    • Do you use any local measures yourself?

A10, B3  Who is responsible for identifying ways to improve the NPD process?

A11, B4  How could people working on NPD improve the NPD process incrementally i.e. if someone had an idea for improving the process what would they do with the idea?

A13, B5  To what extent, if any, do people working on the NPD process suggest or implement ideas for improving the process?
    • Who has suggested improvements?
    • What was the outcome of such improvement suggestions?
    • Examples of improvements to the process

C5  Have you ever had an idea for improving the NPD process?
    • How often?
    • Examples
    • What do you do with your improvement ideas?
    • Who implements your suggestions?
A15, B7 Are changes to the NPD process reactive (responding to a problem) or proactive (taking advantage of an opportunity for improvement)?

C.6 Do you ever consciously engage in resolving problems/hiccups with the NPD process, or seek to improve it in some way?
   • As an individual or a group?
   • Who instigates such activity?
   • What is the motivation for it? Any link to departmental objectives?
   • Examples
   • Do you follow a problem-solving or improvement cycle?
   • Do you use any tools?
   • Do you monitor the impact of any changes resulting from this activity?

A16, B8 Who is responsible for implementing new ideas and changes to the NPD process?

A20, B12, C8 What could get in the way of applying Cl to the NPD process in this company (i.e. barriers)?

A21, B13, C9 What could help people get involved in improving the NPD process in this company (i.e. enablers)?

B6 There is effective working by individuals and groups across internal divisions (vertical and lateral) and external boundaries, at all levels

A8, B2, C2 How does the NPD process work in practice?
   • Extent of cross-boundary communication and co-operation

A20, B12, C8 What could get in the way of applying Cl to the NPD process in this company (i.e. barriers)?

A21, B13, C9 What could help people get involved in improving the NPD process in this company (i.e. enablers)?

B7 People learn from their own and others' experiences, both positive and negative

C7 If you learn something about the NPD process (e.g. how to do something more efficiently), or if you have implemented an improvement, individually or as part of a group, do you tell anyone else about it?
   • How is the learning you have undergone passed on to others?
• Is the learning captured in writing?
• Do you hear about changes / improvements other people have made to the NPD process?

A18, B10 What mechanisms / means are there for converting the learning arising from an improvement to the NPD process into the organisation's memory (e.g. standardising it)?

A19, B11 What mechanisms / means are there for sharing / deploying the learning (a) within and (b) between NPD projects?
• Who is involved?
• Formal or informal?
• Examples

A20, B12, C8 What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?

A21, B13, C9 What could help people get involved in improving the NPD process in this company (i.e. enablers)?

B8 The learning of individuals and groups is captured and deployed

A18, B10 What mechanisms / means are there for converting the learning arising from an improvement to the NPD process into the organisation's memory (e.g. standardising it)?

A19, B11 What mechanisms / means are there for sharing / deploying the learning (a) within and (b) between NPD projects?
• Who is involved?
• Formal or informal?
• Examples

C7 If you learn something about the NPD process (e.g. how to do something more efficiently), or if you have implemented an improvement, individually or as part of a group, do you tell anyone else about it?
• How is the learning you have undergone passed on to others?
• Is the learning captured in writing?
• Do you hear about changes / improvements other people have made to the NPD process?
A20, B12, C8 What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?

A21, B13, C9 What could help people get involved in improving the NPD process in this company (i.e. enablers)?

B9 People are guided by a shared set of values underpinning CI as they go about their everyday work

A10, B3 Who is responsible for identifying ways to improve the NPD process?

A13, B5 To what extent, if any, do people working on the NPD process suggest or implement ideas for improving the process?
  • Who has suggested improvements?
  • What was the outcome of such improvement suggestions?
  • Examples of improvements to the process

C5 Have you ever had an idea for improving the NPD process?
  • How often?
  • Examples
  • What do you do with your improvement ideas?
  • Who implements your suggestions?

A20, B12, C8 What could get in the way of applying CI to the NPD process in this company (i.e. barriers)?

A21, B13, C9 What could help people get involved in improving the NPD process in this company (i.e. enablers)?
Appendix 5  Schedule of questions for interviews in Crendon

COMPANY BACKGROUND

1. Current:
   - turnover
   - number of employees
   - composition of Crendon Group

2. Restructuring changes
   - when put into effect
   - what is current structure (copy of charts)
   - impact of the changes

3. Does the company now have a stated
   - vision
   - mission
   - goals
   - objectives

4. What performance measures are now being used, in addition to man hours per cubic metre of product?

5. Do QA still collect errors (number / type / cause)?
   - If so, is the data acted on?

6. Are measures / targets etc being used on shop floor?

7. Company 'culture' now
   - has it shifted from us/them more to 'we're all in this together'?
   - has there been a shift in attitude to mistakes / learning?
   - relations between depts

8. Training - current policy / level of activity

9. Communications - any changes / improvement / worsening etc?
10. Is there now a specific plan/strategy for CI or do you want to develop that with us?

11. What's the current attitude to CI of
   - Chairman
   - senior managers
   - middle managers
   - supervisors
   - shop floor
   - office staff

12. Apart from the Drawing Office Task Force (summer '92), what other CI activity has there been?
   - was there any follow up by Drawing office TF to monitor impact of changes?

13. Suggestions for improvements
   - any increase?
   - how many now?
   - is there a 'system' (eg ensuring feedback) or still casual?

14. Have you adopted a formal problem solving / improvement cycle?

15. CI tools
   - current range
   - current level of use

NEW PRODUCT DEVELOPMENT - THE TUNNEL PROJECT

A. General (Managing Director only)

1. What's the distinction between a new product and a new job?
   - incremental / radical innovation
   - technology

2. New products
   - how often are there new products?
   - how do they originate
3. What is the 'usual' NPD process?
   - what are the stages?
   - any overlapping?
   - how long is the process (typcial duration)?
   - typical approach eg over the wall; x-functional teams
   - who is involved?
   - what communication mechanisms are used?
   - is there any way of capturing learning (about the product or the process) made while developing a new product?

4. How do you measure the NPD process?

B. The Tunnel Project (Managing Director)

1. Background details
   - customer
   - size of project (£)
   - duration (dates from idea to production for customer)

2. Why and how did the idea / concept originate?
   - what was the impetus behind it (in need for new product; technology push; customer pull; etc)?
   - how did it develop from idea to concept?

3. Who was involved in the project and what role did they play?
   - internally
   - externally

4. What was the process that was followed?
   - stages
   - concurrency
   - teams
   etc
   - differences between this process and the usual one

5. Do you consider this project a success?
   - on what do you base your reply
   - was the project completed (a) on time (b) to budget
6. What are the lessons learnt from this project?
   - how is any learning being captured /deployed?

C. The Tunnel Project (Key Participants)

1. What was your role in the project?

2. When did you become involved?
   - was your involvement continuous or intermittent?
   - when did your involvement end?

3. Who else did you work with on this project and what were their roles?
   - people within Crendon
   - customer
   - suppliers
   - contractors
   - others external to Crendon

4. What process was followed?
   - what stages did it go through from the original idea to the end product?
   - which stages were you involved with?

5. What were communications like during the project?
   - between project members
   - between project team and management
   - between project team and people outside Crendon
   - what form did communications take?
   - which were / were not effective?

6. How was the project's progress monitored?
   - who did the monitoring?
   - did you know how you were doing against budget and time targets?

7. How did this NPD project differ from others you may have worked on?

8. Was this project successful?
   - on what do you base your reply
9. What did you and / or the team learn from this project?
   - how is any learning being captured / deployed?
   - what would you do differently next time?

10. Did you enjoy working on this project?
    - why?
CONTINUOUS IMPROVEMENT SURVEY*
1995

This survey asks about your strategy for Continuous Improvement (CI) i.e. the motives, targets and means you have chosen to support your effort for creating CI.

Please note that all answers will be treated in confidence.

The survey is divided into five sections:

Section 1. Company background.

Section 2. General characteristics of the organisation in your business unit, and previous experiences of change efforts.

Section 3. Issues concerning the organisation and operation of CI.

Section 4. Support for CI, and the tools used in the CI process.

Section 5. The effects of CI.

This questionnaire should be completed by the person with responsibility for operations, or the person with an overview of the unit's improvement activities. The answers should reflect the situation of the business unit, regardless of whether the unit is an independent company, or a factory in a larger organisation.

When completed, please return the questionnaire in the envelope provided.

Thank you for helping us to map European improvement activities!

* This survey is being conducted in the UK by the Centre for Research in Innovation Management at the University of Brighton in conjunction with Works Management magazine. It is part of a pan-European survey co-ordinated by the Eureka project EuroCINET.
NOTE!
The term Continuous Improvement is used here to describe a systematic attempt to involve all employees in incremental improvement.

Section 1. Company background

1. Please indicate (by circling) what best describes your business unit.

2. Please indicate your position in the company: ________________________________

3. Please name the primary product/product line of the business unit: ________________

5. What was the business unit's annual turnover for the last fiscal year? ________________

6. What is the number of employees in the business unit? _______ (direct), _______ (indirect)

7. Please indicate the three most important competitive means (order-winning criteria) for the products of the business unit. Please rank the criteria by using 1 (most important), 2, and 3.
   ______ Quality  ______ Delivery lead-time  ______ Delivery reliability
   ______ Price  ______ Product performance  ______ Time-to-market
   ______ Customised products  ______ Other

8. Please indicate the production volume (in percent of turnover) that consists of:
   a) Totally unique products designed and manufactured to customer order _______ %
   b) Modularised products with moderate customisation to order _______ %
   c) Standardised products manufactured with no adjustments _______ %

Section 2. General characteristics of the organisation in your business unit, and previous experiences of change efforts

9. How would you describe the manufacturing operation of your business unit? Please indicate the percentage of the workforce in each category.
   a) ______% of the workforce work in functional departments consisting of similar machines/tasks;
   b) ______% work in cellular lay-outs based on complete products or sub-systems;
   c) ______% work on assembly lines;
   d) ______% work in continuous processes.

10. How many organisational levels are there, between and including the head of the business unit and operators? ________________________________

11. How many hours of training per year do employees typically receive?
    _______ hours per year direct employees    _______ hours per year indirect employees

12. Please indicate the status of your efforts to accomplish “continuous improvement” (CI).
   □ 1 CI is not a suitable concept for our operations
   □ 2 Some people in the business unit are aware of the need for CI but there are no CI activities
   □ 3 There is widespread awareness of the need for CI but little action has actually taken place
   □ 4 Management have decided to develop CI but very few activities have yet taken place
   □ 5 We have initiated a systematic application of CI
   □ 6 We have a widespread and sustained process of CI
   □ 7 Other:

If some CI activity is currently taking place, please indicate for how long: ________________ years.
13. Is your current CI effort a completely new initiative or has it evolved from a previous change initiative (e.g. TQM, TPM)?
   a) □ New initiative  b) □ Partly new  c) □ Evolved from previous initiative

If (c), please state the name of the previous initiative

14. To what extent are the following true in your business unit?

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>To some extent</th>
<th>To a large extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) The role of CI within the company’s strategy/business plan is clearly stated</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>b) There is effective communication of the CI strategy to everyone within the unit</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c) Individuals/groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d) Managers at all levels display active commitment to, and leadership of, CI</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

15. What are the main motives for working with CI in your business unit?

Please indicate the importance of each of the following on a 5-point scale, from 1 = not important, to 5 = of critical importance.

<table>
<thead>
<tr>
<th>Main motives for CI</th>
<th>Importance (1–5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Because our customers ask for CI</td>
<td></td>
</tr>
<tr>
<td>Increase production volume</td>
<td></td>
</tr>
<tr>
<td>Increase manufacturing productivity</td>
<td></td>
</tr>
<tr>
<td>Improve quality conformance</td>
<td></td>
</tr>
<tr>
<td>Reduced production lead-times</td>
<td></td>
</tr>
<tr>
<td>Improve delivery reliability</td>
<td></td>
</tr>
<tr>
<td>Improve safety and physical environment</td>
<td></td>
</tr>
<tr>
<td>Cost reduction</td>
<td></td>
</tr>
<tr>
<td>Improve administrative routines</td>
<td></td>
</tr>
<tr>
<td>Increase employee commitment/attitude towards change</td>
<td></td>
</tr>
<tr>
<td>Improve organisation, co-operation and communication</td>
<td></td>
</tr>
<tr>
<td>Increase employee skills</td>
<td></td>
</tr>
<tr>
<td>Because CI is a management directive</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
</tbody>
</table>
16. What is the focus of your CI activity? Please indicate the frequency with which CI is applied to each of the following areas, using a 5-point scale from 1 = not frequent, to 5 = very frequent.

<table>
<thead>
<tr>
<th>Focus of CI activity</th>
<th>Frequency (1–5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine up-time and speed</td>
<td></td>
</tr>
<tr>
<td>Set-up time</td>
<td></td>
</tr>
<tr>
<td>Work methods and tools</td>
<td></td>
</tr>
<tr>
<td>Manufacturing quality</td>
<td></td>
</tr>
<tr>
<td>Material waste</td>
<td></td>
</tr>
<tr>
<td>Manufacturing costs</td>
<td></td>
</tr>
<tr>
<td>Buffer stock, lay-out and physical flows</td>
<td></td>
</tr>
<tr>
<td>Product design</td>
<td></td>
</tr>
<tr>
<td>New product development process</td>
<td></td>
</tr>
<tr>
<td>Administrative routines</td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td></td>
</tr>
<tr>
<td>Employee commitment</td>
<td></td>
</tr>
<tr>
<td>Employee skills</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
</tbody>
</table>

17. What is the importance of CI in your business unit?

☐ Of strategic importance  ☐ Of operational importance  ☐ Of minor importance

Section 3. Issues concerning the organisation and operation of CI

18. What is the extent and spread of the CI process in your business unit?

☐ 1. The entire unit including functions such as design, purchasing, sales etc.
☐ 2. The entire manufacturing department including support functions such as engineering and maintenance.
☐ 3. Primarily manufacturing but only including the majority of operators.
☐ 4. Limited sections of the manufacturing department only.

19. What is the level of maturity of working with CI in your business unit?

(Compare it with riding a bicycle – to start with it is a conscious effort requiring intense concentration; with practice some of the procedures gradually become more automatic; as you mature, the effort becomes much easier and less conscious; eventually the activity becomes "second-nature", undertaken with ease and little consciousness of how you really do it.)

☐ Conscious  ☐ Learning how to  ☐ Maturing  ☐ Second nature
20. Which individuals or groups have the main responsibility for directing, monitoring and carrying out the CI process in your business unit? Please indicate with one or more "X" in each column.

<table>
<thead>
<tr>
<th>Who sets direction/influences focus?</th>
<th>Who monitors and co-ordinates?</th>
<th>Who does it/carryes out CI?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business unit manager</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Unit management team</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Manufacturing manager</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Staff function manager (engineering, maintenance, etc)</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Department managers</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Supervisors</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Operators</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Regular (operator) work teams</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>CI facilitator/co-ordinator</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Improvement/problem solving teams</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>Other: ___________________________</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

21. Please indicate when and how the main part of the improvement work is carried out.

The work takes place:

- **When:**
  - □ Regular work time
  - □ Paid overtime
  - □ Unpaid overtime

- **How:**
  - □ Dedicated CI meetings
  - □ Regular work meetings
  - □ Spontaneous, one-off meetings
  - □ As an individual activity

### Section 4. Support for CI, and the tools used in the CI process

22. Which of the following do you use to develop and sustain CI in your business unit?

How important are they? Please indicate the ones you use (with "X" in appropriate column) and their importance on a scale from 1 = not important, to 5 = of critical importance (see example).

<table>
<thead>
<tr>
<th>Example: Use of slogans</th>
<th>Use</th>
<th>Importance (scale 1 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training of personnel in problem solving tools</td>
<td>X</td>
<td>2</td>
</tr>
<tr>
<td>Monitoring the overall CI system (measures, interventions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Support from staff functions (e.g. maintenance, engineering)</td>
<td></td>
<td></td>
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<tr>
<td>Incentive systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supportive leadership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work in teams/work groups</td>
<td></td>
<td></td>
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<tr>
<td>A suggestion scheme</td>
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</tr>
<tr>
<td>A general problem solving cycle (e.g. PDCA-cycle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion through information boards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion through internal media (magazines, TV...)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion through competitions and awards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion through verbal communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promotion through regular visits by management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A quality award model (e.g. British Quality Award, EFQM model, Baldrige)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO 9000/BS5750</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Productive Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal policy deployment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: _________________________</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Continuous Improvement Survey 1995

University of Brighton/Works Management magazine
23. Which one or more of the following statements describe your suggestion scheme, and any other vehicle you may have for encouraging *individual* involvement in CI?

<table>
<thead>
<tr>
<th>Suggestion scheme</th>
<th>Other vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. People submit suggestions via a formal scheme; the suggestions are evaluated by a committee who make an award (e.g. a percentage of savings generated by the idea).</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>2. People submit their suggestions to a co-ordinating body <em>after</em> they have been implemented (e.g. an implemented proposal scheme).</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>3. People check their idea with a supervisor before implementing it themselves.</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>4. People implement their ideas without reference to anyone else.</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>5. The emphasis is on suggestions for small changes that cost little or nothing to implement.</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>6. The emphasis is on suggestions that will bring significant benefit to the organisation.</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>7. Suggestions tend to be directed at other departments/people.</td>
<td>☐ ☐</td>
</tr>
</tbody>
</table>

Please name the other vehicle, if you have one ____________________________

24. Which problem-solving tools are you using in CI activities?

Please indicate which ones you use (with "X" in appropriate column) and their importance on a scale from 1 = not important, to 5 = of critical importance.

<table>
<thead>
<tr>
<th>PROBLEM SOLVING/FINDING TOOLS</th>
<th>Yes</th>
<th>Use Partly</th>
<th>No</th>
<th>Importance (scale 1 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem identification tools/checklists (e.g. waste)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven &quot;old&quot; quality tools (e.g. Pareto, Cause &amp; Effect)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seven &quot;new&quot; management and planning quality tools (e.g. Relations Diagram, Tree Diagram)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process mapping tools (e.g. process flow diagram, flowchart)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPC (Statistical Process Control)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FMEA (Failure Mode and Effect Analysis)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KA (Komahsure Analysis)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QFD (Quality Function Deployment)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prioritising/consensus reaching tools (e.g. Paired Comparison, Weighted Selection, Voting)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creativity tools/idea generation tools (e.g. Brainstorming)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Display/visualisation tools (e.g. charts, histograms)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standardisation tools (e.g. job descriptions, manuals, kanban systems)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5S (cleaning, sorting, systematising etc.)</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: ____________________________</td>
<td>☐</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
25. What percentage of your employees have been trained in problem solving tools? ______ %

26. What incentives are you using to encourage CI activities?

Please indicate which ones you use (with "X" in appropriate column) and their importance on a scale from 1 = not important, to 5 = of critical importance.

<table>
<thead>
<tr>
<th>INCENTIVES</th>
<th>Used</th>
<th>Not used</th>
<th>Importance (scale 1 to 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggestions are evaluated and rewarded with a monetary award</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suggestions are evaluated and rewarded with a non-monetary award (e.g. dinner for two, theatre tickets)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All suggestions receive nominal recognition irrespective of whether or not they are implemented (e.g. box of chocolates, points towards a gift from a catalogue, donation to charity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI activities are rewarded indirectly through e.g. bonuses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI activities are rewarded indirectly through individual salaries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CI is not rewarded monetarily, but through development of individuals' jobs, careers etc</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recognition by publicising the improvement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No incentives used: □

Section 5. The effects of CI

27. Roughly, how many ideas/suggestions were registered and how many were carried out in
   a) 1993: ______ ideas/suggestions registered, and of these were ______ carried out;
   b) 1994: ______ ideas/suggestions registered, and of these were ______ carried out.

28. Approximately, what percentage of the improvement suggestions/ideas were implemented by the suggesters themselves (individual or group)? ______ %

29. What proportion of your employees would you estimate as actively engaged in CI?
   a) ______ % operators (directs)  
   b) ______ % indirect employees

30. Effects of CI
   a) How have the listed performance indicators changed over the last two years?
   b) Roughly, what would you estimate the contribution of CI is to this development?

<table>
<thead>
<tr>
<th>a) Change Better (+), worse(-)</th>
<th>b) Contribution of CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productivity</td>
<td>%</td>
</tr>
<tr>
<td>Manufacturing quality</td>
<td>%</td>
</tr>
<tr>
<td>Delivery performance</td>
<td>%</td>
</tr>
<tr>
<td>Lead time</td>
<td>%</td>
</tr>
<tr>
<td>Product cost</td>
<td>%</td>
</tr>
<tr>
<td>Customer satisfaction</td>
<td>%</td>
</tr>
<tr>
<td>New product development time</td>
<td>%</td>
</tr>
<tr>
<td>Other:</td>
<td>%</td>
</tr>
</tbody>
</table>

Continuous Improvement Survey 1995
University of Brighton/Works Management magazine
31. To what extent do you consider CI has contributed to other more indirect effects?

<table>
<thead>
<tr>
<th>Effect</th>
<th>Not at all</th>
<th>To some extent</th>
<th>To a large extent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased absence</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Improved working conditions</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Improved co-operation</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Increased engagement in work (intrinsic motivation, pride in the job etc)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Improved attitude towards change</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Improved competence</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Improved understanding of the total business (e.g. customer demands, performance)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Improved jobs (job enrichment and job enlargement)</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

32. What are the main problems you have encountered in implementing and sustaining CI? What have you done to try and overcome them?

<table>
<thead>
<tr>
<th>Main problems</th>
<th>Actions taken to overcome them</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
</tr>
</tbody>
</table>

☐ Please tick if you would like to be sent a summary of the survey findings.

Name ____________________________________________________________

Company ________________________________________________________

Address _________________________________________________________

Thank you for your help!

Please return this questionnaire in the envelope provided to: Peter Knutton
Editor, Works Management
Findlay Publications Limited
Franks Hall
Horton Kirby
Kent DA4 9LL
Appendix 7  Questionnaire used at validation workshop

Extending Continuous Improvement to the Process of New Product Development

A CIRCA Special Interest Day

9 December 1997

DELEGATE QUESTIONNAIRE

PART A  Experience of working in new product development

Name........................................................................................................................................

Job title ....................................................................................................................................

Company name ...........................................................................................................................

Industry category ...........................................................................................................................

Main type of products developed by the company ........................................................................

Current role in NPD ......................................................................................................................

Number of years working in NPD at present company ................................................................

Is the company currently applying CI to the NPD processes, or attempting to do so?

       NO       YES

If yes, for how long? ....................................................................................................................

Previous experience of NPD:
Company    Role in NPD     Number of years doing this
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................
..................................................................................................................................................

Continued ➔
PART B  
Views of the framework for CI within NPD based on the CI Capability Model

Please circle the appropriate response, and elaborate as necessary.

1. Do you think that the CI capability ‘theory’ with its concepts of CI behaviours and enablers is feasible and makes sense?

<table>
<thead>
<tr>
<th></th>
<th>YES</th>
<th>NO</th>
<th>DON’T KNOW</th>
</tr>
</thead>
</table>

If No, please explain why not.

2. Do you agree that the following 'key CI behaviours' are appropriate and relevant for the NPD context?

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Managers show active commitment to, and leadership of, CI.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>2. People participate proactively in incremental improvement.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>3. Individuals and groups use the organisation's strategic goals and objectives to focus and prioritise their improvement activities.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>4. There is effective working by individuals and groups across internal and external divisions at all levels.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>5. People learn from their own and others' experiences, both positive and negative.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>6. The learning of individuals and groups is captured and deployed.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>7. The 'CI system'* as it operates within NPD is continually monitored and developed.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>8. Ongoing assessment ensures that the NPD structures and infrastructure, and the 'CI system' as operationalised within NPD, consistently support and reinforce each other.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
<tr>
<td>9. People are guided by a shared set of values underpinning CI as they go about their everyday work.</td>
<td>Yes</td>
<td>No</td>
<td>Don't Know</td>
</tr>
</tbody>
</table>

* The ‘CI system’ refers to all the processes, procedures and other enabling mechanisms put in place to encourage adoption of the key CI behaviours.

Continued →
3. Do you feel that there are any other key CI Behaviours?

YES         NO         DON'T KNOW

If Yes, please identify them.

.................................................................

.................................................................

4. Do the examples of CI enablers for the NPD context seem appropriate and workable?

YES         NO         DON'T KNOW

If No, please explain why not.

.................................................................

.................................................................

5. Does the concept of companies moving through different levels of CI maturity make sense?

YES         NO         DON'T KNOW

If No, please explain why not.

.................................................................

.................................................................

.................................................................
PART C Opinions on the research findings

The conclusions drawn from the research are listed below. Please indicate the extent to which you agree or disagree with each statement by circling the appropriate response. Base your response on your own experience and knowledge of working within the NPD context. If you would like to add a comment, please use the space below each statement.

1. The application of 'continuous improvement' to the process of NPD is appropriate in theory.
   
   strongly disagree  
   disagree  
   no comment  
   agree  
   strongly agree

2. CI* can be applied to the process of NPD in practice.
   
   strongly disagree  
   disagree  
   no comment  
   agree  
   strongly agree

3. Firms probably benefit from applying CI* to the process of NPD.
   
   strongly disagree  
   disagree  
   no comment  
   agree  
   strongly agree

4. The scope for applying CI* to the process of NPD is broad, in that CI can be applied to development processes in a wide variety of firms, regardless of size, industry sector, technology and type of product.
   
   strongly disagree  
   disagree  
   no comment  
   agree  
   strongly agree

*'Continuous improvement' (CI) refers to the involvement of the vast majority of employees in the firm in continuously seeking out and implementing improvements to their work processes and daily activities.
5. There may be some limits to the application of CI* within NPD.

   strongly disagree  disagree  no comment  agree  strongly agree

6. Certain factors or characteristics of the NPD process work in favour of CI* in NPD and others work against it.

   strongly disagree  disagree  no comment  agree  strongly agree

7. There are some 'enablers' which could help to institutionalise the concept and practices of CI* within NPD.

   strongly disagree  disagree  no comment  agree  strongly agree

*Continuous improvement' (CI) refers to the involvement of the vast majority of employees in the firm in continuously seeking out and implementing improvements to their work processes and daily activities.

PART D     Any other comments concerning issues raised during the workshop
### Glossary and Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIT</td>
<td>business improvement team – used in TM Products</td>
</tr>
<tr>
<td>BS5750</td>
<td>a national standard prepared by the British Standards Institution which covers quality management systems</td>
</tr>
<tr>
<td>CAD</td>
<td>computer-aided design</td>
</tr>
<tr>
<td>CAE</td>
<td>computer-aided engineering</td>
</tr>
<tr>
<td>CAM</td>
<td>computer-aided manufacturing</td>
</tr>
<tr>
<td>CE</td>
<td>concurrent engineering – an approach under which the process that will be used to manufacture a new product is developed simultaneously with the design of the product</td>
</tr>
<tr>
<td>CI</td>
<td>continuous improvement – a systematic approach to improvement in which staff throughout an organisation are engaged in implementing changes which, though often small-scale, cumulatively impact on the goals and objectives of the business</td>
</tr>
<tr>
<td>CIAG</td>
<td>continuous improvement activity group – used in British Aerospace</td>
</tr>
<tr>
<td>CIRCA</td>
<td>Continuous Improvement Research for Competitive Advantage – a five year research project at the University of Brighton (1992-7)</td>
</tr>
<tr>
<td>CMM</td>
<td>[The Software Engineering Institute's] capability maturity model</td>
</tr>
<tr>
<td>DFA</td>
<td>design for assemblability – an approach under which factors affecting the ease with which a product can be assembled (e.g. number of parts) are taken into account when the product is designed</td>
</tr>
<tr>
<td>DFM</td>
<td>design for manufacturability – an umbrella term which refers to various methods for bringing issues of manufacturability into the design process earlier</td>
</tr>
<tr>
<td>DFMA</td>
<td>design for manufacturability and assemblability – see DFA and DFM</td>
</tr>
<tr>
<td>EPSRC</td>
<td>Engineering and Physical Sciences Research Council</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>EQA</td>
<td>European quality award – an award promoted by the European Foundation for Quality Management</td>
</tr>
<tr>
<td>ESSI</td>
<td>Ericsson Software Systems Improvement – a corporate improvement programme within Ericsson</td>
</tr>
<tr>
<td>FMEA</td>
<td>failure mode and effect analysis – a systematic examination of the ways in which a product could fail, and the effect of such failures</td>
</tr>
<tr>
<td>Gantt chart</td>
<td>a chart used in project management which uses horizontal bars to depict the planned and actual duration of activities, and indicates milestones</td>
</tr>
<tr>
<td>IEEE</td>
<td>The Institute of Electrical and Electronics Engineers, Inc.</td>
</tr>
<tr>
<td>ISO9000</td>
<td>a series of standards for the maintenance of quality management and quality systems issued by the International Organization for Standardization</td>
</tr>
<tr>
<td>IPT</td>
<td>integrated production team – used in British Aerospace</td>
</tr>
<tr>
<td>'Just-in-time'</td>
<td>a production system developed in Japan by Toyota Motor Corporation in order to minimise inventory and reduce waste. This is achieved primarily by ensuring that the right parts and materials are received just before they are used by the manufacturing process.</td>
</tr>
<tr>
<td>Kaizen</td>
<td>Japanese word meaning 'continual improvement'</td>
</tr>
<tr>
<td>Kamban</td>
<td>Japanese word meaning 'card' or 'chit', used in just-in-time production systems. The kamban indicates delivery of a given quantity of specific parts, and then, when all the parts have been used, it represents an order for more.</td>
</tr>
<tr>
<td>KSF</td>
<td>key success factor</td>
</tr>
<tr>
<td>MRPII</td>
<td>manufacturing resource planning – a computerised system which integrates the key processes in a business</td>
</tr>
<tr>
<td>NPD</td>
<td>new product development – the process by which new products are developed, from the generation of an idea until the product is launched onto the market</td>
</tr>
<tr>
<td>PCP</td>
<td>product creation process</td>
</tr>
<tr>
<td>PDMA</td>
<td>Product Development and Management Association (U.S.A.)</td>
</tr>
<tr>
<td>QC</td>
<td>quality control</td>
</tr>
</tbody>
</table>
QCC quality control circle – a small group of people from the same work group who, voluntarily, carry out quality control activities as part of a company-wide improvement programme

QFD quality function deployment – a methodology which uses a series of matrices to translate customer requirements into design parameters

R&D research and development

SEI Software Engineering Institute at Carnegie Mellon University, Pittsburgh, U.S.A.

'Seven new management and planning tools' seven paper-based tools to assist with problem definition, and planning and organising: K-J diagram; relations diagram; tree diagram; matrix diagram; matrix data analysis; process decision programme chart; arrow diagram

'Seven QC tools' seven paper-based tools used in quality improvement: Pareto analysis; cause & effect analysis; histograms; control charts; scatter diagrams; graphs; checksheets

SIC Standard Industrial Classification – a scheme classifying business establishments and other statistical units by the type of economic activity in which they are engaged

TOP Time Optimised Processes – an improvement programme implemented in Siemens

TQC total quality control – Japanese approach to quality and improvement in which everyone in an organisation is involved systematic efforts to improve performance and achieve customer satisfaction

TQM total quality management – a management philosophy, increasingly adopted by western companies during the 1980s, that promotes an organisation-wide approach to quality which emphasises customer focus, process orientation, and continuous improvement of products and processes
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Caffyn, S., 1995, *Continuous improvement beyond the factory floor: Report of the 12th CIRCA workshop*, University of Brighton, UK.


Caffyn, S., Gilbert, J. and Bessant, J., 1994, *Vehicles for finding improvement opportunities and solving problems*, Report, Department of Trade & Industry / University of Brighton.


Hart, S., 1995, 'Where we've been and where we're going in new product development research', in M. Bruce and W. G. Biemans (eds.) Meeting the Challenge of the Design-Marketing Interface, John Wiley & Sons Ltd: Chichester.


