2001

Introducing concurrent engineering in an Indonesian aircraft manufacturing company: a processual analysis

Zuhriati Zainuddin

University of Wollongong

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INTRODUCING CONCURRENT ENGINEERING
IN AN INDONESIAN AIRCRAFT
MANUFACTURING COMPANY:
A PROCESSUAL ANALYSIS

A thesis submitted in fulfilment of the requirements for the award of the degree

Doctor of Philosophy

from

UNIVERSITY OF WOLLONGONG

by

Zuhriati Zainuddin

Department of Management
2001
This thesis addresses a significant gap in the empirical research on concurrent engineering (CE) implementation, namely the process of change in CE introduction over time. This study captures the dynamic and temporal reality of this process and explores the way CE is shaped and transformed in a setting that is different from its original context. The setting is an Indonesian aircraft manufacturing company. The researcher employs Dawson’s (1994) processual approach to organisational change as the basis for a research framework to address this important issue.

CE implementation is conceptualised and operationalised as a change process in the organisation and management of new product development, influenced by both internal and external contexts as well as organisational power and politics. CE is considered as a loose set of initiatives in product development programs grouped into five categories: (1) organisational integration; (2) communication and decision-making mechanisms; (3) enabling technology; (4) external integration; and (5) human resources. The focus of this study is restricted to the first two of these.

The case study reveals a complex and multidimensional process of CE introduction from a pre-CE stage to the premature conclusion of the implementation. Four implementation stages are identified, each with a different structure and different CE characteristics: (1)
program initiation; (2) engineering matrix; (3) engineering integration; and (4) design-production coupling. The absence of initiatives in ensuring the availability of competent human resources, especially engineers, as well as the availability of systematic protocols to guide the course of the change process significantly and adversely affected the process and final form of CE in the company.

Organisational context and politics also provide important insights into the CE implementation that occurred. A number of important factors are identified. The centralised and compartmentalised organisational structure, the dominant engineering culture, the company's state of maturity as well as the power sources and 'will and skill' of key personnel all contributed to the shape of CE and how it was implemented. The extent of the interrelationship among companies within the aircraft industry and the pursuit of Indonesia's national development and industrialisation contributed to the decision to introduce CE while Indonesia's economic crises forced the abrupt termination of its implementation.

Implementing CE is a major strategic change that requires a thorough preparation and a committed change champion. Internal and external contextual factors as well as power and politics in an organisation are influential in determining which particular set of operational initiatives is selected and how it is implemented.

The complexity of this change process requires more research in order to define operational CE model and framework more clearly. Further research focusing on enabling technology, external integration, and human resource aspects of CE implementation as well as further comparison across industries and across countries are recommended.
ACKNOWLEDGEMENTS

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Last but not least, special thanks are extended to my husband, Arie, and my son, Bhakti, for their love, whole-hearted support, continuous encouragement, and undying confidence in me.
# CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abstract</td>
<td>i</td>
</tr>
<tr>
<td>Certification</td>
<td>iii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>iv</td>
</tr>
<tr>
<td>Contents</td>
<td>v</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xi</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xii</td>
</tr>
<tr>
<td>Glossary of Terms and Abbreviations</td>
<td>xiv</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1. Background</td>
<td>1</td>
</tr>
<tr>
<td>1.2. Research Problems</td>
<td>3</td>
</tr>
<tr>
<td>1.3. Research Objectives</td>
<td>6</td>
</tr>
<tr>
<td>1.4. Processual Approach to Change</td>
<td>8</td>
</tr>
<tr>
<td>1.5. Research Strategy</td>
<td>12</td>
</tr>
<tr>
<td>1.6. Case Study</td>
<td>15</td>
</tr>
<tr>
<td>1.7. Contribution of the Thesis</td>
<td>16</td>
</tr>
<tr>
<td>1.8. Thesis Structure</td>
<td>17</td>
</tr>
<tr>
<td>2. CONCURRENT ENGINEERING AND CONCEPTUAL FRAMEWORK</td>
<td>19</td>
</tr>
<tr>
<td>2.1. Introduction</td>
<td>19</td>
</tr>
<tr>
<td>2.2. Concurrent Engineering and New Product Development Management</td>
<td>20</td>
</tr>
<tr>
<td>2.2.1. Concurrent Engineering History</td>
<td>24</td>
</tr>
<tr>
<td>2.2.2. Concurrent Engineering Definition</td>
<td>25</td>
</tr>
<tr>
<td>2.2.3. Achieving Concurrent Engineering</td>
<td>30</td>
</tr>
<tr>
<td>2.3. Generic Features of Concurrent Engineering</td>
<td>32</td>
</tr>
<tr>
<td>2.3.1. Design Integration</td>
<td>33</td>
</tr>
</tbody>
</table>
2.3.2. Organisational Integration ................................................................. 34
2.3.3. Concurrent Process ................................................................. 36
2.4. Concurrent Engineering Initiatives ......................................................... 37
  2.4.1. Organisational Integration Initiatives ................................................ 41
    2.4.1.1. Cross-Functional Team: Horizontal Integration ......................... 41
    2.4.1.2. Heavyweight Management: Vertical Integration ......................... 48
  2.4.2. Communication and Decision-Making Mechanisms ......................... 52
    2.4.2.1. Formal Communication .............................................................. 55
    2.4.2.2. Collaboration .............................................................. 56
    2.4.2.3. Inter-Team Communication ....................................................... 58
    2.4.2.4. Decision Making Mechanisms .................................................... 59
  2.4.3. Enabling Technology .............................................................. 60
    2.4.3.1. Computer-Based Technology ..................................................... 60
    2.4.3.2. Collocation .............................................................. 62
    2.4.3.3. Formal CE Methods ............................................................... 63
    2.4.3.4. Systematic Protocols ......................................................... 65
  2.4.4. External Integration .............................................................. 66
    2.4.4.1. Supplier Involvement .............................................................. 67
    2.4.4.2. Customer Involvement .............................................................. 67
  2.4.5. Human Resource Management (HRM) Policy and Capability ............... 68
    2.4.5.1. Competency .............................................................. 68
    2.4.5.2. CE-Related Training ............................................................... 70
    2.4.5.3. Human Resource Policies ......................................................... 71
  2.5. Conclusion .................................................................................. 72

3. CONTEXT AND POLITICS OF CHANGE AND CONCEPTUAL FRAMEWORK. 75
  3.1. Introduction ................................................................................ 75
  3.2. The Context of Change .............................................................. 77
    3.2.1. Organisational Context .............................................................. 78
      3.2.1.1. Organisational Structure and Stage of Development .................. 81
      3.2.1.2. Organisational Culture ......................................................... 84
      3.2.1.3. Functional and Professional Culture ....................................... 88
3.2.2. External Context ................................................................. 92
  3.2.2.1. Industry Context ........................................................... 92
  3.2.2.2. National Context .......................................................... 94

3.2.3. Conceptual Framework Refinement Based on Contextual Variables ..... 98

3.3. Organisational Power and Politics ................................................. 98
  3.3.1. Power Sources ............................................................... 103
  3.3.2. Skill and Will ................................................................. 104
  3.3.3. Structure and Context ...................................................... 106
  3.3.4. The Final Conceptual Framework ....................................... 107

3.4. Conclusion ................................................................................. 109

4. RESEARCH METHODOLOGY ....................................................... 111
  4.1. Introduction ........................................................................... 111
  4.2. Research Strategy ................................................................. 111
  4.3. Research Methods ................................................................. 114
    4.3.1. Selection of the Case Study ............................................. 116
    4.3.2. Data Collection .............................................................. 117
      4.3.2.1. Field Research ......................................................... 118
      4.3.2.2. Participant Observation ............................................. 122
      4.3.2.3. Interviews .............................................................. 125
      4.3.2.4. Secondary Data Sources: Documentary Review .......... 129
    4.3.3. Data Analysis ............................................................... 132
    4.3.4. Report Writing .............................................................. 134
  4.4. Validity, Reliability and Generalisability .................................... 135
  4.5. Summary .............................................................................. 138

5. INDACO: THE COMPANY AND ITS CONTEXTS ............................. 139
  5.1. Introduction ........................................................................... 139
  5.2. Overview of Indaco: the Organisational Context ....................... 141
    5.2.1. Organisational Mission ............................................... 141
    5.2.2. Products and Product Development Programs ................... 142
    5.2.3. Organisational Structure ............................................... 143
5.3. Aircraft Industry and Its Relation to Indaco and CE Adoption ........................................... 146
  5.3.1. Overview of the Global Aircraft Industry ............................................................... 146
  5.3.2. New Product Development in Aircraft Industry and the Need for CE .................. 150
  5.3.3. Inter-Firm Relationship within the Aircraft Industry and CE Adoption ............... 153
5.4. National Context and Its Relation to Indaco and CE Termination .................................... 158
  5.4.1. Indonesia’s Development Plan and Its Relation to Indaco and PLI Program .............. 159
  5.4.2. Cultural Tendency and Its Effects in Indaco’s Organisation .................................... 160
  5.4.3. Contemporary Indonesia’s Economic crisis and CE Termination ............................. 162
5.5. Summary ......................................................................................................................... 163

6. THE SUBSTANCE OF CHANGE: CE IMPLEMENTATION ................................................. 165
  6.1. Introduction .................................................................................................................. 165
  6.2. Overview of Indaco’s PLI Program ............................................................................... 168
    6.2.1. Program Phases .................................................................................................... 170
    6.2.2. Program Uniqueness ............................................................................................ 172
  6.3. CE Initiatives at Westaco: The Model of CE for the PLI Program .............................. 176
  6.4. CE Approach in Indaco’s PLI Program ....................................................................... 184
    6.4.1. Overview of Indaco’s CE .................................................................................... 186
    6.4.2. Longitudinal Analysis of CE Introductory Process in Indaco ............................... 191
      6.4.2.1. Program Initiation Stage (November 1993 - August 1995) ............................... 191
      6.4.2.2. Engineering Matrix Stage (August 1995 - October 1996) ............................... 193
      6.4.2.3. Engineering Integration Stage (October 1996 - June 1997) ......................... 205
      6.4.2.4. Design-Production Coupling Stage (June 1997 - June 1999) ....................... 212
  6.5. Discussion and Conclusion ......................................................................................... 223
    6.5.1. Organisational Integration .................................................................................... 225
    6.5.2. Communication and Decision Making Mechanisms ....................................... 229
    6.5.3. Structure Lagging behind the Process ............................................................. 231
    6.5.4. Conclusion ......................................................................................................... 233

7. CONTEXTUAL EXPLANATION OF CHANGE .............................................................. 235
  7.1. Introduction ................................................................................................................. 235
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>General Conceptual Framework: Processual Approach</td>
<td>13</td>
</tr>
<tr>
<td>2-1</td>
<td>Types of Development Team</td>
<td>49</td>
</tr>
<tr>
<td>2-2</td>
<td>Four Modes of Upstream-Downstream Interaction</td>
<td>53</td>
</tr>
<tr>
<td>2-3</td>
<td>The Substance of Change and Its Sub-processes</td>
<td>73</td>
</tr>
<tr>
<td>2-4</td>
<td>Conceptual Framework Refined Based on CE Initiatives</td>
<td>74</td>
</tr>
<tr>
<td>3-1</td>
<td>Organisational Structure and Organisational Culture Interrelationship</td>
<td>86</td>
</tr>
<tr>
<td>3-2</td>
<td>Conceptual Framework Refined Based on the Context of Change</td>
<td>98</td>
</tr>
<tr>
<td>3-3</td>
<td>Tripartite Analysis of Power and Influence</td>
<td>102</td>
</tr>
<tr>
<td>3-4</td>
<td>The Final Conceptual Framework</td>
<td>109</td>
</tr>
<tr>
<td>5-1</td>
<td>Indaco’s Organisational Structure Prior to 1997</td>
<td>145</td>
</tr>
<tr>
<td>5-2</td>
<td>Indaco’s Organisational Structure After 1997</td>
<td>145</td>
</tr>
<tr>
<td>5-3</td>
<td>Aspects of Aircraft Development Process</td>
<td>151</td>
</tr>
<tr>
<td>5-4</td>
<td>Aircraft Development Process</td>
<td>152</td>
</tr>
<tr>
<td>5-5</td>
<td>A Dream for a Specialisation, a Nightmare for Others</td>
<td>153</td>
</tr>
<tr>
<td>6-1</td>
<td>Simplified Milestones of the PLI Program</td>
<td>171</td>
</tr>
<tr>
<td>6-2</td>
<td>Overlapping Timeframes between the Program Phases, CE Stages, and Research Activity</td>
<td>185</td>
</tr>
<tr>
<td>6-3</td>
<td>PLI Program Structure in Engineering Matrix Stage</td>
<td>194</td>
</tr>
<tr>
<td>6-4</td>
<td>PLI Program Structure in Engineering Integration Stage</td>
<td>205</td>
</tr>
<tr>
<td>6-5</td>
<td>PLI Program Structure in Design-Production Coupling Stage</td>
<td>212</td>
</tr>
<tr>
<td>6-6</td>
<td>Operational Level Structure of the Design Centre and the Operation Centre</td>
<td>214</td>
</tr>
<tr>
<td>7-1</td>
<td>Locations of the PLI Team Members in the Company Site at the Beginning of Design-Production Coupling Stage</td>
<td>244</td>
</tr>
<tr>
<td>7-2</td>
<td>Layout of Collocation Area in May 1998</td>
<td>245</td>
</tr>
<tr>
<td>10-1</td>
<td>Generic Model of Processual Approach for Strategy Formation</td>
<td>366</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
<td>Page no.</td>
</tr>
<tr>
<td>---------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>2-1</td>
<td>Operationalisation of Initiatives within Organisational Integration and Communication and Decision-Making Mechanisms Categories</td>
<td>40</td>
</tr>
<tr>
<td>2-2</td>
<td>Operationalisation of Initiatives in Enabling Technology, External Integration, and Human Resource Categories</td>
<td>41</td>
</tr>
<tr>
<td>4-1</td>
<td>Field Study Summary</td>
<td>119</td>
</tr>
<tr>
<td>4-2</td>
<td>Characteristics of Respondents</td>
<td>126</td>
</tr>
<tr>
<td>4-3</td>
<td>Interview Methods</td>
<td>127</td>
</tr>
<tr>
<td>6-1</td>
<td>Dimensions of CE Assessed in the Case Study</td>
<td>167</td>
</tr>
<tr>
<td>6-2</td>
<td>General Features of the PLI</td>
<td>169</td>
</tr>
<tr>
<td>6-3</td>
<td>Development Activities in Each Development Phase</td>
<td>171</td>
</tr>
<tr>
<td>6-4</td>
<td>PLI’s Airplane Level DR&amp;O</td>
<td>172</td>
</tr>
<tr>
<td>6-5</td>
<td>Summary of the Westaco Model of CE</td>
<td>179</td>
</tr>
<tr>
<td>6-6</td>
<td>Summary of the Changing Nature of CE in Indaco</td>
<td>187</td>
</tr>
<tr>
<td>6-7</td>
<td>Matrix between TOP teams and Engineering Specialist Groups</td>
<td>195</td>
</tr>
<tr>
<td>6-8</td>
<td>Organisational Integration Characteristics in Engineering Matrix Stage</td>
<td>198</td>
</tr>
<tr>
<td>6-9</td>
<td>Communication and Decision-Making Mechanisms in Engineering Matrix Stage</td>
<td>202</td>
</tr>
<tr>
<td>6-10</td>
<td>Organisational Integration Characteristics in Engineering Integration Stage</td>
<td>208</td>
</tr>
<tr>
<td>6-11</td>
<td>Organisational Integration Characteristics in Design-Production Coupling Stage</td>
<td>216</td>
</tr>
<tr>
<td>6-12</td>
<td>Communication and Decision-Making Mechanisms in Design-Production Coupling Stage</td>
<td>220</td>
</tr>
<tr>
<td>6-13</td>
<td>Variation between the Intended Model and the Emergent Indaco Model</td>
<td>224</td>
</tr>
<tr>
<td>7-1</td>
<td>Contribution of Initiatives in Enabling Technology, External Integration and Human Resources</td>
<td>239</td>
</tr>
<tr>
<td>7-2</td>
<td>Influence of the Organisational Context</td>
<td>287</td>
</tr>
<tr>
<td>8-1</td>
<td>Tripartite Analysis of Power: Mark</td>
<td>307</td>
</tr>
</tbody>
</table>
List of Tables

Table 8-2: Tripartite Analysis of Power: Clive .............................................................313
Table 8-3: Tripartite Analysis of Power: Alan .............................................................323
Table 8-4: Tripartite Analysis of Power: William .......................................................329
Table 8-5: Tripartite Analysis of Power: Robert and Lucas .......................................334
Table 10-1: Operationalisation of CE through CE Initiatives and Their Dimensions ....365
GLOSSARY OF TERMS AND ABBREVIATIONS

2-D Two-dimensional view
3-D Three-dimensional view
ASD Advanced System Development
CAD/CAM Computer Aided Design/Computer Aided Manufacturing
CADCAM A division in Indaco, eliminated in the latter structure
CAE Computer Aided Engineering
CALS Computer Acquisition and Logistic Supports
CATIA Computer-aided Three-dimensional Interactive
CE Concurrent Engineering
CERC Concurrent Engineering Research Center
Chief Engineer Head of the Design Centre of the PLI Program
Chief of Operation Head of the Operation Centre of the PLI Program
CSCW Computer Supported Cooperative Work
DARPA Defence Advance Research Project Agency
DBP Design Build Process, a group of production-related representatives for supporting the PLI Program
DFA Design for Assembly
DFM Design for Manufacturing
DFM/A Design for Manufacturing and Assembly
DFPLC Design for Product Life Cycle
DFS Design for Services
DFT Design for Testing
DFX Design for X-ilities
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DoD</td>
<td>U.S.'s Department of Defense</td>
</tr>
<tr>
<td>DR&amp;O</td>
<td>Design Requirement and Objectives, the deliverable of conceptual phase of the development process</td>
</tr>
<tr>
<td>DRI</td>
<td>The pseudonym of a PLC derivative</td>
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<tr>
<td>DRX</td>
<td>The pseudonym of a product derivative in Westaco</td>
</tr>
<tr>
<td>EMC</td>
<td>Executive Management Council</td>
</tr>
<tr>
<td>FAA</td>
<td>US Federal Aviation Administration</td>
</tr>
<tr>
<td>Fabrication</td>
<td>A division under Production Division, became part of the Airplane Group in the latter Indaco structure</td>
</tr>
<tr>
<td>HoQ</td>
<td>House of Quality</td>
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<tr>
<td>HR</td>
<td>Human Resource</td>
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<td>HRM</td>
<td>Human Resource Management</td>
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<td>IDA</td>
<td>Institute of Defense Analyses</td>
</tr>
<tr>
<td>Indaco</td>
<td>Pseudonym for an Indonesian aircraft manufacturing company, the object of the case study</td>
</tr>
<tr>
<td>JAA</td>
<td>European’s Joint Aviation Authority</td>
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<tr>
<td>MLW</td>
<td>Maximum Landing Weight</td>
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<tr>
<td>MPP</td>
<td>Master Phasing Plan</td>
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<tr>
<td>MTOW</td>
<td>Maximum Take Off Weight</td>
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<tr>
<td>NC-program</td>
<td>Numerical control-programming</td>
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<td>NPD</td>
<td>New Product Development, a department under Technology Division</td>
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<tr>
<td>PLC</td>
<td>Pseudonym of the 35-passenger commuter aircraft designed by Indaco and the other company</td>
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<tr>
<td>PLI</td>
<td>The pseudonym of new product platform (100-passenger jet) of Indaco, the main object of the case study</td>
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<tr>
<td>PLP</td>
<td>Pseudonym of a product platform (50-passenger commuter airplane) of Indaco developed prior to the PLI</td>
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<td>PLX</td>
<td>Pseudonym of a product platform of Westaco</td>
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<td>PMO</td>
<td>Program Management Office</td>
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<td>Prico</td>
<td>Pseudonym of an Indonesian private company which acted as the financier for the PLI Program</td>
</tr>
<tr>
<td>QFD</td>
<td>Quality Function Deployment</td>
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<tr>
<td>SE</td>
<td>Simultaneous Engineering</td>
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<td>Term</td>
<td>Definition</td>
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<tr>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>Sidina</td>
<td>A system that specifically developed to support the PLI development program in Indaco.</td>
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<td>TC</td>
<td>Type certificate, granted by aviation regulation to confirm that the design is compliance with its standards</td>
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<tr>
<td>TIP</td>
<td>Tim Integrasi Produk, Product Integration Team</td>
</tr>
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<td>TOP</td>
<td>Tim Optimasi Produk, Product Optimisation Team</td>
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<tr>
<td>TQM</td>
<td>Total Quality Management</td>
</tr>
<tr>
<td>WBS</td>
<td>Work Breakdown Structure</td>
</tr>
<tr>
<td>Westaco</td>
<td>Pseudonym for a western aircraft manufacturing company, from which the Indaco's CE approach was adopted</td>
</tr>
</tbody>
</table>
1.1 Background

In recent years, the importance of new product development for competitive success has increased, particularly in terms of the ability to bring excellent products to market before the competitors. The necessary speed in product development is derived from quick problem solving and integration of engineering understanding with critical manufacturing knowledge. These capabilities are also seen as critical in achieving cost reduction (Wheelwright and Clark, 1993).

Concurrent engineering (CE) has been introduced in a number of companies as an approach to product development that proposes simultaneous rather than sequential processes in order to achieve better, cheaper and faster product development. It has been advocated as a solution, particularly for Western companies, for coping with the shorter life cycle of the products and the continuous improvement and rapid response to the market, which marked the Japanese success in the 1980s and early 1990s.

The term CE was first used in the United States to capture various best practice initiatives in product development by several ‘high-tech’ companies involved in tendering for U.S. Defense procurement (Winner, Pennel, Bertrand and Slusarczuk, 1988). Such initiatives were implemented in order to achieve three important
objectives:
1) to achieve high quality products to meet customer expectations;
2) to achieve faster product development time to gain an early marketing advantage;
3) to obtain lower product development costs in order to stay competitive.

As high-tech and complex industries typically have a long product development time, CE was initially proposed as a means of minimising this. Over the years, the popularity of CE has grown (Patti, Gilbert and Hartman, 1997), and been adopted across industries and countries. Along with this growing popularity, the rhetoric around CE’s objectives and advantages has also increased. The objectives have been expanded to encompass the total effectiveness of the product development process, considering every aspect of the product life cycle from conceptualisation to disposal. The term CE has become a fuzzy concept with this change in its scope, because it means different things to different people and hence has many definitions (e.g. Winner, et al, 1988, Cleetus, 1992).

In this study, CE is conceptualised as a strategic approach to product development that relies on a multi-disciplinary approach to integrate all product life cycle considerations up-front, minimise changes in the later stages of development and maximise overlap and parallel activities in order to produce products that meet customer expectations with reduced lead time and cost. This conceptualisation of CE is used to guide in the empirical investigation.

In the research literature, a CE approach typically means that the product development process has distinct features of organisational integration, holistic design and concurrence processes (Zanko, Couchman, Badham, Schubert, and Zainuddin, 1998). A CE product development project is often associated with bringing together
departmental representatives across functions in cross-functional teams, emphasising early and intensive dialogue between 'upstream' and 'downstream' functions, using collocation to foster further effective communication, and utilising advanced computer technology for complex development tasks.

Taking these features into account, CE calls for an organisational arrangement which is designed differently to the traditional 'functional silos' in the sequential product development process. The sequential arrangement usually employs a 'throw over the wall' approach (Stoll, 1990), where the task of developing a new product is handed over sequentially from one function to the next, i.e. from design to manufacturing, and then to sales and marketing. This arrangement is associated with problems of time and cost as well as losing the focus on the customer's desires. For a concurrent process, Wheelwright and Clark (1993) suggest the formation of a 'heavyweight' project team in which the project manager has direct access to, and is responsible for, the work of all those involved in the project. This arrangement is believed to be able to overcome most problems associated with the traditional sequential approach in delivering better products faster and cheaper.

1.2 Research Problems

During this period of the growth in popularity of CE, an Indonesian aircraft manufacturing company (due to confidentiality issues, the pseudonym 'Indaco' has been used) decided to adopt this approach in its new development program of a 100-passenger jet airplane. This decision raised questions about CE's suitability for the Indaco context, which in turn, led to the researcher's interest to investigate the process of CE introduction. As an engineer who has worked in Indaco for 13 years, the
researcher has first hand experience and understanding of Indaco and its context.

The decision to use CE by Indaco also raised more fundamental questions about the process of introducing CE in general. Despite the growing research literature on CE, there is very little empirical research on its introduction in an organisation (Gerwin and Susman, 1996). The CE approach is often presented as the application of new tools or methods, emphasising the result, e.g. the percentage of time and cost saving compared with the previous approach, rather than on the process.

CE is claimed as able to overcome the barriers for competing in an increasingly tough environment. Its introduction, however, is far from easy. Moving away from the sequential process, overcoming the functional silos and associated ‘throw over the wall’ attitudes to create integrated processes involves not only technological change but also substantial organisational and cultural changes. Despite the growing literature on the importance of managing change for organisations that undergo technological and organisational changes (e.g. McLoughlin and Clark, 1994; Carnall, 1991), there is very little in CE literature that has paid attention to this change process.

The CE research literature can be broadly divided into two main groups: firstly, engineering which focuses on manufacturing and design automation and secondly, the management of technology and innovation (Moffat and Gerwin, 1994). The first is heavily influenced by the engineering knowledge domain and primarily concerned with the technical aspect of complex development process (e.g. Kusiak, 1993; Syan and Menon, 1994). The aim is to develop various “enabling technologies” to support CE implementation, such as software development for Design for X-ilities (DFX) and Quality Function Deployment (QFD), integration simulation models, etc. (e.g. Syan and Menon, 1994; Halevi and Weill, 1992). Although this domain acknowledges that
process complexity has implications for organisation and management (e.g. Vasilash, 1990, Evans, 1990), it does not explore this aspect further.

The second grouping in the CE literature is grounded in the management of technology and innovation domain. This literature recognises the complexity of the process but is primarily concerned with the organisational complexity and the implication of CE initiatives, such as the cross-functional team and the heavyweight project team in work organisation and management (e.g. Clausing, 1994; Adler, 1995). This domain often ignores the complexity of the CE process and therefore does not provide enough depth and richness in its analysis. Klein and Maurer’s study (1995), for example, acknowledges the existence of more than one group supporting a single product by mentioning the existence of product teams and process teams (who support the product teams), but focuses only on the communication mechanism within a single team and between the team and management. In this domain, CE might be in danger of becoming a management fashion (Abrahamson, 1996) emphasising the rhetoric of the objectives and advantages of the approach. Only in the mid 1990s did detailed empirical studies of CE implementation begin to appear in the literature but the complex and often messy change process that is associated with CE has not been adequately addressed (e.g. Haddad, 1996; Klein and Maurer, 1995).

In order to address this knowledge gap, this study uses the introduction process of CE at Indaco as a case study and seeks to provide a rich and in-depth empirical study of this process using a processual approach (Pettigrew, 1973; Dawson, 1994) as its research framework to analyse organisational change. The processual framework is used because it provides the necessary in-depth and longitudinal analysis of the introduction process by considering historical events, internal and external contextual
factors and the organisational politics surrounding the process. It enables the study to bring out the dynamic reality of the messy change process underlying the application of the new approach often superficially seen as smooth. So far, this form of research has never been used to investigate CE implementation and by doing so, this study aims to make a significant contribution to CE literature.

Apart from the theoretical and conceptual contribution to the literature, this research is also expected to offer practical benefits, particularly for companies that attempt to introduce CE in their new product development program. By thoroughly investigating the introduction process of CE, this study provides information that will assist the implementation process and increase the readiness for technological, organisational and cultural changes that are inherent in introducing CE.

In addition, the effect of cultural differences in business and workplace is strongly advocated by several researchers (e.g. Hall, 1960; Trompenaars, 1994; Hofstede, 1984) and widely recognised (Katz and Seifer, 1996; Morden, 1995; Foster, 1995; Weldon, 1996; Bridges, Floersheim and John, 1996) albeit some criticisms, particularly upon its deterministic influence (Kanter and Corn, 1994; Wilkinson, 1996). Although CE has been applied across countries (Ashley, 1990), cultural aspect of its implementation has never been explored. Therefore, by investigating the introduction of CE in a country different from its cultural origin, this study may provide insights in implementing and adjusting CE to culturally different context.

1.3 Research Objectives

This study investigates the process of introducing CE into Indaco, an Indonesian
aircraft manufacturing company. The case study specifically involves the aircraft industry where CE has been a very influential part on product development initiatives (Winner et al, 1988). The first main objective of the study is to explore and bring out the dynamics of introducing a ‘vague and fuzzy’ concept, such as CE in a particular and changing context that is significantly different from its origins. The second main objective is to longitudinally capture the dynamic reality of the change process during the introduction of CE using the processual change analysis (Pettigrew, 1973; 1997; Dawson, 1994). Processual analysis enables the exploration of the ‘constellation of forces’ (Hofstede, 1997) shaping the character of the process and its outcomes.

Using this processual change framework, research questions are developed around the following two main issues:

- **Defining the process of CE introduction in Indaco:**
  1) What does the introduction of CE in a product development project look like in practice? What are the key characteristics of CE that are significantly different from the traditional development process?
  2) What stages occur in the introduction of CE and how does the organisation introduce it?

- **Explaining how the process took a particular form:**
  3) What are the key factors that influence the change process?
  4) How do those factors influence such a transformation?

Thus, this study explores the way CE is shaped and transformed into a specific form during its introduction in Indaco. The generic holistic, integration and concurrent features of CE (Zanko et al., 1998) and the particular model of CE from a Western aircraft manufacturing company (due to confidentiality issues, the pseudonym
Chapter 1: Introduction

'Westaco' has been used), are viewed as the substance of change. This 'substance of change' was transformed into a specific model of CE during the implementation process as the result of adjustment processes and was influenced by contextual factors as well as organisational power and politics.

1.4 Processual Approach to Change

Processual research is defined as "research concerning any process that exists between two points in time, regardless of whether the actual processes are observable" (Tuttle, 1997, p. 350). Pettigrew (1997) defines a process as "a sequence of individual and collective events, actions and activities unfolding over time in context" (p. 338). He further contends that while resulting from actions, processes cannot be explained only by reference to individuals or groups. Actions are embedded in context, which limit individuals or groups information, insight and influence. Contexts are shaping and shaped by actions. Processual analysis draws on phenomena at vertical and horizontal levels of analysis of the context of a process and the interconnection between those levels through time (Pettigrew, 1990).

A source of change is the assymetries between levels of context, where processes at different levels often have their own momentum, pace and trajectory (Pettigrew, 1997). The processual approach emphasises that change, particularly a large scale transition, is a complex and dynamic process and should not be treated as a series of linear events (Dawson, 1994). Dawson (1994) argues that organisations undergoing change should be studied ‘as it happens’ so that the processes can be examined over time and in context. He further argues that the dominant or official version of change may often reflect the political position of certain key individuals or groups rather than
being a true representation of what actually happens.

The usefulness of the processual framework in studying an organisation’s dynamic process of change or decision-making can be seen in Pettigrew’s (1973) study of politics in decision-making. This study sought to complement existing work by exploring the nature of organisation politics in the context of an innovative decision process. The decisions were empirically tracked back to find out what actually happened rather than what ideally was expected or was represented by particular actors reflecting the argument that an organisation or any other social system may most usefully be explored as an ongoing system with a past, a present, and a future.

Pettigrew (1997) offers five guiding assumptions for carrying out processual analysis:

1) Embeddedness across a number of levels of analysis.

2) Temporal interconnection between past, present and future.

3) A role in explanation for context and action; action derives process.

4) A search for holistic rather than linear explanation.

5) A need to link process analysis to the location and explanation of outcomes.

Reflecting the above guiding assumptions, Dawson (1994) formulates the processual approach to cover three stages that reflect the temporal elements of change and three main groups of determinants used to explain the process of change. The three temporal stages are (1) the conception of a need to change, (2) the process of organisational transition, and (3) the operation of new work practices and procedures. In between these stages lie complex non-linear processes of change. Transition rarely occurs in a neat linear fashion; it is difficult to identify the start or completion of a major change. According to Dawson (1994), three basic determinants of processual change are (1) the substance, (2) the context and (3) the politics of change. The
Chapter 1: Introduction

substance of change refers to the type and scale of organisational change. The context of change refers to the past and present, external and internal operating environments as well as the influence of future projections and expectations on current operating practice. The politics of change refers to the ‘political activities’ of consultations, negotiations, conflicts and resistance that occur at various levels within and outside an organisation during the process of change.

Pettigrew (1973) considers that behaviour observed in a change process cannot be adequately explained without reference to the past. A historical perspective on both internal and external contexts is central to understanding the opportunities, constraints and organisationally defined route to change (Kelly and Amburgey, 1991, p. 610). The coexistence of a number of competing histories of change can significantly shape the process and outcomes of an ongoing change program. The context is divided into the internal organisational context and the context pertaining to the environment in which the organisation operates (Dawson, 1994).

The third basic determinant of change in the processual approach is the politics of managing change. Pettigrew (1973) considers the organisation as an open political system in which its sub-units are both interdependent and have different interests that may lead to conflicts. An understanding of organisational politics should be central to any approach that seeks to explain the process of managing transition, e.g. middle managers’ commitment toward the intended change cannot be taken for granted (Porter, Crampon and Smith, 1976). Variations in commitment can significantly influence the success of the change process (Guth and McMillan, 1989), particularly in cases where differing vested interests between management levels and functions do not align with strategic objectives (Wilkinson, 1983). Following Child (1972), it is
possible to view these strategic choices as being modified and challenged collectively by the workforce or by individual and groups of managers who are responsible for implementing a strategy.

Using the processual framework, this study specifically explores the process of introducing CE in Indaco. The important of the processual framework with its context and politic determinants, particularly in analysing technological changes is emphasised by Thomas (1994). In power process perspective, Thomas (1994) sees technological change as a process and the relationship between technology and organisation is dynamic which only visible by extending the temporal and organisational context and assessing the role of power and politics.

However, in this study the organisation is not viewed as the substance of change as in the Pettigrew’s (1973) and Dawson’s (1994) studies. Rather, based on research objectives outlined in the previous section, this study takes the initiation to establish CE as the substance of change that undergoes the shaping and forming processes while being implemented in different organisational contexts. Such a framework is expected to provide the process dynamics of such undertaking that are often ignored as most case studies focus on a discrete process of change.

CE initiatives introduced in Indaco appeared in the form of a vague and general concept with a set of broad generic features. Typically, the translation and adoption of such a general concept depends on the contextual factors and the means used to introduce it including the implementation process employed (Leonard-Barton, 1995; Rogers, 1995; Badham (ed.), 1993). This translation and adoption process results in a specific model. Thus, this study explores how a ‘Western’ model of CE was introduced to the company and was gradually shaped and transformed into a specific
Chapter 1: Introduction

‘Indaco’ model by its contextual factors and the organisational power and politics.

The context of change is represented by the internal and external environment of the company. In this study, the context of change is of particular interest because it involves transferring the substance of change (the CE approach) into a context that is significantly different from its origins, namely Indaco organisational within the Indonesia’s national context, apart from operate in the same industry. This has implication for the implementation process. Adopting Schneider and Barsoux (1997) this study frames the environment as sets of contextual factors consisting of society, industry, organisation, and function/department that capture both soft and hard aspects of the environment. These contextual factors not only influence and affect the change process but also interact with one another.

The politics of change is represented by activities carried out by individuals involved in the attempt to bring CE into the organisation. By using their power and by engaging in organisational politics, these individuals continuously affect the change process, influence the outcome of the process and determine the dominant spheres at any points in the process. In this framework, organisational power and politics act either as the catalyst mediating the effect of the contextual factors in the process.

Arranging all these three determinants of processual framework, the general approach taken in this study is illustrated as Figure 1-1.

1.5 Research Strategy

Adopting the processual approach and the argument that theory and methodology are interdependent (Pettigrew, 1973), this study is designed as a qualitative, longitudinal
in-depth, single case study. Using three generic and interrelated features of CE (Zanko, et al, 1998) as the basis of its CE literature review, this study identifies CE initiatives as consisting of five generic elements: (1) organisational integration, (2) communication and decision-making mechanism, (3) enabling technology, (4) external integration, and (5) human resource.

Using this set of initiatives as a reference point, this study investigates the CE introduction by focusing on two of the five categories: (1) organisational integration and (2) communication and decision-making mechanism. CE initiatives in these two categories include cross-functional teams, heavyweight management, formal communication, collaboration, inter-team communication, and decision-making mechanism. These initiatives are investigated thoroughly. CE initiatives in other categories, e.g. enabling technology, external integration and human resources, are also discussed and their interrelations with the focus initiatives are also investigated.
but not in such depth. Internal and external contextual factors as well as the organisational power and politics of this transformation process are identified. Focusing on the internal context and micro-politics in the organisation, influences of these factors on the process are investigated. External contexts, e.g. societal and industrial contexts, are broadly discussed.

To obtain a rich and in-depth case study that allows such processual analysis, within almost four years research period a significant amount of time was allocated to two field studies, each of duration of 5 to 6 months. Normally, the development process of a new product platform in the aircraft industry is 7 to 9 years, which made it impossible, in term of resource and time available, for this research to investigate the overall process. The field study, therefore, used two main strategies to fulfil its objectives:

1) Observing the process as it happened through participant observation, interviews and documentary review during the field study periods.

2) Reconstructing the relevant significant events through a combination of interviews, documentary review, and the experience of the researcher as an 'insider' in the organisation.

The insider position of the researcher provides immense advantage in carrying out the research. The researcher's past experience in the company, before the research began in June 1996, enabled her to reveal the detail of the complex change process and provided understanding to the context as well as access to the data and people relevant to the process. However, it also had disadvantages. This involves cross-cultural and language problems as the researcher and most of respondents and materials are Indonesian and use Bahasa Indonesia, the Indonesian's national
language. The researcher as an engineer had to deal with theory of management as part of the research for such a domain. As an insider, the researcher acknowledges potential biases due to 13 years of personal involvement in the company, such as the opinions of the fairness of some company’s policies and the character of some respondents. To minimise the effect of these biases, the researcher intentionally put her personal knowledge of such issues as a background information that needs further data collection and vigorous verification through cross-checking and triangulation.

1.6 Case Study

The case study focused on the introduction of CE in the development of a new 100-passenger aircraft program (pseudonym as the PLI Program) of Indaco. The 100-passenger jet PLI was the third aircraft designed by Indaco after the 35-passenger commuter PLC (co-designed with a European company) and the 50-passenger commuter PLP. The PLI Program started at the end of 1993. Its completion was scheduled for 2004 but the program, due to the Indonesian financial crisis, was prematurely terminated in 1999.

The introduction of CE, modelled on that of Westaco, started in 1995. A thorough investigation and analysis of the case study revealed that the CE implementation in this program was a complex transformation process. The study found four stages that reflect this complex multidimensional process. Each stage was characterised by a distinct program organisation. The focal CE initiatives (i.e. cross-functional team, heavyweight management, formal communication, collaboration, inter-team communication, and decision-making mechanism) in each stage also differed. At each stage, there was a degree of increase in some initiatives, others became weaker or
remained less strong. In general, it tended to deviate from the intended Westaco model.

Analysis of the context and politics of change reveals the underlying factors affecting this complex transformation. The analysis of the CE initiatives showed that the lack of competence and systematic protocols significantly influenced the character of each stage of the transformation. The strong technology sub-culture in the company was an important factor that led to the formation of two parallel design and production teams in the PLI Program rather than a single integrated one. This was also the factor underlying the rivalry between the PLI Program and the functional design units that led to the lack of competency in the 'program team'. In addition, Indonesian's cultural tendencies also influenced the communication and decision-making mechanisms.

Other external contexts played a more remote but nevertheless vital role. The industry was the most significant factor in the push to introduce CE, while the contemporary crises in Indonesia led to the termination of the Program and CE experiment. The analysis of the politics of change revealed a complex and messy intertwining of the contexts, the power sources as well as the skill and will of key personnel who were responsible for various actions and non-actions instrumental in the process.

1.7 Contribution of the Thesis

The thesis provides significant conceptual and theoretical contributions to CE literature. It provides a rich and detailed empirical account on dynamic reality of introducing CE by using the processual framework that takes into account the contextual factors and organisational power and politics surrounding the change
process. In doing so, this thesis offers an operationalisation of CE through classifying CE initiatives into several groups, defining the dimensions of each initiative, and defining the possible range of each dimension that could be developed further for measurement of the level to which CE is applied. In addition, by taking a company from a developing country as the object of the case study, this thesis also provides insights of the probable underlying causes of introduction other than commercial benefits.

This thesis also offers practical benefits for companies that attempt to introduce CE. By thoroughly investigating the introduction process of CE, this thesis provides useful insights in increasing the readiness for technological, organisational and cultural changes that are inherent in introducing CE. It also increases the awareness of the messiness of such process by outlining the roles and the dynamics of the organisational context and politics in such a change. For practitioners from developing countries that have a context different from which CE was originated, the case study provides useful insights in implementing and adjusting CE.

1.8 Thesis Structure

The thesis is arranged in the following structure:

Chapter 1: Introduction
Chapter 2: Concurrent Engineering and Conceptual Framework
Chapter 3: Context and Politics of Change and Conceptual Framework
Chapter 4: Research Methodology
Chapter 5: Indaco: the Company and Its External Context
Chapter 1: Introduction

Chapter 6: The Substance of Change: CE Implementation
Chapter 7: Contextual Explanation of Change
Chapter 8: Politics of Change
Chapter 9: Dynamics of Change: Summary Discussion
Chapter 10: Conclusions and Recommendations

Chapters 2 to 4 provide reviews of the relevant literature that leading to the refinement of the general conceptual framework adopted from the processual approach and the methodology employed in undertaking the research. Chapter 2 provides conceptualisation and operationalisation of introducing CE as a process. Chapter 3 reviews the organisational context and politics and conceptualises and operationalises them as the explanation of the change process. Chapter 4 describes the appropriate methodology employed in this study.

Chapters 5 to 8 present the case study. Chapter 5 describes the company and its industrial and national contexts and provides a bird eye view of CE introduction process. Chapter 6 describes the complex process of introducing CE, focusing on organisational integration and the communication and decision-making mechanism aspects. Chapters 7 and 8 offer some explanation of the change process. Chapter 7 discusses the contribution of other CE initiatives, i.e. the inner context, as well as the wider organisational context in shaping the transformation process of CE initiatives. Chapter 8 discusses the influence of organisational power and politics.

Chapters 9 and 10 are the concluding chapters. Chapter 9 provides a summary of research findings and discusses the correlation between these findings and the relevant research literature. Chapter 10 outlines conclusions, conceptual and practical implications, and recommendations for future research in CE.
CHAPTER 2

CONCURRENT ENGINEERING AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This study explores the process of introducing concurrent engineering (CE) as a distinctive approach to new product development approach. In this chapter, CE approach and various literatures associated with it are discussed to provide a comprehensive theoretical basis for investigating such process. CE is conceptualised as an approach to product development, which seeks to achieve simultaneous rather than sequential processes. It is defined as a systematic multi-disciplinary approach to product development that focuses on integrating all product life cycle considerations at the outset of the process to achieve customer expectations with maximum quality, and reduced lead-time and cost.

Guided by the processual approach, the introduction of CE is viewed as a change process in which the concept of CE was adapted and continuously shaped. Using the identified generic features of CE (Zanko et al, 1998) as a framework in reviewing the CE-related literature, namely: holistic design, organisational integration and concurrence, CE is conceptualised as a set of initiatives under several categories, i.e.
organisational integration, communication and decision-making mechanisms, enabling technology, external integration, and human resources. This set of CE initiatives is conceptualised as the substance of change in the processual analysis.

This study focuses on initiatives within the organisational integration and the communication and decision-making mechanisms, which include the cross-functional team, heavyweight management, formal communication, collaboration, inter-team communication, and decision-making mechanism. Each initiative is reviewed and operationalised into dimensions and sub-dimensions. Drawing from the interdependent nature of the generic features (Zanko et al., 1998), initiatives in the other three categories are also reviewed and conceptualised as influential to the longitudinal process of implementation of the focus initiatives.

The chapter begins with an overview of CE within the product development management literature. It is followed by a review of CE features and initiatives. This review focuses on the organisational integration and the communication and decision-making mechanisms. Initiatives in these aspects are included as the substance of change in the processual analysis adopted in this study and operationalised into dimensions and sub-dimensions. This leads to a refinement of the general framework incorporating CE initiatives in those categories as the substance of change that are interrelated and interdependent of each other.

2.2 Concurrent Engineering and New Product Development Management

In an ever increasing competitive and globalised environment, high-tech companies in
Chapter 2: Concurrent Engineering and Conceptual Framework

particular, are striving to improve their new product development performance. Some researchers have argued that improving this area is the only way to survive in such competition (Trygg, 1993; Wheelwright and Clark, 1993), which means a need for the ability to bring higher quality new products to market faster and cheaper. Wheelwright and Clark (1993) argue that this ability involves solving problems quickly and integrating insight and understanding from the engineering perspectives with critical knowledge from the manufacturing area which are critical in achieving cost reduction in its final product.

Concurrent engineering (CE), which emerged from Western high-tech industries in the late 1980s, has been represented as an approach to acquire these capabilities (e.g. Braham, 1992; Nevins and Whittney 1989). This approach calls for a change from a sequential to a simultaneous process in product development. In particular, CE has been seen as an approach that can help Western companies to acquire the ability to carry out faster and integrated product development that is responsive to market expectancy (Evans, 1990; Gordon and Isenhour, 1990; Syan, 1994). Cleland (1991) argues that the success of Japanese manufacturing industries, one of the stimuli to the formulation of the CE approach, was derived from characteristics of their product development, such as problem sharing and mutual respect between design and manufacturing, close relationship with suppliers, attention to reliability and quality, and cross-functional involvement at each stage. Japanese companies have followed approaches similar to CE long before the CE became popular in the West (Clark and Fujimoto, 1991; Bowonder and Miyake, 1992).

Developments in many large Western corporations in the post-war period, notably in the aerospace, automotive and electronics industries, showed the following tendencies
Chapter 2: Concurrent Engineering and Conceptual Framework

(e.g. Iansiti, 1995; Cleland, 1991):

1) increasing specialisation due to increasing complexity of the product,

2) compartmentalisation of functions that lead to 'stove-piping' and 'silo-ing', and

3) linear sequential process for efficiency purposes, such as to ease the co-ordination and control of tasks.

These led to compartmentalisation with specialists looking inward within their own speciality (Clausing, 1994).

This compartmentalisation is characterised by the traditional 'relay race' in which the tasks of development are 'thrown over the wall' from an upstream function to the downstream function in the development process (Cleland, 1991). In design and production activities, for example, the sequential approach means that the product is designed as completely as possible before being handed over to production (Riedel and Pawar, 1991). The apparent benefits of the sequential approach as a means of managing complexity include the formation of simple managerial tasks, escaping early investment for down-stream activities, relatively safe and risk free, simple communication channels, less frequent interaction, the insulation of the design team from marketing and production pressures.

The sequential approach, however, causes many problems associated with the cost and schedule, which, in part, reflect conflicts among functions due to differences in attitudes and values. This lead to communication difficulties that hamper integration (Cleland, 1991). The approach is inherently problematic in upstream-downstream interaction (e.g. communication, co-operation, co-ordination, and goal displacement). These disadvantages include (Riedel and Pawar, 1991):

1) it increases the possibility of longer lead-times for product introduction;
2) it is less flexible and less innovative;

3) passing the tasks from one group to the other is often accompanied by crucial problems at the interface that cause a hiccough-like process with stops and starts;

4) bottle-necks demotivate specialists and may lead to interpersonal and inter-departmental conflicts;

5) the isolation of specialists may cause technology mismatch to both the supplier’s and customer’s expectations as well as the competitor development; and

6) the risk of design modification at the production stage that increases both the lead-times and cost of development.

A number of authors have argued that the 'time to market' for new products has become central to competitiveness in 1990s (i.e. Adachi, Shih and Enkawa, 1994; Cleland, 1991; and Trygg, 1993). Faster lead-time means getting ahead of competition and possibly lower development cost which can lead to winning in the market (Cleland, 1991). Using their simple formula, Carter and Baker (1992) show that a 2-month launching delay for a product with 12-month market window leads to 24% loss in total lifetime revenue. For manufacturing companies, a 6-month late will result in a 34% reduction of potential profit over the life of the product, while a 20% cost over run will result in just 8% reduced of potential profit (Harrel, Emanuel and Kroll, 1995). Other advantages of being earlier include the ability to charge the premium price, to incorporate more up to date technology, and to response faster to changing market needs and taste (Trygg, 1993).

Companies strive to make a shift toward faster product development process. Yet, as Trygg (1993) has noted, product development has also become increasingly complex with longer development time, increasing cost, increasing product complexity,
decreasing life cycle time, more frequent new technology, more rapid change demand, and increasing competition and glamorisation. Within this context, CE, characterised with simultaneous activities, has been prescribed by its advocates as a major solution to deal with the problems of product development and the need to stay competitive in 1990s (Clausing, 1994, Trygg, 1993). Braham (1992) even coined CE as a condition of survival for manufacturing companies.

2.2.1 Concurrent Engineering History

CE is not an entirely new concept (Smith, 1997); it has antecedents, e.g. design for manufacturing and assembly (DFM/A) and simultaneous engineering (SE). The formal history of CE started when the U.S.'s Department of Defense (DoD) asked the Institute for Defense Analyses (IDA) to investigate CE and its possible application to weapon system acquisition in the 1987. This project aimed at improving concurrency in product development programs (de Graaf, 1996). Prior to this project, the Defence Advance Research Project Agency (DARPA) had undertaken a study of the emerging new product development approach in 13 U.S. major weapon system suppliers (Moffat and Gerwin, 1994). The IDA reviewed those various initiatives on the DARPA Concurrent Engineering Workshop in December 1987. After the workshop, the IDA study group continued the investigation, contacted many experts, sponsored several workshops, and visited companies involved in the initiatives (Winner et al., 1988).

It was understood that to achieve concurrency, U.S. companies had used various similar approaches for decades as an inherent part of their development process (Owen, 1992). This U.S. Government initiative, however, focused its attention on
large high-tech companies engaged with the government's defence contracts such as General Electric (GE) and Boeing (de Graaf, 1996). The Concurrent Engineering Research Center (CERC) was founded in West Virginia University to support the initiative with the enabling tools (de Graaf, 1996). Although the formalisation of the concept occurred in the U.S. as a result of the DoD initiative, within a few years CE had become more widely adopted within various industries across geographic boundaries (Ashley, 1990).

2.2.2 Concurrent Engineering Definition

CE was initially proposed as a means to minimise product development time. However, its focus and scope has been progressively elaborated in successive publications (Prasad. 1996). A tendency toward a wider scope of CE can be traced from the evolution of its definitions. The first formal definition of CE, also the most widely cited, is provided in the IDA report R338 by Winner et al. (1988) as the following:

A systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause developers, from the outset, to consider all elements of product life cycle from conception through disposal, including quality, cost, schedule and user requirements (Winner et al., 1988, p. v ).

Built on the earlier definition, another widely cited definition of CE is offered by CERC (Cleetus, 1992; 1993):

CE is a systematic approach to integrate product development that emphasis response to customer expectations and embodies team values of co-operation, trust and sharing in such a manner that decision making proceeds with large interval of parallel working by all life cycle perspectives early in the process, synchronised by comparatively brief exchanges to produce consensus (Cleetus, 1993, p. 43. bold original).

The broadest definition is offered by the Computer Acquisition and Logistic Support
(CALS) Office, which emphasises the logistic support aspect after the product delivered to the customer as part of the design consideration in the product development process:

CE is a systematic approach to creating a product design that considers all elements of product life cycle from conception through disposal ... CE defines simultaneously the product, its manufacturing process, and all other required life cycle processes such as logistic support. CE is not the arbitrary elimination of a phase of the existing, sequential, feed forward engineering process, but rather the co-design of all downstream processes toward a more all-encompassing, cost-effective optimum... CE is an integrated design approach that takes into account all desired downstream characteristics during upstream phases to produce a more robust design that is tolerant of manufacturing and use variation at less cost than sequential design. (CALS Office, 1991, p. iv)

Other definitions of CE vary in their scope and emphasis. They range from a narrow scope considering only simultaneous design of product and its tooling (Weill, 1992) to very broad with an emphasis on multi-disciplinary (Clausing, 1993; Liu and Fisscher, 1993), involving design, manufacturing and maintenance (Vos, 1993) marketing, quality control, purchasing (Slade, 1993) and even disposal activities (Wu and Choong, 1993). The emphasis in these definitions ranges from organisational issues, such as establishing multifunctional teams (Clausing, 1993, Slade, 1993) and achieving earliest possible integration of resources and experience (Wu and Choong, 1993), to technical issues, such as co-ordination methodology (Liu and Fisscher, 1993) and iteration procedures to solve a multi-criterion optimisation problem (Olhoff, Lund and Rasmussen, 1993).

In short, CE can be viewed from the narrow focus of integrating product and process engineering (product design and production process design) into a wider scope of integrating the whole product life cycle. The narrow focus of integrating design and production is of particular interest to many researchers (e.g. Anderson, 1993; Riedel and Pawar, 1991; Krishnan, 1996), while the wider scope is less extensively explored. This reflects the engineering focus of much of the CE literature on those
themes that have been discussed since the early 20th century (Smith, 1997). In fact, there are two distinct research traditions in CE: system engineering oriented manufacturing automation approach and management of innovation and technology approach (Moffat and Gerwin, 1994).

Focusing on the design and production interface, Riedel and Pawar (1991) describe CE as a means to prepare for production while the design process is still in progress. They argue that CE involves two risks: locking in investment in manufacturing facilities early in the design stage and the possible modification of facilities as the process unfolds. These risks are traded-off with the gains: being early to market, minimal modification due to manufacturing difficulties, maximum compatibility with manufacturing facility, and more efficient production. They further argue that the choice between sequential and concurrent processes has a strategic impact. Its adoption should consider three strategic issues: time benefit versus cost of the risk, the firm ability to lay initial investment early, and the availability of competent engineers and managers (Riedel and Pawar, 1991). In short, they see CE as a strategic approach to improve new product development performance, and therefore to organisational survival, by delivering products to the market, faster, with higher quality and lower cost. However, Riedel and Pawar also illustrated that this strategic approach is not suitable for every context and type of product development project.

Many concerns and issues in CE have been addressed in other knowledge domains such as product innovation, organisational design, design management and project management. In these areas CE appears to 're-discover' and integrate concepts that have previously been addressed elsewhere. Smith (1997) has argued that CE is a summary of best practices in product development rather than the adoption of a
radically new set of ideas. In 1986, for example, Takeuchi and Nonaka (1986), have argued that design and manufacturing overlap enhances shared responsibility and cooperation, stimulates involvement and commitment, sharpens problem solving focus, encourages initiative taking, develops diversified skills, and heightens sensitivity toward market conditions. They also observed that this overlap creates more tension and conflict and requires extensive interaction among team members and with suppliers. Similarly, the issues surrounding integration and differentiation have been addressed for quite some time in organisational design literature (e.g. Lawrence and Lorsch, 1967; Burns and Stalker, 1961).

In general, CE remains a fuzzy term. CE means different things to different people. People look at CE with different emphases that lead to different definitions and different names. Other concepts have also been proposed to refer to similar approaches, e.g. synchronised engineering, simultaneous engineering, collaborative engineering, design for excellence, design for manufacturing, process driven design, integrated product development, parallel product development, team approach, life cycle engineering, black-box engineering, early manufacturing involvement, and integrated design and engineering (Trygg, 1993). Most descriptions in the literature present CE as an unstructured set of concepts and tools (Blackburn, Hoedemaker, and Wassenhove, 1996).

CE is variably presented as a set of methods, a methodology, an environment, a technique, a systematic approach, or a strategy. This variation of opinion makes what is the essential of CE difficult to grasp (Vasilash, 1990; Trygg, 1993). Blackburn et al. (1996) admit the lack of a clearly defined template for CE may become an obstacle to its implementation. CE has all the hallmarks of what Abrahamson (1996) called a
'management fad' (Abrahamson, 1996). Despite this fuzziness, however, there are common elements in the various approaches. There is, for example, a widespread agreement on the main objectives of CE in developing products that satisfy customer, faster and with less cost (Prasad, 1996; Wu and Choong, 1993; Sharon, 1992).

To reduce terminology confusion, This study takes operational definition of CE as a strategic approach to the organisation and management of design and development programs that systematically relies on a cross-functional approach to integrate all product life cycle considerations at the outset of a program, to maximise overlap and parallel activities, and to minimise changes in later stages of development processes so as to meet customer expectations, provide maximum product quality, and reduce development lead-time and cost. This working definition is intentionally broad and built upon various CE definitions to enable the viewing of CE comprehensively. It implies the wider scope of consideration in the development process than the design-production interface. However, it does not embrace the new product strategy or the marketing aspect of new products.

This working definition is operationalised into three interrelated features: holistic design (design integration), organisational integration, and concurrence (Zanko et al., 1998). Holistic design refers to the extent that life cycle considerations are taken into account up front in order to reduce down stream cost. Organisational integration refers to the extent that the process taken breaks down 'functional silos'. Concurrence refers to the extent that it minimises the relay races in the development process. These features are generic and reflect the underlying concept of CE. The use of these features as the basis of operationalisation provides a clearer picture of CE and escapes the trap to viewing it in terms of specific tools such as computer integration and
analytical tools (Trygg, 1993) which are often associated with CE. Rather, these features emphasise what such tools actually represent.

2.2.3 Achieving Concurrent Engineering

As an approach, CE is realised through the introduction of various types of organisational arrangement, system and procedures, and supporting tools. There is a tendency in CE literature towards universalism. Many researchers have attempted to study and define its generic elements (e.g. Trygg, 1993; Haddad, 1996). After reviewing successful CE practices, Trygg (1993) concluded that the generic elements of CE success cases are the cross-functional teams, computer integration and analytical methods and tools. In the cross-functional team, representatives from involved functions, sometimes including suppliers, collaborate to ensure that the design reflects both customer needs and downstream function restrictions. Computer integration, particularly in the form of computer-aided design and computer-aided manufacturing (CAD/CAM), aims to support the design and manufacturing parallel work. Analytical tools, such as the design for manufacturing and assembly (DFM/A) and the quality function deployment (QFD) seek to ensure that information needed is available as early as possible to reduce slack time, unnecessary re-work and the earliest start.

Apart from cross-functional teams, other elements remain inconsistently associated with CE. Evans (1990), for example, argues that computer integration is not absolutely necessary, and uses Japan as an illustration where, while integration is common, the use of an advanced computer system is less so. The use of computer integration relates to the team interaction and is more likely to be used when face to
face interaction is not possible due to the size of the task or diverse locations. Computerisation eases both the technical tasks and the management of large programs (Evans, 1990). The tools and methods for producibility and manufacturability cannot be standardised, but rather they are dependent on the type of tasks and therefore cause variation on the way these aspects are taken into account during design decision process. Although computer integration and analytical tools are apparently not the most important elements of CE, research on CE has mainly focused on these enablers (e.g. Blackburn et al, 1996; Hauptman and Hirji, 1996; de Graaf, 1996; Syan and Menon, 1994). It seems that literature in the manufacturing automation approach is ahead in detailing the operationalisation on the CE concept.

Although it is widely acknowledged that introducing CE involves organisational change, the change processes associated with it have not been given adequate attention. Much research in CE implementation has focused on the result, i.e. comparing the previous old, traditional and typically functional-based development process with the cross functional based CE process, rather than on the change process per se. Haddad’s (1996) study is an example of this. Although it covers a reasonably long period of time, from 1991 to 1994, this study did not capture the longitudinal and contextual aspects in the implementation process. The CE literature tends to be general and conceptual, with a strong tendency towards ungrounded prescriptions (Gerwin and Susman, 1996), and does not address the problematic nature of its implementation that involves organisational and cultural change. This may contribute to the growing rhetoric of the excellence of CE that neglects the detail transitional aspects of its introduction and put CE in the danger of becoming an Abrahamson’s (1996) ‘management fashion’. Zbaracki (1998), in his evolutionary model of rhetoric and reality, shows a similar pattern in which the rhetoric aspect of Total Quality
Management (TQM) has driven out its technical aspect which in turn had led to decreasing popularity of TQM.

Detailed empirical studies of CE only started to appear in mid-1990s (Gerwin and Susman, 1996). In her study in the U.S. automotive industry, Haddad (1996) presents the CE implementation model (CEIM) for operationalising CE. This model argues that the central mechanism of CE is the establishment of product-focused, cross-functional teams to foster functional integration, information sharing and collaborative problem solving. These teams are supported by organisational and technological enablers. Organisational enablers involve changes in organisational structure and practice such as cross-group communication, decentralisation and participative decision-making and human resource practices that breaking down traditional knowledge boundaries and control. Technological enablers are structural artefacts, equipment, systems and physical design to support the teams such as building design, computer aided design and computer networking. Other empirical studies into CE, albeit at a simple team level of analysis, can also be seen in Harrel et al. (1995), and Klein and Maurer (1995).

2.3 Generic Features of Concurrent Engineering

This study uses three inter-related generic features of CE: holistic, integration and concurrence, as proposed by Zanko et al. (1998). These features address particular problems experienced in the product development process and what CE seeks to achieve as well as the means that can be used. In this review, the initiatives associated with the means to achieve each feature (i.e. organisational arrangement, system and procedure, and supporting tools) are laid out and become the basis of CE initiatives as
the operationalisation of a CE approach in the next section.

2.3.1 Design Integration

One of the main objectives of CE is reducing lead-time. Design changes disrupt product development process, delay it, and increase its cost. Changes in later stages disrupt more. However, changes are inherent in the development process (Stoll, 1990). A particular problem associated with the linear-sequential process in product development is that it leads to an increased number of design changes throughout the development process, especially at the interfaces due to the practice in which one group of specialists do the work, make decisions, and 'throw them over the wall' to the next group. Such practice can create problems of wasted time, weak understanding, and inadequate commitment to earlier decisions (Clausing, 1994).

Clausing (1994) suggests a problem prevention approach in product development through a more holistic development taking into account all the product life cycle considerations up-front. The ideal process, therefore, is to have an activity that addresses all parameters in the system and eliminates all kinds of partitioning. This activity should be executed as early as possible and, therefore, causes a shift of activities to the earlier stage of the process (Clausing, 1994). This is addressed through re-integration of the design process using various concepts and methodologies, such as quality function deployment (QFD), design for manufacturing (DFM), design for assembly (DFA), design for services (DFS), design for testing (DFT) and, design for product life cycle (DFPLC). To embrace all the above concepts, the term 'design for X-ilities' (DFX) is often used (Trygg, 1993; Clausing, 1994). Some of those concepts have been developed as computer-based tools to help
the designer in a concurrent engineering environment to work faster (Clausing, 1994).

In a CE that focuses on coupling between engineering and production, this concern is reflected in the manufacturability and producibility of the product.

2.3.2 Organisational Integration

Another major problem in the development process is functional specialisation that leads to 'sil‐o-ing' in which specialists look inwardly toward the optimisation of their own specialisation rather than toward the optimisation of the whole product. In the 1960s, this problem was addressed in the organisational design literature (e.g. Lawrence and Lorsch, 1967; 1968; Burns and Stalker, 1961) and more recently in the product innovation literature (e.g. Wheelwright and Clark, 1992; 1993). The organisational integration feature of CE specifically seeks to address this issue.

To achieve a holistic design, development is conducted through integrating all involved functions and specialisation that contribute to the process. Reviewing design and manufacturing relationship, Adler (1995) argues for the use of team integration together with the use of standardisation, schedule and multiple adjustment. Adler further argues for the contextual mode of integration reasoning that the most efficient interdepartmental co-ordination mechanism is the one that is able to deal with the uncertainty of product and process fit at the least cost. Wheelwright and Clark (1993) argue that cross-functional integration, which may go beyond the organisational boundary, is essential for a superior program in its cost, time, and quality. They further argue that this integration may be achieved by fostering intensive communication, information sharing, and collaboration between involved functions.
Kahn (1996) proposes that integration is a multidimensional process that subsumes formal interaction and collaboration. Formal interaction refers to the structured and formal nature of co-ordination activities between involved functions including routine meetings, memos, and other regulated communication. It is characterised by transaction relationships and a competitive environment between relatively independent functions. Collaboration refers to the unstructured, affective nature of interdepartmental relationship emphasises on strategy alignment through a shared vision, collective goals, joint rewards through an informal structure. It is characterised by a continuous informal relationship, interdependent, and co-operative environment. He concludes that formal interaction may be necessary but is not sufficient; collaboration makes the difference between success and failure in product development. Similarly, Schrage (1995) argues that the ultimate aim of any interaction media such as meetings or teams is actually collaboration, which requires a shared space where each collaborator can add value to the task in hand. The shared space can be as simple as white board or as sophisticated as stereo-lithography rapid prototyping.

There are different approaches to integration. Many researchers suggest the use of the cross-functional team as the organisational means to achieve integration (e.g. Trygg, 1993; Clausing, 1994). Wheelwright and Clark (1993) add the necessity of heavyweight feature in such teams in which the team leader had full authorities to manage the process. They further suggest the use of integrated problem solving as an interaction mode in which downstream functions participate in the preliminary stage through an ongoing dialogue with the upstream functions to obtain early information to enable a ‘flying start’ on their own work. To foster interaction, the team members are collocated in one location. Another strong trend, particularly in the engineering
literature, is the use of computers as an integrating mechanism (e.g. Norman, 1990; Volk, 1992; Fan, 1995). The development of computer-based information system, CAD/CAM, and rapid prototyping provides a significant contribution in providing easy and faster communication and collaboration media (Schrage, 1995).

2.3.3 Concurrent Process

A key issue in reducing development lead-time is how to achieve as much concurrency, simultaneity and overlapping activities as possible. The design integration and organisational integration features facilitate opportunities to reduce lead-time by shortening, simplifying, or overlapping the activities at all stages without sacrificing cost and quality (Fujimoto, 1997).

Hauptman and Hirji (1996) argue that at the macro level, a high level of concurrency is fostered by effective two-way communication, overlapping problem solving, and willingness to release uncertain and ambiguous information. But, the use of such information should be limited for collaboration before the decision is made rather than for decision-making. Krishnan (1996) introduced a model based on upstream information evolution and downstream sensitivity to obtain effective overlapping of activities. He concludes that the best opportunity for overlapping is achieved by preliminary product information exchange when the sensitivity of downstream activities is low and by early finalisation of product information when the upstream information evolution is fast.

Blackburn et al. (1996) argue that the process of design concurrency takes two different forms: concurrency in activities and concurrency in information. Activity
Concurrency refers to the tasks and design activities that are performed simultaneously by different people or groups (i.e. within-stage, across-stage, and across-platform overlaps). Information concurrency refers to the integrated development (team approach) in which all the concerns of the different functions are addressed through a flow of shared information. They suggest two enablers linking both types of concurrency: architectural modularity that divides design problems into modules with well-defined functionality and interfaces, and synchronicity that co-ordinates parallel activities, which is prime responsibility of the program leader.

Clausing (1994) argues that in a concurrent process frequent information exchanges occur at the level of the small unit design tasks. At the micro level of the detail task, the tasks may remain sequential, but the overall effect in the higher level perspective is concurrence. It can be achieved through different means, such as partitioning, overlapping, compressing, switching, deiterating, and front loading (Fujimoto, 1997). The CE engineering automation domain shows that computer-based technology has also been used in this area, particularly for “front loading” information through computer-aided engineering (CAE) simulation software (e.g. 3-D CAD/CAM) and virtual prototyping (e.g. stereo-lithography) (Fujimoto, 1997).

2.4 Concurrent Engineering Initiatives

This section categorises initiatives associated with the means of achieving CE in order to operationalise the CE concept. This operationalisation is used as the basis for analysing the case study. Based on the previous discussion of its generic features, initiatives to realise a CE approach can be applied in three main areas:

1) in the organisation and management of a new product development (NPD)
program with the establishment of heavyweight cross-functional team(s) and encouraging interaction/communication;

2) in enabling technology with the establishment facility and technological support for new product activities; and

3) in human resources with the establishment of supportive human resource management (HRM) policies.

However, apart from the cross-functional team that seems to be accepted in most of the literature, other generic elements are still largely indeterminate. Research on CE has focused mainly on the organisational and technological enablers and overlooked the reason for investing in those enablers: to achieve effective and efficient team processes and attitudes (Hauptman and Hirji, 1996). This leads to another area of initiatives in achieving CE: the HRM supports to ensure those involved have the appropriate skills, knowledge, motivation and behaviour for engaging in CE. CE introduction may require changes in those areas. This is the gap in the CE literature that has only recently begun to receive attention with a growing literature in ‘softer’ CE within the management of innovation and technology domain.

This study focuses on initiatives in organisational integration because this integration is considered as a most important feature of CE. Organisational integration is the primary means for achieving the other two features of CE: design integration and concurrence. Without organisational integration, a truly holistic design cannot be achieved which, in turn, will inhibit the effort to increase concurrency of the process. However, the study is not only interested in the structural issue of integration, i.e. vertical and horizontal integration, as reflected by the cross-functional team and heavyweight management initiatives but also in the processual issues of integration.
This brings the initiatives in communication and decision-making mechanisms as the other focus of the study. The reason behind this research decision is that the structural issues, more often than not, do not reflect the real process in the organisation.

In order to provide adequate emphasis on the focus of this study, the initiatives in organisation and management of product development program are classified into two categories: the organisational integration and the communication and decision-making mechanisms. Further, external integration categories are also added to reflect the expansion of functional integration involving institutions outside organisational boundary. As the result, efforts and initiatives in achieving CE in this study are categorised as follows:

1) Organisational integration: cross-functional team and heavyweight management.
2) Communication and decision-making mechanisms: formal communication, collaboration, inter-team communication, and decision-making mechanism.
3) Enabler technology: computer-based technology, collocation, CE methods and systematic process protocols.
4) External integration: supplier involvement and customer involvement.
5) Human resources: competency, CE-related training and human resource policies.

These five categories are used as the CE framework of this study. By specifically including the communication and decision-making mechanisms and human resources, this study attempts to fill in the gap in the CE literature relating to these issues. The first two categories are the focus of the longitudinal processual study and are discussed and analysed further in their dimensions and sub-dimensions in the following sections. The summary of this discussion is provided in Table 2-1.
Table 2-1: Operationalisation of Initiatives within Organisational Integration and Communication and Decision-making Mechanisms Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>CE Initiative</th>
<th>Dimension</th>
<th>Subdimension</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Functional Team</td>
<td>Size and architecture</td>
<td>Number of member</td>
<td>small to large</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of (sub)team</td>
<td>single to multiple</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of layer of teams</td>
<td>single to multiple</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scope</td>
<td>Division of team</td>
<td>functional-based or product-based</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of function involved</td>
<td>dual function coupling to company-wide</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Level of functional representation</td>
<td>focal point, representative or full membership</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Membership pattern</td>
<td>Role of functions</td>
<td>main or supporting roles</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Position at functional unit</td>
<td>low (eg. staff) to high (eg. senior manager)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nature of member activity</td>
<td>operational, managerial, or liaison task</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Level of dedication</td>
<td>partial dedication to full dedication</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temporal characteristic</td>
<td>temporary to permanent</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Multiple membership</td>
<td>single to multiple</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Higher team composition</td>
<td>inclusion to exclusion of lower team</td>
<td></td>
</tr>
<tr>
<td>Heavyweight Management</td>
<td>Hierarchical position</td>
<td>Formal structure</td>
<td>lower, equal or higher than of the functions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Authority of the program leaders</td>
<td>limited (eg. design only) to extensive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nature of delegation</td>
<td>Delegation from program manager</td>
<td>none to extensive</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Delegation from functions</td>
<td>none to extensive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seniordness of leader</td>
<td>Tenure</td>
<td>short to long tenure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age</td>
<td>young, eg under 35, to mature</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Education</td>
<td>low to high</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Communication mode</td>
<td>Richness of media</td>
<td>sparse (eg. notes) to rich (eg. face to face)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Frequency</td>
<td>batch type to intensive, on-line type</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Direction</td>
<td>one-way monologue to two-way discussion</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timing</td>
<td>early (at initiation) to late (at completion)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type of data conveyed</td>
<td>Type of data released</td>
<td>ambiguous to certain</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Type of data used</td>
<td>ambiguous to certain</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Interational relationship pattern</td>
<td>close &amp; friendly to distant &amp; competitive</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conflict &amp; negotiation process</td>
<td>confrontation win-lose to dialogue win-win</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presence of collective goal</td>
<td>independence to interdependence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Presence of shared vision</td>
<td>program or functional self association</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-team Communication</td>
<td>Formal communication</td>
<td>(see formal communication)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-team Collaboration</td>
<td>(see collaboration)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision-Making Mechanism</td>
<td>Authority of teams</td>
<td>non to full authority</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Respect to lower team decision</td>
<td>respected to ignored</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power differential perception in lower and higher teams</td>
<td>low to high</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 2-2: Operationalisation of Initiatives in Enabling Technology, External Integration and Human Resource Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>CE Initiative</th>
<th>Dimension</th>
</tr>
</thead>
</table>
| Enabling Technology | Computer-based Technology | Supporting individual design task  
Integrating across function  
Assisting information management  
Supporting collaboration work |
|                   | Collocation   | Collocation area  
Space layout |
|                   | Formal CE Methods | Direct utilisation  
Utilisation of informal methods |
|                   | Systematic Protocols | Formal description of CE-in-practice  
Implementation strategy and planning |
| External Integration | Supplier Involvement | Number of supplier  
Position in the team  
Temporal characteristic |
|                   | Customer Involvement | Number of customer  
Position in the team  
Temporal characteristic |
| Human Resources   | Competency     | Educational background  
Experience  
Multiskilling  
Knowledge and skill parity |
|                   | CE-Related Training | Team-related training  
Training on CE concept and initiatives |
|                   | Human Resource Policies | Recruiting  
Career development and training  
Performance measurement  
Reward system |

### 2.4.1 Organisational Integration Initiatives

This section reviews two important initiatives in achieving organisational integration: the formation of the cross-functional team and the heavyweight management.

#### 2.4.1.1 Cross-Functional Team: Horizontal Integration

A cross-functional team is often formed when a form of co-ordination mechanism is needed to integrate several functions (Adler, 1995). In cross-functional teams of
product development programs, representatives from involved functions collaborate to ensure that the design incorporates the customer's needs as well as restrictions and possibilities in downstream functions (Trygg, 1993). This collaboration may go beyond the organisation's boundary to involve suppliers and customers in the team (Adachi et al., 1994; Wheelwright and Clark, 1993; Cleland, 1991).

In the CE approach to product development, the cross-functional team is the only indisputable generic element (Trygg, 1993). A cross-functional team is a means for achieving integration (Clausing, 1994). A similar argument also appears in the product innovation literature. Wheelwright and Clark (1993), for example, argue that cross-functional effort is essential for the superior development program in industries with dynamic markets and technologies, and where time is a critical element. Some studies and some companies (e.g. Boeing, Xerox) interchange the term 'CE' with 'integrated product development team' which reflect the importance of the cross-functional team in such an approach (e.g. Clausing, 1994; Klein and Maurer, 1995; Stantham and Kleiner, 1996). Other elements of organisational change in CE are basically derived from the existence of such teams in CE implementation.

Henke, Krachenberg and Lyons (1993) found that firms realised four primary benefits of cross-functional teams in a product development: overcoming the shortcoming of hierarchical structure by its ability to cut across vertical authority, decentralising decision-making, reducing information overload at a higher level, and providing higher quality decisions. However, establishing a cross-functional team is a challenging task. From the engineering management domain, Thamhain and Wilemon (1987) have argued that team building involves taking a collection of individuals with different needs, background and expertise and transforming them into an integrated,
effective work unit. They argue that team ‘output’ is not only task-related outcomes (e.g. technical success, on-time and on-budget performances) but also involves people-related outcomes, such as communication effectiveness, interface effectiveness, team spirit and mutual trust.

For larger development programs, the team may comprise of a ‘team of teams’ (Clausing, 1994). Depending on its complexity, a product can have numerous teams and each team may have several sub-teams. They are integrated or co-ordinated by a product management team. The product management team itself is a cross-functional team at a higher level (Henke et al., 1993). According to Clausing (1994), the team leader (e.g. program manager) and the managers who directly report to him/her constitute one team, often referred as the ‘core team’. Typically, the core team is responsible for everything related to the program. The membership of a core team may include sub-team leaders. Clausing (1994) considers such formation of an interlocking structure of teams as a key factor for success.

Many studies focus on the structural characteristics of the team (Page, 1993; Henke et al., 1993; Adachi et al., 1993). In his study of multi-disciplinary teams in new product development, Page (1993) uses three dimensions of team structure: the type of organisation, the level of functional involvement, and the role of product champion. Henke et al. (1993) describe the team structure in terms of functional representation, hierarchical and lateral relationship within and among teams, and supplier involvement. Adachi et al. (1994) identify the structural dimensions of a cross-functional team to include its size, location, and composition. Team’s composition is defined by the authority of its leader, membership pattern, level of specialisation, and internal and external integration. Similar dimensions are also identified in the
Chapter 2: Concurrent Engineering and Conceptual Framework

literature on team and teamwork (e.g. Ellis and Fisher, 1994). For example, Katzenbach and Smith (1993) include small size and having adequate complementary skills, meaningful purpose, clear working approach, mutual accountability, and members who enjoy being part of the team, as the characteristic of an effective team.

Thus, the structural dimensions of a cross-functional team include: the team size and architecture; membership pattern; internal and external scope of integration; leadership pattern; communication pattern; and location. This section only focused on 3 structural dimensions: (1) team size and architecture, (2) scope of internal integration, and (3) membership pattern. Other structural dimensions are discussed later to provide a thorough discussion of each dimension.

- Team Size and Architecture:

The size of a cross-functional team relates to the scale of development program and the level of specialisation. Some researchers argue that the team size is crucial for team effectiveness as the larger size hampers communication (Katzenbach and Smith, 1993). To remain effective, a large team is normally divided into a core team and several layers of sub-teams (Adachi et al., 1994; Ellis and Fisher, 1994), and is often supported by a computerised information support system. As can be seen later in the intended model of CE in Chapter 6, the division of development team can either primarily be functional-based (e.g. production groups and design groups) or product-based (e.g. wing group and cockpit group). The dimension of the team size and architecture varies in the following four sub-dimensions:

1) The number of member involved in the program team: small to large number.

2) The number of sub-team within the program team: single to multiple teams.

3) The number of layer of teams within the program team: single to multiple layers.
4) The division of team: functional based or product based

In a case study, it is possible that the ‘teams’ are defined and constructed on the basis of the role of a group of people as observed by the researcher, rather than on the basis of a formal organisation of people by the organisation under study. The existence of the core team, for example, may be a researcher’s construct to simplify the organisation mechanism observed in the study.

- **Scope of Integration:**

This dimension refers to the range of functions involved, represented, and coordinated within a cross-functional team to achieve integration (Adachi et al. 1994). This dimension varies from dual function involvement (coupling) such as a design-production team to a full organisational-wide involvement, in which all organisational functions are represented in the team. Slade (1993) and Adler (1995), for example, focus on product design and manufacturing process; Clausing (1994) includes design, production, logistic and field support; while Pawar (1994) goes further and includes product design, process, engineering, marketing, service, purchasing, and selected suppliers. This dimension seems contextual dependent, functions represented in the team vary according to industry and market. In part, this variation in the scope of the cross-functional team contributes to many definitions of CE as discussed previously.

The matrix arrangement identified in the heavyweight management (Wheelwright and Clark, 1993; 1992) implies functional representation in the product development teams. Along the continuum of this representation, the functional involvement can be distinguished into three following levels:

1) full-membership, in which functional experts are part of the program and report only to the program leaders;
2) representative, in which functional experts are partly part of the program and report to both program and functional leaders; and

3) focal point, in which functional experts are not part of the program and report only to the functional leaders. Typically, the focal points are specifically assigned by functional units to internally co-ordinate support for the program.

Cross-functional teams, however, are vulnerable to problems associated with its temporary nature and diverse backgrounds and perspectives that lead to conflicting goals, weak desire to co-operate, and weak allegiance (Pinto and Pinto, 1991). This different perspective between functions can be derived from differences in orientation toward particular goals, time orientation, interpersonal orientation, and formality of structure (Lawrence and Lorsch, 1967). These differences exist between engineering specialisation, which coined as the 'object world' by Bucciarelli (1994). He notes that the object world of a mechanical engineer and an electronic engineer, for example, can be quite different in seeing a technological problem. In a product development program, this diversity often leads to the relative role of each function in the development activities. In Haddad's (1996) case study of automobile industry, for example, the main development activities (i.e. design) were carried out by product-based teams that consisted entirely of engineers from the design function while representatives from other functions (e.g. marketing, manufacturing, finance, purchasing) provided support for those teams.

Based on this discussion, the scope of team cross-functionality can be divided into three sub-dimensions:

1) The number of function involved: ranges from dual function coupling to company-wide functional involvement.
2) The level of functional representation in the program: ranges from focal point, representative and full membership.

3) The role of each of those functions in the program: ranges from playing main role to playing supporting role.

- **Membership Pattern:**

  This dimension is concerned with the members’ positions in the team vis-a-vis their position in their functional area, whether the members are partially or completely withdrawn from their functional area, and whether the members are fully dedicated or not to the program. Page (1993) observed that the membership pattern of a cross-functional team involves who, when and how far they are involved. In Haddad’s (1996) case study, for example, representatives from non-design functions were involved in the core team and provided liaison with their respective functions while engineers were full-dedicatedly involved at the operational level in product-based design teams.

  Further, Henke et al. (1993) argue that multiple membership, horizontally within product-based development team, may facilitate information flow. Closely related to the team size and architecture is the formation of the interlocking structure (Clausing, 1994) represented by the nature of the relationship and interface arrangement between layers of core team and sub-teams (Ellis and Fisher, 1994). This can be reflected through the composition of the core team and higher-level sub-teams, for example, whether the leaders of sub-teams become members of the next higher level teams.

  Based on the above discussion, the membership pattern varies in the following six sub-dimensions:

  1) The hierarchical position of members in their respected functional unit: ranges
Chapter 2: Concurrent Engineering and Conceptual Framework

from operational level engineer to top level manager.

2) The nature of members’ activities: ranges from working on operational, managerial or liaison tasks.

3) The level of member’s dedication: ranges from all partly dedicated to fully dedicated and completely withdrawn from their functional area.

4) The temporal aspect of their involvement: ranges from the whole lifetime of the product development phase to only a temporary one in a single phase.

5) The extent of multiple membership within a single program (i.e. a member being part of two or more sub-teams): ranges from single to multiple membership.

6) The composition of the higher level teams: ranges from the absence to the existence of lower level team representatives.

2.4.1.2 Heavyweight Management: Vertical Integration

The heavyweight management initiative refers to the organisational arrangement that provides team leaders at every level with more power than their functional counterparts in program-related matters. In particular, the heavyweight management refers to the presence and authority of team leaders in relation to the seniority, rank and position of the leaders in the company and authority assigned to them (Adachi et al., 1994). Heavyweight management initiative is concerned with the co-ordination mechanism of the inherent interdepartmental interdependence of product development process (Adler, 1995). Wheelwright and Clark (1992; 1993) used the term heavyweight program team to describe the ideal type of organisational structure and leadership for the managing a new product development program, yet it is rarely presented in the product development practice.
Along the continuum of the matrix of function-division structure, Wheelwright and Clark (1993) distinguish four types of development team: functional, heavyweight, lightweight and autonomous, as diagrammatically shown in Figure 2-1.

Functional teams reflect the traditional sequential process of product development. Heavyweight program managers are senior managers who have the primary influence over those involved in the program and supervise their work directly through key functional people on the collocated core team. In contrast to the heavyweight team, the lightweight program managers, typically junior managers with little status or influence, lack of the power to directly execute and control the process which in to large part remains under the control of various functional managers. In the
autonomous team, on the other hand, individuals from functional units are assigned and totally removed, at least temporarily, physically and administratively from their functions and totally dedicated to the team.

In a heavyweight program team, the program leader is responsible to ensure the achievement of product development’s objectives in its phases (Gordon and Isenhour, 1990). To do so, the leader should have direct access to and responsibility for the entire work of all functional representatives involved in the development program. Heavyweight management provides a powerful team leader without losing the opportunity to benefit from the accumulated expertise in functional units. This leads to the first dimension of the heavyweight management initiative: the program position within the organisational hierarchy. This position is reflected in the formal structural position of the program manager relative to functional managers and the extent of the authority assigned to the program manager and other program leaders.

The engineering culture, in which the main part of development process takes place, has been characterised as a culture fostering competition, high individualism, and aversion to co-operation (Thamhain and Wilemon, 1987). In addition, the matrix arrangement that is embedded in a cross-functional team adds other challenges in terms of horizontal and vertical communication, resource sharing among programs, multiple reporting relationship, and dual accountabilities (Pinto and Pinto, 1991; Thamhain and Wilemon, 1987). Facing the above challenges, the leadership becomes a crucial factor (Thamhain and Wilemon, 1987).

A cross-functional team works at the operational level (Wheelwright and Clark, 1993). Therefore, the extent of the program manager authority is delegated to the lower-level program leaders and the extent of the functional authority is delegated to
functional representatives working in the team become crucial for effective functioning of the team. This leads to the second dimension, namely the nature of delegation, which involves the authority delegation from the program manager and from the functional leaders.

Wheelwright and Clark (1993) further suggest that the senior heavyweight managers not only have expertise but also have significant 'organisational clout'. They have full control over resources contributed by the different functional groups and become the evaluators of the contribution made by individual team members. McDonough (1993) argues that the characteristics of the team leader include tenure for understanding internal functioning of the company, position tenure for understanding the necessary knowledge and procedures, age for accumulating experience, and education for understanding technical issues. This leads to the third dimension of heavyweight management: the seniority of the program leaders.

Based on the above discussion, heavyweight management is operationalised into the following dimensions:

- **Program hierarchical position:**
  1) Formal structural position ranges from lower, equal or higher than of the functional positions.
  2) The authority of the program leaders ranges from limited (i.e. design aspect only) to extensive (i.e. overall aspects).

- **The nature of delegation:**
  1) Delegation of program manager's authority ranges from none to extensive.
  2) Delegation of functional authority ranges from none to extensive.
• **Seniority of program team leaders:**

  1) Tenure ranges from short to long.

  2) Age ranges from young (i.e. under 35 years of age) to mature.

  3) Education ranges from low to high level.

### 2.4.2 Communication and Decision-making Mechanisms

Initiatives within this category deal with the processual aspect of organisational integration (Kahn, 1996). These initiatives are critical for integrating design and development activities. Closely related to the task dimension, these initiatives can be seen as both part of CE initiatives and as the result of them. Cross-functional integration can only be achieved by fostering intensive communication, information sharing and collaboration between involved functions (Wheelwright and Clark, 1993). Trygg (1993) argues that team and other aspects such as job rotation, regular meeting, social interaction and physical proximity aim for fostering interdepartmental communication. Schrage (1995) even sees that the ultimate aim of all organisational initiatives is achieving better interaction and collaboration to ensure effectiveness.

The importance of the communication and decision-making mechanisms in CE has been noted by many researchers (e.g. Kahn, 1996; Blackburn et al., 1996). Blackburn et al. (1996) suggest its importance by arguing that concurrent activities performed by various individuals and groups require a flow of shared information in which all the concerns of different functions are addressed. As mentioned, Kahn (1996) argues that integration process include formal interaction and collaboration. Formal communication and collaboration patterns exist simultaneously in a cross-functional team(s) albeit in different degree across teams. Formal communication is dominant
when the network is characterised by 'wheel-and-hub' pattern (Ellis and Fischer, 1994) with the leader in hub position. In contrast, collaboration is dominant when the communication network is characterised by an 'all channel' network (Ellis and Fisher, 1994) with the leader as catalyst to foster dense and frequent collaboration.

Wheelwright and Clark (1993, p. 147) identify four dimensions that jointly determine the quality and effectiveness of communication: the richness of its media, its frequency, its direction, and its timing. Based on these dimensions, they identify four modes of upstream-downstream interaction: serial/batch, early start in the dark, early involvement and integrated problem solving, as illustrated in Figure 2-2.

Integrated problem solving is a particular mode of interaction for effective cross-
functional team characterised by intensive, rich, face-to-face dialogue between upstream and downstream participants early in the beginning of the process with more comprehensive problem solving style. In this mode of interaction, downstream participants are involved in early activities and in an ongoing dialogue with the upstream counterparts in the preliminary stage and use that information and insight to get a flying start on their own work (Wheelwright and Clark, 1993).

In studying the effect of communication and the level of concurrence between upstream and downstream activities, Hauptman and Hirji (1996) conclude that high degree of two-way communication, overlapping problem solving, and the release of uncertain and ambiguous information lead to more favourable outcomes in terms of product cost, schedule and quality as well as in team satisfaction; while the use of uncertain and ambiguous information leads to negative outcomes. These contradictory findings on the release and the use of uncertain/ambiguous information suggest that such information should be used for further collaboration between upstream and downstream participants rather than for the downstream’s decision-making. This finding refines the Wheelwright and Clark (1993) suggestion in the way of downstream participants use the information from the upstream participant.

This study follows Kahn (1996) and divides initiatives in this category into formal communication and collaboration. In addition, inter-team communication is also discussed considering the existence of several layers of sub-teams in large-scale development programs. This initiative focuses on the interaction between members from different teams within a product development program. With this addition, the previous two initiatives are dedicated to the intra-team communication and collaboration. The decision-making mechanism is further added in respect to how the
information, gathered through communication initiatives, is used to make decision.

2.4.2.1 Formal Communication

This initiative refers to the establishment of structured, formal and intentional communication media that facilitate interaction between functions, including routine meetings, memoranda, forms, reports, faxes and any kind of regulated interaction among functions (Kahn, 1996). Such media are characterised by a formal transaction relationship among independent functions within an environment in which they may have different and conflicting interests.

Following Hauptman and Hirji (1996) and Wheelwright and Clark (1993), formal communication is operationalised into two dimensions: the mode of communication and the nature of data conveyed. Using communication dimensions identified by Wheelwright and Clark (1993) and the conclusion of the Hauptman and Hirji study (1996), these dimensions are further operationalised as follows:

- **The communication mode:** refers to how information is released by the upstream counterpart and how this information is used in the process.
  
  1) Richness of media ranges from sparse, e.g. the use of document and computer network, to rich, e.g. face to face communication.
  
  2) Frequency: ranges from low, e.g. one-shot, batch type, to high, e.g. piece by piece, on line, intensive.
  
  3) Direction: ranges from one-way, e.g. monologue, to two-way, e.g. dialogue.
  
  4) Timing: ranges from late, e.g. completed work, at the end of the process, to early, e.g. preliminary, at the beginning of the process.
• **The nature of data conveyed:**

  1) The nature data released: ranges from ambiguous to certain.

  2) The nature of data used in the decision: ranges from ambiguous to certain.

2.4.2.2 **Collaboration**

As mentioned previously, according to Kahn (1996) collaboration refers to the informal, unstructured and affective nature of inter-functional relationships that emphasizes strategy alignment among collaborators through a shared vision, collective goals and joint rewards. The suggestion that cross-functional integration “rests on a foundation of tight linkages in time and in communication between individuals and groups working on closely related problems” (Wheelwright and Clark, 1992, p.175) is closely related to the notion of collaboration. This involves a shared act of purposive relationship, mediated by shared space (Schrage, 1995), in a problem solving process through which different aspects of a problem are constructively explored and goes beyond the limitation of individuals (Gray, 1989).

Many authors argue that collaboration is the ultimate form of relationship sought in teams (e.g. Trygg, 1993; Schrage, 1995; Kahn, 1996). Kahn (1996) views collaboration as being characterised by a continuous relationship, informal media, relatively interdependent and co-operative environment, shared vision and collective goals. Collaboration can occur simultaneously with co-ordination (e.g. means used to ensure that separate activities from different people can fit together), while not every co-ordination results in collaboration. Levine (1994), using Senge’s (1990) and Bohm’s (1990) notion of dialogue versus discussion, takes the importance of this continuous relationship even further by arguing that the vehicle of dialogue is selfless
listening that creates a common vessel of collective spirits. In contrast with discussion in which choices are made and held, dialogue is a conversation between individuals that are examining possibilities together and are willing to suspend and alter their positions (Levine, 1994). This, in effect, is similar to collaboration.

Collaboration distinguishes teamwork from team work (Donellon, 1993; 1996). In her study on interaction between individuals in the cross-functional teams in four large US companies, Donellon (1993; 1996) assessed team interaction using six dimensions: dependencies, identification, conflict management tactics, negotiation processes, power differentiation, and social distance. Combining these dimensions with Kahn’s (1996) collaboration characteristics, the dependency dimension relates to the presence of a collective goal; the identification relates to the presence of a shared vision; the conflict management and negotiation process relates to the presence of shared media; while power differentiation and social distance relate to the interaction pattern.

Based on the above discussion, collaboration can be seen as a form of informal interaction characterised by a communication pattern that is intensive face-to-face dialogue since the beginning of the process and supported with the shared-space media among those who share collective visions and goals. This study, therefore, uses the following four dimensions to operationalise collaboration:

1) The relationship pattern between people involved ranges from a close and friendly to a distant and competitive relationship.

2) Conflict and negotiation process ranges from a confrontation process toward win-lose situation or a dialogue process in order to reach win-win situation.

3) The presence of collective goals ranges from independence goals (e.g. achieving
individual goals) to interdependence goals (e.g. achieving collective goals).

4) The presence of shared vision ranges from personal identification (i.e. no shared vision) to group association, either toward the program or toward the function (i.e. shared vision presence).

2.4.2.3 Inter-team Communication

This initiative specifically relates to the relationship patterns both vertically between the core team and sub-teams and horizontally between sub-teams in term of channelling and sharing information. The interlocking structure between layers of development teams, co-ordination mechanism between them, and multiple membership across teams are important in the effective development process (Clausing, 1994). Although many development teams, particularly in high-tech manufacturing industries, are made up of core team and sub-teams due to the team size constraint and the complexity of the product (e.g. Clausing, 1994; Fan, 1994; Haddad, 1996), there has been very little research in this aspect of teamwork.

Most inter-team relationship involves higher level issues rather than operational tasks. This leads to the extent of the formal communication and collaboration presence although in this process both formal communication and collaboration patterns exist together. The communication may rely less on informal and personal face to face media and more on formal and impersonal media, such as budget and schedule documents, regular meetings, and technical reports. This initiative, therefore, is operationalised as follows:

1) The presence of formal communication (see formal communication in 2.4.2.1).

2) The presence of collaboration (see collaboration in 2.4.2.2).
2.4.2.4 Decision-making Mechanism

This initiative is concerned with how the team uses the information gathered through the communication media in various teams and sub-teams in decision-making mechanism. Decision-making mechanism relates closely to the authority and responsibility relationship among teams and among individuals. In an interlocking structure, co-ordination mechanism is represented by an authority relationship between core teams and sub-teams, which reflects on the extent to which the sub-team decision is respected and not being ignored by the higher level team (Clausing, 1994). Henke et al. (1993) argue that authority and responsibility relationship among teams depends on the extent of authority possessed by sub-teams vis-a-vis to the authority of the core team or higher level teams.

The composition of the higher level teams, i.e. whether sub-team leaders become members of higher-level teams (Clausing, 1994), is closely related to the perception of relative power between team leader and sub-team leaders and between sub-team leaders and sub-team members which, in turn, influences the effectiveness of the overall process. Sub-team leaders who are part of the core team may be perceived as having greater proximity and less status differential with the program leader than the leaders who are not parts of the core team. They may also perceive themselves as having a higher level of status differential with members of the team than leaders that are not part of the core team.

Therefore, the decision-making mechanism is operationalised through the following three dimensions:

1) Authority of the program teams: ranges from none to full authority.

2) Respect over the lower level teams’ decisions: ranges from respected to ignored.
Chapter 2: Concurrent Engineering and Conceptual Framework

3) Power differential perception: ranges from low to high.

2.4.3 Enabling Technology

Enabling technology refers to initiatives that utilise various physical tools and structured methodologies that have been promoted as means of realising a CE approach. They include computer-based enabling technology, collocation, formal CE methodologies, and systematic protocols. While collocation initiative is often regarded as part of organisational integration category, in this study it is classified as one of the enabling technology initiatives based on the fact that it refers to physical means (e.g. building and space layout), as oppose to organisational means. Some have argued that part of its functions can be substituted by computer-based technology (e.g. virtual collocation) (Adachi et al., 1994; Fan, 1995). Although effectiveness and applicability in supporting CE objectives are still in doubt, their contribution in supporting CE in large-scale development program is largely acknowledged. CE application in aircraft and auto industries, for example, are supported by these enablers (Fan, 1995; Haddad, 1996).

2.4.3.1 Computer-Based Technology

Computer-based technology initiative refers to the utilisation of both hardware and software of computer technology in the application of CE. This initiative is widely advocated, particularly in the engineering literature, as a means of achieving and supporting integration (e.g. Volk, 1992; Syan and Menon, 1994; de Graaf, 1996). The
Chapter 2: Concurrent Engineering and Conceptual Framework

utilisation of computer-based technology includes the following areas:

1) Supporting the individual engineering tasks e.g. CAM, CAE (Fujimoto, 1997).

2) Supporting cross-functional integration, e.g. CAD/CAM, CATIA (Trygg, 1993).

3) Assisting information management, e.g. enterprise resource planning (ERP), intranet and internet (Hameri and Nihtila, 1995).

4) Supporting collaborative work, e.g. rapid prototyping, computer-supported cooperative works (CSCW) (Fan, 1995; Fujimoto, 1997).

Although its position in CE can be argued about (Evans, 1990), the computer does make communication easier especially for large development tasks due to the large amount of information involved and their complex interdependency (Clausing, 1994; Schrage, 1995; Fujimoto, 1997). There is a relationship between the mode of interaction and the use of the computer technology. When the more intensive face to face interaction is not possible either due to the task’s size or location, it is substituted by computer integration (Adachi et al, 1994; Hameri and Nihtila, 1995).

Recent developments in computer technology, such as computer networking, integrated CAD/CAM system, and rapid prototyping system, provide significant contribution in providing and easier and faster communication (Schrage, 1995). It support collaboration. It can also support concurrence work, particularly for a front loading strategy, in terms of simulations such as 3-D CAD-CAE, CAE simulation, and stereo-lithography (Fujimoto, 1997). However, King and Majchrzak (1996) argue that the assumptions made by developers of such CE tools are likely to inhibit the tools for successfully enabling CE because they are often inconsistent with documented behaviours of people using similar technologies.
2.4.3.2 Collocation

The term collocation is used to describe the intentional physical proximity of people involved in the development process, e.g. a group is collocated into a single area. It relates to the physical location in which team members reside. The team’s location may be scattered in the case when members are located all over the organisation’s buildings and only meet from time to time in designated spaces or they are collocated at the same place. Allen (1977) argues that increased physical distance exponentially reduces the probability of communication between counterparts (i.e. ‘communication distance curve’). However, this negative impact of physical distance on communication appears to be less evident with computer and electronic communication (Hameri and Nihtila, 1995). In this sense, location becomes one of the determining factors for the selection and design of an information support system (Adachi et al., 1994).

Collocation is widely cited as conducive to achieve cross functional interaction and integration (Trygg, 1993; Pelled and Adler, 1994; Pawar, 1994; Jurgen, 1997). Pelled and Adler (1994) argue that physical proximity plays a role in influencing the outcomes of a task conflict, whether it enhances effectiveness and leads to functional outcomes or it becomes an emotional conflict that reduces effectiveness and leads to dysfunctional outcomes. This argument underscores the importance of collocation in understanding others’ perspectives through free interaction and socialisation. Similarly, Pawar (1994) argues that collocation helps informal consultation and improves relationships leading to faster problem resolution.

Pawar (1994), however, admits that loyalty to the functional unit for some members may prevent them from talking to members from other functions. It seems that the
way they arrange the layout of the allocated space is influential in reducing the effect of functional loyalty. Another issue is concerned with which functions are collocated. In many large programs, often only engineering related functions are collocated (e.g. Haddad, 1996, for automotive development programs) which is understandable considering the size of the team.

2.4.3.3 Formal CE Methods

Formal CE methods refer to the use of various formal analytical methods frequently associated with the CE approach in the product development process. Most of these systematic methodologies are developed within the discipline of engineering design 'pre-CE' as part of the rationalisation of the design process (Smith, 1997). However, they are regarded as important elements of CE (Trygg, 1993; Hales, 1994). Clausing (1994) argues that the movement toward a more holistic way of development has led to several concepts and methodologies, while Hales (1994) argues that without tools the CE approach is only a 'catch phrase'. The focus of these methodologies is to ensure that the information needed is available as early as possible to reduce slack time and unnecessary rework (Trygg, 1993).

These methods include DFM, DFA, QFD, Taguchi methods, DFS, DFT and ultimately DFPLC or DFX (Trygg, 1993; Clausing, 1994). The use of some of these tools and methods as other names of CE (Trygg, 1993) marks the importance of their contribution in the conceptualisation of CE. The most frequently cited and used tools are DFM, DFA, and QFD (Syan and Menon, 1994; Waterbury, 1986; Stoll, 1990). DFM and DFA take the issues that the cost of production is mainly determined in the design phase. They are systematic methodologies of designing the product in such a
way as to minimise the total cost of manufacturing and assembly. In more general terms, they are conceived as manufacturability and producibility evaluation.

The objective of DFM is to obtain a product concept that is inherently easy to manufacture by focussing on design for the ease of manufacture and integrating the manufacturing process and product design for the best matching of need and requirement (Stoll, 1990). DFM guidelines consist of all encompassing rules for best practice for economic manufacture, such as minimising the number of parts, developing modular designs, minimising part variations, and minimising handling (Syant and Swift, 1994a). The objective of DFA is to obtain product concepts that are inherently easy to assemble. DFA consists of rules and techniques specific to assembly which can be applied methodically for assembly rationalisation, and design of components for ease of handling and assembly (Syant and Swift, 1994b). Some of DFA techniques include Corbett’s checklist for DFA, Hitachi’s assemblability evaluation method, the Boothroyd Dewhurst Inc.’s DFA procedure, and the Lucas DFA Technique (Syant and Swift, 1994b, Waterbury, 1986).

Quality function deployment (QFD) originated in 1972 at Mitsubishi’s Kobe shipyard (Hauser and Clausing 1993; Prasad 1996). The objective of QFD is to incorporate the voice of customers into all phases of the product development cycle in order to effectively match product concept and performance specification to market needs (Slade, 1993; Hales, 1994; Prasad, 1996). QFD involves tiered matrices of ‘what’ and ‘how’ from customer requirements down to the production control (Hauser and Clausing, 1993; Prasad, 1996). QFD basic matrix is the house of quality (HoQ), which translates the voice of the customer into the engineering, design process, and production stages (Prasad, 1996). The translation process involves sequentially
constructing several matrices of customer requirement versus design requirement, design requirement versus engineering design, engineering design versus product characteristics, and so on (Menon, O'Grady, Gu and Young, 1994).

As with computer technology, there is criticism over the effective use of CE methodologies (e.g. Evans, 1990; King and Majchrzak, 1996). The main point in the criticism is that such methods cannot be standardised but rather depend on the type of task as long as these aspects are taken into account during design decision process (Evans, 1990). Considering this issue, this study considers both formal and informal utilisation of these methods. The more informal methodologies include all efforts that are effectively utilised to ensure producibility and manufacturability of the design.

2.4.3.4 Systematic Protocols

This initiative refers to the effort to establish a set of systematic guidelines that assists the organisation in maintaining commitment to the CE approach. Protocols encapsulate the key element of how the approach is realised in a particular context. Procedure manuals are common in engineering functions to help them deal with the complexity of their task. CE methodologies such as DFA and DFM, for example, are derived from such a custom (Syan and Menon, 1994a, 1994b).

Introducing CE implies a large-scale transition from the sequential approach. CE also involves more intense and demanding activities and interaction than the sequential approach, and creates more tension and conflict within the program team (Riedel and Pawar, 1991). Pinto and Pinto (1991) note that the team’s rules and procedures are significant predictors of the success of a cross-functional co-operation. Unfortunately,
only a few studies have examined the importance of such protocols in implementing CE. This issue is another gap in the CE literature. Cleland (1991) is among the few researchers who underline the importance of protocols in the implementation process. He argues that several important strategies have to be laid out at the start including the descriptions of the cross-functional team, how it influence the overall process, team charter, system support committed and resource allocation planning.

The necessity of systematic protocols in CE implementation involves two issues:

1) What CE initiatives are carried out, which is represented by operating manuals consisting of an applied set of CE initiatives (i.e. CE-related manuals);
2) How CE is implemented in the organisation, which is represented by a structured and systematic approach to its implementation (e.g. CE charter and plan).

2.4.4 External Integration

Cross-functional integration may go beyond the organisational boundary and involve both suppliers and actual or potential customers in the process. Many researchers and practitioners have suggested such an involvement, particularly in high-tech industries, such as aerospace and aircraft (i.e. Fan, 1995; Slade, 1993; Henke et al., 1993; McDonough and Griffin, 1997). This category covers such initiatives and can be seen as an extension of the scope of a cross-functional team. Therefore, the membership pattern of the cross-functional team is also applied in the dimension of this category, which include the following:

1) the number of supplier/customer involved,
2) the relative position of external counterparts in the team (e.g. whether they work in the operational level, or mainly as the representatives in the higher-level team),
3) the stage of the process they are involved (e.g. whether only sporadic in a particular stage or throughout the whole process).

2.4.4.1 Supplier Involvement

The involvement of supplier representatives as part of a cross-functional team is often cited as an important element of CE and of successful new product development (e.g. Fujimoto, 1997; Slade, 1993; Jurgen, 1997). Slade (1993) argues that the relationship with suppliers is often complex and problematic, and therefore requires supplier integration, in which suppliers' engineers work together with design and manufacturing engineers in the design teams, early in the design cycle and continues throughout the product cycle. The involvement of key suppliers provides the opportunity to rationalise and harmonise operating system interfaces, i.e. quality standards, production and paperwork process, and delivery schedule (Henke et al., 1993). Supplier involvement is more apparent in large development programs with long development cycle (e.g. 5-9 years), such as aircraft development. Fan's (1995) study of extended enterprise in CE, draws the experience of many aircraft manufacturers that involved key suppliers in their cross-functional teams and were engaged with some them in a risk and cost sharing partnership.

2.4.4.2 Customer Involvement

The involvement of key or potential customers in the cross-functional team is a significant initiative in CE, particularly in the industrial and contract-based customers (McDonough and Griffin, 1997). In the aircraft industry, for example, the
development of a new platform involves a long period of time (i.e. 7 to 9 years). Any customer’s doubt about the design (e.g. product safety) will greatly affect the sales and bring about changes to the design in later stages to incorporate such concerns. In a long development cycle program, it will greatly affect delivery to market, which in turn will affect sales more adversely.

2.4.5 Human Resource Management (HRM) Policy and Capability

Katzenbach and Smith (1993) argue that to be effective and successful the team should have adequate complementary skills: technical, problem solving and interpersonal. This argument implies that HRM issues should be included to facilitate required changes and to develop necessary competencies in establishing a cross-functional team. This aspect relates to the competencies necessary for establishing a CE approach and organisational policies that develop and foster such competencies within the organisation. However, HRM issues are largely ignored in CE literature.

2.4.5.1 Competency

This element refers to the building of key competencies required in new product development, which are acquired through HRM policies and practices. Nakayama (1997) argues that innovative product development is knowledge creation, which requires interaction between tacit and explicit knowledge held by involved people. Explicit knowledge is derived from the organisation’s knowledge represented by specification, calculation, or blue prints, which later materialised into the product. Explicit knowledge is tangible and transferable from one person to another.
Tacit knowledge is derived from the organisation’s knowledge that is kept and internalised by each member of the organisation. It is intangible and, therefore, the transfer is difficult (Nakayama, 1997).

At the group level, knowledge creation activity evolves through interaction, which leads to the sharing of tacit and explicit knowledge and results in the conceptualisation process (Nakayama, 1997). Development technology refers to the tacit knowledge internalised in each engineer of the development teams and brought to the next development effort (Nakayama, 1997). It comprises the field work knowledge (e.g. intuition, experience and analogy), which provides the insight necessary for understanding overall circumstances and actively re-framing or integrating various technologies to fit the needs of a product development program.

Klein and Maurer (1995) argue that an integrated product development team needs technical experts who possess integrative knowledge across multiple functions. These integrators are needed because an effective group process relies on the ability to communicate and synergistically integrate its combined skills and knowledge throughout the development process. An integrator bridges functional knowledge bases. To be an integrator requires deep knowledge of and experience in one field plus basic understanding of several adjacent fields (Iansiti, 1993; Klein 1994).

Crucial to this integration is a set up of overlapping knowledge or multi-skilling. Klein and Maurer (1995) further argue that overlap between individual members in many areas is not necessarily duplication of knowledge but often varying degrees of expertise or different types of knowledge. The areas of overlap are essential for the team to function. If only one member possesses the overlapping knowledge (even peripheral in some instances) he or she would become the de facto team leader.
Similarly, Volk (1992) argues that multidisciplinary education is required to balance the requirements of more specialisation. Furthermore, professional equality and trust among members seems to be a determinant in interaction. The higher the professional trust and equality among members, the stronger their tendency is toward collaboration. Indeed, Reidel and Pawar (1991) argue that competency of engineers and managers of the company should become one of the basic considerations in the decision to implement a CE approach.

Based on the above discussion, the dimensions of required competency for this study include: educational background to capture the explicit knowledge; experience in previous programs to capture the tacit knowledge of development; multi-skilling or overlapping expertise to become effective integrators; and the knowledge disparity level to ensure professional trust and equality.

2.4.5.2 CE-Related Training

This initiative refers to the availability of specific training courses in supporting the application CE. Gordon and Isenhour (1990) suggest that members in integrating teams be trained in team building and problem solving skills. The adoption of a cross-functional team implies a break from a traditional hierarchical and isolated functional work environment (Donellon, 1993) toward specialists working closely together with other specialists from different functional areas. This experience can cause a cultural shock (Anderson, 1993). Specific team-related training courses, such as team building and interpersonal skills, are important in breaking down people’s barriers to effective functioning of the team (Donellon, 1993; Anderson, 1993). In addition, the applied CE concepts and guidelines need to be introduced to the entire functional units, and in
particular to direct participants.

Thamhain and Wilemon (1987) view team building as a process of taking a collection of individuals with different needs, background and expertise and transforming them into an integrated, effective working unit. Another team related skill needed is collective listening that is necessary in reaping the benefit of 'teamness' (Levine, 1994). However, Henke et al. (1993) found that more effort has been invested in the structure than in the preparation of team members to ensure them to function effectively through such training courses.

2.4.5.3 Human Resource Policies

Human resource management (HRM) issues play important role in product innovation for manufacturing success. HRM policies had to be congruent with new product development practices; otherwise the expected result can not be achieved (Zanko et al., 1998). Breaking the silos that hinder the integrated process raises a concern for the long-term maintenance of strategic competencies. To retain critical functional knowledge and skills, an organisation needs an HRM system with an appropriate balance between short-term product related needs and long-term strategic business and employee development goals (Klein and Maurer 1995).

HRM policies that are considered important for CE are recruitment, training and career development, performance measurement and reward system (Jurgen, 1997). Klein and Maurer (1995) report a case in which these issues were handled through a set of policies starting with skill registration or skill inventory to list the core and other expertise available in the organisation and the knowledge map that reflect the
knowledge required for the product development. The selection system reflects the matching of the individual with the knowledge map. Training needs are identified through the gap between the skill register and the knowledge map. Career development is handled considering the continuity of knowledge. This includes job rotation to facilitate overlap knowledge. Performance is measured through team based peer appraisal rather than individual appraisal. Reward systems include team based pay plans and skill based pay systems. However, Zanko et al. (1998) suspect that in much CE implementation HRM has been addressed more as ad-hoc issues rather than as a systematic whole and, these issues are undertaken mostly by the involved line managers which put the HRM function in a reactive and clerical mode.

2.5 Conclusion

CE conceptualisation and operationalisation reveal that introducing CE is not as simple as its concept would indicate. It involves the selection of a combination of these initiatives as well as the types most appropriate to be applied in a particular context. Therefore, it covers a wide range of CE models.

Throughout the introduction process these initiatives may change and be shaped by the context and politics surrounding the process and may take different forms to that they initially intended. Each initiative may go through different paths and be influenced by the context and politics in different ways. The interrelation and interdependence of the identified generic features (Zanko et al., 1998) imply that all these initiatives are also interrelated and interdependent. The substance of change, therefore, consists of several interrelated sub-processes as illustrated in Figure 2-3.
This study focuses on initiatives in organisational integration and communication and decision-making mechanisms, which include: cross-functional team, heavyweight management, formal communication, collaboration, inter-team communication, and decision-making mechanism. Focusing on these initiatives, this study analyses the longitudinal development of each sub-process of these initiatives through their dimensions and sub-dimensions.

Initiatives from other categories are also discussed. Drawing on the interrelationship between initiative sub-processes, these initiatives are used as part the explanation of what happened in the focus initiatives, which are central to the study and used to characterise the shape and the transformation development of the CE in the case study. This discussion on CE leads to a refinement of the general processual framework developed in Chapter 1. This refinement is illustrated in Figure 2.4.
operationalisation of focus initiatives into dimensions and sub-dimensions is provided in Table 2-1 (p. 40). The operationalisation of other initiatives into their dimensions is provided in Table 2-2 (p. 41). The internal and external contexts as well as organisational power and politics surrounding the implementation process are discussed in the following chapter.

![Conceptual Framework Refined based on CE Initiatives](image)

Figure 2-4: Conceptual Framework Refined based on CE Initiatives
3.1 Introduction

Introducing CE into an Indonesian aircraft manufacturing company means bringing CE to a context that is different from its origins, and involves a significant change from the previous approach adopted by the company. The choice and process of change are influenced by the organisational structure and context, as well as the political manoeuvring of those who have access to the development process, particularly when such change is viewed as an opportunity to alter the structure and to express their worldviews (Thomas, 1994).

Guided by the processual approach to organisational change (Dawson 1994; Pettigrew, 1990), this study aims to explore through longitudinal research how a model of CE was over time shaped and formed by the contextual factors and the organisational power and politics surrounding its introduction to an organisation. Furthermore, following Thomas (1994) argument in his power process perspective, this study expands the organisational and temporal context in analysing the process of change in order to see the dynamics and interactive nature of such a process.
In order to define a conceptual framework for such exploration on the context, this chapter reviews research literature on contextual factors and organisational power and politics, particularly ones that surrounding the implementation of a new approach or strategy in an organisation. This chapter is divided into two parts. The first part is devoted to the review of contextual factors that comprise the context of change and the incorporation of these factors into the research framework. Pettigrew (1997, 1990) and Dawson (1994) suggest that context of change includes both external and organisational environment within which the process takes place such as the particular circumstances within the organisation and its functional units, industry and society. In this study, the analysis of the context is focused on the organisational context and considering not only its structural but also its processual and cultural dimensions. The external context will only be reviewed in a broad sense.

The second part reviews the literature associated with organisational power and politics. Although often ignored, organisational politics play a central role in process innovation, either in the decision to adopt an approach or in the implementation of the adopted approach (Thomas, 1994). Politics can be viewed as the practical domain of power in action (Buchanan and Badham, 1999), which may go beyond the traditional authority in directing activity of others (Madison, Allen, Porter, Renwick, and Mayes, 1980). The discussion is arranged based on tripartite analysis of power (Pettigrew and McNulty, 1995): power sources; context and structure; and will and skill. This review is used to conceptualise the role of organisational politics in this change process of introducing CE to complete the elements of a processual analysis. The final conceptual framework incorporating the above analysis of context, power, and politics is presented at the end of this chapter.
3.2 The Context of Change

In processual analysis, the context of change refers to the past, present and future projection of internal and external operating environment (Pettigrew, 1973; Dawson 1994). The internal or organisational context is represented by contextual factors inside the organisation. The external context covers competitor strategy, international competition, government legislation, changing social expectation, technological innovation, and changes in business activities (Dawson, 1994). The external factors can be grouped into the industry and the society in which the organisation operates. Typically, the management of an organisation has more control and influence over internal context, but less or no such control or influence over the external context.

Thomas (1994) argues that in order to attain deeper understanding on the dynamics of the change process, it is necessary to expand the organisational and temporal context in which the process occurs. However, to make the research tasks 'manageable', this study focuses on the organisational context. To satisfy the necessity of expanding the organisational context, the literature on the external contexts, namely the industry and the society is reviewed broadly, with a particular purpose to provide guidance in describing the organisation and its environment rather than to intentionally seek explanation from it. Using this review, the overview of the industry and society in which the subject of case study operated, namely the aircraft industry and Indonesia, are provided in Chapter 5 which introduces the company and its environment.

The reason to choose the organisational context as the focus of the study is two-fold. Firstly, organisational context, at least partly, represents the intersection of the industry context and the society contexts (Schneider and Barsoux, 1997). Organisational context is both moderating and affected by the conflicting aspects of
the industry and society. Hawkins (1999), for example, notes the complex criss-crossing of national, professional, and departmental cultures as well as the cultures of different clients while working in an international company. In this line, Hosftede (1991) outlines the relationship between the organisational culture and mechanism and the societal culture of its members. From the contingency theory proponents, Thompson (1967) suggests the technology employed by an industry determines the degree of complexity, uncertainty and interdependence within an organisation operates in that industry. Secondly, since the external context is in the outer layer of the process, the direct influence of its factors is expected to be more remote than the influence of the inner context.

### 3.2.1 Organisational Context

As discussed in Chapter 2, many researchers acknowledge that moving from sequential to integrated process involves not only technological change but also substantial organisational and cultural changes and hence emphasise the organisational aspects of CE initiatives (e.g. Clausing, 1994; Adler 1995; Klein dan Maurer, 1995). Central mechanism of CE is supported by both technical and organisational enablers (Haddad, 1995). These organisational enablers involve changes in organisational structure and practices. More specifically, Zanko et al. (1998) argue that organisation integration is one of the distinct features of CE, which calls for an organisational arrangement designed differently to the traditional functional silos (Zanko et al., 1998). The fit between organisational context and CE approach being introduced greatly affects the implementation of CE in a company. Therefore, organisational context is an important issue in the discussion of successful
CE implementation.

Basically, an organisation is the grouping of individuals into one or more groups in order to accomplish a given task (Ensign, 1998). Organisational context covers hard, formal structure and mechanism of the organisation as well as its soft, behavioural, attitudinal, and cultural aspects of people within the organisation. According to Dawson (1994), five main factors in the internal organisational context are human resources, administrative structures, technology, product, and history and culture.

Contingency theory argues that there is no best way of organising (Galbraith, 1973; Child, 1984). Galbraith (1973: p. 2) states “there is no single best way to design the structure of an organisation” and “any way of organising is not equally effective”. One of these contingency factors is the size of organisation (Child, 1984; Handy, 1985; and Wong and Birnbaum-More, 1994). Other contingency factors that are considered as determinants of organisational structure are market environment (Burns and Stalker, 1961), production technology (Woodward, 1965), industry characteristics and its technology (Handy, 1985; Chapman and Jehn, 1994), strategy (Chandler, 1962; Child 1972), type of work and environmental demands (Lawrence and Lorsch, 1967; Lorsch and Allen, 1973); objectives, history and ownership of the organisation (Handy, 1985), product characteristics, administrative heritage, and the organisational stage of development (Schneider and Barsoux, 1997).

Child (1984) further argues that contingencies are themselves interrelated. He emphasises the important of choice in defining organisation of the firm by arguing that it is not simply a technical matter but also reflects the preference embodied the dominant culture of the organisation. This confirms Buchanan and Boddy’s (1983) argument of interrelationship between the organisational structure and organisational
culture in their analysis of technical change. In fact, many researchers argue that organisational culture is reflected by organisational structure (Harrison, 1972; Handy, 1985; Hofstede, 1991; Pheysey, 1993).

Furthermore, many of these contingencies, such as market, type of work and technology, relate to the external context, namely the industry in which the organisation operate, indicating contribution of the industry context in defining the organisation structure (Woodward, 1965; Thompson, 1967). Thompson (1967), for example, argues that greater technical complexity of the industry results in increased structural differentiation. In a sense, this technology deterministic argument contradicts the above argument of strategic choice put forward by Child (1972, 1984). In this respect, Thomas’s (1994) argues that in addition of the ‘invisible hand’ of exogenous technological deterministic and the ‘visible hand’ of strategic choice, change may occur as a result of the ‘political hand’: initiated in response to existing structure by means of technology. This Thomas’s power process perspective sees relationship between technology and organisation as dynamic and interactive rather than static and unilateral.

Meanwhile, Hofstede (1991) argues two dimensions of societal culture (i.e. power distance and uncertainty avoidance) influence the structural aspect of the organisation. He argues that power distance and uncertainty avoidance dimensions of societal culture are represented by the centralisation and formalisation dimensions of organisational structure (1991). He also made comparison between his quadrants and Mintzberg (1979) organisation typology indicating interrelation between the organisation context and the national/societal context.

In summary, the organisational context in this study is represented by the
organisational structure and stage of development of the organisation, organisational culture, and functional culture. This is taken considering the contingency theory’s (Galbraith, 1973) argument for the interrelation between structure and the contingency factors, Schein’s relationship of organisational history and culture (1985), and Lawrence and Lorsch’s functional orientation (1967).

3.2.1.1 Organisational Structure and Stage of Development

This section discusses the organisational structure and its co-ordination mechanism and the organisation’s stage of development. The stage of development of a company is included here because it affects some structural contingencies, such as the size, administrative heritage, goals and objectives and particular strategy employed by the organisation (Schneider and Barsoux, 1997).

Organisational structure is a major factor within the organisational context. In simplest term, it is the way in which organisation divides its people into distinct tasks and achieves co-ordination among them (Mintzberg, 1979). Child (1984) and Handy (1985) refers to organisation structure as a means for allocating formal responsibility that provide a framework for operation and co-ordination mechanism within the organisation. Similarly, Scott (1992) argues that a formal structure defines the formal roles and relationship among people, and thus creating a certain authority pattern. According to Child (1984), organisational structure has three main aspects:

1) The basic structure: a formal allocation and co-ordination mechanism of people and resources. This includes organisation charts, job descriptions, and the constitution of boards, committees, and teams.
2) Operating mechanism: a set of devices that govern what is expected from the people. This includes operating procedure; standard performance, rewards and appraisal systems; and planning, scheduling and communication systems.

3) Decision-making mechanism: mechanisms to attain decision and its associated information, such as environmental scanning and information systems.

Matteson and Ivancevich (1990) use three dimensions of formalisation, centralisation and complexity (differentiation/specialisation) in analysing organisational structure. Formalisation refers to “the extent to which rules, procedures, and other guides to action are written and enforced” (p. 653). Centralisation refers to “the extent to which authority to make decisions is retained in top management” (p. 651). Complexity (differentiation/specialisation) refers to “the number of different jobs and/or different units within an organisation” (p. 652).

In line with his three aspects of organisational structure, Child (1984) argues that organisation structure has six major dimensions: design of jobs (specialisation), design of formal relationship, hierarchy and span of control (the shape), the grouping (functional/divisional), integration, delegation of authority, and performance appraisal and rewards system. This list seems to accord with the above Matteson and Ivancevich’s (1990) three dimensions of organisational structure.

Similarly, Scott (1992) describes the structural features that integrating an organisation include formalisation, hierarchy, centralisation, and various way of facilitating the lateral flow of information. Hierarchy is associated with the way people are linked into a single pyramidal structure of control relation, while centralisation is a structural mechanism that defines who participates in decision making (Ensign, 1998). These descriptions of ‘centralisation’ and ‘hierarchy’ are
similar in their essence to the definition of ‘centralisation’ in Matteson and Ivancevich’s (1990) dimensions of organisation structure.

On the basis of key dominant parts of the organisation, Mintzberg (1979) developed a typology of the organisation structure, each with different co-ordination mechanism:
1) simple structure of the strategic apex with direct supervision,
2) machine bureaucracy of the techno-structure with standardisation of work process,
3) professional bureaucracy of the operating core with standardisation of skill,
4) divisionalised form of the middle management with standardisation of output, and
5) adocracy of the support staff with the use of mutual adjustment.

This typology can also be described in term of formalisation, centralisation and differentiation with adocracy represents the low end of formalisation, centralisation and differentiation dimensions while full bureaucracy represents the high end of formalisation, centralisation and differentiation dimensions.

Based on the above discussion, it seems that the Matteson and Ivancevich’s (1990) dimensions of organisation structure covers all aspects of the organisation structure more comprehensively. Therefore, following Matteson and Ivancevich’s (1990), this study operationalises organisational structure and co-ordination mechanism through three dimensions of centralisation, formalisation, and specialisation.

The operationalisation of the organisation’s stage of development is sought in various organisation models within the strategy imperative framework, i.e. whenever strategy change the organisation must change (Galbraith, 1991; Mintzberg, 1991; Chandler, 1962). This framework indicates that organisation is more than just structure. The elements of both strategy and organisation should be combined to suit a particular context (Mintzberg and Quinn, 1991). Mintzberg and Quinn (1991) relate their
context with the stage of development of the organisation: entrepreneurial context of the start up companies, mature context of the large business organisations, and diversified context of the conglomeration. Start up organisation is typically used a simple structure to deal with the entrepreneurial context, while the large business organisations and conglomeration use machine bureaucracy and divisional structures respectively.

The above discussion shows that the stage of development of an organisation is closely related to the age of the company and its business maturity relative to other players in the industry. Considering that this study is concerned with new product development process, knowledge and technology accumulation also become highly relevant. In this aspect, Riedel and Pawar (1991) warn that the adoption of CE should also consider the issue of availability of competent engineers and managers other than the time-cost trade off and the ability to lay substantial capital investment at the outset. Their case study emphasises the importance of the technological and managerial competency. Therefore, the stage of development is operationalised through the following three aspects:

1) the age of the company relative to other players in the industry,
2) the business maturity, and
3) the technological competence maturity.

3.2.1.2 Organisational Culture

The term organisational culture is used to reflect a wide range of the organisational dynamics from behavioural attitudes and values. There is a wide body of literature on this subject, but there is disagreement on its definition; to some extent it is still a
polemical concept. For example, Bloor and Dawson (1994) emphasise its features on facilitating sense making and guiding working behaviour, and therefore, see organisational culture as patterned systems of perception among people that share common experiences. Schein (1985), on the other hand, has deliberately excluded overt behavioural patterns from his widely cited definition. He further argues that organisational culture provides consensus on organisational mission, goals, means, measurement criteria, and repair strategies in dealing with survival and external adaptation issue. It provides common language and consensus over group boundaries.

Organisational culture consists of the core values that maintain an organisation as a bounded unit and provide it with a distinct identity (Chatman and Jehn, 1994). In its essence, these core values also play a role as a normative control that continuously forces members of the organisation to behave in accord with the organisation's objectives (Kunda, 1992). Schein (1985) suggests the dominant influence of the founders and strong leaders, the dominant groups, and the unique history of organisation in shaping the core values of organisational culture. Kunda's empirical study on 'engineered engineering culture' (1992) in a high-tech company is also underscore the strong influence of the founder and senior management members in defining and shaping the intended organisational culture.

Organisational culture is not static but develops over time in a complex interplay with the external environment (Schein, 1985). Using Hofstede's (1991) model, Pheysey (1993) suggests that the organisational culture is the golden means of achieving the organisational mission. This means an organisation evolves from one culture to the other whichever best fits the organisational context. Similarly, Charles Hampden-Turner (1994) sees organisational culture as the way the organisation deals with the
dilemma of contradictory choices that may create either a vicious cycle that goes from one extreme to the other, or a virtuous cycle that creates solution to achieve harmony.

In conceptualising organisational culture, Roger Harrison (1972) and Charles Handy (1985; 1987) develop similar quadrants with four types of culture and coined with different names. Their quadrants are derived from a similar formalisation and centralisation dimensions and represent co-ordination mechanism and organisational structure. Interestingly, these typologies closely resemble Hofstede's (1991) organisational culture quadrant and Mintzberg's (1979) organisational typology mentioned in the previous section. These interrelationship between organisational culture and organisational structure is illustrated in Figure 3-1.

![Organisational Structure and Organisational Culture Interrelationship](image)

Figure 3-1: Organisational Structure and Organisational Culture Interrelationship (Adapted and Extended from Hofstede, 1991)

These typologies highlight the interrelation between structural and cultural aspects of the organisation context as well as the interrelation between the organisation context and the external contexts. Furthermore, the use of key part of the organisation as the
basis of Mintzberg’s (1979) typology leads to the notion of the existence of different parts and functions in organisation. This implies the relationship of the structure and the nature of various functions in organisation, which leads to the functional culture.

Meanwhile, Martin (1992) views organisational culture from three different perspectives: integration, differentiation and fragmentation. The integration perspective views organisational culture as a set of shared-values, often espoused by the organisational management as bringing organisational members together. The differentiation perspective takes the view that the espoused organisational culture sometimes conflicts with organisational sub-cultures that exist in the organisation. The fragmentation perspective views that several, and sometimes conflicting, sub-cultures exist in an organisation and their interplay shapes the organisational dynamics. This three-perspective of organisational culture is strongly supported by the empirical result of Kunda’s ethnographic study in a high-tech company. Kunda (1992) found that the engineered ‘tech-culture’ was intensively brought forward by the management while other members reacted to it quite differently, either embracing or distancing, according to the his/her particular circumstance at a particular time.

Within this framework, the above discussion on organisational culture represents the integration perspective of culture characterised with the notion of espoused, united and shared culture. Two other perspectives imply the importance of sub-cultures (i.e. various functional cultures) that coexist in the organisational context and the way of individuals within the organisation deal with the espoused and intended culture. This is supported by one dimension of organisational culture suggested by Schein (1985) and by the result of Kunda’s (1992) study, namely the dominant group within the organisation, which implicitly recognised the distinct identities of various groups
within the organisation. This organisational sub-culture (i.e. functional cultures) is discussed further in the next section.

Based on the above discussion, this study follows Schein (1985) and Kunda (1992) and assesses the organisational culture through the dimensions of founder and strong leaders and the unique organisation history. These two dimensions are the major contributors that define a set of distinctive common cultural attributes that are shared by the entire organisation and often intentionally espoused.

3.2.1.3 Functional and Professional Culture

Professionals acquire judgement through intensive training, supervision and socialisation. Different professions differ in their values and beliefs, and what is considered as appropriate behaviour. These differences may reflect differences in mission, method, and concerns (Schneider and Barsoux, 1997). However, some professions are often blurred with the occupation. Engineers, for example, while coming from the same profession, are more likely addressed according their functional occupations (e.g. production engineers, designers). Hansen (1995) notes that while being part of the same profession, hardware and software development departments have different cultures. In this study, this sphere is not taken into consideration. The influence of particular professions, if relevant, will be included as part of this discussion on functional culture.

Following Martin’s three perspectives (1992), this study acknowledges the potential coexistence of a united organisational culture that is shared across functional departments and various differentiated and fragmented sub-cultures (i.e. functional
cultures) with conflicting interests within an organisational context. Schein (1993) argues that sub-units of an organisation are likely to develop their own subcultures because they share core technologies and learning experiences. These subcultures imply differences in languages, assumptions about reality, and mental models.

Similarly, Kunda (1992) found significant differences in the ownership of an intended culture among three different categories of employees in his case study of high-tech culture. This case study shows that design engineers became the centre of the culture and the effort to inseminate that intended culture. Design engineers was clearly the first class employees and the main target of the intended culture put forward by the senior management members. Other groups, including production engineers, are less important. This empirical result is in line with Lawrence and Lorsch (1967) argument for the degree of domination of a particular function as one dimension in describing industry environment.

Schein (1993) suggests that subcultures tend to form around any stable social unit. This stability is a function of relative stability of membership, the duration of the founders leading the group, the potency of leadership, the number and intensity of common coping experiences, the life time of the group, and the “smallness” of the group to foster mutual acquaintance and trust. Program teams, functional groups, geographical units, or hierarchical strata, each inevitably creates a common frame of reference, a common language, and a common assumptions-forming sub-culture due to their differences within the organisation (Schein, 1995). Bloor and Dawson’s (1994) definition of culture emphasises patterned systems of perception that facilitate sense making and guide behaviour at work, suits the concept of functional culture as a group level phenomena linked by the ‘sharedness’. Each function (e.g. marketing,
R&D, production) has its own particular culture.

The reasons for these differences are related to the nature of the task and what is considered to be the best way to achieve success (Schneider and Barsoux, 1997). Lawrence and Lorsch (1967) identify specific differences in the way of thinking and working of three functional units: sales and marketing, production, and research, which are rooted in cognitive and emotional orientations as follows:

1) orientation towards the goals of their particular units,
2) time orientation: short term versus long term of sales and research,
3) interpersonal orientation: task versus people orientations of production and sales,
4) formality of structure: formal-hierarchical versus flat-less precise control of production and research.

The effect of functional cultures on the CE implementation process is apparent. Schein (1993) argues that, although it is often overlooked, understanding differences in functional cultures is important when cross-functional teams are created to develop new products, design new policies or explore new market. The domination of one function over others may affect the structural hierarchy and mechanism within the cross-functional team. In such teams, particular attention should be paid to the design and production functions that normally become the main players in CE product development process. In this respect, Thomas’s (1994) and Kunda (1992) accounts from their case studies provide useful information about these two main functions of high-tech companies.

Design function is typically a dominant function (Thomas, 1994; Kunda, 1992). As the heart of product development process, this function is considered worthy to become the focus of attention in insemination engineered culture (Kunda, 1992). The
Chapter 3: Context and Politics of Change and Conceptual Framework

Hegemony and substantial power of this function come from its unique skill to confront complexities in designing parts and integrating them into a coherent system (Thomas, 1994). Thomas (1994) further argues that this hegemony itself is the product of core assumptions about the nature of product and the organisation necessary to produce it.

On the other hand, production functions and engineers in production area are accorded to a lower status and less critical than the design function (Thomas, 1994). In contrast with the organic organisation of design function, production function tends to be mechanical in nature with traditional functional units, standardisations, documentation, and bureaucratic organisation (Burns and Stalker, 1961). Its activities continue to be perceived as secondary, e.g. responding order, executing design, and devoting energies to diminish variation rather than creating it). Consequently, it is granted less control over resources, and considered substitutable (Thomas, 1994). This inequality may trigger political actions to assert a worldview and interpretation either to reinforce or to alter the existing structure and power relation which discusses further in the next section.

In summary, functional cultures are represented by differences in language and assumptions about reality and mental model (Schein, 1993). These differences are rooted in four orientation differentials (e.g. goals orientation, time orientation, interpersonal orientation, and structural formality) between various functions within the organisation (Lawrence and Lorsch, 1967). Therefore, these four orientation differentials and the degree of domination of a particular function are used in this study to assess the existence of various functional cultures in the organisation and their effect to the introduction of CE.
3.2.2 External Context

3.2.2.1 Industry Context

Industry context refers to both structural and processual aspects that are specific to the industry and distinguishes one industry from others. A solid description of industry context is important as part of extending the organisational context to provide better understanding of the change process (Thomas, 1994).

In their analysis on organisational environment, Lawrence and Lorsch (1967) use three dimensions to describe industry environment: the degree of risk, the speed of feedback, and the degree of domination of a particular function. The degree of risk indicates the degree of certainty in various aspects (e.g. market and technology) in a particular industry. The speed of feedback indicates the time needed to obtain feedback about a decision taken. Based on these dimensions, they suggest that industries differ along the continuum from the most stable to the highly dynamic. The aircraft industry, for example, was classified as a dynamic industry because it deals with high uncertainty (i.e. high degree of risk) in its technological aspect and needs a long time before the technology is confirmed (i.e. low speed of feedback).

Porter's (1985) competitive advantage model of industry structure provides further useful insight on underlying factors that define the structural characteristics of a particular industry. He suggests five structural forces that determine the level of competition within an industry: rivalry, threat of substitute products and new entrants, and bargaining power of suppliers and buyers. He further argues that the strength of each factor is a function of the underlying economic and technical characteristics of an industry.

Chatman and Jehn (1994) also suggest that technology is one of the most salient
similarity among firms in the same industry. They suggest that technology differences create most organisational variance since technology constrains the variation in how things are done by defining what is being done. Within contingency theory framework, Thompson (1967) argues that the technical core of an organisation determine the degree of complexity (diversity), uncertainty (unpredictability), and interdependence. Greater technical complexity results in increased structural differentiation; greater technical uncertainty results in less formalisation and centralisation of structure; and greater technical interdependence requires greater co-ordination.

In assessing industry culture which reflects processual aspects specific to an industry, Schneider and Barsoux (1997) identify five reasons for differences across industry: (1) the nature of decision-making, (2) the nature of products or services, (3) the rate of technology change, (4) the degree of state intervention, and (5) market characteristics. There is a relationship between the structural and processual aspects of an industry. Schneider and Barsoux (1997) argue that nature of decision-making is determined by the degree of risk involved and the amount of time required to know the consequence of a decision, and suggesting the use of cultural quadrant developed by Deal and Kennedy (1982). This quadrant uses the Lawrence and Lorsch’s (1967) speed of feedback and degree of risk dimensions. The nature of product/services, the rate of technological change, and the degree of state intervention are closely related to the technological core of the industry, while the market characteristic relates to the market and economic core of the industry.

In summary, factors associated with industry characteristics developed by Lawrence and Lorsch (1967) and Schneider and Barsoux (1997) are interrelated and closely
related to the underlying factors of an industry, namely the technology and economic characteristics. These overlapping dimensions provide a guide in describing the industry context relevant to this study, namely the global aircraft industry.

The effect of this industry context on CE is obvious. CE approach was originated, developed and then diffused within and across industries to balance the inherent technical complexity and uncertainty with the need for integration in order to achieve better products with faster and cheaper development process (e.g. Winner et al., 1988). However, CE is of greater relevance to some industries than to the others. Aircraft and other high-tech and complex manufacturing industries seem to be the ones that benefit most from CE in their product development, as reflected by their domination in the IDA report (Winner et al., 1988). As noted in the previous discussions, the underlying aspects of an industry (i.e. technology and market) also influence the process indirectly through their effect in organisational structure and culture. For example, the more complex industry leads to high differentiation and specialisation, and therefore needs more sophisticated integration mechanism.

3.2.2.2 National Context

As with the industry context, the description of national context is important as part of extending the organisational context to provide better understanding of the change process (Thomas, 1994). National context consists of two interrelated aspects: societal institutions and societal culture. Societal institutions are represented by a set of systems of governance (i.e. law, economics and political system) applied in a politically bounded society (i.e. nation state), which lead to the contemporary political and economical circumstances of a particular nation. This, in turn, affects the
organisation that operates within an nation state, its mission, and its governance system and practices.

Schneider and Barsoux (1997), for example, argue that government regulations influence the degree to which technologies are developed and protected and signal which industries are more valued and perceived as crucial to national security or economic sovereignty. The effect of national context in the introduction of CE, either directly or indirectly, is mainly rooted in this issue. In a developing country, state-owned companies typically have not only economical objectives (i.e. profit making) but also political objectives of the government. A state-owned company is often seen as a vehicle for technology transformation of the country to become part of industrialised world. These objectives often cause the company to become vulnerable of government’s intervention. The economic and political systems of governance influence the degree of this intervention.

Culture is originally an anthropological term used to describe different behavioural patterns between geographically divided societies (Kluckhohn, 1962). Societal culture is represented by layers of cultural artefact; values, norms, and believes; and underlying assumptions held by the members of a society (Hofstede, 1984, Schein 1985, Trompenaar, 1994). Some researchers argue that social institution is part of the artefact, the observable part of culture (Wilkinson, 1996; Ralston et al., 1995). There is reciprocal relationship which reflects the interrelated layers of culture: culture shapes social institution, and in turn, social institution and their reproductions shape culture (Schneider and Barsoux, 1997).

Societal culture has been related to many organisational issues including: organisational structure, leadership style, interaction and group dynamics,
organisational system and processes, human resource management, organisational culture, and international business (e.g. Hall, 1960; Hofstede, 1984; 1991; Lane and DiStefano, 1988; Trompenaars, 1994; Adler, 1991; Jackson, 1993; Mead, 1994; Schneider and Barsoux, 1997). This wide range of issues can be summarised into two main aspects of organisation and management practices: the institutional (e.g. structures, policies, systems and procedures), and processual and behavioural (e.g. leadership and interaction).

A widely cited and tested framework in analysing societal culture is Hofstede’s (1984) study (e.g. Lane and DiStefano, 1988; Adler, 1991; Jackson, 1993; Pheysey, 1993). Defining culture as “the collective programming of the mind which distinguishes the members of one group category of people from another” (Hofstede, 1991, p.5), Hofstede constructs four dimensions of culture (Hofstede, 1984):

1) Power distance: the level of the less powerful members of a society expect and accept that power is distributed unequally.

2) Individualism/Collectivism: the level of individual ties in a social relationship.

3) Masculinity/Femininity: the level of distinction of gender role in social relationship.

4) Uncertainty Avoidance, the level of the society feels threatened by uncertain situations.

While widely cited, Hofstede’s study is also the subject of criticism. The main objection is the use of quantitative approach in assessing culture. Critics consider that culture must be assessed using a more qualitative approach (see for example Schein, 1984; Pettigrew, 1973). Mead (1994) lists five criticism over Hofstede’s framework: assuming homogeneity within national territory, conceptual and methodological
problems, the research is in itself culture-bound, some findings are out of date, and concentrate on single industry and single multinational.

There are only a few studies that link the product innovation with societal culture. Among these, Jurgen (1997) contributes an empirical study on variation in product development restructuring from four countries: Japan, US, Italy and Germany. In assessing the effect of culture in organisation, Hofstede (1991) further suggests that power distance and uncertainty avoidance dimensions are related to the institutional aspect, while individualism and masculinity dimensions are related to the processual and behavioural aspect. Likewise, societal culture is likely to affect CE introductory process, either directly or indirectly in both structural and behavioural aspects. Power distance and uncertainty avoidance dimensions are likely to influence organisational integration, e.g. how the cross-functional team is structured and managed, while the individualism and masculinity dimensions are likely to influence team’s interaction.

In summary, national context can be described into two aspects, the national system of governance and the societal culture within the nation. The system of governance leads to the contemporary situation that influences the organisational context, particularly for the state-owned company in a developing country. The societal culture affects the process, either directly or indirectly, in both structural and behavioural aspects. The use of Hofstede’s framework (1984) is common in such analysis. However, aware of criticisms of this framework as pointed out by Mead (1994), this study not only relies on Hofstede’s framework but also on anthropology and other social science literature which provide richer descriptions of the culture and with more appropriate qualitative methodology (e.g. Geertz, 1960; Hill, 1994).
3.2.3 Conceptual Framework Refinement Based on Contextual Variables

Based on the above discussion, the conceptual framework is refined to incorporate the operationalisation of contextual variables. This framework is illustrated in Figure 3-2.

![Conceptual Framework](image)

Figure 3-2: Conceptual Framework Refined Based on the Context of Change

3.3 Organisational Power and Politics

As mentioned previously, introducing CE involves a process of change. In such a process, organisational politics is influential and may become a dominant contributor of the result attained (Thomas, 1994). Commitments from various functions and
individuals cannot be taken for granted, particularly due to competing interests across functions and levels within an organisation (Guth and Mc Millan, 1989; Wilkinson, 1983; Porter, Crampon and Smith, 1976). However, Thomas (1994) notes that researchers tend to treat the role of politics and political action lightly in the process of innovation. The reasons include: innovation is considered as in accord with a broader organisational objectives; consensus is assumed as essential while conflict is considered dysfunctional and indication of ineffectiveness; and politics and conflict are sensitive issue involve questioning rationality of management action.

Using his power-process perspective in studying technological change process, Thomas (1994) argues that politics is far more central to the process than has been recognised. Innovation and change in technology and organisation may be as much products of internal political action as they are products of exogenous forces, conscious design of top leaders, or efforts of units formally sanctioned to it. In this respect, Thomas (1994) views politics not only influential in the process of implementing change but also in the decisions over the choice of what need to be changed prior to the implementation process. Such a choice involves three screens: technical, economic, and political or interest. Apart from its technological and economical advantages, this choice also represents a vehicle to express and enact worldviews for individuals or groups of individuals (e.g. functional units) that may embody both self-interest and genuine collective interests. Desire for status, recognition, and balanced inequities, can trigger functional groups to enact their views (Thomas, 1994).

From this perspective, it can be argued that the process of introducing CE is immensely influenced by political maneuvering of key individuals and groups
involved in the process, particularly considering the unbalanced domination of one functional group (i.e. design engineering) over others (i.e. production and production engineering). In fact, Thomas (1994) notes that approaches, such as CE or simultaneous engineering, are beneficial in balancing the power between functional groups, but their prescriptions miss the opportunity for changing the perceived relationship between those functions.

In broader management literature, many authors acknowledge the importance of politics in organisation (e.g. Buchanan and Badham, 1999; Pettigrew and McNulty, 1995; Buhler, 1994; Mintzberg, 1991). Buhler (1994), for example, views organisational politics as one mechanism that enables managers to get things done through people. He argues that politics is unavoidable, but the degree to which politics is used, discussed and even encouraged varies across organisations. In his study of decision-making, Pettigrew (1973) views an organisation as an open political system in which its sub-units are interdependent and have different interests, which is likely lead to conflict. He views political behaviour as behaviour of individuals and sub-units in making a claim against the resource sharing system of the organisation.

Many other studies relate political behaviour to organisational decision-making (Drory, 1993; Kozlowski and Doherty, 1989; Allen and Porter, 1983; Garguilo, 1993). However, Egan (1993) argues that the politics of the workplace often takes place out of sight. This shadowy side consists of all those things that substantially and consistently affect the productivity and quality of the working life but which are not found on organisational charts, in company manuals, or in formal meetings. In this respect, Thomas notices that "political actions might be a vital though not necessarily a comfortable part..." (1994, p. 230)
Much research takes a negative view of organisational politics (Ferris and Kacmar, 1992). Matteson and Ivancevich (1990) identify politics as a potential source of stress. Drory (1993) suggests that organisational politics have a potentially damaging effect (i.e. negative attitudes) on lower status employees. Gilmore, Ferris, Dulebohn and Harrell-Cook (1996) view political behaviour as self-serving behaviour that is not sanctioned by the organisation and potentially has negative consequences including conflict and disharmony at both individual and organisational levels. Individuals and/or groups are pitted against each other, or against the organisation itself. This, in turn, results in negative outcomes such as poor job performance, negative attitudes, and employee withdrawal from the hostile and political environment.

Scholars have recently focused on neutral and even positive perspectives of organisational politics (Gilmore et al, 1996). According to Mintzberg (1991), organisations function on the basis of systems of influence: authority, ideology, expertise and politics. The first three are considered as legitimate in some sense, while politics is necessary to correct deficiencies in legitimate systems of influence and to provide some sense of flexibility discouraged by other systems. Buchanan and Badham (1999) view power and political behaviour as significant to the effectiveness of the organisation and the individual, but can also be individually self-serving and organisationally damaging. According to Buchanan and Badham (1999, p. 11), “political behaviour is the practical domain of power in action, worked out through the use of techniques of influence and other (more or less extreme) tactics”. Power can be seen in three perspectives: a property of individuals, a property of relationships, or a property of social and organisational structures and procedures.

In line with Buchanan and Badham’s three perspectives, Pettigrew and McNulty
(1995) have used a "tripartite analysis" of power and influence as the framework for studying the power of the board of directors in several UK companies. This framework views 'power sources' and the individual's 'skill and will' in using such sources are located within broad features of 'context and structure' that have both constraining and enabling characteristics. This framework can be seen in Figure 3-3.

![Figure 3-3: Tripartite Analysis of Power and Influence](Based on Pettigrew and McNulty (1995))

This framework is used to conceptualise the organisational politics in this study particularly because it reflects a dynamic quality of power and politics. As Pettigrew and McNulty (1995) argue, skilful mobilisation of power sources may change the rules of the political game and provides a new context for subsequent influence attempts. The crisis, the history of effective or ineffective users of power, and the violation of trust or codes of conduct may destabilise and change the power relationship. This framework, for example, is useful in explaining why managers often perceive political activity as an influence attempt outside the traditional use of authority (i.e. traditionally defined limits of legitimate power) and attribute political activities to those in positions of high legitimate power (Madison, Allen, Porter, Renwick, and Mayes, 1980). It also useful to explain why managers tend to be more
tolerant toward organisational politics and consider it as less immoral compared with non-supervisory employees (Drory and Romm, 1988).

3.3.1 Power Sources

In line with the view of power and power source as a property of individuals or groups of individuals, Lukes (1974) suggests three ways of viewing power. Firstly, the one-dimensional, traditional, pluralistic view that suggests power is distributed pluralistically (e.g. Dahl, 1957). This view involves a focus on behaviour in the making of decisions on issues over which there is an observable conflict of interests, as expressed in policy preferences, revealed by political participation. Secondly, the two-dimensional view that suggests the pluralistic view was inadequate (e.g. Bachrach and Baratz, 1962) because some issues are intentionally brought into the organisational agenda politics while others are deliberately discarded from the agenda. This view involves an examination both decision-making and non-decision-making. Non-decision-making is a means by which demands for change are killed before gaining access to the decision-making arena.

Third, the three-dimensional view that criticises the first two views as too individualistic (e.g. Lukes, 1974). Lukes (1974) argues that there are ways to keep potential issues out of politics, whether through social forces, institutional practices or individual’s decisions. They occur in the absence of actual, observable conflict, which may have been successfully averted although the issue remains an implicit reference to potential conflict. The three-dimensional view incorporates this latent conflict, which consists in a contradiction between the interests of those exercising power and the real interests of those they exclude.
In line with this three-dimensional view, Thomas (1994) argues that such power relation relates to the domination of one worldview over the others. Therefore, such decisions as introducing a technological change or process innovation may be influenced by both effort to alter structure and effort to reinforce or reproduce existing relation (Thomas, 1994). In this sense, Thomas (1994) criticises the strategic choice perspective (Child, 1972; Buchanan and Boddy, 1983) that only limited their analysis of technological change process to the behaviour of the leaders. Both those exercising power and those they exclude may use one or more of Mintzberg’s (1991) systems of influence (i.e. authority, ideology, expertise, and politics) to enact their interpretation.

3.3.2 **Skill and Will**

Pettigrew and McNulty (1995) argue that power is a relational phenomenon. It is generated, maintained and lost in the context of relationship with others. The will and skill relates to this relational aspect of power. The relational aspect of power, defined as influence, explore personal and group’s ‘will and skill’ in creating and using the power sources potentially available. Power involves the ability to produce intended effect in line with one’s perceived interests (Pettigrew and McNulty, 1995). Power and influence inherently have highly situational character (Knoke, 1990; Pettigrew and McNulty, 1995). Most influences are limited to certain domains and occasions and may not transferable to other setting (Pettigrew and McNulty, 1995). Therefore, power and influence are dynamic and potentially unstable (Knoke, 1990).

Pettigrew and McNulty (1995) also argue that individuals differ in ability, skill and willingness to mobilise and use the features of context and the variety of power source available or created. The perception that political activities occur outside
traditional use of authority (Madison et al., 1980) reflects the importance of the skill and will in the organisational politics. Further, skilful political activities may be required to overcome a lack of power sources or a less valued set of power sources available (Pettigrew and McNulty, 1995). Thomas' (1994) case studies show that resource constraint, lack of influence, and status inequality may increase the will of a group of individuals to take political actions in order to initiate or support changes that conform with its view of the way things should work and, hence, to shape the context by their perceptions and interests.

Within this perspective, many researchers argue that organisational politics closely relates to uncertainty. Tushman (1977) found organisational politics becomes more intensive within uncertain circumstances. Hickson, Hinnings, Lee, Schneck and Pennings (1971) stress that the real basis of power is the ability to cope with the uncertainty and not the presence of the uncertainty alone. Political activity intensifies prior to decisions concerning resource distribution (Frost and Hayes 1979), and when the interdependence among units and individuals on important resources is relatively high (Pfeffer, 1981). Madison et al. (1980) suggests three conditions that relate to high level of perceived political activity: uncertainty, the importance of the situation, and the salience of issue. This makes organisational politics crucially important in the product development process. Pettigrew (1993), for example, argues that political behaviour is likely to be especially pronounced in an uncertain task environment surrounding an innovative decision.

Implementation of new approaches such as CE implies a significant change in the way product development is undertaken and managed, and consequently increases uncertainty in the already uncertain nature of development process. The effect of
organisational power and politics in such circumstances is likely to be highly significant as indicated by Pettigrew (1973). In addition, the inequality between two functional groups closely involves in the process (i.e. design and production groups) that commonly exists in high-tech companies (Kunda, 1992; Thomas, 1994) is likely to enhance political manoeuvring and its effect to the process. In his case studies, Thomas (1994) notices that political manoeuvring involves various tactics, such as being quiet and discreet, being vague on discussion with other groups, going outside for technical help, and forming internal coalition. However, these issues have been largely ignored and have not been adequately dealt with in CE literature and even within the broader product innovation literature.

3.3.3 Structure and Context

Power is not just about interpersonal dynamics; it has a macro or structural aspect and a micro or relational aspect. The structural analysis of power deals with the possession and control of power sources, such as position, rewards, and sanction and information. Giddens (1979) argues that structure and context are not just barriers to action but are essentially involved in its production. Following Giddens’ structuration theory, Brass and Burkhardt (1993) argue that structural and behavioural treatments of power should be regarded as simultaneous and complementary: “The structure provides the contexts within which actors operate to acquire and exercise power. Structure arises from the action of people, and these actions are shaped by structure” (p.443). Features of structure and context enable rather than simply determine the actions (Pettigrew and McNulty, 1995). Madison et al. (1980), for example, note the attribution of political activities to those in managerial position and that such
activities may result in even higher positions of authority. Thomas (1994) notes that features in structure and context often influenced the range of technological change or process innovation considered. The hegemony of design engineering function in the complex aircraft manufacturing company illustrates how structure and context play important role in determining and enabling organisational politics.

Pettigrew and McNulty (1995) further suggest that power should also be understood in its historical context. The outcomes of earlier events may change individual’s power sources and alter key features of context such as rules, roles, and individual interpretations of the world around them. The outcome of historical exchanges feeds the current dynamic and shapes the emerging context for power and influence. In this respect, Thomas (1994) criticises previous research on technological change that narrowed the temporal context to the final moments of change and often ignored the process dynamics altogether. He argues that the analysis must include a full range of activities including the identification of problems, the selection among alternative technology and its configuration, and the implementation of chosen technology. Thomas further argues that the process occurs within social and historical contexts embedded with interests and ideologies influenced by the structure, professional/occupational values, and social status. All of these become apparent when focusing on the dynamics of the process in its extended historical and organisational context.

3.3.4 The Final Conceptual Framework

Based on the above discussion, this study takes Thomas’s (1994) power-process perspective that organisational politics play a central role in the technological change
or process innovation. To review organisational politics on such process, this study takes Buchanan and Badham's (1999) neutral perspective that political behaviour represents both an ugly and deplorable face as well as a positive and beneficial one. Political behaviour is the practical domain of power in action, worked out through the use of techniques of influence and other tactics of power play. Following Pettigrew and McNulty (1995), this study conceptualises power using the tripartite analysis framework involves power sources, skill and will, and structure and context to acknowledge the relational and structural aspects of power.

Following Lukes (1974), this study conceptualises power to encompass all overt and covert, decision and non-decision, and micro and macro aspects. Therefore, organisational politics is operationalised through the actions taken by several key persons and their associated groups in the process. These actions (and in some cases, non-actions) are an illustration of political behaviour of organisational members that reflect micro and macro aspects as well as decision and non-decision aspects of organisational power and politics. By focusing on the key individuals and their groups and investigating their power sources and relational background, the assessment of their actions also infers the skill and will as well as the structural aspect of power relations.

Incorporating organisational power and politics into the previous framework, the final conceptual framework of this research is developed through the addition of two dimensions of organisational politics: power source and skill and will, as can be seen in Figure 3-4. The third dimension is already embedded in the dimensions of internal context that have been developed in the previous discussion on organisational context. These dimensions are used in assessing the element of change process represented by
the actions (or in-actions) of key groups and individuals, which have affecting the process across the contextual barriers.

Figure 3-4: The Final Conceptual Framework

3.4 Conclusion

Guided by the processual approach, this research views the implementation of CE in the case study as a change process. During the process, the concept of CE is
continuously being shaped to fit with the contextual environment. The context of change is captured as a set of cultural spheres that capture both the soft and hard aspects of the environment. The internal context is represented by the organisational context including the organisational stage of development, organisational structure, organisational culture, and functional culture. The external environment is represented by industry and national contexts. The politics of change is operationalised through the actions taken by several key persons or groups in the process. These actions (and in some cases, non-actions) reflect micro and macro aspects as well as decision and non-decision aspects of organisational power and politics.
4.1 Introduction

This chapter describes research methodology employed in this study as well as the reasons and appropriateness in employing such a methodology. This description includes the research design and strategy, data collection methods, data analysis, and report writing. The description also outlines the advantages and disadvantages of the methodology and efforts taken to deal with their limitation to ensure the reliability and validity of the research and its findings.

This chapter is arranged as follows. Section 4.2 discusses research design and strategy adopted for this study. Section 4.3 describes research methods employed, including field research, data collection, data analysis, and report writing. Section 4.4 discusses validity, reliability, and generalisability issues. Section 4.5 provides a summary.

4.2 Research Strategy

Following the argument that theory and method are necessarily interdependent and that it is most appropriate to explore an organisation as an ongoing system with a past, present and future (Pettigrew, 1973), the research strategy here is to be a single
longitudinal case study. This longitudinal design is adopted because the study attempts to understand a real process of CE introduction with all its attendant messiness. Such a processual analysis cannot rely on time-series snapshots (Pettigrew, 1990). The processual research studies a certain phenomenon over time within its context (Johnson, 1987). It observes how the process unfolds and how it is shaped by various factors, actions and politics within the context (Van de Ven and Huber, 1990).

The objective of this study is to explore how the CE approach is shaped within a particular context. The study involves a case study (Yin, 1989; 1993) of introducing the CE approach to the organisation and management of a product development program. The case study is an exploratory one and focuses on what the company intended to do and what actually happened. The present case study is an intrinsic and instrumental single case study according to Stake’s (1994) case study classification.

The case study aims to provide a better understanding of a particular phenomenon (i.e. the introduction of CE approach) as well as insights on more general issues. The decision to use a case study approach also provides the opportunity for longitudinal research design that suits the processual analysis intended in the study while the processual aspect of the study enables the researcher to further investigate why particular actions or decisions were taken.

The research framework conceptualised in the previous chapter is similar to Pettigrew’s approach in his study of politics in decision-making (1973) in emphasising the effect of the past events on the present and focusing on the influence of the organisational context and politics and how they continuously influenced and shaped organisational practices over time. This framework also enables to observe aspects of the broader context of the change process that might provide a more
complex picture of the process and a better understanding of the relationship of the technical and social systems. This present study resembles the processual approach of Pettigrew and Whipp (1993) and Dawson (1994). However, it attempts to achieve a more detailed account, i.e. the 'thick description' (Geertz 1973), than those studies by using more in-depth ethnographic research methods. This effort brings the study to more closely resemble Thomas’s (1994) case studies.

The research strategy adopted in this study has both advantages and disadvantages. The main advantage is its ability to provide the opportunity to investigate the process of an organisational change in its real context and in 'real-time', and to discover issues which had previously remained hidden and hence, broaden the understanding of the object being studied (Dawson, 1997). Such a research framework enables the researcher to present something unique about the case (Stake, 1994). This uniqueness includes the nature of the case, its historical background, its physical and societal settings, and its other contexts, such as the economic and political situations.

The disadvantages and limitations include:

1) It is messy. It may prohibit the researcher from seeing the ‘big picture’ of the change process as the researcher struggles to obtain and later is drown under the huge amount of detail and rich data. For this reason, the processual approach remains contentious among social science researchers.

2) Since the political issues are not immediately evident in public, the researcher must seek out and then carefully weight the competing worldviews and rationalities that exist in the process (Thomas, 1994).

3) A single case study as a study of the particular, raises issues of generalisability (Stake, 1994).
However, this research does not focus on 'working the data' to strengthen the generalisability of the findings (Strauss & Corbin, 1990), but rather to provide a narrative accounts of complex organisational dynamics that develop continuously (Dawson, 1994).

The researcher believes that given the above advantages and limitations this research design provides a valuable contribution to the CE literature on the detailed and problematic nature of introducing CE. Like Stake (1994), the researcher also believes that readers with an intrinsic interest in the case learn more about it from its description, and particularly from what Geertz (1973) calls 'thick description'.

4.3 Research Methods

The single longitudinal case study design and the intention to provide a 'thick description' of the change process has led to the use of a qualitative research methodology. This type of study is designed to observe how a process unfolds over time and how various contextual factors, actions and politics influence such a process (Van de Ven and Huber, 1990, Thomas, 1994). Such a research design typically requires (although it is not restricted to) qualitative research.

Qualitative research refers to multi-method research involving an interpretive, naturalistic approach to its subject matter (Silverman, 1993, Denzin and Lincoln, 1994). This means researchers study things in their natural setting, attempting to make sense of, and interpreting the meaning of their phenomena (Denzin and Lincoln, 1994). Similarly, Silverman (1993) argues that qualitative research traditions share a commitment to the assumption that systematic social inquiry should be conducted in a
natural setting rather than an artificially constrained one such as experiment.

Considering the above arguments, the researcher adopted qualitative research as the most appropriate methodology for the study. This approach has been widely employed in other studies with a similar conceptual framework (e.g. Pettigrew, 1973, Pettigrew and Whipp, 1993, and Dawson, 1994). Another significant reason to use qualitative research methodology in this study is that the research involves assessment of the soft aspect of cultural spheres, e.g. national, organisational, and functional cultures. The researcher agrees with the argument that culture must be assessed using a more qualitative approach (Schein, 1984; Pettigrew, 1973).

The process of qualitative research usually begins with a framework that specifies a set of questions that are then examined in a specific way and result in empirical material to be analysed and written about (Denzin and Lincoln, 1994). In doing so, Janesick (1994) argues that at various stages in the process, the researchers are situating and recontextualising the research within the shared experience of the researchers and the research participants. Typically, qualitative researchers start with tentative questions of what they want to know, then select appropriate methods considering the social setting of the subject to be studied and with an intention of living in that setting over time.

This technique bears a 'double-faced ghost' (Denzin and Lincoln, 1994). Firstly, it is assumed that competent researchers can report their observations of the social world with considerable objectivity, clarity and precision. Secondly, it relies on the subject (e.g. interview respondents) to report their experiences as true accounts. The main cause of these problems is that there is no objective observation. Observation is always socially situated in the world of researchers and respondents and has filters
such as language, social class, and ethnicity (Denzin and Lincoln, 1994).

Qualitative research is not restricted to a single method. Many methods including interviews, participant observation, and visual methods can be categorised as part of this methodology (Silverman, 1993; Denzin and Lincoln, 1994). The aim is to make the case study more understandable and to secure as rich and in-depth data as possible, although objective reality might never be captured (Denzin and Lincoln, 1994). The most common methods include interview, participant observation, documentary analysis, or a combination of them (Pettigrew, 1990).

Following the argument that the best way to understand a process is to become part of it (Pettigrew, 1973), participant observation was chosen as the principle method of investigation. Fieldwork data collection and data analysis tasks were, following Yin (1993), undertaken interactively toward the final definition of the study questions. This means the analysis of the earlier data was used to refine the research questions that would be used in the later stages of the fieldwork.

4.3.1 Selection of the Case Study

This case study was selected because of the accessibility of the site and its involvement with the introduction of CE. Its familiarity, the result of the researcher's working experience in the company since 1983, was the trigger for the decision to undertake the research. Silverman (1993) considers most case studies are selected based on the accessibility. Detailed studies of CE implementation especially outside Western countries and Japan are extremely rare, while such diffusion has raised many issues about the concept and difficulties in achieving substantial organisational
change. Direct access to such a research site, therefore, provided a unique opportunity to explore those issues.

The selected case study was defined as a recent attempt (i.e. 1995 – 1999) to introduce CE into a new product development program in a state-owned aircraft manufacturing company in Indonesia. It involved a series of inter-related change initiatives aimed at making the development program run like those at a Western aircraft manufacturing company. Initially, the case covered two parallel development programs that were carried out by the company. One was the new platform 100-passenger jet aircraft (pseudonym PLI) and the other was a derivative of the 35-passenger commuter airplane (Pseudonym DRI). During the study, the derivative DRI Program was terminated. Hence, the final report of this case study only covers the PLI Program although data were drawn from both programs.

4.3.2 Data Collection

Considering the research strategy, research questions, the context and researcher's capacity to obtain the data in such a setting (Denzin and Lincoln, 1994), this study employed a combination of various data collection methods including participant observation, in-depth interviews, and the review of documents. Participant observation was the main method and, in turn, required the researcher to spend a significant amount of time at the field study site. Through participant observation the researcher observed the development of current situation by being present and in close contact with the program teams and by attending various program-related meetings. Through a combination of interviews and a review of secondary data sources, significant events in the past were identified to gain a historical perspective
of the case study. Given the scale of the development program and the intention of the research, it was necessary to focus on a particular area of the development process in order to gain a sufficient depth of data. The field study, therefore, focused on one element of the overall development process (i.e. the design of the body component).

4.3.2.1 Field Research

The main body of fieldwork was carried out in two stages. The first was from October 1997 to April 1998, and the second, from October 1998 to March 1999. In addition, there were also four informal field-site visits during July 1998. Correspondence with participants and other employees of the company via E-mail enabled the researcher to monitor the development of the program and the company while not at the field-site.

During the first field study, the researcher observed both the PLI and the DRI programs that were currently undertaken by the company. The PLI and DRI programs were in two different stages of their development process. The DRI was in the detail design phase and the PLI was in the preliminary design phase. Observing both programs enabled the researcher to gain a more comprehensive picture of the overall development process. At the time of the second field study, however, only one, the PLI, survived Indonesia’s economic crises and could be studied. The summary of field research conducted for this study can be seen in Table 4-1.

During the field study, the researcher spent an average of 4 days a week, 4 to 8 hours a day, at the field site. Because the researcher was also an employee of the company, the researcher was based at the company’s management centre building. However, in order to obtain rich and in-depth data, the researcher always attempted to spend as
much time as possible near the engineers involved in the programs. In the first field study, the researcher spent most of the time at the PLI Program's various locations as well as in the headquarter of the DRI to observe, talk and discuss with engineers and managers involved in the programs. During the second field study, the researcher was located in the collocation area, at the Operation Centre quarter of the PLI Program.

Table 4-1: Field Study Summary

<table>
<thead>
<tr>
<th></th>
<th>First Field Study</th>
<th>Informal Visitation</th>
<th>Second Field Study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Studied</strong></td>
<td>DRI, PLI</td>
<td>DRI, PLI</td>
<td>PLI</td>
</tr>
<tr>
<td><strong>Data Collection</strong></td>
<td>Participant Observation Interview &amp; Conversation Documentary Review</td>
<td>Interview Conversation</td>
<td>Participant observation Interview &amp; Conversation Documentary Review</td>
</tr>
</tbody>
</table>

As a long serving employee, the researcher was also able to draw on her first hand experience of the company's history and culture. This provided advantages as follow:

1) It minimised the accessibility issues to the selected field study site.

2) It facilitated access to information particularly at the operational level, the level addressed in this study. Since the beginning of the field study the researcher had a general idea about where the information lay and who was to be approached to acquire that information.

3) It eliminated the usual familiarisation phase to the research site that normally takes a significant amount of field study time (e.g. Pettigrew, 1973).

4) It ensured full co-operation of the respondents. The researcher never experienced rejection for interviews or discussions because the respondents or respondent's superiors were her acquaintances. The respondents often relaxed considering they
were talking with an ‘insider’ and in most cases, someone they knew.

5) It helped in the interpretation of the collected data. Pettigrew (1973) argues that a researcher is in a stronger position to interpret historical material if his/her data collection and analysis are undertaken after he has acquired a thorough knowledge of the present day culture of the society he/she is studying.

6) It enabled the researcher to speak, read, and write in the same language with most respondents (i.e. Bahasa Indonesia) and understand its nuisance subtleties.

On the other hand, such a position also raised problems, such as possible bias and ethical issues. It is important, however, to recognise that the researcher does not claim that she is unbiased. Having worked for the company for almost 15 years, the researcher’s opinions would always contain biases based on her personal experience throughout those years. These biases could not be eliminated. The researcher, for example, shared the opinion of most members of non-design functions that the value of the additional reward system was unfairly favourable to the members of design-related functions. Given the understanding of these biases, the researcher took an extra care with the data collection not to pass judgement on information gathered based on her personal knowledge. Steps taken to minimise the personal bias involved vigorous verification through cross checking and triangulation. For example, when the researcher suspected an information was untrue, such information was not immediately regarded as untrue, but the researcher rather waited until it revealed itself through findings gathered from other respondents or through other methods.

The ethical dilemma faced by the researcher was derived from two facets: the company’s commercial confidentiality and the interviewers’ personal confidentiality. The issue of commercial confidentiality was associated with the problems of
accessing and reporting on commercially sensitive data. The researcher prior and
during the study had known of confidential materials considered relevant to the study.
The Program Manager only imposed a loose confidentiality guidance, which the study
should not jeopardise the intellectual property of the PLI Program, and relied on the
researcher’s own judgement in deciding which issues should be considered as
confidential. While this guidance provided immense opportunity and generated
flexibility in data gathering, it also created a burden in the sense that the researcher
continuously applied self-censorship and had to deal with the ever present doubt
whether or not the writing went too far and, hence, violated the Program Manager’s
trust. The solutions to address these concerns included disguising the company name
and designating the thesis as a non-public domain.

Another source of ethical dilemma concerned personal confidentiality. Some
respondents had long been in close working relationship with the researcher. In some
cases, the relationship could be traced back as far as university undergraduate days.
While such relationships provided advantages in terms of accessibility and frankness,
it could also affect the researcher’s judgement in establishing the character of key
persons involved in the case study and therefore contributing to the researcher’s
personal bias described above. The concern involved the issue as to how far the
person could be characterised without revealing private knowledge based on personal
relationship. On this issue, the researcher took precautions not to include the
researcher’s personal view. After each characterisation (see especially in Chapter 8), a
careful review was taken to ensure that it was based on the research findings and
respondents’ opinions.

The frankness, particularly in data gathered from casual conversation, also created a
moral dilemma in that the researcher continuously self-questioned how far the personal relationship contributed to this frankness and hence how far it could be used as part of the research writing. This anxiety reduced immensely for the data gathered in the interview because of the respondents' knowledge on the nature of the conversation. The researcher handled this issue by using such data as background information and only used them in direct quote after personal permission from the respondents involved.

On the other hand, a respondent's frankness, particularly over sensitive issues, might jeopardise his/her career and position in the company as well as relationships with other people involved. To deal with this issue, the researcher decided to disguise the name of all respondents. Company-wise, however, it would be obvious who some of respondents were because their particular positions were revealed in the case study. This issue was solved by restricting the thesis to the non-public domain.

4.3.2.2 Participant Observation

The aim of observation in qualitative research is to gather information about a process in a naturally occurring context (Silverman, 1993). This method enables a direct observation of processes, facilitates interview opportunity with key players, and allows first hand experience on the organisational context. Pettigrew (1973) argues that the method is not atheoretical and participant observation was considered as most appropriate in qualitative longitudinal research. Following this argument, this study used the participant observation as the main data collection method, which involved sharing the respondents' lives in an attempt to understand their world (Denzin, 1970). The rationale in this research decision was the Olesen and Whittaker (1968) argument
that the best way to understand a process is to become part of it and observe how the practices, processes, and interactions among involved people are really carried out rather than formally espoused.

Beside its relation to the theoretical conception, the participant observation method gives several other advantages as the result of a close relationship with the respondents. It enables to correctly evaluate impute motives, avoid pointless and abrasive questioning, and get best-informed respondents (Dalton, 1964). It also allows the researcher to build rapport before asking disturbing questions and to gain access to sensitive material. Its flexibility enables the researcher to ‘wait and see’ what the critical research questions are (Pettigrew, 1973). However, this method also has some disadvantages. Silverman’s (1993) list of its disadvantages include:

1) it may blind the researcher of important events occurred before his entrance;
2) respondents may be entirely unrepresentative of the less open participants;
3) researchers may change the situation just by their presence;
4) researchers may ‘go native’ forgetting the principles underlying the study.

The researcher acted as a participant observer in two development programs in the first field study. In the derivative DRI Program, the researcher established a full participant role as part of the program management team and was involved in the daily operation of the team. The main tasks of the researcher in the team were to ensure the integration and compatibility between the ‘engineering release date’ from the design engineering and the ‘number-one flow’ schedule from the production and to improve the effectiveness of the interaction between the design and production functions. In fulfilling these tasks, the researcher was involved in various schedule reviews. The data collected from the DRI Program included minutes of various
meetings, excerpts of conversation in selected meetings, and the researcher's personal observations that were recorded in the field journal. This participant observation provided an understanding of the nature of the relationship among various functions within design and production areas and between design and production functions. Due to the national economic crisis, the DRI Program was later terminated.

Throughout both field studies, the researcher also participated in the PLI Program as a non-official member of the computer support group of the Program. The researcher's task was to improve the effectiveness of the approach taken by this group in dealing with both the program's design team (i.e. Design Centre) and its production engineering team (i.e. Operation Centre). However, the interaction between the researcher and the members of the Program was not limited to this participation, rather the researcher moved quite freely across various groups within and outside the Program. The researcher was involved in various discussions and meetings at the middle and operational levels within the Operation Centre and the Design Centre. The researcher also attended several program reviews that involved the Program Manager. The relevant information from those meetings was later documented in the field study journal. When available, the minutes of those meetings were kept. A list of formal meetings and discussion attended can be seen in Appendix-A.

The time spent with the engineers in both the Design Centre and the Operation Centre also allowed the researcher to observe how they interacted with each other and to see how their superiors and others, such as technical advisers, interacted with them. It also revealed how they dealt with technical and non-technical problems. All observational information was kept in the field study journal.
4.3.2.3 Interviews

From the perspective of a symbolic interactionist, interviews are social events and, consequently, the social context of the interview is intrinsic to understanding any data obtained (Silverman, 1993). It is argued that open-ended questions are the most effective way to gain authentic understanding of people, but its flexibility frequently results in a lack of comparability of one interview with another and raises problems of reliability in data collection (Silverman, 1993). Furthermore, Denzin (1970) notes that interviewees’ responses are influenced by several issues, such as the different interactional roles and relative status between interviewers and interviewees; the context of the interview; the self presentation of interviewees, especially in early stage; the short-term relationships that cause little commitment and tale fabrication; and the difficulty of penetrating private experience.

In this study, open-ended questions were used for the interview. The possible distortions were minimised by researcher’s familiarity to the site and some of interviewees. The main objectives of the interview were:

1) to understand how different actors contributed to and interpreted the change process,

2) to gain their interpretations of CE, and

3) to gain an understanding of past events within the company and their context.

During the field study, the researcher carried out formal interviews with 36 managers and employees. 25 out of 36 interviewees worked in the PLI Program and comprised 25% of the total full-time members of the program. Other interviewees were not part of the program although some were closely involved with the development process of the program. The characteristic of interviewees can be seen in Table 4-2.
Table 4-2: Characteristics of Respondents

<table>
<thead>
<tr>
<th>Program Member</th>
<th>Number of Interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Program Manager</td>
<td>1</td>
</tr>
<tr>
<td>Middle Manager</td>
<td>10</td>
</tr>
<tr>
<td>Other</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non Program Member</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Management Member</td>
<td>4</td>
</tr>
<tr>
<td>Middle Manager</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
</tr>
</tbody>
</table>

| Total Respondent     | 36                     |

Most interview sessions were conducted privately in the interviewees’ office. Typically, each interview took around 1 hour, but some expanded up to 2 hours. Some interviewees, particularly the key persons within the Program or the company management were interviewed several times in order to follow up the progress of the program or the development of the company overall situation. Some interviews were carried out as group interview. The researcher also carried out a series of discussion sessions with a focus group of 5 to 7 engineers. The sessions involved 7 one-hour-meetings in 3 weeks of the first field study and were held in a meeting room at lunchtime. In addition, the researcher was also engaged in many informal discussions and casual conversations related to the study with a wide range of people in the company. The interview methods used in this research are summarised in Table 4-3.

Most interviewees were selected due to their involvement in the PLI Program. Only 4 interviewees were chosen for their involvement of the DRI Program, which was later eliminated by the company. However, the interview data from the DRI Program was
kept due to its high relevance with the case and used as part of the case study data. The approach to the interviewees varied with the extent of their familiarity with the researcher as well as their position in the organisation. The interview with the PLI Program Manager that was carried out very early in the beginning of the study, i.e. June 1996, enabled the researcher to identify the key persons in the Program as well as gaining permission to interview them. Discussions with these key persons, who were middle managers of the Program, opened up the opportunity to be introduced to and subsequently, discuss with and interview the supervisory and operational-level staff involved in the Program.

Table 4-3: Interview Methods

<table>
<thead>
<tr>
<th>Interview Method</th>
<th>Number of Interviewee</th>
<th>Number of Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Private Interview</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Multiple Private Interview</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Single Group Interview</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Multiple Group Discussion</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Casual Conversation</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>75</strong></td>
<td><strong>83</strong></td>
</tr>
</tbody>
</table>

Interviewees from outside the PLI Program were selected based on their close relation with the Program as observed through meetings or revealed from the interviews and casual conversation. They were personally approached and asked to be part of the study as interviewees. Beside the Program Manager, three other senior managers were also interviewed. They were chosen because of their accessibility and their roles in the early period of the program or previous programs.

Typically, the researcher prepared a set of open-ended questions based on the operationalisation of the research framework prior to the interview sessions. These
questions varied according to the position of the respondents in the Program or in the company. However, these open-ended questions were used in a flexible way. The researcher added or eliminated questions during the interview sessions according to the situation and interviewee’s response. The open-ended questions were used only as guidance. Except for the discussion sessions and the interviews involving expatriates, Bahasa Indonesia (the first language of both the interviewee and the researcher) was used. In the interviews with expatriates, English (the second language of all) was used. In the discussion sessions, English was used based on the preference of the interviewees although it was the second language for them and the researcher.

At the beginning of all interview sessions, the researcher explained the nature of the research and that the research had no relation with the company management. She also ensured them that the confidentiality would be protected. She requested their frankness, and their permission to use a tape recorder to record the conversation. Except for 9 interview sessions, the researcher was granted permission to use the tape recorder. The conversations were taped and transcribed. For non-taped sessions, the researcher took notes and then rewrote them after each interview session.

Informal discussions and casual conversations were held with a wide-range of people from various functional organisations. The discussion sessions held in the first field study significantly helped in bringing those respondents and some of their colleagues closer to the researcher and obtaining their trust. At a later stage of the field study, they often engaged in casual conversations with the researcher and gave their frank opinions on various issues related to the Program and the company. The participant observation method employed in the field study provided the opportunity to engage in many such conversations. Some casual conversations involved people who were not
part of the Program. Some of them indirectly related to the Program and some others had no involvement in the Program at all. These people provided the other side of the story and balanced the information gathered by the researcher. The casual conversations were not taped but the relevant issues were recorded in the field study journal immediately after each occasion.

To reduce biases and errors in data collected from the interviews and casual conversations, the following precautions were taken:

1) data were collected from primary sources only (i.e. direct witnesses); second-hand accounts (hearsay) were not drawn in;
2) data were checked against documentary material;
3) interviewees' statements were internally checked for contradictions, and externally checked against the information obtained from other sources.

4.3.2.4 Secondary Data Sources: Documentary Review

Documents are used both to check verbal statements and to find out whether positional bias occurred in the other methods of data collection (Pettigrew, 1973). The documentary review in this study can be divided into two categories based on the nature of the document being reviewed. The first category was the ad-hoc documentary review. This category involved a documentary review conducted in-line with other data collection methods to provide hard evidence from accounts gathered from other methods. It included various documents shown during or after discussions, interviews or conversations that were used to emphasise or clarify issues raised on such occasions. It also included a documentary review on documents searched by the researcher for similar purposes, such as organisational structures, company policy, the
company's short and long term planning, and the company's systems and procedures.

The researcher's long term service in the company provided knowledge on where to search for such documents. Some of these documents were classified as confidential or could be considered as confidential. Due to the loose restrictions applied to the researcher on the issue of confidentiality, the researcher used her own judgement which documents should be considered as confidential and should not be used for the research purpose as discussed in the previous section.

The second category was the pre-selected documentary review. This category involved the files and documents that were deliberately chosen by the researcher to be reviewed in order to gain comprehensive understanding of the process. After accustomed with several key persons in the Program, their work, and their interaction patterns, the researcher decided to review the inward and outward files of both the Chief Engineer (Head of the Program's Design Centre) and the Chief of Operation (Head of the Program's Operation Centre). These files contained various types of documents such as memos, reports and draft reports, proposals and draft proposals, and minutes of various meetings.

Administratively, these files covered most of the development-related correspondence because of the Chiefs' central positions as the administrative gatekeepers of the Centres. Formally, all outward correspondence on behalf of the centres came from and were signed by those Chiefs. When a supervisor needed materials, for example, he/she would draft a memo to be signed by the Chief and sent to the Procurement Department. When a supervisor composed and signed a letter, he would ensure that his/her Chief received the copy. Likewise for inward correspondence, most letters that requested attention from anybody within the centres were usually directed to the
Chiefs who then allocated the tasks to supervisors or other members. When the correspondence was directed directly to persons within the Centres, the Chiefs also usually received a copy. Further, these files contained some relevant correspondence from the higher management level, as the Program Manager usually distributed copies of relevant materials from his own correspondence to the Chiefs. This tactic to pre-select the ‘gatekeeper files’ was proven to be very beneficial in understanding the whole complex process as could be seen in Pettigrew study (1973).

However, since both Design Centre and Operation Centre were only established in 1997, these files did not capture much of the early stages of the program. There was not enough data to establish the overall evidence before the establishment of the Centres. To fill in this gap, the inward and outward files of one supervisor in the Operation Centre, who had been involved in the Program since 1995 was reviewed. Likewise, some old files from a manager who had been involved in the engineering aspects since 1995 were also reviewed.

To capture a high level information on the program, the relevant folder from one of senior managers involved in pursuing support for the Program from outside the company was also reviewed. This folder contained memos, reports, and proposals that ranged from the early initiation of the program in 1993. Putting them together, all these files provided information that covered the beginning of the program in 1993 to the end of the field research in early 1999. They also contained information across the organisational hierarchy, from the top management level to the operational level. All information gathered from this method were summarised and kept in separate files.

List of documents reviewed during the field study is provided in Appendix-B.
4.3.3 Data Analysis

Data collection is followed by data analysis and evaluation in an iterative process. With a massive amount of field data, this stage is a difficult task. The strength of a qualitative research in refocusing as new data become available in the subsequent iteration can easily be spoiled due to disorganised field data (Silverman, 1993). The interpretation of data and its relevancy to the case study can be obtained through data categorisation after considerable familiarisation with the process and linking these data categories to one another (Silverman, 1993). These classifying and recombining data, coined as decoupling process, enable researchers to develop, redefine, create, and present new authentic accounts (Dawson, 1997). Hammersley and Atkinson (1983) suggest using broad descriptive categories, e.g. types of people, activities, topics, periods, etc, in which one item may be assigned to more than one category.

As the result of rigorous data collection methods and the intention to collect ‘rich data’ from the field, this study dealt with a large and diverse body of data from both primary (i.e. participant observation and interview) and secondary (documentary review) sources. Interpreting this huge amount of field data involved categorising data in two different ways to fulfil both longitudinal and contextual elements of the processual study. Firstly, data were categorised and arranged in a time-line that spans from the initiation of the Program to its termination in order to review the order of past and present events and their relation to internal and external contexts. Data collected from the documentary review formed the backbone of this process, with refinements from data collected through interview and participant observation. By establishing three levels of time-line, i.e. top management, middle management, and operational levels, those events could be presented in a way that enabled the
researcher to relate them to their respective context for further analysis. These Event Time-Lines can be seen in Appendix-C.

Secondly, field data were codified into accounts and categorised into several theoretically driven categories. These categories were developed based on the conceptual framework and its operationalisation developed in Chapter 2 and Chapter 3. After being codified, each account was designated into a tree-diagram filing system. Data from interviews provided the backbone of this coding. By combining both analyses in time-line and theoretically driven categories, the researcher was able to interpret data in both longitudinal and contextual accounts that, in turn, became the body of research report.

The analysis stage commenced in the middle of the first field study. Therefore, the researcher had the opportunity to construct an early version of the study report and then brought it back to the multiple interview sessions and continually refined the construct based on the later interviews. This iterative process of field research and data analysis stages was maintained for the whole period of the field study. By doing so, the researcher was not only able to refine the construct as new data become available (Silverman, 1993) but also to ensure its validity through respondent validation as suggested by Denzin (1970). This respondent validation involves the researcher asking respondents' feedback from a tentative result and refining it in line with their response (Reason and Rowan, 1981).

Another important activity during the data analysis stage was triangulation to ensure validity of accounts. Triangulation is a process of using several accounts from different sources to clarify meaning and verify an observation or interpretation (Stake, 1994). The process involved comparing data from different data collection methods to
see whether they corroborated with one another and presented a complete picture (Denzin, 1970). Denzin (1970) has suggested this technique as a solution to minimise three possible flaws in field research: negligence toward important past events, unrepresentative informants, and the change of situation due to researcher present.

In this study, each interview transcript was internally checked for consistency. Then, the interview transcripts were cross-checked against one another. The transcripts were also triangulated with data from the documentary review method and with data from participant observation. Likewise, data collected from the documentary review and participant observation were treated in the same manner. Several unclear issues found in the interview transcripts, documents or observations were brought back to some of key interviewees as part of open-ended questions in subsequent interview sessions or as part of casual conversation with some respondents. Another validation technique offered by Denzin (1970) is respondent validation discussed above.

4.3.4 Report Writing

This stage involved bringing a large amount of information across a language barrier. Most data collected were in Bahasa Indonesia, the national language of the country of the field study, while the report was written in English. The researcher, an Indonesian, relied on her own bilingual ability to translate all material for the final report.

Specific for direct quotations, an Indonesian colleague from the company with a degree in English was asked to translate them. For each quote, the researcher’s translation was compared with his translation. The differences were worked out to achieve a final translation. The option of using an in-house translator was taken after
considering that the in-house colleagues would have a better understanding of the company’s overall process as well as over the terms, jargons, and other specific ‘language’ used in the company. This decision, however, had a communication disadvantage as the researcher and the translator could not have face to face discussions. Most of the discussions over the translation were carried out through e-mail correspondence. To ensure confidentiality, the quotations were sent to the translator without any real name attached to them and the translator was asked not to reveal any quotation material.

4.4 Validity, Reliability and Generalisability

The most important issue in a social science research is how it can be both intellectually challenging and rigorous (Silverman, 1993). Validity, reliability and generalisability are central concepts here although there is considerable controversy about how they might be applied to the social sciences. Arguments on validity, reliability and generalisability are often used as a criticism against qualitative research methodology. For this study, the steps taken during field research preparation, data collection, data analysis and report writing stages had ensured the validity and reliability of the research result as well as its generalisability to the theoretical propositions as suggested by Yin (1993).

Validity refers to the extent to which an account accurately represents the social phenomena to which it refers (Hammersley, 1992). In qualitative research, the opinions about validity claims vary. Some argue it is unnecessary, while others argue it should be addressed. Agar (1980) argues that systematic hypotheses is inappropriate and rejects this traditional scientific control in favour of an intensive personal
involvement seeking to fit the current situation and ability to learn from mistakes as the way to ensure validity. Hammersley (1990, 1992) argues that validity can be claimed with confidence in the knowledge. He, therefore, suggests three steps on judging the validity of claims: first, plausibility of claim given our existing knowledge; second, credibility of claim given research phenomena and the characteristic of researcher; and third, when in doubt convince the plausibility and credibility of evidence (1990, p.61). Silverman (1993) relies only the plausibility and credibility of evidence arguing Hammersley's first two steps are problematic.

Standard criteria of validity involves assessing the impact of the researcher in the setting (i.e. halo effect, the values of the researcher and the genuineness of the respondent's account) and two forms of validation most widely used: triangulation and respondent validation (Denzin, 1970, Silverman, 1993). Both triangulation and respondent validation were employed in this study. However, there are some criticisms over triangulation and respondent validation techniques. Triangulation is criticised as ignoring the context from which each account was gathered (Silverman, 1993). Respondent validation has weaknesses as the respondent may not be interested (Bloor, 1978) and overt validation may only be given if the result is compatible with their self-image (Abrams, 1984). Therefore, this study also follows Silverman (1993) suggestion to rely on plausibility and credibility of evidence, and presents some tables with simple data collection statistics to provide a sense of flavour of the data.

The impact of the researcher’s presence was considered as minimal. The researcher was officially an employee of the company and, therefore, was often considered by respondents as an inclusive part of them (i.e. regarded as one of them). The researcher’s constant presence around them helped relaxing some interviewees who
were new to the researcher. Although the researcher does not claim that the study is bias free, the effect of possible bias due to values and perspectives held by the researcher was minimised. Careful steps were taken to ensure that the study only considered issues raised by interviewees and not researcher's own account. The genuineness of interviewees' accounts was validated by both triangulation and respondent validation.

The reliability refers to the degree of consistency with which data were collected by different observers or by the same observer on different occasions (Hammersley, 1992). This issue derived from reliability of scientific measuring instrument and replicability of scientific experiment. Kirk and Miller (1986) suggest three kinds of reliability: consistency within a single method, consistency over time, consistency over various methods at the same period. Reliability is addressed by using standardised methods to write field note and prepare transcript (Silverman, 1993) and providing information on how field data were acquired as well as the detail of its relevant context (Bryman, 1988, Kirk and Miller, 1986).

To ensure the reliability of this study, field notes and transcriptions were taken using the accepted techniques, such as tape recording, transcribing, summarising, and field journals. The field research and data collection processes previously describe have adequately ensured the reliability of this study. However, it is important to note that not every researcher who comes to this same field and researches the same issues would come to the same conclusions. The difference would be the researcher's knowledge that has been accumulated during 15 years experience with the company.

Dawson (1994) has argued that processual research such as this study deliberately confines itself to one or a small number of organisations. It does not focus on working
the data to strengthen the generalisability of the findings, but rather to provide understanding of the complex dynamic of the organisation. This argument can be seen as a severe weakness as some researchers doubt the generalisability of the data. The issue becomes more severe in a single case study approach.

The researcher, following Bryman (1988, 1990) and Yin (1989), argues that generalisability of cases should be to the theoretical propositions rather than to the population or universe. The aim is not to ensure statistical generalisation but to expand and generalise a theory (analytic generalisation) or inductive reasoning (Yin, 1989). The case study derives its validity not from the representativeness of its samples but from the thoroughness of its analysis (Bryman, 1990). This study, therefore, aims for detailed understanding of a single case (selected with no sampling logic and without the intention of generalising to a population) to provide detailed empirical accounts and generate several propositions based on those accounts.

4.5 Summary

Considering the research objectives and conceptual framework developed in the previous chapters, this study designed as a single longitudinal case study. This research design and the intention to obtain a 'thick description' led to the adoption of a qualitative research using a combination of participant observation, interviews, and documentary review as data collection methods during the extended time spent in the research site. During data analysis and report writing, several actions have been taken to ensure the validity and reliability of research findings and interpretations, which include triangulation and respondent validation.
5.1 Introduction

The case study of introducing CE took place in Indaco, an Indonesian company operated in the aircraft industry. This chapter provides an overview of the organisation and its industrial and national contexts. The aim is to provide a general understanding on the contexts of the change process, the opportunities, challenges and impediments surrounded the process that contributed to the shape of CE introduction process as it took form in the case study. This description of the organisational context provides the background of the attempt to introduce CE as well as the basis for contextual explanation discussed in detail in Chapter 7. This chapter is intended to provide a general understanding on the overall process and its background prior to the detailed description and complex explanation of the process in the next chapters.

In general, the organisation of Indaco reflected the influence of both industrial and national contexts. Indaco organisation could be characterised as ‘centralistic-bureaucratic’ with a strong technology orientation. The need for differentiation of the aircraft industry led to high compartmentalisation of various specialisations into functional units. The industry was also responsible for the high formalisation and
standardisation of various organisational processes. These, in turn, fabricated a high level bureaucratisation. On the other hand, the establishment of Indaco as an inseparable part of national pursuit on technological and industrial development created a strong technology orientation with little concerns for the market, while the Indonesian’s cultural tendency of high power distance (Hofstede, 1984) contributed to the severely centralised organisational structure and mechanism.

As the overview involves extended industrial context from which CE was adopted as well as the national context in which the economic crisis led to the termination of CE introductory process, this chapter also provides the ‘bird eye’ view of CE introduction, from its beginning to its end. In particular, this overview discusses the contribution of the industrial context in the decision to introduce a selected CE configuration as well as in shaping the Indaco organisation in general. This overview also discusses the role of national context in the existence of Indaco in general and in the effect of the economic crisis in the termination of Indaco’s CE. Overall, the effects of these extended contexts were more remote but nevertheless crucial and vital to the existence of CE in Indaco. As the outer layer of contextual factors, the contribution of these contexts might be more remote and indirect than the contribution of the other contextual factors.

In order to fulfil the above objectives, this chapter is arranged as follows. Section 5.2 describes Indaco, the Indonesian state-owned aircraft manufacturing company in which the case study took place. This description is the basis of contextual explanation (discussed in Chapter 7) of the detailed change process (discussed in the next Chapter 6). Section 5.3 describes the global aircraft industry and its relation to the CE introduction in Indaco. In focuses on the typical aircraft development process.
and the common relationship among aircraft companies that led to CE adoption by Indaco. Section 5.4 describes the Indonesia national context and its relation to Indaco organisation as a vehicle for national development as well as the contemporary Indonesian economic and political crises that led to CE termination. Section 5.5 provides a summary and brief discussion on interrelationship between organisational, industrial and national context.

5.2 Overview of Indaco: The Organisational Context

5.2.1 Organisational Mission

Indaco was established in 1976. As a state-owned company, it has a mission to act as a vehicle for Indonesian industrial transformation by becoming a centre of excellence in the aircraft and aerospace industries. This mission was carried out through four consecutive and overlapping phases of technology acquisition¹:

1) **Familiarisation of the aircraft technology phase.** This phase started in 1976 and was undertaken via various licenses and subcontract programs to expose the company to process and manufacturing technology in the industry.

2) **Integration of the existing technology phase.** This phase started in 1978 and took the form of a joint development program with another company to gain access to technologies available in the industry and integrate them in the product. The joint development of a 35-passenger commuter airplane, the PLC, was part of this phase. In this program, Indaco was responsible for the design and manufacturing the fuselage of the aircraft.

¹ Item (36) Appendix-B
3) **Integration of new technology phase.** This phase was carried out through the application of acquired technology for local design. The development of the PLP, a new platform 50-passenger aircraft, started in 1989, was a major part of this phase.

4) **Implementation of R&D for future technology phase.** The applied R&D activities were undertaken in 1990 and their results were implemented in the PLI, a new product platform for a 100-passenger jet airplane.

In 1976, Indaco employed 500 staff with 17 engineers and 2 small hangars of 11,000 square metres. These facilities were inherited from a small research department of the Indonesian Air Force. Subsequently, the Government provided US$ 170 million for production facilities and allocated on average of US$ 100 million per annum working capital for several years (Todd and Simpson, 1986). The Government also secured the company’s domestic market with a decree in 1980 that forbade all domestic airlines to import products that could be provided by Indaco. By 1997, Indaco employed 15,000 people including more than 3000 engineers. Its production facilities included various conventional and computerised machine tools, autoclaves and other heat and surface treatment facilities, and assembly lines for various airplanes and helicopters. All facilities were centralised in its 75-hectare site. The total assets of Indaco were valued at US $ 1 billion at the end of 1996.

5.2.2 **Products and Product Development Programs**

During the time of case study, Indaco involved in various business activities commercialising their product lines as well as developing new aircraft platform or
derivative products. During the case study, there were five main category aircraft programs:

1) Under licence programs from various aircraft and helicopter manufacturers that produced and sold 15-passenger turboprop airplane, as well as light, medium and heavy helicopters.

2) PLC, the joint development of 35-passenger airplane and its derivatives. This aircraft had been in the product line since 1985 with various derivatives to suit its customers.

3) PLP, the development program of the first indigenous 50-passenger airplane, which was undergoing certification program during the time of the case study.

4) PLI, the development program of the 100-passenger jet airplane, which was the subject of the case study, and

5) Subcontract programs from various global primes, including Westaco from which CE was adopted.

Other than the above aircraft development and production programs, the company was also engaged in aircraft services particularly for Indaco's products, defence system, and satellite businesses to fulfil the need of Indonesian Government.

5.2.3 Organisational Structure

The complexity of the aircraft industry (Lawrence and Lorsch, 1967) was reflected in Indaco's complex organisational structure. Before June 1997, Indaco used a functional structure where activities were centralised in functional units. Matrix mechanisms (Davis and Lawrence, 1977) had been adopted since 1984 to bridge and co-ordinate functional supports to each program. A program was defined as any product line in the form of either a serial line, a new platform, or a product derivative.
undertaken by the company. A program manager was responsible for managing a particular program and co-ordinating resources from various functions to support the program.

Prior to the PLI development program, program managers were perceived as having a lower status than a head of functional units, mainly because they did not have resources directly allocated to them. The role of those program managers was 'lightweight' (Wheelwright and Clark, 1993): monitoring the progress and negotiating support from various functions. They were often sandwiched between conflicting interests of various functional units. Over time, however, the program management moved toward the 'project team' (Pawar, 1986) in which a program manager had more discretion in allocating resources and greater influence over team members. Nevertheless, except for their significant roles on functional budget allocation that required their approval for outflows budgeted to support the Programs, the influence of program managers over design and manufacturing processes remained limited.

In 1989, functional units were organised into eight main divisions: Technology, Production, Fabrication, Purchasing, Commerce, Finance, Program Co-ordination, and General Affairs as can be seen in Figure 5-1. Production Division was divided further into Fixed Wing, Rotary Wing, Defence Systems, Industrial Engineering, Production Engineering, and Manufacturing Development divisions. Technology was divided into Aircraft Technology, Aircraft Design, Aircraft Engineering, Aircraft Interior, Satellite, Electronic Measurement, and Flight Test divisions. The Chief Executive Officer, Chief Operating Officer, and heads of main divisions formed the Executive Management Council.
In order to improve the company’s performance, in June 1997 Indaco was restructured into a more product-based organisation, shown in Figure 5-2 (Bold box indicated member of Executive Management Council).

Figure 5-1: Indaco’s Organisational Structure Prior to 1997

Figure 5-2: Indaco’s Organisational Structure After 1997
5.3 Aircraft Industry and Its Relation to Indaco and CE Adoption

5.3.1 Overview of the Global Aircraft Industry

According to Todd and Simpson (1986), the global aircraft industry can be divided into three tiers. Firstly, the tier-1 companies or the primes which are the airframe producers, i.e. companies that design and assemble the whole aircraft or aero-engine and install the power plants and other components and systems manufactured elsewhere to the airframe and wing. Secondly, the tier-2 companies, which are airframe component manufacturers that make the required components for the primes. Thirdly, the tier-3 companies, which are companies deal with aircraft maintenance, repair and overhaul services.

Lawrence and Lorsch (1967) regard the aircraft industry as industry that operates in a complex, diverse and dynamic environment. Working in such an environment, the global aircraft industry has developed the following characteristics:

1) Technology intensive. The aircraft industry is characterised by invention, innovation and development of new and complex materials and products. Research and development play a fundamental role (BIE, 1993) and make the industry very sensitive to technical changes. Todd and Simpson (1986) argue that the relationship between customer demand and technical progress in aircraft industry is interactive; innovation probably owes as much to customer stimulus as customer enthusiasm responds to technical performance. Its evolution is contributed by 'a combination of technology-push and demand-pull' innovations.

2) Long development time. Developing an aircraft involves a very complicated process from concept definition, preliminary design and analysis, detail design to
testing and certifying the product before it is ready for the customer. Typically, the development time for a new aircraft platform takes seven to nine years.

3) **Capital intensive.** The aircraft industry normally requires state-of-the-art manufacturing facilities and modern design tools and with high development cost. The gap between initiating a new design and full-scale production due to long development time must also be covered by sufficient working capital.

4) **Labour intensive.** The industry requires a large quantity of highly skilled labour. The industry is regarded as a high value-added sector, in which high level of productivity is expected (BIE, 1993). Since educating such skilled labour takes a long time, there is a preference toward employment stability and a desire to retain skilled labour despite fluctuations of business (Todd & Simpson 1986; BIE, 1993). Only recently this preference is lessening due to more business pressure.

5) **A relatively small number but demanding customers.** The aircraft market can be divided into civil and military market. The market of military aircraft is determined by the size of national defence budgets (Todd and Simpson, 1986), while the civil market is basically determined by the growth of air traffic. The military demand for new features often results in significant innovation, which typically supported by the government. In the U.S., this takes form in research and initiatives within National Aeronautics and Space Administration (NASA) and the Institute of Defense Analyses (IDA). International marketing strategy in both civil and military markets usually involves customer financing, offset programs (i.e. some portions of the contract packages are carried out in the customers' countries), and counter trade. This marketing package puts an additional burden on the financial aspect of the industry.
6) **Demanding regulatory environment.** Each military customer normally has its own safety standards. In global civil market, there are two most respected authorities to which most countries referring to: the US Federal Aviation Administration (FAA) and the European Joint Aviation Authority (JAA). Manufacturer has to comply with any standard required by its customer. These standards have tended to increase not only in regard of the safety of the product but also the safety of the product to the environment.

7) **Close relationship with suppliers.** This industry requires materials and components made to specific standards. The suppliers are normally short-listed to a list of approved suppliers in which the manufactures periodically audit their compliance to specific standards of production process. Aluminium and forging material, for example, are supplied by two or three specialists for the whole industry. Bought-out components like engines, landing gears, avionics, electronics and hydraulics systems require close contact with the suppliers from the early stages of development.

8) **Extensive government involvement.** The basis of government involvement in nurturing a domestic aircraft industry comes from a perception that this industry is a national asset. It is important in major industrial economies and has a strategic importance for national sovereignty due to of its military function. It also has the ability to generate multiplier effects and sizeable balance of payment gain (Todd and Simpson, 1986). Government involvement takes various forms such as providing direct investment; facilitating R&D; being a customer; creating government financing scheme; and providing protection through tariff, regulation and other barriers (Todd & Simpson, 1986). This involvement has put the industry
in the position of 'permanent receivership' (Lowi, 1975), as companies in the aircraft industry are the recipients of state attention in order to guarantee their continued stability and success.

With these characteristics, the aircraft industry is often regarded as a 'high-tech' industry dominated by engineering and technological orientations. The industry evolves around the uncertainty in all aspects of its environment (i.e. market, science and socio-technical) and continuous venture to new frontiers of technology. In its core is technological imperatives with a belief that the product will sell itself at its own price (Schneider and Barsoux, 1997). However, the combination of immense uncertainty, long feedback time, and heavy investment makes the aircraft industry become more conservative than other high-tech industries, particularly ones with speedier feedback (e.g. computer and electronics industries) that are typically risk-taker (Deal and Kennedy, 1982). The decision-making process is typically conservative and involves careful assessment of all risks. This leads to heavy reliance on standard manuals, standard operating procedures, detail implementation plan, protocols, and prudent technical documentation.

These characteristics of the aircraft industry result in various common practices. Internally, their managers have to deal with the inherent paradoxical issues of differentiation and integration (Lawrence and Lorsch, 1967). According to Thomas (1994), aircraft companies are companies in contrasts, risk-taking and risk-aversing at once: flexible and organic in design and development functions while rigid and mechanical in production functions. Eventually, this industry becomes one of the incubators of management concepts that try to find solution in dealing with specialisation and integration, such as matrix organisation and concurrent engineering
This is reflected in Indaco through highly compartmentalised structure in combination with matrix mechanism between program and functional organisation, highly formalised procedures, and strong technology orientation and the domination of design and technology functions as described in the previous section and elaborated in detail in Chapter 7.

Externally, the companies' managers have to deal with various demanding stakeholders such as customers, suppliers, government, and regulation bodies. With heavy investments at stake, companies in this industry typically maintain a close inter-organisational relationship within the industry and with their constituents. Launch customers (i.e. customers who are the first in a product's booking order) are important part in the 'go-ahead' decision of a development program and, typically, enjoy many financial and technical benefits. Some key suppliers become risk and cost-sharing partners (Fan, 1995). Subcontracting and manufacturing under-license are common production practices. Many companies are involved in joint design development, technological research and human resource development. These inter organisational practices and its contribution to Indaco's decision to adopt CE is discussed further in Section 5.3.3.

5.3.2 New Product Development in Aircraft Industry and the Need for CE

Aircraft development is a risky initiative that involves various disciplines to find a small optimum 'envelope of solutions'. The stakes are high due to high investment cost, long development time, high standard regulation, and increased competition, particularly in the low-end and smaller products. Due to its high technological
complexity, the aircraft development process typically involves considerations over a wide-range of aspects in its design decisions, such as technological, operational, financial, commercial and environmental, as illustrated in Figure 5-3.

![Diagram of Aircraft Development Process](image)

Figure 5-3: Aspects of Aircraft Development Process (Source: Internal Course, 1998)

The overall aircraft development process can be illustrated in a sequential diagram as in Figure 5-4.

Given the nature of highly differentiated specialisation, an aircraft development program normally struggles to integrate and harmonise various and often conflicting specialisation perspectives in order to achieve a commercially and technologically viable design. Often, a specialist seeks optimisation only in terms of his own 'object-world' (Bucciarelli, 1994). This situation of competing interests of specialisation in the aircraft development process can be illustrated as Figure 5-5.
Figure 5-4: Aircraft Development Process (Adapted from Internal Course, 1998)
aircraft industry had directly played a significant role in bringing the CE approach to Indaco which triggered the Indaco's management decision to apply it in the PLI Program, and influenced the introduction process of CE in Indaco:

1) Licensing, subcontracting and co-development relationship. These business relationships were common within the industry. Beside their business prospect, new entrants often saw these relationships as a means of technology transfer.

2) Technical and managerial consultation relationship. The large primes (i.e. companies that design and assembly the aircraft) often had a management service division that offered technical and managerial consulting services for smaller manufacturers world-wide, particularly in the area of design and production process. Many new and smaller manufacturers acquired this service as part of their effort to comply with the standards set by the large primes, which in turn would create opportunity to become subcontractors. Compliance with these standards was also seen as a means of achieving compliance with the standards of the internationally respected regulatory bodies.

3) Internship program. The less developed and smaller manufacturers engaged in internship program with larger primes in which they temporarily released their engineers to work with the primes for 1-2 years. During this period, those engineers were typically treated as primes' employees. Sometimes, the internship program was tied to an international purchase contract, as part of an offset agreement. But, often it was a voluntary co-operation between the two companies in which the larger primes fulfilled their short-term shortage of engineers while the smaller manufacturers gained the opportunity to upgrade the skills and knowledge of their own engineers.
Since its establishment, Indaco has had business relationships with other companies in the global aircraft industry through licensing, subcontracting and joint development programs. Westaco was one of the companies with whom Indaco engaged with in the above three types of relationship. Indaco had been a Westaco subcontractor since the late 1980's and this subcontract program had forced Indaco to standardise its production system prior to signing a contract agreement. As part of the strategy to win this contract, Indaco had engaged in various agreements with Westaco since 1984, in which Westaco agreed to provide some managerial and technological supports and consulting services.

As part of these services, Westaco sent its people as technical assistants, up to 20 people at a time, in Indaco to help establishing adequate working systems and practices in various areas. Some of these technical assistants even spent more than five years in the company. Several worked as functional specialists in the design process. Some assisted functional units (e.g. Production, Quality Assurance, Engineering, etc.) to improve Indaco's design and production systems in order to comply with internationally recognised regulatory standards, (e.g. FAA and JAA), so that the company could market its products world-wide. These systems included configuration management and control, quality systems, product specification systems, and computational and information systems. Some others worked in the program divisions (i.e. PLC, PLP, and PLI programs) to establish program management systems and assisted in running the programs.

Indaco had started the internship program in 1990 by sending Indaco's 4-5 engineers annually to work for 1-2 years in Westaco. This internship covered various areas, such as aircraft design, production, customer support, and system administration.
These engineers brought back the experience of implementing the 'Westaco Way' as it was documented in various Westaco procedure manuals. The most prominent ex-intern was the PLI Program Manager. Several other ex-interns also directly or indirectly supported the PLI Program.

These contracts for support and consulting services between Indaco and Westaco were terminated later due to the Indaco's financial crisis. However, as the result of these various engagements with Westaco, some understanding towards those systems and various Westaco's protocols, standard manuals, and operating procedures started to accumulate in Indaco. Many Westaco's manuals and protocols were adopted as part of Indaco's standard manuals and system procedures. Various CE protocols from Westaco's development programs were available in Indaco through a similar pattern. These protocols were, partially, used as references in establishing the mechanism applied to Indaco's development programs.

The previous PLP development program, for example, adopted the Design Production Team which actually was a part of CE initiatives in one of Westaco's development programs (see Chapter 6), albeit with some fundamental deviations. In Westaco, this initiative is involving production-related engineers in the early stage of the development process in order to incorporate production considerations early in the design process. In the PLP Program, however, the Design Production Team was established late in the detail design phase. Therefore, its purpose reduced only to filter the design drawings prior to the engineering release in order to reduce the number of engineering changes and to discuss producibility and manufacturability of those design drawings. It was too late to talk about the optimum process or ease of production. One of the engineers from production recalled:
The pursuit to obtain optimal solution for such competing interests and objectives with immense risk at stake and long feedback time that triggered various initiatives in the aircraft companies to find a better concept and approach in their product development program. It is unsurprising that some aircraft companies is among the first that came up with and implement the concurrent engineering approach (albeit often with different names) as indicated in Winner et al. (1988).

5.3.3 Inter-Firm Relationship within the Aircraft Industry and CE Adoption

As mentioned in Section 5.3.1, the characteristics of aircraft industry lead to close interrelationship among companies that constitute the industry. In turn, this inter organisational relationship permits the spread of various management and technological concepts and approaches such as matrix management and concurrent engineering through out the industry. In particular, three common practices within
[In the PLP Program,] we were involved at the detail design [phase]. The design had been completed. So, we only assessed whether this part [design] could be fabricated. If we suggested a new idea, it would take a long time and many steps [back to the design process]. ... It was only 'could we do it' question. If we could, [the design] was released. If not, we sent it back to the designer. ... Since the design loop had been completed even a small change would go back to the design cycle, analysis and verification, which took months (Kevin, Tooling Engineering, January 1999).

Not surprisingly the Design Production team was eventually abandoned. Another issue that surfaced from this experiment was concerning the competency of personnel in both Design and Production Divisions, which led to many disappointments in the PLP development process. One of senior manager from production function recalled:

People assigned to [the Design Production Team] often did not have the necessary qualification as there were to many teams to be fulfilled .... We worked with ‘for information only’ drawings with an assurance [from Designers] that they would not be changed. But, when the drawings were formally released, they had been changed. Designers [apparently] went through the weight and balance analysis and several other calculations, found several mistakes and modified the drawings. It happened many times ... There were [also] a lot of parts that were compliance with design drawings but when assembled together, they did not fit. The design must be changed... (Steve, Fabrication Division, July 1998).

Unfortunately, these issues were not taken into full consideration when the CE implementation in the PLI Program began, despite the concerns expressed by many, including the engineer who was the Project engineer of both PLP and PLI programs. Nevertheless, this experience enhanced some team members’ understanding of CE and became part of the lessons learned as they went through the PLI Program:

Based on our experience [in the PLP program] we try to provide input to design people while they are carrying out early aircraft planning. (Peter, Operation Centre, November 1997)

The introduction of the CE approach in the PLI Program started when the PLI Program Manager, who had two years internship experience in Westaco, early after his assignment announced that he would apply the CE modelled on Westaco’s. This move was intended to take benefit of his own and other ex-interns hands-on experience, the availability of various Westaco’s CE protocols, and the previous experience in the PLP Program.
However, it was clear that computer-based technologies as CE enablers were the focus of attention. Later in the interview in 1996, the Program Manager stated:

[Westaco] termed it as enabling technology. With this enabling technology, [engineers] can work optimal. [Westaco] uses 100% digital [design]. So is our [PLI], no compromise. We will define the product with 100% digital CATIA and we will utilise the digital mock up in which engineers can compare and find the areas that require changes due to design faulty or part interference... For [PLI], we will use that. [Westaco] has used that... (Clive, Program Manager, June 1996)

There was a less serious effort in adopting other aspects of Westaco's CE practices, which in turn, led to difficulty in realising other aspects of CE, such as cross-functional teams and sufficient communication mechanism as can be seen later in Chapter 6.

5.4 National Context and Its Relation to Indaco and CE Termination

National context played a vital role in the existence of Indaco and its organisational mechanisms. The very existence of the company, for example, could not be separated from Indonesia's pursuit for industrial development, while its cultural tendencies played a role in shaping the organisation's structure and practices. In particular, this section discusses the following three aspects of national context that significantly contributed to Indaco and its CE:

1) Indonesia's national development plan that led to the existence of Indaco and its PLI Program.

2) Cultural Tendencies of the society, particularly the high power distance and collectivism, that led to centralised structure and its social-professional leakage was contributed to the acceptance of CE adoption.

3) The contemporary Indonesia's economic crisis that led to the termination of the
Chapter 5: Indaco: The Company and Its Contexts

PLI Program and its CE.

5.4.1 Indonesia’s Development Plan and Its Relation to Indaco and PLI Program

The establishment of aircraft industry was an integral part of Indonesia’s national development program (Todd and Simpson, 1986). Economically, it was part of industrialisation plan to promote economic growth and development in order to become one of the new industrialised countries. Rich in natural resources, Indonesia’s domestic revenue in the 1970s was heavily relied on such resources, oil tax in particular which accounted for more than 50% (Tanter, 1990). In comparison, manufacturing sector was accounted only for 2% of national export (Todd and Simpson, 1986).

Indaco, established as a state-owned company operating in aircraft manufacturing industry in 1976, was seen as the vehicle toward industrialisation. It was intended to diversify the composition of national export, facilitate import substitution and at the same time fulfil the country’s high-tech industry ambition. This labour intensive industry was also beneficial in creating and tending new highly skilled jobs for Indonesia which its growing workforce became a major challenge for the government (Edwards, MacIntyre, and Asra, 1994). Politically, the national aircraft industry was also seen as a strategic factor for promoting further integration throughout Indonesia by enabling to develop air transportation suitable in connecting and bridging the archipelago. These broader objectives were clearly reflected in Indaco’s organisational mission that emphasising technology transfer as well as its strong orientation toward technology advancement and less attention toward marketing and financial aspects of the business. Eventually, the company had accumulated a
significant loss and later faced financial difficulties in the time of national economic crisis during which the government’s aid stopped flowing.

During the 1990s, the government viewed that the global economic competitiveness could only be captured through high-level of scientific and technological capability (Hill, Marsh, Merson, and Siregar, 1994). This view was reflected in the objectives of the Government’s Sixth Five Year Plan (REPELITA VI) that covered the period of 1994-1999. This plan included establishing industry as the economic motor and primary absorbent of the labour forces and increasing industrial productivity and efficiency through the enhancement of the quality of human resources and improvement in skills, creativity, discipline, technological mastery and managerial skills (Nomura Research Institute, 1993).

The combination of these government’s objectives and Indaco’s success in the first flight of the first indigenous design of PLP in 1995 provided the opportunity for Indaco to propose another aircraft development program, the jet engine PLI. Due to its limited available fund for such undertaking, the Government fostered the establishment of a private company as a financial scheme to accumulate public funding for the PLI Program.

5.4.2 Cultural Tendency and Its Effects in Indaco’s Organisation

Indonesia has great ethnic diversity with hundreds of ethnic groups each with their own cultural and social heritage (Prijadi and Rachmawati, 1998). Among these, Javanese is the biggest ethnic group, accounted for one-third of the population and widely dispersed throughout the country. The unifying forces of this diversity were
accounted in national language, artistic expression, tradition, history of their struggle against Dutch colonialism, as well as in the national ideology, ‘Pancasila’ (the Five Pillars: belief in one God, just and civilised humanitarianism, a united Indonesia, democracy guided by wisdom through consultation and representation, and social justice for all Indonesian people) (Vatikiotis, 1993). Lubis (1990) argues close relationships and inter connections within those ethnic groups went far back into the pre-colonialisation era.

In assessing Indonesian cultural tendencies, this study uses Hofstede’s (1984, 1991) framework as a starting point. Aware of the limitation of Hofstede’s study, further confirmation is sought in more qualitative studies from anthropology literature and contemporary reports on politic and sociology, such as Geertz (1960), Vatikiotis (1993), and Guinnes (1994). According to Hofstede (1991), Indonesia is a country with a tendency towards high power distance, high collectivism, low masculinity, and low in uncertainty avoidance. This classification implies that people are likely to prefer to work in a group, be less competitive, and prefer co-operation and group harmony. Relationships are personal and activities are oriented toward the group interests. The organisation is likely a centralised structure that relies more on the individual who has the power rather than on the system (Hofstede, 1984).

This implication is broadly confirmed by anthropological work of Geertz (1960) on the Javanese culture, which is argued as the primary source of the contemporary Indonesian culture and social practices (Vatikiotis, 1993; Guinnes, 1994). Focusing on the Javanese culture, Geertz (1960) has classified the Javanese into three vertical sub-cultures: the ‘abangan’ culture of village peasants and urbanised working class, the ‘santri’ culture of the market traders, and the ‘priyayi’ culture of aristocrats and
government bureaucrats. These sub-cultures share many common values, such as value for harmony and against overt aggressive behaviour, value for proper behaviour according to status, disregard for open expressions of opposition, and the value of politeness and polite suppression of feelings.

These cultural tendencies were clearly reflected in Indaco's organisation. The tendency of high power distance was reflected by high level of centralisation of the organisational structure, in which the 'man at the top' had an enormously wide span of control, much wider than most top management in Western countries. His direct control by-passed the control of his direct subordinates as all heads of the divisions had also a reporting line directly to him, beside the reporting line to their respective directors. Managers, even the senior ones, often hesitated to make decisions, and sought direction from the top. Influenced by the tendency of high collectivism, the decision-making process was slow and dominated by several consultation meetings among the executives prior to bringing the issue to the top, even for insignificant issues. The consultation process among those executives was slow as they avoided direct confrontation and sought for the necessary 'face saving'. This slow process was regarded by the impatient middle managers as the 'bolt-and-nut executive meeting'.

5.4.3 Contemporary Indonesia's Economic Crisis and CE Termination

The financial crisis that devastated South East Asia since in the middle of 1997 has had a great impact on Indonesia's economy and politics. The Indonesian currency, Rupiah, had fallen by more than 60% against US dollar, the stock market index had dropped by more than 30% and inflation raised rapidly to more than 80% by early 1998 (Prijadi and Rakhmawati, 1998). The financial crisis led to economic and social
problems. Unemployment rapidly increased; manufacturing and construction workers were affected most. This situation eventually led to civil unrest that led to political crisis. The pressure for reform brought about by student and general demand, ultimately toppled the more than 30 years old regime on May 21 1998. Reformation in political, economics and social institutions as well as law reinforcement was highlighted as urgent in the new administration. However, social, political and economic situations remained uncertain.

Unlike other parts of Indaco that were affected since the end of 1997, the financial impact of the economic crisis only started to seriously affect the PLI Program in late 1998. This one-year lag was instrumental in allowing the PLI Program to complete its preliminary design phase. However, when the crisis was eventually felt, it totally eliminated the program’s source of finance. There had been indications of financial difficulties since the mid 1998 when the Program Manager issued a directive stated that the main objective of the Program was reduced to the completion of the preliminary design phase by the middle of 1999. At the end of 1998, the private company set up to finance the Program, decided to liquidate itself for various political and economic reasons. This development erased a hope of the PLI Program continuing the development process in the near future. With the termination of the PLI Program, the implementation process of CE initiatives was also ended.

5.5 Summary

Indaco was a fully state-owned Indonesian aircraft manufacturing company. Its establishment in 1976 was linked to the Indonesia’s national pursuit of economic growth and development toward industrialisation. The industry was intentionally set
up in the perception that it could fulfil the economical mission for export diversification and import substitution while fulfil the nation ambition of high-tech industry. Although it also had commercial missions, the engineering and technological orientation was enormous. This company operated in the industry through various way, including under license production, new aircraft developments, subcontract services for other primes, and aircraft maintenance services. Influenced by both national and industrial contexts, Indaco, had an elaborated organisational structure with highly differentiation, highly centralisation, and highly formalisation. The characteristics of aircraft industry contributed to high level of differentiation and formalisation, the cultural tendency associated with high power distance led to high centralisation, while the collectivism tendency led to slow decision making process.

Extending the organisational contexts towards the external environment of the company, also provided the bird-eye view of CE adoption: the background of its initiation and the reason of its termination. The effect of external context on CE implementation was more remote but nevertheless crucial to its existence. Industry common practices (e.g. subcontracting, technical and managerial consulting services and internship program) had exposed CE to Indaco and triggered the decision for adoption. However, as Indaco was one symbol of national technology development, this adoption was not solely triggered by the market and competition in the industry but also, and more intensely, by high-tech ambition which led to strong attention toward the enabling technology of this approach, namely the computerised support system. The Indonesian economic and political crisis that started in 1997 had forced Indaco to terminate the PLI Program due to the ending of the program’s source of finance. This termination also ended the CE introduction process in Indaco.
6.1 Introduction

As outlined in Chapter 2, CE is conceptualised as an approach to new product development process that focuses on integrating all product life cycle considerations at the outset of the process to achieve customer expectations with maximum quality, and reduced lead-time and cost. This approach is operationalised through several sets of initiatives. This study focuses on two of these sets, namely initiatives on organisational integration and communication and decision making mechanisms. The organisational integration has horizontal and vertical dimensions. The degree of cross functionality in a team represents the degree of horizontal integration, while the degree of heavyweight management represents the degree of vertical integration. Communication and decision-making mechanisms represent the processual dimension of such integration.

In analysing the introduction process of CE approach, this chapter looks at the changing shape of CE initiatives throughout the introduction of CE into the Indaco’s PLI Program - from its initial adoption and adjustment to the current approach used at that time to its
final result. During this process, the model was adjusted, shaped, adapted to the specific organisational and temporal context. The changing nature of CE in this introduction process is assessed through operationalised dimensions of the above two initiatives.

In the organisational integration initiatives, the changing nature of the cross-functionality is assessed through the size and architecture, the scope, and the membership pattern of the program teams. The changing nature of heavyweightness is assessed through the structural position, the degree of assigned delegation, and the seniority of the leaders of the program teams. The initiatives on communication and decision making mechanisms are assessed through the degree of which formal communication, collaboration, inter-team communication, and involvement of lower level teams in the decision making process. The assessment in this chapter involved all levels of program teams (i.e. core, middle-level, and operational teams) that existed throughout the introduction process. The dimensions assessed are summarised in Table 6-1.

In this assessment, the intended CE model is represented by the Westaco model. This model was drawn from initiatives related to the CE approaches undertaken by Westaco, in particular CE approaches from its two recent product development programs. The assessment reveals that this intended model had a high degree of organisational integration. Its cross-functional teams had a wide-ranging and in-depth involvement of various relevant functions. It also had a heavyweight management at all levels of the development team, which composed of senior and high position leaders with extensive authority in controlling the development process. Communication and decision making mechanisms in this intended model was characterised by a systematic communication system with a high degree of both formal and informal communication within and across
all levels of the development teams as well as a significant involvement of lower level teams in the decision making process. This communication system was supported by an advanced computer system.

Table 6-1 Dimensions of CE Assessed in the Case Study

<table>
<thead>
<tr>
<th>Category</th>
<th>CE Initiative</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational Integration</td>
<td>Cross-functional Team</td>
<td>Size and architecture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Scope</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Membership pattern</td>
</tr>
<tr>
<td></td>
<td>Heavyweight Management</td>
<td>Hierarchical Position</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nature of delegation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seniority</td>
</tr>
<tr>
<td>Communication and Decision Making</td>
<td>Fomal</td>
<td>Communication mode</td>
</tr>
<tr>
<td>Mechanisms</td>
<td>Communication</td>
<td>Type of data conveyed</td>
</tr>
<tr>
<td></td>
<td>Collaboration</td>
<td>Interactional relationship pattern</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Conflict &amp; negotiation process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Presence of collective goal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Presence of shared vision</td>
</tr>
<tr>
<td>Inter-team Communication</td>
<td>Formal</td>
<td>Formal communication</td>
</tr>
<tr>
<td></td>
<td>Communication</td>
<td>Collaboration</td>
</tr>
<tr>
<td>Decision-Making Mechanism</td>
<td>Authority of teams</td>
<td>Respect to lower teams' decision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power differential</td>
</tr>
</tbody>
</table>

The assessment of CE introduction in the Indaco’s PLI Program is intentionally detailed to see the dynamics of its changing shape and nature throughout the process. As discussed in Chapter 2, many studies of CE only provide a superficial understanding of the complex organisational arrangements involved in multi-teams product development projects. Their models, analyses, and prescriptions appear too simplistic. The assessment of Indaco’s PLI Program in this thesis reveals four stages of the Program in relation to CE. The first stage represented the traditional approach, while other stages represented the CE introduction process to a new product development program. Each stage had a different characteristics of organisational integration and communication and decision
making mechanisms. Further more, this longitudinal analysis reveals no consistent path of this variation toward the intended model. Rather, this variation seems to be ad-hoc and strongly influenced by the temporal and organisational contexts. This variation is the subject of the explanatory assessment in the next chapter.

The sections of this chapter are arranged as follows. It begins with an overview of the Indaco’s PLI Program. Then, CE initiatives at Westaco as the model of CE being introduced to Indaco are described. This is followed by a detailed discussion on CE implementation in Indaco throughout the phases of the PLI’s development process. Four stages of change process were identified, characterised by differences in organisational integration and communication and decision-making mechanisms. This is followed by a discussion on the extent of variation between the intended Westaco model and what was emerging as the Indaco model and its changing nature throughout the process.

6.2 Overview of Indaco’s PLI Program

The PLI was conceived as a new generation of regional jets for the 21st century. Indaco forecasted that there would be an increasing demand for regional aircraft in order to fill an increasing gap between the supply of jumbo jets and regional airplanes that usually serve as the jumbo jet’s feeders. The PLI was intended meet that demand (Indaco, 1997). Company-wise, the PLI was regarded as a major vehicle to bring Indaco to the fourth phase of its planned strategic development, i.e. the implementation of R&D in future technology. The PLI was the third new aircraft platform development undertaken by Induce after the co-development of the 35-passenger commuter PLC and the development
of the first indigenous 50-passenger commuter PLP. The objective of the PLI program was to develop, build and, certify prototypes of a new platform 100-passenger jet airplane that could fulfill the world market by 2004. At the outset, the estimated development cost was US$ 2 billion. The general features of this new aircraft are provided in Table 6-2.

Table 6-2: General Features of the PLI (Source: Indaco )

<table>
<thead>
<tr>
<th>Dimension</th>
<th>PLI-100</th>
<th>PLI-200</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic Gross Weight</td>
<td>Increased Gross Weight</td>
</tr>
<tr>
<td>Wing:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gross Area (m2)</td>
<td>107.4</td>
<td>107.4</td>
</tr>
<tr>
<td>Span (m)</td>
<td>29.9</td>
<td>29.9</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>8.4</td>
<td>8.4</td>
</tr>
<tr>
<td>Sweepback (0.25c) (degree)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Overall Length (m)</td>
<td>31.25</td>
<td>31.25</td>
</tr>
<tr>
<td>Fuselage Diameter (m)</td>
<td>3.95</td>
<td>3.95</td>
</tr>
<tr>
<td>Weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Take Off Weight (kg)</td>
<td>49550</td>
<td>51500</td>
</tr>
<tr>
<td>Max. Landing Weight (kg)</td>
<td>44600</td>
<td>46350</td>
</tr>
<tr>
<td>Max. Payload (kg)</td>
<td>11400</td>
<td>11400</td>
</tr>
<tr>
<td>Engine Thrust (KN)</td>
<td>2x83</td>
<td>2x86</td>
</tr>
<tr>
<td>Passenger Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All tourist Class (pax)</td>
<td>114</td>
<td>114</td>
</tr>
<tr>
<td>Mixed Class (pax)</td>
<td>104</td>
<td>104</td>
</tr>
</tbody>
</table>

The lifetime of the PLI Program ran from November 1993 to June 1999 when it was terminated due to the ongoing economy crisis within the country. The initial engineering study of PLI development was begun in November 1993 by the New Product Development (NPD) Department, a department within the Technology Division. The PLI Program was officially launched in March 1994 and initially led by the Head of NPD Department as the Chief Engineer. In August 1995, a program manager was assigned to

1 Item (83) Appendix-B
manage the PLI Program. The Program Manager, who recently completed his internship in Westaco, decided to introduce CE using the Westaco initiatives as the model. At the time of the field study from October 1997 to March 1999, there were more than 130 people from various specialisations fully dedicated to this Program, while a significant number of others were supporting the Program through their work in functional areas.

6.2.1 Program Phases

The PLI Program established a typical five-phase aircraft development process:

1) conceptual design phase,
2) preliminary design phase,
3) detail design phase,
4) prototype production (fabrication and assembly) phase, and
5) flight test and certification phase.

This, however, was not so much a linear sequential process, rather a process of continuous iterative and overlapping development. Despite the decision to use CE, the program schedule showed no significant expectation of a faster development time. Rather, the schedule can be seen as 'moderate' for such a development program. It was slightly longer than the schedule of the previous PLP Program reflecting that the PLI was larger and more complex than PLP. The Program's Master Phasing Plan can be seen in Appendix D. The activities planned in each of the development phases are given in Table 6-3, while the simplified version of its major milestones can be seen in Figure 6-1.
Table 6-3: Development Activities in Each Development Phase (Source: Indaco²)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activities</th>
</tr>
</thead>
</table>
| Conceptual     | Definition of Design Requirement and Objectives (DR&O)  
|                | Development of basic configuration (cabin space, maximum take off weight (MTOW), wing size, engine size)  
|                | Definition of baseline configuration options (80, 100 and 130 passenger)  
|                | Preliminary assessment of aircraft systems (hydraulics, electrics, avionics)  
|                | Wind tunnel database for design  
|                | Numerical models for computational fluid dynamic (CFD) and finite element analysis (FEA)  
|                | Specification of statement of works (SOWs), program planning, and financial planning                                                      |
| Preliminary Design | Configuration optimisation and trade-off analysis  
|                | Preliminary performance and economic analysis of the aircraft  
|                | Wind tunnel test for configuration optimisation  
|                | Manufacturability and producibility analysis  
|                | Fixed configuration decision                                                                                                               |
| Detail Design  | Analysis of local strength and functional requirement of component/part  
|                | Design refinement based on test and analysis results  
|                | Detail design of structures, systems, mechanisms, joints, fittings, and attachments                                                        |
|                | Detail engineering documents                                                                                                                 |
| Fabrication and Assembly | Manufacturing engineering, manufacturing planning and NC-programming  
|                | Tooling engineering and manufacturing                                               |
|                | Quality engineering and quality planning                                                                                                     |
|                | Detail part manufacturing                                                                                                                     |
|                | Component assembly and final assembly                                                                                                          |
|                | System installation and functional tests                                                                                                       |
| Flight Test and Certification | Documentation and analysis to comply with airworthiness regulation(s)   
|                | Flight test to validate airworthiness compliance                                                                                    |

<table>
<thead>
<tr>
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<td></td>
</tr>
</tbody>
</table>

Legend  
DR&O: Design Requirement and Objective  
TC: Type Certificate  

Δ DR&O  
Δ 90% Completion  
Δ Roll Out  
Δ First Flight  
Δ TC/First Delivery  

Figure 6-1: Simplified Milestones of the PLI Program (Source: Indaco³)

² Extracted from items (9), (10), (13), and (16) of Appendix-B  
³ Item (83) Appendix-B
The program had completed its conceptual phase and delivered the design requirement and objectives (DR&O) at the beginning of 1997. The airplane-level DR&O of the PLI Program can be seen in Table 6-4. The DR&O was continually refined and detailed during the next preliminary design phase.

Table 6-4: PLI’s Airplane Level DR&O (Source: Indaco⁴)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payload</td>
<td>114 passengers all tourist class 32” seat pitch (baseline)</td>
</tr>
<tr>
<td></td>
<td>132 passengers all tourist class 32” seat pitch (stretched version)</td>
</tr>
<tr>
<td>Design Range</td>
<td>2963 km (1600 nm)</td>
</tr>
<tr>
<td>Long Range Cruise Speed</td>
<td>0.8 mach</td>
</tr>
<tr>
<td>Take-off Field Length</td>
<td>1750 m (5742 ft) (MTOW, ISA+18, sea level)</td>
</tr>
<tr>
<td>Landing Field Length</td>
<td>1750 m (5742 ft) (MLW, ISA+18, sea level, wet runway)</td>
</tr>
<tr>
<td>Service Ceiling</td>
<td>11890 km (39000 ft)</td>
</tr>
</tbody>
</table>

At the time of the field study from October 1997 to March 1999, the Program was undertaking the preliminary design phase with some parallel activities covering the detail design and certification process. By the end of 1998, due to Indonesian economic difficulty, Indaco decided to temporarily terminate the Program on the completion of this preliminary design phase scheduled on June 1999. The aim was to make the design concept ready for potential investors.

6.2.2 Program Uniqueness

Compared to Indaco’s other programs, the PLI Program had two distinctive features: a

⁴ Item (83) Appendix-B
unique financial arrangement and the deliberate attempt to use CE as its approach to the organisation and management of the development process. These features affected the whole process of development within the Program and the relationship between the Program and the rest of the company.

1) Financial arrangement:

Officially, the PLI Program was undertaken by Indaco through a contract with the ‘owner’, a private company (pseudonym: Prico), specifically formed to acquire funding for the PLI development. The contract between Indaco and Prico, signed in August 1996\(^5\), made in effect that Indaco acted as a sole contractor to Prico. However, as the idea of the program was proposed by Indaco, it effectively acted as the virtual owner of the Program, particularly in defining the airline features and program schedule. Prico was typically seen as part of a scheme to ensure financial support for the Program.

Prico reserved the right to audit cost disbursement of the PLI Program. To simplify the audit procedure and to limit exposure of the company’s financial affairs to outsiders, the Program’s financial management was set up separately from Indaco’s. By this arrangement, the PLI Program was authorised to manage its own financial affairs using the statement of work authorisation. The statement of work was used both to authorise the execution of tasks and to control the process. Periodically, the Program submitted a work plan to Prico in the form of a statement of work draft, which included targets on deliverables, schedules and man-hours required. Prico then authorised this statement of work and provided money to the Program based on the agreed man-hours required.

\(^5\) Item (35) in Appendix-B
similar procedure was also in place (or at least attempted) for the functional units within the company that provided services to the Program.

This specific financial arrangement allowed the Program to have flexibility in allocating its financial resources and relative freedom from the myriad of Indaco's slow corporate procedures. It increased the 'heavyweightness' of the Program organisation and influenced the decision to become an autonomous program. This arrangement created more flexibility for the Program than any other divisions, including the ability to bring functional expertise from outside Indaco rather than rely on the internal support. However, this arrangement also created inconsistency in the overall company policies. It was perceived by others as an indication of the Program's exclusiveness and created displeasure among other senior managers and jealousy among other employees. This, in turn, affected the interaction between the Program and other divisions.

2) Concurrent engineering approach:

When he was appointed in 1995, the Program Manager, an engineer in a functional design unit (i.e. Technology Division), had just returned from an internship in Westaco. His announcement to implement CE in the PLI Program was seen as an opportunity to improve the product development process, particularly by people from production-related functions who were concerned with the problems they had encountered in the previous PLP Program. Basically, the PLI Program attempted to implement an approach that was modelled closely on Westaco's DRX Program. The Program manager stressed in the interview:

In my opinion, [the DRX] Program was more concurrent because it was truly product oriented. ...
For [the PLI], we will use that. (Clive, Program Manager, June 1996)

A wide range of Westaco’s manuals were available to Indaco and often used as references to support CE implementation. The Program Manager established a group to develop the ‘Sidina’ system as CE enabling technology for this Program. This group, coordinated outside the Program team by the Head of CADCAM Division, aimed to prepare, develop and set up the necessary enabling technology to support CE implementation. The Sidina group ran two pilot projects: one dealt with the idea of using a cross-functional team in the application of digital product development process, and the other attempted to develop a system based on knowledge-based engineering. Further analysis of enabling technology provided by Sidina group is discussed in Chapter 7.

Apart from the Sidina projects and the availability of Westaco’s manuals, there was no deliberate attempt to introduce and socialise CE, neither within the PLI Program team nor in the rest of the company. Within the PLI Program, CE was interpreted variously and given different meanings by different people and groups. Since this issue was never brought into a formal cross-functional discussion at any level, there was no single agreement on what a CE approach meant to the Program. As a result, despite the Program Manager’s intention to follow Westaco’s approach, the implementation process revealed that the realisation of CE in Indaco’s PLI Program varied over time and did not follow the intended model. Detailed assessment of this variation is provided in the next sections.

In addition, most senior managers within Indaco were not well informed about the consequences of implementing CE. There was no deliberate link between the Program’s CE initiatives and the company-wide organisation and human resource policies. The
objectives and consequences of introducing such an approach were only casually addressed in the Executive Management Council meetings. This lack of communication raised conflicts during the development process between the Program and the involved functional units. These conflicts mostly appeared in functional units’ hesitation to provide the human resources demanded by the Program which, in turn, was perceived by the Program as a resistance toward the CE approach.

6.3 CE Initiatives at Westaco: The Model of CE for the PLI Program

In this case study, CE initiatives in product development applied by Westaco, a major player in the aircraft industry, are taken to represent the intended model that was introduced into Indaco for the following reasons:

1) The Westaco model of CE was an explicit basis for the introduction of CE in Indaco. At the beginning of the program, the Program Manager of the PLI continuously expressed his intention to implement CE and to bring a particular set of initiatives and concepts from Westaco to be implemented in the PLI Program. These concepts were learned either indirectly through the availability of manuals and protocols concerning those concepts at Indaco, or through hands-on experience by Indaco’s engineers in an internship program at Westaco.

2) Westaco is one of the most respected companies in the global aircraft industry and its model was a representative of CE application in the industry. CE initiatives from Westaco have been widely researched and reported on in various books, journals and
magazines, and regarded as 'one of the best practices' in the aircraft industry.

For the purpose of this thesis, the key characteristics of the Westaco model were those elements communicated to and within Indaco rather than the complex and most probably involved reality of Westaco’s longer-term implementation of CE. CE initiatives at Westaco were identified indirectly through the following sources:

1) Published materials, including CE books, journal and magazines.
2) Unpublished materials, particularly in the form of Westaco’s procedures and protocols that were widely available in Indaco.
3) Accounts from primary sources, i.e. ex-interns, who experienced and witnessed Westaco’s development processes.

According to these sources, Westaco’s CE approach was applied through various sets of initiatives. These varied from one program to another. Typically, initiatives applied in the later development programs were more advanced than in the earlier programs. In part, this variation reflected the cumulative experience that Westaco has gained through its previous programs. It also reflected the development of both the CE concept and computer technology as its enabling technology since Westaco’s major CE initiatives involved advanced computer support systems.

Two sets Westaco’s CE initiatives were particularly influential in the Indaco’s CE: CE initiatives for a new platform program (pseudonym: PLX) established in 1991 and CE initiatives for a major derivative program (pseudonym: DRX) established in 1994. Although the Program Manager of the PLI Program often expressed his preference to use the DRX model of CE, the PLX model was also significantly influential in the PLI...
Program. There were two major reasons of this. Firstly, the protocols of the PLX model are more widely available in Indaco than the protocols of the DRX model. Technical assistants hired from Westaco even long before the PLI Program had started brought these protocols. Secondly, most ex-interns who brought hands-on experience of CE from Westaco were involved in the PLX program rather than in the DRX Program. Therefore, these two sets of Westaco CE initiatives are included in this review and regarded as the ‘Westaco Model’ as intended to be introduced in Indaco. Table 6-5 provides a summary of this review, which is discussed in more detail in the remainder of this section.

In general, CE initiatives in the PLX and DRX Programs were similar. Despite the obvious difference of the size and the nature of these programs (i.e. new platform versus derivative development), they both had a sizeable team divided into several layers of a core team and sub-teams. They had a wide ranging cross-functionality and a heavyweight program management with similar communication and decision-making mechanisms. A detailed analysis on organisational integration and communication and decision making process revealed their differences in the nature of how their sub-teams were divided, the role of the functions involved, and the pattern of team membership as follows.

1) Organisational Integration

Cross-Functionality:

Both programs involved company-wide full members and functional representatives representing both engineering and non engineering functions, such as airframe structure, aerodynamic, system, stress analysis, weight analysis, manufacturing planning, NC-programming, tooling engineering, design to cost analyst, customer service,
manufacturing, quality control, purchasing, business, training, computer services, and scheduling. They also involved external organisations, such as main manufacturing contractors, suppliers and potential customers.

Table 6-5: Summary of the Westaco Model of CE

<table>
<thead>
<tr>
<th>CE Initiative and Dimension</th>
<th>Westaco</th>
<th>PLX</th>
<th>DRX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Functional Team</td>
<td>Size and Architecture</td>
<td>Large with core team and several levels of sub-teams</td>
<td>Primarily based on specialisation</td>
</tr>
<tr>
<td>Functional Scope Role Level Involved functions</td>
<td>Design functions in the main role, others in equal roles in design teams</td>
<td>Supporting role</td>
<td>Full membership/representative</td>
</tr>
<tr>
<td>Membership Pattern</td>
<td>Position</td>
<td>Staff and middle managerial level</td>
<td>Operational and liaison</td>
</tr>
<tr>
<td>Pattern</td>
<td>Member's activity Dedication Temporal Multiple membership Higher team's composition</td>
<td>Fully dedicated</td>
<td>Permanent</td>
</tr>
<tr>
<td>Higher team's composition</td>
<td>Lower team leaders were part of higher teams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organisational Integration</td>
<td>Heavyweight Management Hierarchical Position Authority</td>
<td>Equal to functional division</td>
<td>Equal to functional subdivision</td>
</tr>
<tr>
<td>Delegation Program Functional</td>
<td>Extensive</td>
<td>Extensive to all members</td>
<td></td>
</tr>
<tr>
<td>Seniority Tenure</td>
<td>Senior leaders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age Education</td>
<td>Senior engineers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>Highly educated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Richness Frequency Direction Timing</td>
<td>Several levels of systematically arranged regular meeting with intensive discussion and minutes of meeting</td>
<td>Integrated computer-based media for sharing technical data</td>
</tr>
<tr>
<td>Type of data Released Used</td>
<td>Ambiguous data released and used but became more certain during the process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration Interaction Conflict Management Collective goals Shared vision</td>
<td>Collaborative at all levels characterised by close and friendly interaction to achieve program's goal, dialogue to solve problems in interdependent work fostered by indoctrination process and social activities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter-team Communication Formal Communication Collaboration</td>
<td>Formal and informal Intensive, triggered by formal and informal communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision Making Authority Program - Function High level - Low Level</td>
<td>Semi autonomous matrix structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower teams had extensive authority</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanism Respect to lower teams Power differential</td>
<td>Lower teams' decisions were respected by higher teams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low power differential between higher and lower teams</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the PLX Program, the team was primarily based on the design specialisation (e.g. structure, system) and then divided further into several layers based on product division (e.g. wing structure, aileron structure). Design engineers comprised and played the main role in the sub-teams. Members from other functions played supporting roles as functional representatives outside the operational design teams. In contrast, the DRX Program team was primarily divided based on fully integrated end product incorporating various design specialisations (e.g. wing, aileron). Design engineers and members from other functions comprised the operational sub-teams and played equal roles.

Overall, the team architecture, scope of integration, and membership pattern of the PLX's cross-functional team resembled the findings of CE teams on the U.S. automobile industry (Haddad, 1996). The overall cross-functional team covered a wide range of functions and specialisation through permanent and fully dedicated representation, but the operational design teams were dominated by engineers. In a sense, the horizontal integration of the DRX Program was a refinement from the PLX Program. It refined the interlocking structure of the core team and sub-teams of the PLX program through specific membership pattern of the high-level teams. It pushed the involvement of various engineering and non-engineering functions into the operational levels and freed those levels from the confusion of a matrix mechanism. By integrating all specialisations to work together in an operational team, its architecture also provided a truly product-focused team structure.

**Heavyweightness:**

At Westaco, the program managers had the highest authority in the development process,
while the functional units served as ‘support pools’ to provide the required skill competencies and to ensure the compliance with any relevant regulations. The Program Manager was responsible and accountable for the product’s features and performance, as well as for the program’s management including planning, budgeting, allocating resources and controlling the progress. To provide the program with sufficient power, Westaco had established program teams with heavyweight management.

Structurally, the management of both programs had formal hierarchical positions equal with the functional heads at their levels. The difference in the nature of the program (i.e. platform versus derivative) caused the difference in the hierarchical position of the program managers of these two programs. The program manager of the new platform PLX program was a vice president reported to the president director of the group. The program manager of the derivative DRX program was a subdivision head and reported to a vice president. However, both program managers had extensive authority and access to control the overall development processes. They and other team leaders at all levels were typically senior members of the company in terms of age, tenure and experience with a sufficient degree of education. These program leaders had extensive delegation from both the programs and functional units to make and execute decisions throughout the development process.

2) Communication and Decision Making Mechanism

Both Westaco’s programs had the same pattern of communication and decision making mechanisms. At the operational development process, technical information was shared and channelled across the teams through the on-line computer system, but updated
authorisation remained with the originators. The whole program teams were also linked by four levels of systematically arranged regular meetings. This also reflected the decision-making mechanism of the programs that had a low degree of power differential and respect the authority of low-level teams.

- **Operational meeting**: Each development team had its twice-a-week meeting chaired by its leader and attended by all engineers and representatives worked for that team. The agenda of this meeting typically included discussion of new design issues, and closing issues that involved team decisions signed by every member including finalising drawings so that they could be passed on to manufacturing. Minutes of meetings were distributed to all attendants after each meeting.

- **Progress Review Meeting**: This was a weekly co-ordination meeting at the middle management level for clearing up issues and problems from the above operational meetings. The meeting was conducted with a formal time-controlled agenda and a circulation of minutes of meeting afterward. Typically, the agenda involved reports from Chief Engineers, representatives, lead engineers, and key engineers, each of which was followed by a discussion. The decisions were made in the meeting.

- **Design Review Meetings**: The development process was divided into several design reviews. Typically, the design review meetings were conducted every two months. The aims of these meetings were to review the overall development process and to straighten out any engineering problems. Prior to each of these meetings, the design process was frozen, and the administration services distributed the list of design interferences (i.e. the mismatch between one part or aspect of the design and other
parts or aspects) to be resolved at the meeting. As most interferences involved more than one operational team, these meetings represented the formal communication across teams to resolve issues in the first and second meetings. Therefore, these three program meetings systematically interlocked across all layers of teams.

- **Program Management Meetings**: These meetings represented the communication and decision-making mechanisms in the program top management. The meeting covered a wide range of issues encountered by the program, such as training, major purchasing, interactions with the authority, and changes of important material.

Formal communication at various levels was accompanied with more informal collaborative modes that ranging from on the spot discussion, e-mail, and telephone conversation. Within the operational development teams, this intensive collaboration was fostered by collocation and the ‘indoctrination process’ of a program familiarisation course through which any new member was introduced to the programs’ overall plans and protocols at the very beginning of his/her involvement in the programs.

Informal collaboration across operational teams also occurred, typically triggered by the preparation for design review meetings. As engineers from various teams had to establish their joint course of actions to resolve the interference problems prior to these meetings, informal interactions even with unfamiliar colleagues were intensified. Any problem resolution as a result of these interactions within and across teams was respected. Only issues that could not be resolved through interaction at the lower level were brought to higher level meeting for decision.
6.4 CE Approach in Indaco’s PLI Program

This section captures the process of introducing CE in the Indaco’s PLI Program. During the PLI Program’s lifetime (1993-1999), four different structures in organising its development teams were identified in regard to organisational integration aspect of CE. This led to four different stages of CE implementation as follow:

   This stage corresponded with the beginning of the conceptual phase of the PLI Program. In general, this was a pre-CE stage. At this stage, there was no intention to implement CE. Instead the task was carried out by the New Product Development (NPD) Department with the team exclusively made up of design engineers.

   The commencement of this stage marked by public launching of the PLI development program in August 1995. The Program Manager, officially appointed by the Indaco’s President Director in this event, established a program structure that primarily consisted of matrix between the Program’s component-based design teams and engineering specialists groups supported by functional design units.

   This stage was marked by the launching of a new program structure that internalised engineering specialists and functional representatives within the Program organisation. The internalisation involved merging the component-based design teams and engineering specialists into the Program’s Design Integration teams, and addition of five functional representatives as part of the Program team, including the
Operation Co-ordinator representing production-related functions.


In this stage the PLI Program restructured its organisation to become an autonomous division internalising all functions necessary to develop and build the aircraft as parts of the Program. The main feature of the Program was the Design Centre and the (production) Operation Centre; each consisted of parallel product-based teams.

In general, these various structures and stages can be seen as part of the effort to find an appropriate means of implementing CE. The field study started in the beginning of the design-production coupling stage. The overlapping between these stages, program development phases, and field study time can be seen in the Figure 6-2.

![Figure 6-2: Overlapping Timeframes between the Program Phases, CE Stages, and Research Activities](image)
Chapter 6: The Substance of Change: CE Implementation

The review of this section is constructed around the CE initiatives that are the focus of this study (i.e. organisational integration and communication and decision making mechanisms). It starts with outlining the changing nature of CE initiatives in organisational integration and communication and decision making mechanisms within the program teams throughout four identified stages. A longitudinal analysis of each stage is provided afterward to clearly capture the dynamics of the change process and the temporal and organisational contexts that might influence the process and the variations, either against one another or against the intended model, that were present throughout the process. Therefore, this analysis is intentionally detail, exploring the nature of each team involved throughout four identified stages, from the core team to the operational teams.

6.4.1 Overview of Indaco’s CE

Throughout four identified stages, the changing nature and shape of CE initiatives in the PLI Program can be summarised in Table 6-6. In general, both organisational integration and communication and decision making mechanism were undergone significant changes. The introduction of CE started at the second stage, the engineering matrix stage, and was marked by the effort to establish a cross-functional team with a heavyweight management for the PLI Program and separate the Program team from the functional design units (i.e. Technology Divisions) that traditionally housed such development activity. This was accompanied by another effort to establish an integrated computer system to support product development activities.

Throughout all stages, however, this effort took a different path from the intended
Westaco model. By the end of this introduction process, the Program abandoned the heavyweight matrix organisational arrangement to become an autonomous division that independent from the influence of functional units. The process was dominated by the design-related functions. Consistent support came only from production-related functions. The computer-support system remained a stand-alone rather than an integrated system. Decision making process was dominated by high-level teams and individuals. Involved teams were not linked either by systematic formal meetings or by informal collaboration. The changing nature of CE initiatives in each of organisational integration aspect and in communication and decision making mechanism aspect is as follows:

Table 6-6: Summary of the Changing Nature of CE in Indaco

<table>
<thead>
<tr>
<th>CE Initiative and Dimension</th>
<th>Program Initiation</th>
<th>Engineering Matrix</th>
<th>Engineering Integration</th>
<th>Design- Production Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross Functional Team</td>
<td>Size and Architecture</td>
<td>Small</td>
<td>Single team</td>
<td>Design team was divided primarily based on integrated and product</td>
</tr>
<tr>
<td>Scope</td>
<td>Design engineering</td>
<td>Wide range company-wide functions</td>
<td>Design function in the main role Weak support from other functions, including production (focal points)</td>
<td>Design function in the main role Support from other functions, including production (representatives)</td>
</tr>
<tr>
<td>Membership Pattern</td>
<td>Permanent and fully dedicated members</td>
<td>Mixed fully/barely dedicated members of design teams with overlapping and interlocking membership</td>
<td>Mostly fully dedicated members of design teams with overlapping and interlocking membership</td>
<td>Permanent and fully dedicated members separated into Design Centre and (Production) Operation Centre Internalisation of all relevant functions</td>
</tr>
<tr>
<td>Organisational Management</td>
<td>Hierarchical Position</td>
<td>Functional department</td>
<td>Middle level</td>
<td>High level authority</td>
</tr>
<tr>
<td>Nature of Delegation</td>
<td>Extensive</td>
<td>Extensive to Program Manager, senior leaders, and senior engineers</td>
<td>Extensive</td>
<td>Extensive</td>
</tr>
<tr>
<td>Seniority of leaders</td>
<td>Senior leader</td>
<td>Mixed of junior and senior leaders in design teams</td>
<td>Junior leaders/engineers in design teams</td>
<td>More senior in operation teams</td>
</tr>
<tr>
<td>Communication and decision making mechanisms</td>
<td>Formal Communication</td>
<td>Routine meeting Early information</td>
<td>Communication modes were ad hoc based on preference and situational context</td>
<td>Computer-based media were stand alone</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Extensive</td>
<td>High level collaboration within the subteams but rarely extended across teams</td>
<td>Extensive</td>
<td>Extensive to Program Manager, senior leaders, and senior engineers</td>
</tr>
<tr>
<td>Inter-team Communication</td>
<td>Rich two-way communication</td>
<td>Formal and less collaborative</td>
<td>Faded to maintain a rich two-way dialogue that flourished earlier this stage</td>
<td></td>
</tr>
<tr>
<td>Decision Making Mechanisms</td>
<td>Small autonomous design team</td>
<td>&quot;Semi autonomous&quot; hierarchy of teams strongly influenced by functional design units</td>
<td>&quot;Semi autonomous&quot; hierarchy of teams less influenced by design units as engineers were integrated</td>
<td>Large autonomous design / production teams increasingly centralised in the core team</td>
</tr>
</tbody>
</table>

*Focal Points: functional experts assigned by functional units to support a program"
1) Organisational Integration

CE initiatives in this aspect caused a significant change in Program organisation. Prior to CE introduction, PLI development activities were carried out as functional activities in the NPD Department of Technology Division. At the engineering matrix stage, when CE was first introduced, the development activities were managed by a heavyweight program team involving all design-related functions through a matrix between the Program's operational design teams and the engineering specialist groups backed by functional design units. In the next stage, (i.e. engineering integration stage) engineering specialists were integrated to the design teams but the PLI Program managed a matrix between the Program and other supporting functional units. In the last stage, rather than keeping the matrix arrangement as the intended Westaco model, the PLI Program became an autonomous division, mainly consisted of design-related and production related functions. The heavyweightness of the Program team was reflected by the structural position of the Program Manager who reported directly to the President Director throughout all stages. However, these efforts did not ensure that the Program achieved its intention in implementing CE to its development process.

Horizontal Integration: Cross Functional Team in the PLI Program

Cross-functionality in the PLI Program evolved in line with the increasing complexity of the development process and the growth of the program team. Initially, the Program was carried out by a small team. Over time, the size had grown to become more than 130 people by the last stage. Starting at the engineering matrix stage, the Program team was divided into a core managerial team and several levels of sub-teams. At the program initiation stage, the development team only covered the design-engineering
specialisation. With the decision to introduce CE, the Program started to involve other functions in the engineering matrix stage. Unlike the cross-functionality in the DRX Program, however, functions other than design-related functions were only involved in supporting roles and were separated from the design teams. Only at the last stage did other functions (i.e. production-related functions) become involved in the main development activities through the formation of the Operation Centre along side the Design Centre.

In the program initiation stage, team members were permanent and fully dedicated engineers. In the engineering matrix stage, additional partly dedicated engineers from various design specialisations were brought to the design teams as part of the matrix arrangement. In the engineering integration stage, most of representatives became fully dedicated to the Program. In the last stage (i.e. design-production coupling stage), with a few exceptions all involved parties belonged to the Program and became permanent and dedicated members of the Program.

*Vertical Integration: Heavyweight Management in the PLI Program*

From the beginning, the top management of the PLI Program had enjoyed an equivalent position and authority to that of the heads of functional units on issues such as budget and resource allocation. However, the Program struggled to gain control over some development processes carried out by the functional design units (i.e. technical analyses that were central to making design decisions) particularly because the leaders of the PLI Program were less senior in their age and less experienced than their counterparts in the functional design units. The complexity of the relationship between the functional units
and the PLI Program under a matrix arrangement in the second and third stages led to the creation of a stand-alone independent program in the fourth stage. In this stage, functional representatives became full members of the Program team, and thereby gave up their positions in the functional units.

2) Communication and Decision Making Mechanisms

In a development process of the PLI's scale, the release and use of uncertain information by engineers were necessary in the initial stages to establish an 'engineering solutions envelope'. This information was shared through the computer system and continuously updated when more refined data (e.g. analyses and test results) were available. The process in the core team and middle level teams was dominated by formal communication, such as meetings, reports and memoranda. Over time, these higher level teams increasingly ignored and disregarded decisions made by the lower level operational teams. There was evidence of difficulties in maintaining interaction across teams both horizontally and vertically. However, the communication and decision-making mechanisms within the operational design and (later) production sub-teams were often dominated by collaboration based more on friendly and informal communication and dialogue to achieve mutual goals. Formal communication was typically used to formalise the result of the collaboration process, rather than in the decision making itself.
6.4.2 Longitudinal Analysis of CE Introduction Process in Indaco

6.4.2.1 Program Initiation Stage (November 1993 – August 1995)

The PLI Program was first initiated in November 1993 when the President Director of Indaco asked the Head of NPD Department to assess the possibility of developing a regional jet airplane. The preliminary design requirements and objectives (DR&O), a rough concept of the PLI, was completed in January 1994. A series of management kick-off meetings was conducted during March – July 1994. These meetings decided that the PLI would be a 100-passenger wing-mounted engine regional aircraft and outlined the program milestones with the first delivery targeted in 2006. By the end of 1994, the PLI’s two-year plan of the conceptual design phase was completed. Following this, the President Director assigned the Head of the NPD Department as the Project Engineer of the PLI Program. He was responsible for the overall product performance aspects as well as the progress of the development program. Consequently, most engineers worked at the NPD Departments worked for this Program. Detailed analyses of organisational integration and communication and decision making mechanism in this stage are as follows:

1) Organisational Integration:

Cross Functionality:

In this stage, the size of the team working for PLI was around 20 members. The team was divided into nine overlapped informal groups in which one member might belong to more than one group: Configuration, Flight Mechanic, Aerodynamics, Structure, Wing Design, System, Fly-by-Wire, Load Alleviation, and Propulsion. Each group had 3-6 members.
Despite this sub-grouping, the whole team, due to its relatively small size, was able to perform as a single team without hierarchical division of core team and sub-teams. As part of the NPD Department, all members were representing design engineering. There was no representation of other functions. All members worked at the operational level and were fully dedicated to the development of PLI. Their involvement was permanent as part of their task in the department.

**Heavyweightness:**

The Project Engineer was the Head of NPD Department, a middle manager who reported to the Director of Technology. As all team members were part of his department, he had full authority and was able to directly control and supervise the process. Due to his involvement as the Project Engineer in the previous PLP Program, he often had direct access to the President Director and, therefore, influential in engineering-related issues. However, his discretion over budget and resource allocation was limited. His request for additional facilities, for example, had to proceed through the Director of Technology.

The team members were mainly junior, 20 – 35 years old, engineers. Typically, this Program was their first involvement in product development process. Most co-ordinators of the sub-groups were equally juniors, typically appointed on the basis of either their qualifications or their experience. These co-ordinators had little delegated authority in design process or in controlling other members. Supervision and direction of the process came directly from the Project Engineer.

2) Communication and Decision Making Mechanisms

The PLI development team had a weekly meeting led by the Project Engineer that
discussed and decided various interface issues between sub-groups. The release and use of uncertain and ambiguous data were common. The design concept was continuously refined, as more valid data became available.

The interaction among members was highly collaborative. Inspired by the often quoted President Director's vision "Mastering advanced technology is an effort to accelerate national development"\(^6\), team members were typically determined to prove that they were capable of making such a contribution to the company's and the nation's future. These shared vision and goals led to a relatively cohesive team. The cohesiveness among these particular members remained throughout all stages. The overlapping small-size groups made informal discussion within and between groups possible. Engineers who belonged to more than one sub-group acted as catalysts in inter-group communication. Although friendly, there was a significant power differential between the Project Engineer and team members. Most major decisions were made by the Project Engineer.

6.4.2.2 Engineering Matrix Stage (August 1995 – October 1996)

In August 1995, the PLI Program was publicly launched and the President Director officially appointed its Program Manager. The Program Manager, who reported to the President Director, decided to introduce CE. This marked the commencement of this stage. As part of CE introduction, the Program Manager established a matrix arrangement involving the Program's product-based teams and specialist groups from various

\(^6\) e.g. Item (36) Appendix-B
engineering specialisations. Other functional units supported the Program through their focal points specifically assigned to provide functional supports for the Program. The Program organisation was structured as in Figure 6-3.

The main part of this structure was the matrix between the product-based design teams called TOP (stands for ‘team optimisasi produk’: product optimisation team) and the engineering specialist groups. The TOP teams were responsible for the physical features and configuration of the aircraft and aircraft components. There were four TOP teams: Fuselage, Wing, System and Propulsion, co-ordinated by the TOP-Airplane Manager. This manager reported to the Program Manager and was responsible for the whole aircraft configuration development. The typical work plan of the TOP teams during this conceptual design phase included preliminary design concept definition; trade-off study on sizing and configuration; design concept validation and tool evaluation; and application for preliminary design.
Engineering specialist groups were functional-based groups that responsible for the necessary non-physical products, such as analysis and calculation, to support the TOP team in the development process. There were four engineering specialist groups:

1) Aeromechanics, Aerodynamics and Aerolastics;
2) Aerophysics and Flight Mechanics;
3) Airframe Structure, Material and Processing; and
4) Aircraft System.

These groups were supported by functional design units. They consisted of engineers and specialists who were assigned as representatives to the PLI Program by functional design units. These specialists worked in the TOP teams. Table 6-7 illustrates the typical task division between various engineering specialist groups in a component-based TOP team.

<table>
<thead>
<tr>
<th>Engineering Specialist Groups</th>
<th>TOP-Wing</th>
<th>Non-Physical Product</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Airfoil Family</td>
<td>High-lift Devices</td>
</tr>
<tr>
<td>Aeromechanics</td>
<td>Specify pressure distribution</td>
<td>Obtain optimum configuration</td>
</tr>
<tr>
<td>Aerophysics and Flight Mechanics</td>
<td>Obtain geometry</td>
<td></td>
</tr>
<tr>
<td>Airframe Structure, Material and Processing</td>
<td>Define wingbox thickness</td>
<td></td>
</tr>
<tr>
<td>Aircraft System</td>
<td>Define volume and space of system boxes</td>
<td>Define mechanism</td>
</tr>
<tr>
<td>Physical Product</td>
<td>Aerofoil</td>
<td>Flap and Slat</td>
</tr>
</tbody>
</table>

Table 6-7: Matrix between TOP Teams–Engineering Specialist Groups (Source: Indaco7)

The Program organisation also had a Deputy Program Manager, a Program Management Office (PMO) Manager, an Engineering Operation Manager, and Executive Representatives from Business and Finance Divisions. The Deputy Program Manager was assigned to the previous Project Engineer. He was responsible in managing the

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7 Item (11) Appendix-B
technical aspects of development process. In addition, the Program Manager also requested company-wide functional units to assign their focal points. Focal points were representative assigned by functional units to provide and co-ordinate functional support for a particular program. These focal points were involved in various activities to support the Program.

The attempt to extend the scope of CE was reflected in activities under the Engineering Operation Manager who was responsible for co-ordinating early involvement of production-related functions in the Program and assessing enabling technologies necessary for CE implementation. This Manager established the design build process (DBP) team to co-ordinate production activities and the advanced system development (ASD) team to co-ordinate enabling technology assessment. The design build process team consisted of focal points from production-related divisions, such as Fabrication, Fixed Wing, Production Engineering, Industrial Engineering, and Quality Assurance. This team aimed to make necessary preparation for the production phase and to provide insights to TOP teams on producibility and manufacturability issues of their designs.

The advanced system development team consisted of focal points from Information Technology, CADCAM, and Manufacturing Resource Planning Divisions. Its objective was to support CE implementation in the PLI Program. In April 1996, this team obtained management’s approval to develop a computer-based integrated digital system called ‘Sidina’. Later, known as ‘Sidina’ group, this team was co-ordinated outside the program organisation by the Head of CADCAM Division. Further analysis of ‘Sidina’ initiative is provided in Chapter 7.
The PMO Manager was responsible for the program management, which involved planning, monitoring, and controlling the process. The PMO manager co-ordinated company-wide focal points to establish the program’s Master Phasing Plan (MPP). This activity involved a series of weekly meetings. By the end of this stage, the Master Phasing Plan was submitted to the Program Manager for approval. The Business and Finance Representatives were primarily involved in the establishment of the Preliminary Feasibility Study of the PLI Program. With this feasibility study, Indaco’s top management lobbied the Government officials for financial support. This resulted in the formation of Prico to finance the development cost of the Program in March 1996. Subsequently, the contract between Indaco and Prico was signed in August 1996. Detailed analyses on CE initiatives in organisational integration and communication and decision making mechanisms in this stage are as follows:

1) Organisational Integration

The characteristics organisational integration of the PLI Program in the engineering matrix stage can be summarised in Table 6-8.

Cross-Functionality:

The size of the Program team expanded to over 60 members, excluding the functional-based focal points. The hierarchical division into three levels was evident on the basis of their regular meetings: the core team of the Program Manager and its direct subordinates; a middle level team consisted of the TOP-Airplane Manager and the leaders of design-related TOP teams; and operational level teams represented by the TOP teams. The scope of the Program team expanded through the assignment of focal points from all relevant
functional units. However, functional focal points were typically involved in supporting roles. The main role laid in the functions that were involved in the core team and design-related TOP teams.

Table 6-8: Organisational Integration Characteristics in Engineering Matrix Stage

<table>
<thead>
<tr>
<th>Size and Architecture</th>
<th>Main Development Role</th>
<th>Support Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large, over 60 people (excluding focal points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core team</td>
<td>TOP teams</td>
<td>MFP team</td>
</tr>
<tr>
<td>Core team</td>
<td>Full/representatives</td>
<td>Full/representatives</td>
</tr>
<tr>
<td>TOP teams</td>
<td>Design, Business, Finance</td>
<td>Design functions</td>
</tr>
<tr>
<td>MFP team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP team</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASD/Sidra team</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The core team included representatives from design, business, and finance functions. Its members were considered as high and middle level managers. The Program Manager, the PMO Manager, and the Engineering Operation Manager were full members and fully dedicated to the managerial tasks of the Program. Business and Finance representatives were partly dedicated to the Program and involved in liaison tasks linking the PLI Program with their functional units. The Project Engineer and the TOP-Airline Manager were representatives from Technology Divisions. They were partly dedicated to the Program and mainly handled engineering supervisory tasks.
The component-based TOP teams (i.e. Fuselage, Wing, System and Propulsion) involved design-related functions only. To reduce task complexity, each TOP team was divided into sub-teams. The TOP-Wing, for example, was divided into Airfoil, High-Lift Devices, Clean Wing, and Movable Surfaces. The TOP teams consisted of fully dedicated designers from the PLI Program (i.e. engineers from the previous New Product Development Department) and partly dedicated engineering specialists from various functional design units (i.e. Technology Divisions). Some members were involved in more than one TOP team due to the limited number of available engineers and created multiple membership among these teams. These teams carried out the operational tasks of the design process. TOP team leaders handled both operational and supervisory tasks. Most of them were not fully dedicated and had other responsibilities from their functional design units. The inclusion of the TOP-Airplane Manager in the core team and the leaders of TOP teams in the middle level team provided interlocking structure in the program teams.

Other functions played supporting roles in the process as their focal points became parts of three support teams: the master phasing plan team, the design build process team, and the advanced system development (later known as Sidina) team. Most of focal points held middle managerial positions. Typically, they were partly dedicated and performed liaison tasks between the program and functional units. The master phasing plan team involved company-wide focal points. The design build process team involved production-related focal points and led by the focal point from Production Division. The growing activities in this team led some members to become representatives and fully dedicated to the PLI Program. The advanced system development/Sidina team involved focal points
from divisions related to information technology. Some members of this team performed operational tasks, evaluating advanced technology possible to support CE implementation. These support teams had multiple membership as most focal points took part in the master phasing plan team and some of Sidina members were members of the TOP teams and the design build process team.

**Heavyweightness:**

Structurally, the Program Manager’s position was at the same high level as the heads of functional divisions as he reported directly to the President Director. At 30 years of age, the Program Manager was a ‘junior’ in the company compared with his counterparts in functional units. But, his doctoral degree in Aeronautics and his intensive internships in various Western aircraft companies were considered as substitutes for this lack of tenure and experience.

The Program Manager had some authority over budget allocation but had problems in allocating and controlling the resources requested by functional units for PLI purposes. Although functional units were required to get approval from the PLI Program for any supporting facility funded by the Program, they afterwards retained full control over such resources. They were not required to report on the utilisation of those facilities. The PLI Program often had problems in requesting functional units to share their facilities with other divisions or to use facilities acquired from other programs.

The Program Manager also had problems in gaining access to control the product development process. He had less authority than the heads of functional design units over people who worked for the Program. Most members of his core team were
representatives with extensive delegation from functional units and were not fully dedicated to the Program. Officially, they were members of functional units. Their salary and career path remained attached to those divisions. The Program Manager provided extensive delegation to members of this core team in performing their tasks.

Leaders of the design-related TOP teams and sub-teams were a mixture of inexperienced and experienced engineers but they were increasingly dominated by the young and inexperienced ones albeit with Master or Doctorate degrees. The experienced leaders had extensive delegation from both the Program and the functional design units they represented to perform and co-ordinate design tasks. The young and less experienced leaders had less delegation from the TOP-Airplane Manager. Inexperienced leaders and engineering specialists also had little delegation from their functions to perform the tasks and also had to report to their experienced functional leaders. Consequently, the inexperienced TOP team leaders had problems in controlling engineering specialists within their teams as these specialists were closely supervised by more experienced functional leaders. Furthermore, the engineering specialists reallocated some analytical tasks (e.g. the finite element analysis) to other specialists controlled entirely by functional design units. Such analysis became a ‘black box’ for the TOP team leaders. They did not know how it actually proceeded. This raised some design variation concerns that contributed to the internalisation of engineering specialists in the next stage.

In supporting teams, the master phasing plan team was led by the PMO manager, a member of the core team. The design build process team was led by the Production Focal Point, a young engineer who held a Master degree. He had been given an extensive delegation to co-ordinate focal points from production-related divisions, but neither had
the authority nor direct access to control them as they were experienced focal points who also had extensive delegation from various functional units. As most of the members of this team were experienced engineers, he played a co-ordination role and maintained a collegial relationship. The advanced system development team was led by the experienced Head of CADCAM Division, who had extensive delegation from the Program Manager and significant influence over other members due to his seniority.

2) Communication and Decision Making Mechanisms:

The characteristics of communication and decision-making mechanism in this stage is summarised in Table 6-9. Formal communication, such as formal meetings and written reports were often used to deal with both increasing complexity of development process and increasing number of team members. Typically, each team had a weekly meeting complemented with minutes of meeting. The minutes were circulated to other teams.

Table 6-9: Communication and Decision-Making Mechanisms in Engineering Matrix Stage

<table>
<thead>
<tr>
<th>Core Team</th>
<th>TOP Teams</th>
<th>Master Phasing Plan Team</th>
<th>Design Build Process Team</th>
<th>Sidina Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Weekly meeting and some discussion</td>
<td>- Weekly meeting and some discussion</td>
<td>- Weekly meeting and some discussion</td>
<td>- Weekly meeting and some discussion</td>
<td></td>
</tr>
<tr>
<td>- Minutes of meeting</td>
<td>- Minutes of meeting</td>
<td>- Minutes of meeting</td>
<td>- Minutes of meeting</td>
<td></td>
</tr>
<tr>
<td>- Reports and memos</td>
<td>- Communication Memos</td>
<td>- Late, in batch after each section by section</td>
<td>- Early and batch type, section by section</td>
<td></td>
</tr>
<tr>
<td>- Mainly late, after all information gathered</td>
<td>- Early and on-line sharing of technical data</td>
<td>- Some release and use of ambiguous data</td>
<td>- Some release and use of ambiguous data</td>
<td></td>
</tr>
<tr>
<td>- Friendly and distant</td>
<td>- Friendly and some close</td>
<td>- Friendly and distant</td>
<td>- Friendly and close</td>
<td></td>
</tr>
<tr>
<td>- A few dialogue</td>
<td>- On the spot dialogue</td>
<td>- A few dialogue</td>
<td>- On the spot dialogue</td>
<td></td>
</tr>
<tr>
<td>- Relatively independent</td>
<td>- Interdependent</td>
<td>- Relatively independent</td>
<td>- Relatively independent</td>
<td></td>
</tr>
<tr>
<td>- Some identified with the Program</td>
<td>- Mainly identified with the Program</td>
<td>- Mainly identified with functional divisions</td>
<td>- Mainly identified with functional divisions</td>
<td></td>
</tr>
<tr>
<td>- On-line shared technical data, particularly within TOP teams and between ASDISidina and TOP teams</td>
<td>- Less collaborative except for within some TOP teams</td>
<td>- More distant, less dialogue, independent, and more functional or other identification rather than to Program</td>
<td>- Less collaborative except for within some TOP teams</td>
<td></td>
</tr>
<tr>
<td>- Some design decisions were influenced by functional design units (i.e. Technology Divisions)</td>
<td>- Lower level teams (i.e. TOP teams) increasingly had less authority in making decisions</td>
<td>- Decision made by lower level teams were mainly respected</td>
<td>- Decision made by lower level teams were mainly respected</td>
<td></td>
</tr>
<tr>
<td>- Increasingly high power differential perception between low-level teams and high-level teams</td>
<td>- Decreasingly high power differential perception between low-level teams and high-level teams</td>
<td>- Increasingly high power differential perception between low-level teams and high-level teams</td>
<td>- Decreasingly high power differential perception between low-level teams and high-level teams</td>
<td></td>
</tr>
</tbody>
</table>
In the core team, formal communication was dominated by weekly meetings and written reports. The information was communicated after the completion of tasks or decisions were made. Informal collaborative activities were less evident. Relationship among members was distant although friendly. Conflicts were not solved through dialogue. Resolution process typically depended on who had the most legitimate authority on the issue. Some members identified themselves with the Program but others, functional representatives in particular, remained loyal to functional units.

The middle level team and most of design-related TOP teams held regular weekly meetings. Within these teams, technical data was intensively shared through the computer system. To increase design compatibility, they also used communication memos to circulate design decisions to all members. A communication memo was a written medium in which a team listed both their design decisions and design commitments with other teams or engineering specialists. The release and use of uncertain technical data increasingly reduced. Engineers tended to consult their superiors before sharing the information with other members.

Within the TOP teams, the processes were dominated by informal collaboration. Lead Engineers typically worked together with other engineers. Engineers involved in the previous stage fostered friendly and close relationship among most members of the TOP teams. Conflicts were solved through dialogue and informal discussion. Collaboration across TOP teams was catalysed by engineers involved in more than one TOP team. Some members identified themselves to the Program but others remained identified to their functional design units.
Formal communication in three supporting teams was dominated by regular weekly meetings. In the master phasing plan team, communication occurred late, after each functional unit had worked out its plan. Although friendly to one another, members did not have close relationship, and therefore informal dialogue rarely occurred. In the design build process team and the advanced system development team, communication occurred early and in batches, one section at a time. These two teams were also collaborative. Some members had friendly and close relationship fostering by similarity in their occupations. Conflicts were often solved through informal discussion. As focal points, members of all supporting teams were relatively independent of each other and remained identified themselves to their functional units.

Inter-team communication was mainly characterised as formal. Co-ordination meetings and written reports were particularly used when involving the core team. The middle, operational and support teams mainly used meetings and the circulation of communication memos and minutes of meeting. The leaders of supporting teams usually attended the meetings of design-related TOP teams.

The matrix between TOP teams and engineering specialist groups allowed some analyses and design decisions to be outside the control of the Program teams and heavily influenced by the functional design units (i.e. Technology Divisions). Low level teams (i.e. the TOP teams and their sub-teams) initially had extensive authority in decision making. This authority was later reduced as inexperienced engineers involved in those teams increased. Their decisions also became less respected. Power differential between high-level and low-level teams increased which led to more dependent low-level teams.
6.4.2.3 Engineering Integration Stage (October 1996 – June 1997)

The engineering integration stage was marked by the new program structure (Figure 6-4) that internalised engineering specialists and functional representatives within the Program organisation. The internalisation involved merging the TOP teams and engineering specialists into the Program’s design integration teams. This was expected to eliminate the anxiety over the development process experienced by the members of design teams due to a dual reporting relationship of the matrix. The Program also internalised the marketing and customer support functions by appointing a Manager for Marketing and Customer Support. The organisation involved Sales, Operation, R&D, Procurement and Finance Co-ordinators who were representatives from functional units. To maintain the relationship with Prico, the Program also appointed a Prico Co-ordinator.

![Figure 6-4: PLI Program Structure in Engineering Integration Stage](image)

This structure was adopted by the Program Manager for several reasons including: (1)
dissatisfaction over the level of control gained by the PLI Program team for the tasks allocated to functional units, (2) the growing importance of the above functions as the Program progressed, and (3) the increasing urgency of facility investment and procurement issues. With this new organisation, design engineers were 'hired' from functional design units and reported only to the leaders of the PLI's design integration teams. To add design and technical expertise in the design teams, several technical advisers were contracted.

Similar to the TOP teams in the previous stage, the Airplane Integration Manager co-ordinated four component-based design integration teams: Body Integration, Wing Integration, System Integration, and Propulsion Integration teams, and the Configuration Management and Certification Department. Each team had several sub-teams with the same grouping as the previous TOP teams. The Configuration Management and Certification Department was responsible for engineering documentation to ensure the compliance with the regulatory standards.

Although administratively remained as the members of functional units, the Co-ordinators were appointed by the Program Manager. They did not participate directly in the development process. Their roles were to provide advice and to ensure the Program gained the necessary supports from their functional units. Their tasks typically involved co-ordinating functional activities for the Program. The R&D Co-ordinator linked the PLI Program and the functional design units (i.e. Technology divisions). Previously, this link was maintained through the matrix between the TOP teams and engineering specialist groups. With this new arrangement, the necessary matrix mechanism was moved from the operational teams into the core team. The R&D Co-ordinator became the
junction of the matrix between the Program and functional design units with espoused dual reporting relationship to the both of them, but remained primarily report to his functional unit.

The addition of the Operation Co-ordinator reflected the increasing activities in the production-related design build process team. Within this team, the Operation Co-ordinator formed four component-based production-related teams called TIP (stands for ‘tim integrasi produk’: product integration team): TIP Fuselage; TIP Wing; TIP Assembly and test; and TIP System. This Co-ordinator arranged a matrix between these TIP teams and production specialist groups, mirroring the matrix of the TOP teams and engineering specialist groups in the previous stage. Production specialist groups were supported by their respective functions from functional production units (i.e. Production Divisions), such as tooling engineering, quality engineering, manufacturing engineering, industrial engineering, and material processes. Activities in these production-related teams were actively pursued by the Operation Co-ordinator. These increasing activities in the production related aspects contributed to the change of the PLI program structure to balance the hierarchy and authority of design-related and production related teams which led to the next stage of the CE process in the PLI program.

Detailed analyses on CE initiatives from organisational integration aspect and communication and decision making mechanism aspect for this stage are as follows:

1) Organisational Integration:

The organisational integration initiatives in this stage is summarised in Table 6-10.
Table 6-10: Organisational Integration Characteristics in Engineering Integration Stage

<table>
<thead>
<tr>
<th>Cross-Functional Team</th>
<th>Size and Architecture</th>
<th>Three layers: core team, middle management team, and sub-teams</th>
<th>Scope:</th>
<th>Main Development Role</th>
<th>Support Role</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large, 100 people</td>
<td>Core team</td>
<td>Role</td>
<td>Full membership/representatives</td>
<td>Representatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Design Integration Teams</td>
<td>Functions Involved</td>
<td>Design, Production, Finance</td>
<td>Design functions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DSP and TIP teams</td>
<td>Procurement, Sales</td>
<td></td>
<td>Production functions</td>
</tr>
</tbody>
</table>

| Membership Pattern     | Cross-Functionality: | The size of the whole team expanded to over 100 people due to the inclusion of functional co-ordinators, internalisation engineering specialists, and expansion of the production-related design build team. Team's architecture was similar to the previous stage: a core team of the Program Manager and its direct subordinates; a design related middle level team of the Airplane Integration Manager and the leaders of design integration teams; and the operational level teams represented by design integration teams and their sub-teams. The core team and the design integration teams played the main role in the development process. The core team consisted of 11 members covering design, production, finance, sales, marketing, customer support, R&D, and procurement functions. Co-ordinators | 208 |
representing these functions typically held middle managerial positions in their functional units and performed both liaison and managerial tasks in co-ordinating support for the Program. Unlike the previous stage, all core team’s members were assigned permanently, fully dedicated to the Program and no longer had other responsibilities in their functional units.

In contrast with the previous stage, all leaders of design integration teams were full-time members of and fully dedicated to the Program. The internalisation of engineering specialists into the design integration teams changed the nature of membership of these design teams. Most engineering specialists, who previously were functional representatives, became full members and were fully dedicated to the Program. However, it did not significantly change the size, the architecture, or the scope of the design integration teams in comparison with the previous TOP teams.

The design build process team and its production-related TIP teams (i.e. Body, Wing, System, and Assembly and Test) were the only support teams that remained in the Program organisation. These teams involved 30 members, a significant increase from 14 members in the previous stage. Each TIP team had around 10 members. Typically, they performed both liaison and operational tasks (e.g. carried out preliminary assessment on design concepts). All members were functional representatives. Although administratively they were members of functional units, most were fully dedicated to the PLI Program. Their assignment was permanent and intended as a preparation for the production phase of the PLI. Production specialists often supported more than one TIP team, and therefore, created overlapping membership among these TIP teams.
**Heavyweightness:**

The Program Manager had increasingly gained power and influence over the product development process and resource allocation issues. He gained more direct access to control the PLI’s development process as all leaders of design integration teams were administratively members of the Program. The relative power of the Program Manager over functional units was demonstrated by the fact that he, and not the respective functional heads, chose and appointed the functional co-ordinators although those co-ordinators were administratively members of functional units. The PLI Program’s unique financial arrangement provided access to control and allocate program-funded facilities across functional units as only the Program reserved the right to assess and approve requests from functional units.

In the design integration teams, the hierarchical position and the seniority of their leaders remained the same as that of the leaders of TOP teams in the previous stage. The internalisation of engineering specialists made the engineers of the Program had full delegation to perform tasks that previously under the control of functional design units. This provided more authority to the leaders of design integration teams. However, some problems of controlling the development process remained for three reasons. Firstly, some members were not collocated due to the lack of adequate office space. Secondly, functional design units released only ‘second-class’ engineers to the Program. Thirdly, some engineers remained functional representatives ‘hired’ by the Program, and therefore, performance evaluation of these engineers were administered by functional design units. Due to their limited competence, members of design integration teams often turned back to their functional supervisors nearby for assistance in solving design
problems. As the Chief Engineer and one of the Design Centre members recalled:

[Technology Divisions] did not want to provide the best engineers and they did not like the idea of engineers being fully dedicated to and collocated in [the PLI Program]. (Robert, Chief Engineer, October 1997)

Everything is much easier now. The real challenge was during [the Engineering Matrix and Engineering Integration Stages]. We only had little authority and barely had facility ... We borrowed engineers [from Technology Divisions] but those engineers were not committed to the program. (Frank, Design Centre, November 1997)

In addition, most leaders of design integration teams were less experienced than their counterparts in functional design units. As a result, most leaders of design integration teams remained with less influential than their functional counterparts in the process carried out by engineering specialists.

In the design build team and production-related TIP teams, most leaders were middle managers in their functional units. Operation Co-ordinator had extensive delegation from the Program and his functional unit. The leaders of TIP teams had no hierarchical positions in the Program, and so has little authority to direct the process. Most were experienced engineers, some with a university degree. This seniority created some access to control the process through their influence. Similar to the previous stage, these leaders basically maintained collegial relationship and played co-ordinator roles.

2) Communication and Decision Making mechanisms

In general, communication and decision-making mechanisms, particularly involving the core team and design integration teams, remained the same as at the end of the previous stage. There was a significant change in the decision making process. Due to the internalisation of engineering specialists into the Program teams, the Program teams had
more control over development process and design decisions were less influenced by the functional design units. A few other changes included the increasing use of written communication, more identification self with the Program in the TIP teams, and the increasing in the use and release of more certain information in both design integration teams and production-related TIP teams as the product development proceeded and the results of analysis and engineering tests started to be made available.

6.4.2.4 Design-Production Coupling Stage (June 1997 – June 1999)

This stage corresponded with the beginning of the Program’s preliminary design phase and its termination in mid 1999. In line with the Indaco’s restructuring program, the PLI Program restructured its organisation to become an autonomous division internalising all functions necessary to develop and build the aircraft as parts of the Program. This program structure is provided in Figure 6-5.

![Figure 6-5: PLI Program Structure in Design-Production Coupling Stage](image-url)
Chapter 6: The Substance of Change: CE Implementation

The Program Manager adopted this structure for two reasons: (1) the continuing dissatisfaction over the Program’s ability to directly control some engineering activities as discussed previously, and (2) the increasing contribution of the production-related teams. The intention of this restructuring was to make the Program relatively independent from and did not rely on the support of functional units. With this internalisation, the selection and deployment of members, the evaluation of their performance and rewards, and their career path planning were administered and managed by the Program.

The main parts of the structure were the Design Centre and the Operation Centre. The Design Centre was led by a manager who also functioned as the Chief Engineer. The Chief Engineer was responsible for the design aspect of the Program. The Design Centre was the incarnation of the Design Integration teams of the previous stage and had the same four component-based Design Integration teams (Body, Wing, System, and Propulsion) and a Configuration Management Department.

The production-related Operation Centre was led by a manager who also functioned as the Chief of Operation. He was responsible for co-ordinating the production aspects of the Program. The Operation Centre can be considered as the incarnation of the previous design build process team and production-related TIP teams since most members of this Centre had been involved in those previous activities. The Operation Centre housed three functional departments: Production Planning, Facility Planning, and Quality Planning, and, as in the previous stage, four TIP teams: Body, Wing, Assembly and Test, and System and Propulsion. The Operation Centre focused its activities on the assembly of aircraft and components, for two reasons. Firstly, assembly was seen, particularly by the Chief of Operation, as the Centre’s core activity, while detail part manufacturing and
tooling activities might be 'out-sourced' either internally to Indaco’s Fabrication Division, or externally. This view was inspired by the global trend of outsourcing within the aircraft industry. Secondly, manufacturing and tooling concepts were technically defined by the assembly concept. Defining assembly concepts, in effect, means also broadly defining manufacturing and tooling concepts without wasting their resources for that purpose.

The design integration team and the production-related TIP team responsible for the same component were expected to work concurrently and interact directly. The Body Integration team and its sub-teams from the Design Centre, for example, would work concurrently with the TIP Body team and its sub-teams from the Operation Centre. The operational level structure of the Design Centre and Operation Centre in which this working relationship was expected to occur is illustrated in Figure 6-6.

![Figure 6-6: Operational Level Structure of the Design Centre and the Operation Centre](image-url)
However, the Program intention to be a truly autonomous division was not achieved. The engineers brought into the Design Centre were young and inexperienced, who typically either became dependent upon the expatriate technical advisers or would informally seek advice from experts in functional design units. On the operation side, the focus on assembly as the core activity had left the crucial tooling engineering and manufacturing functions outside the Operation Centre. These functions were vital in the development tasks currently undertaken by the Design Centre. In effect, the Design Centre often saw the Operation Centre as an unnecessary ‘bridge’ in interaction with those functions. This contributed to the increasing tension between the Design Centre and Operation Centre.

Furthermore, the rest of Indaco’s top management was not well informed about CE, the comprehensive plan to implement it in the PLI Program and its implications for the overall organisational working system. This lack of information had caused conflicts between the Program and the functional design units involved in the development process, which at this stage felt ‘locked out’ by the intention of the Program Manager for the PLI Program to become an autonomous division. This issue is discussed further in the next chapters.

The Indonesian economic crisis that started in July 1997 and peaked in early 1998 badly affected most Indonesian companies including both Indaco and Prico. In February 1998, the Program Manager released a directive that the Program would progress only until the completion of the preliminary design phase due to financial problems faced by Prico. In mid-December 1998, Prico’s shareholders decided to liquidate Prico. With this development, any prospect of continuing the PLI development program disappeared, at least until Indaco could find another source of finance. Consequently, the experience with
Chapter 6: The Substance of Change: CE Implementation

CE was also cut short.

Detailed analysis on each CE initiatives of organisational integration aspect and communication and decision making mechanism in this stage is as follows:

1) **Organisational Integration:**

The change in the Program structure had caused several changes in the characteristics of organisational integration as summarised in Table 6-11.

Table 6-11: Organisational Integration in Design-Production Coupling Stage

<table>
<thead>
<tr>
<th>Size and Architecture:</th>
<th>Large, over 130 people</th>
<th>Three layers: core team, middle management teams, and sub-teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope:</td>
<td></td>
<td>Design Centre and Design Integration teams</td>
</tr>
<tr>
<td>Role</td>
<td>Core team</td>
<td>Design Centre and Design Integration teams</td>
</tr>
<tr>
<td>- Level of Involvement</td>
<td>Full membership</td>
<td>Mainly full membership</td>
</tr>
<tr>
<td>- Functions Involved</td>
<td>Design, Production, Finance, Business</td>
<td>Design functions</td>
</tr>
<tr>
<td>Membership Pattern:</td>
<td></td>
<td>A few functional staff representatives</td>
</tr>
<tr>
<td>- Position</td>
<td>High and middle level</td>
<td>Full membership</td>
</tr>
<tr>
<td>- Activity</td>
<td>Managerial tasks</td>
<td>Full membership</td>
</tr>
<tr>
<td>- Dedication</td>
<td>Fully dedicated</td>
<td>Fully dedicated</td>
</tr>
<tr>
<td>- Temporal</td>
<td>Permanent</td>
<td>Permanent</td>
</tr>
<tr>
<td>- Multiple membership</td>
<td>Multiple membership within Integration teams</td>
<td>Multiple membership in/across TIPs</td>
</tr>
<tr>
<td>- Higher teams's composition</td>
<td>Include leaders of lower teams</td>
<td>Include leaders of lower teams</td>
</tr>
<tr>
<td>Hierarchical Position:</td>
<td></td>
<td>Equal to functional division</td>
</tr>
<tr>
<td>- Structural</td>
<td>Equal to functional division</td>
<td>Equal to functional department</td>
</tr>
<tr>
<td>- Authority</td>
<td>Extensive authority</td>
<td>Mainly little authority</td>
</tr>
<tr>
<td>- Access to Control</td>
<td>Extensive access to control</td>
<td>Extensive access to production activities</td>
</tr>
<tr>
<td>Program delegation</td>
<td>Extensive delegation</td>
<td>Little delegation</td>
</tr>
<tr>
<td>Functional delegation</td>
<td>Full delegation</td>
<td>Full delegation</td>
</tr>
<tr>
<td>Seniority:</td>
<td></td>
<td>Mainly young</td>
</tr>
<tr>
<td>- Age</td>
<td>Mainly young</td>
<td>Mainly mature</td>
</tr>
<tr>
<td>- Tenure &amp; Experience</td>
<td>Mainly inexperienced</td>
<td>Mainly experienced</td>
</tr>
<tr>
<td>- Education</td>
<td>Highly educated</td>
<td>Mixed of highly and less educated</td>
</tr>
</tbody>
</table>

**Cross-Functionality:**

The whole team expanded to more than 130 full-time members. It consisted of the core team, two middle level teams of the Design Centre and the Operation Centre, and operational level teams in both Centres (i.e. Design Integration teams and TIP teams).
The production-related Operation Centre had equal positions to the Design Centre as the main player in the development process. In the core team, the size was reduced to six members covering design, production, finance, and business functions. All members were full-members permanently assigned by the Program Manager and were fully dedicated to the PLI Program. Administratively, they belonged to the PLI Program.

The Design Centre had over 60 members covering design-related functions, such as configuration management, aerodynamics, load analysis, stress and fatigue analysis, structural design, system analysis, and system design. It had four design integration teams (i.e. Body, Wing, System, and Propulsion), each led by a supervisor. The Chief Engineer, Technical Adviser, and all supervisors of design integration teams comprised the middle level team of the Design Centre. This level mainly performed managerial tasks.

Each design integration team had around 15 members, and as in the previous stages, was divided into several sub-teams of 4-6 engineers, each led by a lead engineer. The Body Integration Team, for example, had four sub-teams: Nose Section, Mid-Section, Empennage, and Payload System. Initially, each design integration team covered all design-related functions. Later in 1998, the Chief Engineer moved all aerodynamic specialists from these teams to a separate group under his supervision in order to reduce aerodynamic inconsistency at the airplane level. Chief Engineer argued these specialists' involvement in design teams had exposed them to too many design constraints that led to aerodynamic inconsistency. This removal reduced the scope of design integration teams.

Most members of the Design Centre belonged and were fully dedicated to the Program except some system engineers who remained as functional representatives. Lead
engineers had operational responsibilities and worked at the operational level together with other members. The multiple membership occurred within a design integration team (i.e. across sub-teams in a design integration team) but not across teams. The involvement of supervisors of the design integration teams in the middle-level team created the interlocking structure between the high and low level teams.

The Operation Centre had over 35 members, covering most of production-related functions, such as production planning, industrial management, material and process development, facility planning and maintenance, quality engineering, and quality control. All members belonged and were fully dedicated to the Program. This centre consisted of three functional-based departments that housed the above specialist groups, and four product-based TIP teams (i.e. Body, Wing, System, Assembly and Test) each lead by a TIP co-ordinator. The Chief of Operation, supervisors of functional departments, and TIP co-ordinators comprised the middle level team of the Operation Centre.

The TIP teams performed and co-ordinated operational tasks related to their components. Initially, TIP co-ordinators reported to the Production Planning Supervisor, but later this reporting line was upgraded to the Chief of Operation. Each TIP team had around 10 members and was divided to sub-teams, each led by a lead engineer. Multiple membership was present within and across TIP teams as production specialists typically supported more than one team. Interlocking mechanism between the low and high level teams was provided by the involvement of TIP co-ordinators in the middle level team.

**Heavyweightness:**

Overall, the seniority of the program leaders remained the same as in the previous stage,
but some significant changes occurred in the hierarchical position and delegation dimensions. As the PLI Program became an autonomous division, the program management had full authority to perform and control tasks that previously, at least partly, under the control of functional units. The appointment of the Program Manager to also be the Director of the Airplane Group made him a member of the Executive Management Council. This significantly increased his 'influence'. Fabrication and assembly divisions that involved in the Program were part of this Airplane Group and, therefore, under his control. Furthermore, as an autonomous division, the Program had full discretion on functional issues.

In the Design Centre, the leaders of the design integration teams had equal supervisory positions as the department heads in functional design units. However, experienced leaders continued to leave the Program for two reasons: Firstly, they had already held managerial positions in functional design units and opted to remain there when the Program became an autonomous division. Secondly, they had conflict with the domineering Technical Adviser. This left an increasing number of inexperienced team leaders with little authority over technical decisions. Their authority was often overridden by the Technical Adviser in particular who made most decisions for them.

In the Operation Centre, the leaders of component-based TIP teams initially reported to the Supervisor of Production Planning Department. This provided them with less legitimate power than their TOP team counterparts from the Design Centre. Their source of influence was the 'residual' reputations from the previous occupation in functional units. Later, the position of TIP leaders was upgraded to become the staff of the Chief of Operation. However, they did not have the authority to control the work packages.
Chapter 6: The Substance of Change: CE Implementation

authorised to and carried out by a functional unit.

2) Communication and Decision Making Mechanisms

Characteristics of formal communication, collaboration, inter-team communication and decision-making mechanisms in this stage are summarised in Table 6-12.

Table 6-12: Communication and Decision-Making Mechanisms in Design-Production Coupling Stage

<table>
<thead>
<tr>
<th>Core Team</th>
<th>Design Centre</th>
<th>Operation Centre</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formal Communication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekly formal meeting</td>
<td>A few formal meetings</td>
<td>Weekly formal meeting</td>
</tr>
<tr>
<td>Minutes of meeting</td>
<td>Minutes of meeting</td>
<td>Minutes of meeting</td>
</tr>
<tr>
<td>Report documents, memoranda</td>
<td>Communication Memos</td>
<td>Communication Memos</td>
</tr>
<tr>
<td>Manly late, after all data gathered</td>
<td>Early and Online shared technical data</td>
<td>Early and batch type, by sections</td>
</tr>
<tr>
<td></td>
<td>Some released and used of ambiguous data</td>
<td>Some released and used of ambiguous data</td>
</tr>
<tr>
<td><strong>Collaboration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friendly and distant</td>
<td>Friendly and close</td>
<td>Friendly and close</td>
</tr>
<tr>
<td>A few dialogue</td>
<td>On the spot dialogue</td>
<td>On the spot dialogue</td>
</tr>
<tr>
<td>Relatively independent</td>
<td>Interdependent</td>
<td>Relatively independent</td>
</tr>
<tr>
<td>Self indentification with the program</td>
<td>Mainly indentification with program teams</td>
<td>Indentification with program</td>
</tr>
<tr>
<td><strong>Inter-team Communication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal Meetings</td>
<td>Formal meeting with minutes of meeting</td>
<td></td>
</tr>
<tr>
<td>Written reports, memos, routing of COM and minutes</td>
<td>Written reports, routing of minutes and communication memos (COMs)</td>
<td></td>
</tr>
<tr>
<td>Few collaboration, mainly one-way communication</td>
<td>Online shared technical information</td>
<td>Online shared technical information</td>
</tr>
<tr>
<td></td>
<td>Some collaboration in the beginning but reduced toward the end</td>
<td></td>
</tr>
<tr>
<td><strong>Decision Mechanism</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authority of making individual decision</td>
<td>Lower teams rarely made decision</td>
<td>Lower teams made decisions</td>
</tr>
<tr>
<td>Individual decisions were respected</td>
<td>Decisions they made often ignored</td>
<td>Their Decisions were respected</td>
</tr>
<tr>
<td>High power differential</td>
<td>High power differential</td>
<td>Low power differential</td>
</tr>
</tbody>
</table>

In the core team, formal communication was the same as in the previous stage: weekly meetings, and written reports. The two-way informal dialogue that characterised collaboration was rarely evident. Open conflicts were avoided rather than solved through dialogue. Conflicting perceptions about CE, the dissatisfaction over Sidina support, and the uncomfortable situation due to the domineering role of the Technical Adviser, for examples, although privately complained were never be discussed until the process had greatly deteriorated. Decisions individually made by members of the core team were respected as Program decisions. Due to the high power differential between the Program Manager and the rest of the core team, however, many of these decisions were referred to
the Program Manager for his approval.

Inter-team communication involving the core team was mainly formal: meetings, reports, minutes of meeting, and communication memos. Collaboration was non-existent. In particular, the Core team had a monthly review with the Design Centre, a monthly review with the Operation Centre, and a configuration review involving company-wide design functions. The objectives of these reviews were to evaluate the progress of design development and production preparation. Each meeting had on average 50 people in attendance. Meetings were characterised by one-way communication, either reports from supervisors to the Program Manager or directives from the Program Manager, without adequate open discussion on the issues presented. These meetings tended to be 'courtesy' meetings as a way of the Program Manager to show appreciation and to motivate his team members. Similarly, feedback from functional design units (i.e. Technology Divisions) in the configuration review was not documented and followed up.

Within the Design Centre, formal meetings were increasingly discouraged and regarded as 'a waste of time' by both Chief Engineer and Technical Adviser. Instead, on-the spot discussion was encouraged and fostered by the collocation, online information system, and the 'management by walking around' approach of the Chief Engineer. This discussion sometimes involved engineers from more than one design integration team. The results were formalised in communication memos and routed to other design integration teams and to the respective production-related TIP teams.

The members of a design integration team worked interdependently and most had identified themselves with their team. However, this collaboration was not extended
Across other design integration teams despite the proximity of their workplace. Instead, written communications were often used. Sensitive conflicting issues, such as over human resource allocation and task division, were resolved through the Chief Engineer. Most design integration teams had little authority and were often intervened by the Technical Adviser. Technical decisions or commitments made with their counterparts (e.g. production-related TIP teams) were often ignored or disregarded. Power differential between the Technical Adviser and the leaders of these design integration teams was strikingly high due to the Technical Adviser’s experience level (i.e. more than 40 years in aircraft industry) and the Program Manager’s reliance on him. On most occasions the decision making was characterised by ‘do as you are told’ situation.

Within the Operation Centre and its TIP teams, the characteristics of formal communication and collaboration mainly remained the same as in the previous stage. As all members belonged to the Program, they identified themselves with the Program. Inter-team communication across TIP teams mainly flowed through regular meetings chaired by Chief of Operation. Written reports were complemented with informal collaboration fostered by multiple membership and collocation. However, informal collaboration between Supervisors and the leaders of TIP teams was limited. They relied more on formal communication. The overlapping of tasks between the TIP teams and functional groups tended to create conflicts over accountability of those tasks. However, considered as sensitive, this issue was never brought into an open discussion.

Communication between the Design Centre and the Operation Centre was mainly formal: on-line information, reports, minutes of meeting, and communication memos. Initially, both Chief Engineer and Chief of Operation encouraged their members to collaborate.
Informal discussions between these two centres flourished. They had a weekly meeting chaired by the Chief of Operation, which involved tooling engineering, manufacturing planning and process development functions from the Fabrication Division. This, however, was reversed later in mid 1998 when the influential Technical Adviser urged the design engineers to concentrate on design tasks and regarded such interaction as ineffective and wasting designer's precious time. The Design Centre, therefore, reduced the level of its direct communication with the Operation Centre. It also started to directly communicate with the Fabrication Division arguing that the Operation Centre was ineffective. The Operation Centre was forced to communicate their manufacturability and producibility assessments to the Design Centre through written reports. The setback to this was that there was no channel for direct feedback from the Design Centre.

6.5 Discussion and Conclusion

In respect to the implementation of CE approach, four stages of the PL1 Program were identified: the program initiation, engineering matrix, engineering integration, and design-production coupling stages. The first program initiation stage represented the traditional sequential approach in which the development task was first assigned to a functional design unit (i.e. the New Product Development Department, Technology Division). The next stages reflected the progressive efforts to introduce CE into the Program modelling the CE initiatives from Westaco. Overall, despite the Program Manager's overt decision and encouragement to use the Westaco model, the CE initiatives that took form during each stage were often not consistent with the intended
Manager's overt decision and encouragement to use the Westaco model, the CE initiatives that took form during each stage were often not consistent with the intended model. In some cases, they moved further away as discussed later in this section.

Reviewing how the process unfolded over time, an additional finding could also be inferred: the CE structures were partially implemented and continuously modified to address the problems that arose throughout these stages. Variation between the intended Westaco model and what was emergent as the Indaco model is outlined in Table 6-13.

Table 6-13: Variation between the Intended Model and the Emergent Indaco Model

<table>
<thead>
<tr>
<th>CE Initiative and Dimension</th>
<th>Westaco</th>
<th>Indaco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size and Architecture</td>
<td>Large with core team and several levels of sub-teams</td>
<td>Increasingly large with core team and several levels of sub-teams</td>
</tr>
<tr>
<td>Role</td>
<td>Primarily based on specialisation</td>
<td>Primarily based on integrated and product</td>
</tr>
<tr>
<td>Level</td>
<td>Design functions in the main role, others in supporting role</td>
<td>Design functions in the main role, others in supporting role</td>
</tr>
<tr>
<td>Involved functions</td>
<td>Full membership, representative wide range company-wide functions, customers and</td>
<td>Changing from representatives to full member</td>
</tr>
<tr>
<td>Position</td>
<td>Staff and middle managerial level</td>
<td>Staff and middle managerial level</td>
</tr>
<tr>
<td>Member's activity</td>
<td>Operation and liaison</td>
<td>Operation and liaison</td>
</tr>
<tr>
<td>Temporal</td>
<td>Permanent</td>
<td>Increasingly permanent</td>
</tr>
<tr>
<td>Multiple membership</td>
<td>Some members were part of more than one team</td>
<td>Some members were part of more than one team</td>
</tr>
<tr>
<td>Higher team's composition</td>
<td>Lower team leaders were part of higher teams</td>
<td>Lower team leaders were part of higher teams</td>
</tr>
<tr>
<td>Hierarchical Position</td>
<td>Equal to functional division</td>
<td>Equal to functional division</td>
</tr>
<tr>
<td>Formal Authority</td>
<td>Extensive authority and control</td>
<td>Extensive authority but limited control until the last stage</td>
</tr>
<tr>
<td>Delegation</td>
<td>Extensive to all members</td>
<td>Extensive only to senior/expertised members</td>
</tr>
<tr>
<td>Seniority</td>
<td>Senior leaders</td>
<td>Increasingly junior leaders</td>
</tr>
<tr>
<td>Tenure</td>
<td>Senior engineers</td>
<td>Increasingly junior leaders and engineers</td>
</tr>
<tr>
<td>Age</td>
<td>Highly educated</td>
<td>Highly educated in design teams, mixed in operation teams</td>
</tr>
<tr>
<td>Education</td>
<td>Integrated computer-based media for sharing technical data</td>
<td>Adhoc and unintegrated computer-based media</td>
</tr>
<tr>
<td>Frequency</td>
<td>Several levels of systematically arranged regular meeting</td>
<td>Mainly weekly meetings, reports and memos</td>
</tr>
<tr>
<td>Direction</td>
<td>With extensive discussion and minutes of meeting</td>
<td>Based on preference of team members</td>
</tr>
<tr>
<td>Timing</td>
<td>Early at the beginning of the process</td>
<td>Adhoc and unintegrated computer-based media</td>
</tr>
<tr>
<td>Released</td>
<td>Ambiguous data released and used</td>
<td>Ambiguous data released and used</td>
</tr>
<tr>
<td>Used</td>
<td>But became more certain during the process</td>
<td>But became more certain during the process</td>
</tr>
<tr>
<td>Interaction</td>
<td>Collaborative at all levels characterised by</td>
<td>Collaborative at all levels characterised by</td>
</tr>
<tr>
<td>Confidat Management</td>
<td>Close and friendly interaction to achieve program's goal</td>
<td>Close and friendly interaction to achieve program's goal</td>
</tr>
<tr>
<td>Collective goals</td>
<td>Dialogue to solve problems in interdependent work, fostered by interdepartmental processes and social activities</td>
<td>Extensively less collaborative although the degree of close and friendly interaction varied between teams</td>
</tr>
<tr>
<td>Shared wares</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formal Communication</td>
<td>Formal and informal</td>
<td>Mainly used formal communication</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Intensive, triggered by formal and informal communication</td>
<td>Intensive, triggered by formal and informal communication</td>
</tr>
<tr>
<td>Program - Function</td>
<td>Semi autonomous matrix structure</td>
<td>Autonomous design team through stages of semi autonomous to autonomous design-production teams</td>
</tr>
<tr>
<td>High level - Low level</td>
<td>Lower teams had extensive authority</td>
<td>Lower teams increasingly had less authority</td>
</tr>
<tr>
<td>Respect to lower teams</td>
<td>Lower teams' decisions were respected by higher teams</td>
<td>Lower team decisions were increasingly being ignored</td>
</tr>
<tr>
<td>Power differential</td>
<td>Low power differential between higher and lower teams</td>
<td>High power differential between higher and lower teams</td>
</tr>
</tbody>
</table>
6.5.1 Organisational Integration

In general, total organisational integration was never achieved in the PLI Program. CE initiatives in organisational integration evolved to become two parallel design and production ‘teams’ under the single integrated umbrella of the ‘program team’:

1) The formation of the design-related TOP teams in the engineering matrix stage, led to the establishment of design integration teams in the engineering integration stage, and later the Design Centre in the design production coupling stage.

2) The formation of the production-related design build process team in the engineering matrix stage led to the appointment of the Production Co-ordinators to co-ordinate design build process team and its production-related, component-based TIP teams activities in engineering integration stage, and later the creation of an Operation Centre in the design-production coupling stage.

While the design-related teams had played the main role in the product development process since the beginning, the production-related teams started as supporting participants and gradually established themselves as more central participants alongside the design teams.

This arrangement of two sets of parallel design and production teams was different from Westaco’s DRX model that integrated both production and design engineering into integrated development teams from the outset. However, considering that both design and production functions consisted of various sub-functions which previously worked within a rigid sequential process, even this movement toward two functional-related teams was a significant change in Indaco and raised major organisational and managerial issues,
particularly in terms of co-ordination and interaction with supporting functional units. The abandonment of the matrix structures of the engineering matrix and engineering integration stages in favour of more autonomous program teams in the design-production coupling stage can be seen as an effort to reduce those problems.

This decision to eliminate matrix arrangement was inconsistent and, even, moved away from the Westaco model. While having a large degree of independence and authority over the product performance and program management, Westaco’s development teams always maintained their relationship with functional units through various forms of matrix mechanism. This relationship was very important, particularly in providing a technological competitive edge for the product. Giving the nature of technological uncertainty within the industry, the technological core competency was too complex to be maintained entirely by the management of a development program. At Indaco, the pitfalls of abandoning the matrix mechanism were apparent. The Program teams struggled with design, manufacturing and communication problems throughout the later stages. Most of this was due to the lack of competency of the team members.

1) Cross-Functional Team

Following the Westaco model, from the engineering matrix stage the PLI Program was divided into several horizontal sub-groupings accompanied by the hierarchical arrangement of a core team and two levels of product-based teams: middle management and operational teams. In this stage, the main part of the PLI Program only involved design-engineering functions. This arrangement resembled more closely the PLX rather than the DRX model, but had much weaker support from other functional units in forms
of functional focal points rather than functional representatives. In the engineering integration stage, support from some non-design functions (i.e. Production, Procurement, Sales, and Finance) became more adequate as their representatives became part of the program's core team as functional Co-ordinators (e.g. Production Co-ordinator). At the design-production coupling stage, the whole production-related functions, not only the Co-ordinator, became the main part of the PLI Program. However, instead of forming an integrated development team as in the DRX Program, the PLI Program established two separate groupings primarily based on functional specialisation (i.e. design and production functions).

Unlike the Westaco model, most additional members brought into the PLI Program at the engineering matrix and engineering integration stages were temporary and not fully dedicated to the Program. In contrast, members became permanent and fully dedicated to the Program in the design-production coupling stage. However, with the total abandonment of matrix arrangement they were also totally independent from the functional units. Following the Westaco models, the interlocking mechanism of the PLI teams was created by incorporating leaders and key members of the design and production teams to the higher level teams. At Indaco, however, this arrangement was not fully supported by complementary initiatives in the communication and decision-making mechanisms.

2) Heavyweight Management

Similar to the Westaco model, the PLI Program Manager enjoyed a high level position, at least equivalent with his counterparts in functional units. However, unlike Westaco's
Program Managers, his seniority in terms of experience and tenure were less than the heads of functional units. A similar situation also occurred at the lower level teams. Most supervisors and lead engineers were significantly more junior than their counterparts in functional units. The situation was worsened by the elimination of the matrix mechanism between the Program and functional units in engineering integration and design-production coupling stages. Many senior engineers, particularly from design-related functions, opted to leave their positions in the Program and stay in their functional units. They were substituted by more junior members. This was contradictory to the Westaco model, which, according to one ex-intern, selected only experienced engineers for the team.

Like the Westaco model, since the adoption of CE (i.e. engineering matrix stage) the PLI’s Program Manager had extensive authority to perform and control the development tasks. He also had significant authority over the budget and resource allocation. However, unlike the Westaco model, this authority was not delegated further down to the lower level teams. Instead, most leaders of the operational teams (i.e. design integration teams) often had difficulties in asserting design decisions on their respective components. All budget and resource allocation issues had to be channelled back to the core team for decisions.

On the other hand, inexperienced engineers and representatives from functional units had little delegation from their units and had to refer their analyses and decisions back to their respective functional managers for further direction. As the result, the relatively inexperienced leaders of the Program teams encountered difficulty in directing and controlling the activities of these members. These difficulties were partly reduced by
abandoning the matrix of TOP – engineering specialist groups and instead internalising engineering specialists as part of the Program teams in the engineering integration stage.

In the design-production coupling stage, as an autonomous division the Program had full delegation from functional units. However, the number of inexperienced lead engineers and supervisors increased. They had little delegation from the Program’s core team and had to refer most of technical decisions to members of higher level teams (i.e. Technical Adviser or Chief Engineer) for validation.

6.5.2 Communication and Decision-Making Mechanisms

1) Formal Communication

Like the Westaco model, the PLI Program used a combination of formal meetings, written documents and a computer-based system for technical information. However, unlike Westaco model that set up communication media to bridge various levels of Program teams, various communication media in the PLI Program were not so well integrated. Rather, they were ad-hoc and based on preferences within various teams. The Design Centre, for example, preferred a more informal medium (e.g. ‘on the spot discussion’, ‘management by walking around’) while the Operation Centre opted for communication by a more formal one (e.g. meetings, written reports). Most of the time, therefore, these various formal, informal and computer-based communications worked separately as a stand-alone medium and their integration were ad-hoc.
2) Collaboration

Similar to the Westaco model, informal collaboration within each of the operational design integration teams was relatively high, particularly within the ‘backbone’ engineers who had worked on the PLI since the beginning. The collaboration within each of the production teams was also relatively high. However, unlike the Westaco model, such collaboration was less evident within the higher level teams.

3) Inter-Team Communication

Unlike the Westaco model, inter-team collaboration remained less evident, despite all efforts and mechanisms (e.g. collocation, computer system) to enhance across-team integration. Conflicts between design integration teams in the Design Centre, for example, tended to be handed to the Chief Engineer for resolution. Since the beginning, the relationship between design-related and production-related teams had also been distant and sporadic. Even though there were times during which these two separate functional teams enjoyed a fairly good relationship and collaboration started to develop, particularly at the beginning of design-production coupling stage, a later development showed that they drifted apart due to the influence of the Technical Adviser.

Unlike the Westaco model that, as suggested by some published reports⁸, had vertical dialogue in their meetings, which often extended into collaboration outside the meeting, vertical communication in the PLI Program tended to be formal and characterised by one-way communication. Often, the meetings were used as a reporting medium that could

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⁸ Due to confidentiality concerns, these reports cannot be revealed in the references
easily and more effectively have been carried out using written communication.

4) Decision-Making Mechanism

Unlike the Westaco model that respected decisions made by low-level teams, in the PLI Program most of the design decisions were made at the higher level (e.g. by members of the core team). This was partly due to the relatively junior status of the Program members and lead engineers. At the program initiation stage this was considered as appropriate as the engineers saw the task as an ‘exercise’. At the engineering matrix and engineering integration stages, decisions of a few experienced lead engineers were highly respected by the higher level teams. However, at the design-production coupling stage most design integration teams had experienced their decisions, often made with collaboration with other teams, being disregarded and ignored.

6.5.3 Structure Lagging behind the Process

Unlike the Westaco model that systematically set up all the structures and protocols from the outset, the PLI Program followed a more ad-hoc emergent process. The program structure was incrementally adjusted based on current activities. The findings showed that the organisational structures set for the Program throughout the stages were continuously lagging behind the process they supposedly supported. This lagging phenomenon can be seen in all three structures applied after introducing CE in the Program and was seemingly part of the reason to change from one structure to another.

In the engineering matrix stage, the structure was adopted from the concept established in
the program initiation stage in which the Program was part of the Technology Division. The matrix arrangement, therefore, involved only various design-engineering functions and did not include other functions required for several tasks during this stage. Marketing, Sales and Finance functions required for carrying out cost estimation and feasibility study, for example, were not included in the program structure. The PLI Program, therefore, became dependent on those 'external' functions.

As the co-ordination tasks with those functions became more demanding, the Program moved to an integration structure that involved Sales, Finance, Production and Procurement Co-ordinators within the program structure, and hence moved to the engineering integration stage. However, the issues around the feasibility study and financial scheme soon decreased after the establishment of Prico. The Program started to face design and production interface issues. In this stage, these issues were tackled by the production-related teams (i.e. the design build process team and the production-related TIP teams) and initially channelled through the Production Co-ordinator. As the relevance of these issues increased due to the development progress, the Program Manager emphasised the need to bring the production to the same status as design functions. This led to the design-production coupling stage in which the Program established two centres: the Design Centre and the (Production) Operation Centre.

In this latest stage, Chiefs of both Centres continuously stressed that the two centres should be regarded as one in the development process. However, there was no sense of clear direction on how to achieve it in a systematic way. Some engineers, particularly from the Operation Centre, expressed concerns over the lack of a common systematic
protocol of CE implementation through all development phases to ensure synchronised activities and they urged a more serious and substantial discussion over the issue. The Program never did tackle this issue.

6.5.4 Conclusion

The framework used in this study places the CE approach introduced to an organisation as the substance of change that underwent a change process through which it was shaped and adapted by the contextual and political factors of the organisation. The longitudinal case study of introducing CE in the Indaco's PLI Program indicates that despite the intention to apply a particular model of CE, the change process had caused different models to emerge during the process and these did not necessarily comply nor show a clear direction toward the intended model.

Furthermore, the analysis of CE initiatives in both Westaco, from which the intended CE was adopted, and Indaco, to which CE was introduced, showed that there was no single model of CE. Rather, there is a wide range variation of CE implementation. It varies in to which initiatives being applied and focused. The application of any initiative also varies in the characteristics of its dimensions and sub-dimensions. The characteristics of one CE initiative may inter-relate with or constrain the characteristics of the other. This set of initiatives and their characteristics defines a particular CE in a particular product development program.

Although Indaco had established a 'CE-like' structure (i.e. cross-functional team
complemented with heavyweight management) similar to the intended model since the beginning of the CE introduction, the organisational structure, team's architecture, scope and level of functional involvement, team membership pattern, as well as the nature of delegation and authority of team leaders were all changed over time to fit in with one another and with their surrounding circumstances. This ‘CE-like’ structure and the availability of computer support system did not necessarily lead to the ‘CE-like’ communication and decision making process. Ironically, the communication and decision making mechanism prior to CE introduction (i.e. program initiation stage) showed more resemblance to the intended model than such mechanisms in other stages.

As we shall see in the next chapter, a number of factors were influential in creating these changing characteristics across the stages. Detailed analysis of each stage in this chapter has revealed that the most significant factors were the shortage of competent engineers, the absence of clear direction on the approach to be applied, the strong and dominant design engineering culture, the rigidity of functional compartmentalisation, and the cultural tendencies associated with personal and group interaction. These factors were affected by the context and politics of the organisation.
INTRODUCING CONCURRENT ENGINEERING

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A PROCESSUAL ANALYSIS

A thesis submitted in fulfilment of the requirements for the award of the degree

Doctor of Philosophy

from

UNIVERSITY OF WOLLONGONG

by

Zuhriati Zainuddin

Department of Management

2001
Chapter 7: Contextual Explanation of Change

CHAPTER 7

CONTEXTUAL EXPLANATION OF CHANGE

7.1 Introduction

The previous Chapter 6 discusses the change process of how CE in the PLI Program developed over time, through which CE continuously changed and transformed. This transformation tended to deviate from the intended CE modelled after the Westaco’s CE. This transformation process started from a relatively traditional program initiation stage, followed by the injection of a Westaco model for CE, and three subsequent stages of engineering matrix, engineering integration, and design-production coupling, each more or less extensive introducing elements of the Westaco model.

The analysis of the substance of change in this CE case reveals the complex multidimensional characters of organisational integration and communication and decision-making mechanisms. At each stage, the degree of integration increased in some ways but was weakened or remained less strong in other ways. The scope of functions represented in various teams of the Program, the vertical control of those who comprised the teams, their degree of expertise, and teams’ authority varied in these stages.
Chapter 7: Contextual Explanation of Change

This study aims to provide some explanation of these complex changes. The main factors considered are:

1) the 'inner' contextual factors within the substance of change;
2) the 'outer' contextual factors in the wider organisational context; and
3) the organisational politics surrounding their implementation.

This chapter focuses on contextual factors both within the substance of change and in the wider organisational context. The organisational politics is discussed in Chapter 8.

As outlined in Chapter 2, the overall substance of change consists of several interrelated sub-processes that undergo a process of change. Due to their interrelationship, any one sub-process has the other sub-processes as a 'context'. The holistic feature of processual approach (Pettigrew, 1997) implies that it may not be possible to establish a single direct cause for a change, rather it provides a holistic analysis across several levels of context about what might be the factors and how they contribute to the change. Hence, one contextual factor might influence changes in several sub-processes and a contextual factor from the outer level might influence different level of the inner layers.

In this case study, the focus is on CE initiatives in (internal) organisational integration and communication and decision-making mechanism sub-process. Consequently, other CE initiatives in enabling technology, external integration, and human resources are seen as 'contextual factors' that influencing those main focal initiatives. These factors are referred as 'the contextual factors within the substance of change' or 'the inner contextual factors'. The wider organisational context in this study refers to other internal factors that influenced and were, in turn, influenced by the CE initiatives. These factors include the company's organisational structure and co-ordination.
mechanism, organisational culture and sub-culture, and stage of development. Because they are not the target of the change initiative, these factors are more stable than factors in the inner context.

The first part of this chapter analyses the contribution of each of 'inner contextual factors' (i.e. CE initiatives in enabling technology, external integration and human resources) on the changing shape of internal integration and communication and decision-making mechanisms. The analysis of the change process has revealed the most significant inner contextual factors were the lack of competent human resources available for assignment to the PLI Program and the lack of systematic protocols which could guide the Program in implementing CE.

The second part discusses the contribution of each factor in the organisational context (i.e. organisational structure, culture, sub-cultures, and stage of development) at Indaco's CE initiatives in the PLI Program. This analysis reveals the role of the nature of Indaco's organisational structure and mechanism in the continuous problems in carrying out heavyweight matrix program organisation that led to the formation of an autonomous program division. The analysis also shows that difficulty in organisational integration and communication initiatives, particularly between the important production and design functions, was stemmed from the history of Indaco that had created a culture that emphasised design engineering.

This chapter is arranged as follows: Section 7.2 provides a brief description of CE initiatives in enabling technology (i.e. computer-based technology, CE tools and methods, and collocation), external integration (i.e. supplier and customer involvement), and human resources (i.e. CE-related training and human resource policies) in Indaco and their intended model from Westaco. The effect of these
initiatives on the internal organisational integration and communication and decision-making mechanisms are also briefly discussed. As the analysis of the case study has revealed the importance of initiatives in systematic protocols and human resource competency, Sections 7.3 and 7.4 are dedicated to these two initiatives. Section 7.3 discusses the contribution of the lack of competent human resource in the change process. Chapter 7.4 discusses the contribution of the lack of systematic protocols. Section 7.5 discusses the contribution of the wider organisational context in the Indaco's CE. Section 7.6 provides a summary.

### 7.2 CE Initiatives in Enabling Technology, External Integration and Human Resources

By focusing on the organisational integration and communication and decision-making mechanisms, the nature of initiatives in enabling technology, external integration and human resources become the changing contextual factors within the substance of change that affect the change. This section discusses the nature of these initiatives in Indaco, compares them with those in Westaco, and outlines their contribution on the complex transformation. The summary of these discussions is outlined in Table 7-1.

#### 7.2.1 Enabling Technology

This section briefly discusses three CE initiatives in enabling technology: computer-based technology, CE tools and methods, and collocation. The other initiative, namely systematic protocols, is discussed in detail in Section 7.4.
### Table 7-1: Contribution of Initiatives in Enabling Technology, External Integration, and Human Resources

<table>
<thead>
<tr>
<th>CE Initiative</th>
<th>Organisational Integration</th>
<th>Communication and Decision Making Mechanisms</th>
<th>Other Effects</th>
</tr>
</thead>
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<tr>
<td><strong>Computer-based Technology</strong></td>
<td>- poorly integrated system&lt;br&gt;- inadequate capacity&lt;br&gt;- technical &amp; compatibility problems&lt;br&gt;- little involvement of program members in the pilot project</td>
<td>- not conducive for effective cross-functional team in later stages&lt;br&gt;- limited on-line shared data throughout stages mainly within design functions&lt;br&gt;- less efficient communication across team in later stages</td>
<td>- limited communication between developers and users led to less user-friendly application, conflict and distrust</td>
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<tr>
<td><strong>CE Tools and Methods</strong></td>
<td>- embedded in the system&lt;br&gt;- manufacturability/productivity</td>
<td>- increasing role of production-related functions throughout stages&lt;br&gt;- foster early design/production communication in Engineering Matrix stage</td>
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<tr>
<td><strong>Collaboration</strong></td>
<td>- full collocation at isolation stage&lt;br&gt;- partial collocation at the engineering matrix and engineering integration stage&lt;br&gt;- train wagon and exclusion of some functions at the last stage</td>
<td>- from mixed part/full dedicated members in engineering matrix stage to many dedicated in last 2 stages&lt;br&gt;- high collaboration within teams across stages&lt;br&gt;- low collaboration across teams&lt;br&gt;- increasingly self association to the program</td>
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<tr>
<td>*<em>Systematic Protocols</em></td>
<td>- absence protocols and implementation plan&lt;br&gt;- under developed standard manuals&lt;br&gt;- under developed operating procedures&lt;br&gt;- absence of clear exit criteria and deliverables</td>
<td>- partly contribute to changing structure and arrangement throughout stages&lt;br&gt;- changing scope and membership pattern of design teams in the last two stages&lt;br&gt;- increasing lack of authority lower teams in the last two stages&lt;br&gt;- slide back to traditional/functional arrangement in the Design Centre in the Design-Production Coupling stage</td>
<td>- ineffective utilisation of support system&lt;br&gt;- no trust for collaboration across team&lt;br&gt;- reduced communication across team&lt;br&gt;- chaotic communication modes&lt;br&gt;- more dependent lower team&lt;br&gt;- expectation mismatch, disappointments and conflicts between the program and functional units&lt;br&gt;- anxiety, chaos, distrust within and between Design and Operation Centres&lt;br&gt;- imposed non-CE approach&lt;br&gt;- lack of CE-related training</td>
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<tr>
<td><strong>External Integration</strong></td>
<td>- mainly absence of customer and supplier involvement&lt;br&gt;- no significant effect during the phase under study</td>
<td>- no significant effect during the phase under study</td>
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<tr>
<td>*<em>Compliance</em></td>
<td>- increasingly lack of competence particularly in design-related members&lt;br&gt;- many young, educated but inexperienced design-related members&lt;br&gt;- many mature, experienced production-related members&lt;br&gt;- many young team leaders</td>
<td>- changing structure and arrangement throughout stages&lt;br&gt;- changing the membership pattern of cross functional teams throughout stages&lt;br&gt;- changing the nature of delegation to members and lower level teams&lt;br&gt;- changing the seniority level of members&lt;br&gt;- hamper total integration between design and production related functions</td>
<td>- poor communication between the program and functional units&lt;br&gt;- increasing high power differential between lower and higher teams in three last stages&lt;br&gt;- reduced communication and collaboration between Design and Operation Centres in the Design-Production Coupling stage&lt;br&gt;- lower teams rarely made decisions and were often ignored and intervened</td>
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<tr>
<td><strong>CE Related Training</strong></td>
<td>- almost absence pilot project&lt;br&gt;- pilot projects involved a few members</td>
<td>- slideback to traditional/functional arrangement in the last stage&lt;br&gt;- hamper inter-team communication&lt;br&gt;- not conducive for collaboration</td>
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<tr>
<td><strong>Human Resource Policies</strong></td>
<td>- functional based/reward system&lt;br&gt;- individual-based performance evaluation</td>
<td>- little access to control representatives during the Engineering Matrix and Engineering Integration stages</td>
<td>- identification with the functional units prior to the Design-Production Coupling stage</td>
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*I discussed further in the next sections*

### 7.2.1.1 Computer-Based Technology

Modelled the Westaco’s CE, Indaco relied heavily on advanced computer-based technology as the enabler for CE implementation. Initiatives in enabling technology were directed toward a paperless design that relied heavily on the availability of state-of-the-art computer technology. However, the development of a computer support
system for the PLI Program was not well integrated into the design and development process and dissatisfied most of the leaders of the program teams.

The computer technology that supports design integration, such as CAD/CAM, 3-D CAD, and CATIA, had been available in Indaco for several years. In addition, the PLI Program Manager, together with the CADCAM Division, established the Sidina group to develop an integrated computer system to support CE in the Program. The main features of the Sidina system were an integrated database, on-line data sharing, an integrated application system, and a digitally controlled product configuration. This included the following initiatives:

1) Fully digital product definition in three-dimensional using CATIA system.

2) Digital mock-up, including digital pre-assembly that electronically simulated assembly of all parts/tools to check the possible fit and interference, and a digital assembly sequence that electronically simulated the assembly of components to optimise the assembly sequence.

3) A product data management system that stored and maintained all product definition data in a single electronic database throughout all phases of the design-build-support process.

4) A distributed computing system that distributed computer power and data to work areas through networked workstations to provide higher performance and availability as well as independency and flexibility.

In preparation to implement this enabling technology, the Sidina group ran two pilot projects: a CE simulation with the application of digital product development and cross-functional team; and a knowledge-based engineering system application to accelerate design process for the PLI Program. These pilot projects paid great
attention to the infrastructure of the support system but mainly ignored organisational and human resource issues. At the time of the field study, i.e. October 1997, the CE pilot project, using the redesign of PLP’s door as the case study, was just finished.

Sidina initiatives, to a large extent, mimicked the enabling technology in Westaco. However, according to an ex-intern that had experience at Westaco, the memory capacity of the computer system was far less than the capacity available in Westaco. This caused prolonged processing time and continuous technical problems. Further, unlike Westaco’s support system that was mainly developed in-house combining the development of the computer technology with Westaco’s cumulative experience and facilities, the Indaco support system relied entirely on what was available and offered by its computer and system development suppliers.

Overall, the computer-based technology in Indaco was not as developed as in Westaco. There were problems partly brought about by the lack of technological capacity and the lack of integration between the technical group developing the support system and the members of the PLI Program. Since the Program was still in its preliminary phase, it was hard to see the impact of the state of these initiatives to the overall performance of the PLI Program. To date, nevertheless, it contributed to less efficient communication particularly for non-design functions since the on-line data were only shared between the design-related functions. Tooling engineering, for example, had difficulties to fully utilise the on-line data from the computer system. This contributed to a lack of support for effective cross-functional integration and to a lesser degree of internal organisational integration.

The use of a non-PLI component as the object of the CE pilot project meant only a few members of the PLI Program were involved. Hence, the CE pilot project did not
provide the hands-on cross-functional team experience as intended for most members of the Program team. Interaction between the system developer (i.e. the Sidina group) and its users (i.e. the Design and Operation Centres) which necessary to ensure a user-friendly system application, also limited. As the result, engineers from both Centres often complained that the Sidina did not provide adequate support.

7.2.1.2 Collocation

As in Westaco, physical collocation was also used to support CE in Indaco. Indaco and Westaco both started with partial collocation involving only design-related functions and then extended to other functions. In Indaco, collocation was a matter of gradual introduction and retained some elements of traditional office division. However, collocation itself did not lead to total integration. Despite the ‘open plan working space system’ adopted in the collocation area, there was a clear separation between one team to another.

At the Initiation stage, all team members worked in one location as part of the New Product Development (NPD) Department. A need for collocation was suggested by the Program Manager in the engineering matrix stage. But, new members that joined the program remained in their original functional locations. As the number of involved members extended from 23 to more than 100 people in the beginning of design-production coupling stage and the single collocation area was not yet available, the relative number of collocated members reduced from 100% in the initiation stage to about 25%. The partial collocation of ex-NPD group which remained mostly intact throughout all stages had contributed to the high level of

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1 for example in the Coordination Forum between the Design and Operation Centres
collaboration within some of design teams, but this was not enough to foster collaboration across teams when the number grew.

At the beginning of the design-production coupling stage (June, 1997), most members of the Design Centre were collocated in one area in the Technology Centre Building. Each design integration team was clustered in an ‘open-plan’ office. Except for the Chief Engineer and a meeting room, there were no real barrier between groups other than desks, filing cabinets, and drawing boards. Later, the Chief Engineer separated the aerodynamic specialists from the design integration teams and located them in a different room. Members of the Operation Centre occupied several rooms on different floor. They clustered according to their positions in the Program’s hierarchy. Supervisors occupied one room, TIP Leaders and other members occupied another bigger room. The Chief of Operation had his own room separated from these two. Functional representatives from tooling engineering, manufacturing development and manufacturing planning were in their functional offices. The Program Manager and other members were in the Management Centre Building. These office locations of various program members are illustrated in Figure 7-1.

In May 1998, both the Design Centre and Operation Centre moved into another location, i.e. Training Centre Building, with a larger space that had been prepared specifically for collocation. The office layout of the new collocation area, which some members coined as ‘the wagon train’ for the obvious reason, is in Figure 7-2. Besides the convenience that they were on the same floor with adequate computer facilities, the layout mirrored their previous space allocation. Walls bordered the Design Centre and the Operation Centre and between groups in the Design Centre. Tooling and manufacturing engineers were excluded and remained in their functional locations.
This situation played a role in changing the status of some of them from fully-dedicated to partly dedicated to the program.

The partial collocation was partly caused by hesitancy of the functional design units (i.e. Technology Divisions) to collocate their assigned members due to the limited number of their competent specialists. The above computerised enabling technology initiative was often used by functional units as an excuse for not collocating design representatives as they could have shared the information online through ‘virtual
Figure 7.2: Layout of the Collocation Area in May 1998
collocation’. This hesitation added to the tension between the PLI Program and the functional design units over human resource issues. It also contributed to the failure to achieve organisational integration through the matrix mechanism during the engineering matrix stage. This led to changes in the Program’s organisational structure.

The single collocation area for both the Design Centre and the Operation Centre in the design-production coupling stage did not significantly increase the degree of inter-team communication within and across the two Centres. The nature of layout and cluster (i.e. train wagon, functional-based clusters) seemingly contributed to this modest effect of the collocation initiative in organisational integration and communication and decision-making mechanism.

7.2.1.3 Formal CE Methods

Both Westaco and Indaco did not include any formal CE methods in their initiatives. Nevertheless, the purpose of these methods, to some extent, was embedded in their design process and computer support system. In Westaco, CE tools and methods were well captured, either in the design process standard manuals/procedures or in their computer-based technology enablers, and integrated with their CE applications. The digital pre-assembly application, for example, focused on easy fabrication and assembly as suggested by DFA/DFMA methods. Another example was the addition of manufacturing engineers in the approval process prior to the formal release of drawing. Previously, the approval process only listed design, stress analysis, and material technology engineers.
Formal methods as described in CE literature, such as DFM/A and QFD were not evident in the Indaco’s PLI Program, but similar to the Westaco, the aim of such tools was attempted to be incorporated in the design process and computer support systems. The Sidina support system included, for example, the digital pre-assembly application as part of its integration system although had not been fully applied. The consideration over manufacturability and producibility issues led to the establishment of the Design Build Process team to foster early communication between design and production functions early in the engineering matrix stage. This had extended and led to the formation of the Operation Centre in the design-production coupling stage. Despite the absence of the formal CE tools, the objective of such tools remained parts of the consideration and contributed to the change in internal organisational integration initiatives.

7.2.2 External Integration

Westaco was also at a considerably advanced stage in integrating its customers and suppliers into its development programs. By contrast, external integration in Indaco was clearly far less than it was in Westaco and very limited in terms of CE ideas. However, during the period of the case study, at least, these differences did not have any significant effect on the CE initiatives in the focal sub-processes.

7.2.2.1 Supplier Involvement

The aircraft industry is normally characterised by a relatively higher degree of supplier involvement due to the complexity of its technology. In Westaco, suppliers
were closely involved early in the development process, either as representatives in a product development team or as a whole sub-team within the program teams. The equipment suppliers were typically involved as representatives and manufacturing subcontractors as sub-teams. These supplier involvement arrangements became part of contractual issues between Westaco and its suppliers and subcontractors.

In Indaco, by contrast, supplier involvement did not go further than a business relationship between the customer and its suppliers. Although some suppliers had their representatives visiting and talking with Indaco's engineers to clarify the material/component specifications, none were involved as part of the PLI cross-functional teams in the development process. Supplier representatives, mainly sales engineers, were typically engaged in lengthy discussion sessions with the team members to clarify the material/component specifications. Some suppliers agreed to the risk sharing clauses in which they would provide the initial investment for making the components specifically met the PLI's requirements, although never be put into practice due to the PLI termination. This contractual clause merely reflected the widespread business trend in the aircraft industry to lock-in suppliers and minimise the investment risk rather than as part of an intention to engage in a cross-functional development team.

7.2.2.2 Customer Involvement

In the Westaco's programs, customers and potential customers were typically involved in two different phases of the development process. Firstly, in the conceptual phase, the programs tapped into customer requirements first-hand by establishing a
series of discussion sessions with potential customers, following up their suggestions and, at the end, presenting back the aircraft concept. Secondly, in the design phase, customer representatives became part of the product development teams. Some Westaco’s engineers reported the advantages of having these representatives as they were typically airlines’ maintenance engineers who understood aircraft operation and, therefore, were able to provide simple suggestions that often turned out to be critical

In Indaco, customer involvement was limited to the airline visitation and the formation of the airline-working group that met annually. During the engineering integration stage, the Program Manager and his staff contacted and visited local and international airlines in order to capture the customers’ views of airliner requirements. Then, the PLI Program established the airline-working group to maintain the relationship with potential customers and organised an annual meeting to obtain updates on the latest developments in customer needs. Other than this annual gathering, there was no direct contact between the programs’ engineers with the airlines’ representatives.

7.2.3 Human Resource Policy and Capability

This section briefly discusses two CE initiatives in human resource policy and capability, which are CE-related training and pilot projects and human resource policies. Another CE initiative in this aspect, namely competency, is discussed in Section 7.3. These discussions on human resource aspect of CE are focused on the ‘local’ policies and initiatives in the PLI Program. However, as we shall see the analysis moves to the broader organisational context as the current state and policies

3 A published report that due to confidentiality reason cannot be referred
in human resources in this inner context were contributed by and, in turn affected the broader organisational context.

7.2.3.1 CE-Related Training and Pilot Projects

In Westaco, CE-related training was provided at the outset of the programs. According to both ex-interns and engineers from a Westaco’s subcontractor, the launch of a new product development program typically started with the familiarisation session for all people involved in the programs. This familiarisation process included the training on the programs’ charter and protocols and all related manuals and procedures. These sessions involved members from inside as well as outside the company. Some outsiders coined this kind of sessions as the indoctrination to the ‘Westaco’s way’.

At Indaco, acknowledging that the new approach required familiarity with features of the computer-based tools, the Sidina group offered regular training courses to prepare engineers for using the advanced computer technology. The Sidina pilot projects offered the potential for providing know-how and hands-on experience in cross-functional teamwork. However, since this pilot project used a component from other program as its case study, the members of the PLI Program were not deeply involved. Only a few engineers were involved, which was ironic given the pilot project’s main objective was to support the PLI Program. Furthermore, although the pilot project intended to simulate CE implementation, it focused more on the infrastructure of the support system than on organisational and human resources. Therefore, even though the effects of team members’ competence were noticed in a Sidina pilot project.

*Personal interview with engineers in the subcontractor site*
report\textsuperscript{5}, no further action was taken.

In contrast with the availability of various training courses in computer-based tools, there was no CE familiarisation and team-related training available for the Program team during all stages of the development process. A few members from the Operation Centre showed some know-how on team-related issues and admitted that they had acquired this through training course in Total Quality Management in their previous functional units. This lack of CE-related training was attributed to the lack of systematic protocols discussed in previous section, and, this also contributed to the state of internal organisational integration and communication and decision-making mechanism in the PLI Program in the same way as the lack of systematic protocols.

7.2.3.2 Human Resource Policies

In Indaco, except for administrative purposes, the involvement of the Human Resource Department in the selection, training, career development, and performance measurement of the employees was insignificant. Decisions over these issues rested almost solely in the hands of line managers of the functional and program units. Thus, CE-related human resource management issues were generally at these units’ discretion. Unfortunately, due to limited sources and failure to obtain access to Westaco, this study does not have sufficient data from Westaco on this issue.

1) Selection:

Almost all team members were drawn from various parts of Indaco. Only a few were newly hired. Members from the Design Centre joined the PLI Program through four

\textsuperscript{5} Item (45) Appendix-B
different paths: 1) early involvement in the program initiation stage as a member of NPD Department; 2) assignment as representatives from functional units; 3) voluntary application to move from a functional unit and join the Program; and 4) new recruitment. Members from the Operation Centre joined the PL1 Program through four different paths: 1) involvement as focal points; 2) being approached and asked by one of Program leaders; 3) voluntary application; and 4) functional assignment. Managers and supervisors were selected by their respective superiors. This selection were based on: 1) involvement in previous stages; 2) experience and specialisation; and 3) previous activities as focal points.

As mentioned in the previous section, internal recruitment typically added tension between the Program and the functional units due to scarcity of competent engineers, particularly in the design area. This issue also contributed to the state of competency of the Program members which is discussed further in the Section 7.3.

2) Training and career development:

The career development issue was one major cause of a tension between the PL1 Program and functional design units. Collocation and full dedication demands from the Program, which had been aired since the beginning of engineering matrix stage, were seen as reducing the role of functional units to merely a ‘human resource pool’ that supplied engineers to the program, particularly at the design production coupling stage in which the Program intended to become an autonomous division. This pool-user relationship raised issues of who would control the specialists and who was responsible over their performance evaluation.

Functional design units (i.e. Technology Divisions), in particular, resisted the notion
that they served only as a pool of expertise for the Program. This ‘pool’ role was in stark contrast with their roles in the previous PLP Program in which they had had significant influence in the development process. Furthermore, functional design units viewed that product development competence involved cumulative learning of both tacit and explicit knowledge, and hence assignments on a particular program should ensure fitness with longer-term career development in the company and organisational knowledge rather than being solely based on the short team specific interest of the program. They believed that it was part of their responsibility to get involved in systematically assigning and routing engineers to various stages of the development process in various programs in order to ensure the program assignments matched the overall career development system and organisational knowledge.

This conflicting view was never properly addressed. The PLI Program only provided to the functional design units the opportunity to suggest a list of engineers for functional representatives to be selected by the Program, which obviously dissatisfied those units. Although it could be considered as a major strategic issue, it was never put in the agenda of Indaco’s top management council. Overall, this issue contributed to various forms of tensions, conflicts, suspicions and distrust between the PLI Program and the functional design units as mentioned in the discussion of competency, which affected the state of organisational integration and communication and decision-making mechanisms as discussed later in this chapter.

3) Performance measurement and reward system:

In Indaco, the link between the company-wide performance evaluation and the reward system was indirect and not always clear. The company-wide performance evaluation was based on individual contributions administered twice a year. The company
reward system basically consisted of a base salary and an incentive system for individual contribution. The base salary system was developed on the basis of the education level with a gradual annual increase given for the appropriate level of performance. The incentive was discreetly granted on the basis of the Heads of the Divisions' subjective evaluation of the individuals' achievement. It was widely believed that a great disparity of the incentive level existed. Design engineers were believed to receive much higher incentive compared with other employees at equal positions. Since the nominal amount of the incentive was significant to the total paycheque (i.e. it could be much higher than the base salary for the engineers), this system was widely regarded as unjust and needed a major overhaul. Efforts to improve this salary system had taken place in the company since mid-1980s but no significant improvement had been achieved.

During the design production coupling stage, in addition to the company-wide performance evaluation and reward system, the PLI Program initiated an additional reward system based on individual performance on program's tasks exclusive to the people involved in the Program. Since this program-specific reward system directly linked to the performance, it was seen as an improvement to the company system. Similar to the company-wide appraisal system, it involved superiors filling in individual-based evaluation forms about their subordinates. However, this reward system was cancelled after its first application due to objections from many other top managers who considered this as unfair to other employees who were not involved in the Program. Given its financial situation, Indaco was unable to afford a similar additional system to the entire company.

In the PLI Program, awareness of strong attachment between representative engineers
and their functional superiors (i.e. a large portion of their income attributed to the subjective valuation from those superiors) contributed to the continuing anxiety over the loyalty of functional representatives. This, in turn, contributed to several structural changes in the pursuit to achieve effective integration. Within this perspective, the attempt to have an exclusive performance and reward system could be seen as a 'lure' to buy loyalty from members and functional representatives. However, it had a contrary effect as it added more tension to the already tense relationship between the Program and functional design units.

7.3 Competency and the Effects of the Lack of Competent Human Resources

7.3.1 Level of Competency in the PLI Program

Overall, most design-related members of the Indaco’s PLI Program were inexperienced but highly educated engineers. Only a few managerial positions were occupied by senior persons. The production-related engineers and team leaders were typically more experienced but with less formal education. This situation was different from Westaco’s programs that mainly consisted of senior experienced engineers and managers.

Most members of the PLI’s design integration teams were young engineers, between 25 to 35 years of age. Some of them held doctoral and master degrees in engineering from various universities world-wide. For most of them, the Program was their first practical design experience at a development program. Despite their education, they were considered by managers from functional design units as not mature enough to be
independently involved in such a big project. On the other hand, most members and leaders of the Operation Centre were experienced engineers who had been with the company for more than 10 years. They had mostly been involved in the production phase of the previous development programs. Most of them held engineering degrees from local universities. A few had Masters degrees. Some members started their careers as mechanics or support staff and completed their degree in engineering by taking part-time study. All supervisors and leaders of the production-related TIP teams were engineers.

In the program initiation stage, the lack of competency of design engineers was compensated for by the experienced team leader (i.e. the Project Engineer) who was considered to be one of most respected engineers in Indaco. The scheme to have experienced engineers leading a largely inexperienced design team was attempted in the next two stages. Initially, most leaders in the design related TOP teams during the engineering matrix stage were experienced engineers with recognised reputations in their specialisation. However, the Program Manager’s policy requesting full-dedication assignments to the PLI Program had made functional design units pulling out their experienced engineers from the Program during the engineering integration stage because these engineers were also needed to support other programs. In the design-production coupling stage, only a few lead engineers and supervisors in the Design Centre were sufficiently competent for independent design work. This created the opportunity for the Technical Adviser, who was initially assigned to assist the Program in technical issues, to impose his design approach and play a more dominant role.

The main reason for this situation was the limited number of ‘competent engineer’
available as the functional design units struggled to support all programs with competing schedules. In the view of these functional units, assigning competent specialists only to one program could jeopardise other programs. Furthermore, these competent specialists most likely were managers or supervisors in their respective functional units. A compromise scheme to resolve this issue was proposed and discussed between the functional design units (i.e. Technology Divisions) and the Design Centre at the beginning of the design-production coupling stage. The scheme involved the Design Centre working together with Technology Divisions to define the PL1 design concept during the preliminary design phase. This design concept would be dispatched in work packages and allocated to various Technology Divisions for detail design. The deliverables (i.e. detail drawings and specifications) would be handed back to the Design Centre for sign-off. However, this scheme was never put into practice.

In a later development, there was a mutually agreed scheme to use the statement of work for acquiring personnel support from functional units. The Design Centre had full responsibility for product performance and full control over the personnel assigned to the Program. The Design Centre was also able to reject assigned engineers based on their qualification. Technology Divisions could provide suggestions over technical issues, but the technical decisions’ sign-off was in the Design Centre. During the case study, however, this scheme was only partly implemented for aircraft system specialisation. These ineffective schemes to overcome shortages in competent design engineers resulted in conflicts and tensions not only between the Program and Technology Divisions but also between the Design Centre and the Operation Centre within the Program.
The increasing conflicts and tensions between the PLI Program and functional design units (i.e. Technology Divisions) attributed to four factors:

1) the Program's demand for fully dedicated engineers;
2) the scarcity of competent engineers in the Technology Divisions in relation to the demand from all programs;
3) the strong commitment of the Technology Divisions to other programs, especially the PLP Program; and
4) the expectation of the Technology Divisions that they would be given autonomous PLI's work packages.

Initially, Technology Divisions committed more senior people to support the PLI Program according to their perception and expectation. However, as they did not devote enough resources to fulfil the Program Manager's demand, the Program Manager tried to get engineers to be integrated into the Program and under his managerial control that led to several changes in program structures. In response to this action, the Technology Divisions pulled out their more experienced engineers and gave only junior ones to the Program. This meant that expert dependence continued on the functional design units, and ongoing conflict was the norm.

The relationship between the Design Centre and the Operation Centres was also affected. The Design Centre had less senior people than the Operation Centre. Both Centres could not have the full sign-off authority because the need to check design adequacy and tooling requirement with functions outside the Program due to the intentional exclusion of those functions from the Operation Centre. This situation displeased the Design Centre. The result was suspicion and distrust in various forms.
7.3.2 Effects of the Lack of Competent Human Resource

Although sometimes mentioned in the CE literature as part of a CE requirement that could be an impediment in its implementation (e.g. Fujimoto, 1997, Statham and Kleiner, 1996), the importance of competency was rarely emphasised in supporting CE. It seems that much CE discussion has an embedded assumption that the engineers have had adequate design (both tacit and explicit) competence. The case study findings showed how the lack of competency shaped CE practices in the PLI Program. The precondition of skill necessary to apply CE was not available and this caused several adjustments in CE initiatives that led to the deviation from the intended approach.

In Indaco, several senior managers in both design and production units were convinced that the company-wide lack of competent personnel was a major obstacle in applying CE. One top management member support this view:

The main obstacle for CE is that our people are not qualified enough. ... Although we have enough in number [of engineers], engineers that could be given fully delegation are not many. (Steve. Top Management Member. April, 1998)

The Ex Project Engineer expressed his concerns in applying CE in Indaco because of this competency issue, particularly regarding the engineers’ level of experience:

At [the PLI]... it is not CE. ..... For me, the ability of [Indaco’s] designers is not mature enough; the system could not compete with the accumulation of experience. That should be handled first. It should be based on discipline...then we have to increase communication, interaction, and dialogue. But, they should be in the strict specialisation because they haven't got enough experience to provide judgement.... Otherwise, the quality will be deteriorated...... We are not ready for CE yet. ... CE is not only a tool.... CE is a culture.... It cannot be planted right away (Mark. Ex Project Engineer. July 1998)

In a later interview with the Chief Engineer, he admitted that members of his team, including him, were far from adequate for the job to develop a new aircraft and that they were ‘learning by doing’ as he stated.
There are two types of design people, designers and analysts. ... An analyst is a deeper specialist such as structural analyst or stress analyst. ... A designer needs to know analysis issue and design issues that relate to producibility. ... Designers are the ones who shape the product. ... It is hard to find people who know the knowledge deeply. All [engineers in Design Centre] are far from it, no experience. I myself still need a lot of learning. I started with aerodynamics, although I got structure at school, it does not detail enough. I could not argue on a detail issue.... (Robert, Chief Engineer, February 1999)

However, rather than the explicit competence such as the level of education in relevant disciplines, the case study findings emphasised the importance of the more intangible aspect of design competence that related to tacit knowledge, which could only be acquired through the accumulation of experience and involvement in product development programs. While the level of explicit knowledge was rarely mentioned as a problem, the level of experience was found to be very important. Almost all of the competency concerns were attributed to the limited experience. One engineer involved in the Design Centre expressed his concern in these words:

We made mistake in [the PLI Program]. We have established an unbalanced team; too many youngsters. The youngsters are good because they are dynamic, but if too many we cannot bring with us previous experiences. ... We intend to create a multi-functional to be an integral one. To understand the right portion of each discipline, we should have the experience in product development... Without that, people will easily become out of proportion, which leads to a domination of a discipline in [cross-functional] teams. That what happens in the PLI [Program]. [To understand the right portion of each function] we need the experience because it is not written. (John, Design Centre, January 1999).

Even the Chief Engineer himself noted that his team caused concerns:

Sometimes, I have the impression that [Technology Divisions] do not trust us... (Robert, Chief Engineer, November 1997).

The more explicit statements about lack of experience in the Design Centre came from some of its supervisors, as one of them, for example, said:

No one of the current [Design Centre] members experienced the hectic of [the PLP Program]. ... [These young engineers], do they know what it was like being here 24 hours, [including] Saturday and Sunday, and had not gone home for weeks...(Roger, Design Centre, November 1997).

Within the Design Centre to which most of the concerns were expressed, most of the engineers had considerably high levels of education, mainly master degrees in various
engineering specialisations. Yet, most of them were young and inexperienced engineers. Most of them also admitted that the PLI Program was their first, and that they were ‘learning by doing’. However, most were confident that they were capable to do the job and in some cases implied that their seniors might not be better than they were, as one of them put it:

Here, seniority does not mean senior. Maybe he is senior because he is older... (Susan. Design Centre, March 1998).

This situation was in contrast with Westaco practices, which only assigned experienced design engineers to its large-scale development programs, as one of Indaco’s ex-interns recalled:

When [Westaco] was developing [the PLX], I was there. They took my Lead [Engineer], the best in my team, the most knowledgeable person technically. They posted him in [the PLX] Program. They took many Lead [Engineers] and made them configuration managers. When a company develops a brand new product, normally there are a lot of ‘ifs’. It is a matter of common sense to assign experienced engineers. isn’t it? (John. Design Centre, January 1999).

Although most concerns were about engineers at the operational level, there were also concerns of the lack of competency at the managerial level. Those who were concerned pointed out that the Program Manager, the Chief Engineer, and the Chief of Operation had never been part of the managerial level of the previous programs.

One design engineer expressed in the interview:

... The Program Manager also lacks of experience. He has no life of experience and he is unable to see that everyone in his Design Centre has to be able to express their creativity. Without creativity they could not do the best. This can only be achieved after experiencing design job. [The Program Manager] does not see this. He thinks by following [the Technical Adviser’s] advice, everything must be OK. He has not yet understood the essence of the problem. (John, Design Centre, January 1999).

One engineer from the Operation Centre expressed his concern about the Chief of Operation and supervisors in the Operation Centre with the following:

There is a tendency that [some members] do not trust them [because] they do not have the guts to decide things. ... I am fully aware that they had never been worked directly down [in the production area]. ... Their experience in this particular matter is relatively low. (Peter.
Similarly, an engineer from Design Centre admitted the indecisiveness of the Chief
Engineer as follows:

... sometimes he is indecisive. ... If there were two options, then he asked for more study. He
was often unable to make up his mind even though the study has been completed (Frank,
Design Centre, March 1998).

The Program Manager's lack of experience was, in particular, considered by his team
as a major factor contributing to his indecisiveness and his reluctance to inform his
team about the update of organisational restructuring plans during the economic
turmoil. This further demotivated some of his team members who saw it as a betrayal
of his previous confidence in the team. As a team member recalled:

At the beginning, he highly praised us saying that we were selected people and that many
others strongly wished to be in the program. Then he said, “I cannot tell you yet about this,
please be patient.” ... Those were contradictory statements ... (John. Design Centre. January
1999).

Obviously, it was not the intention of the company to assign so many inexperienced
engineers to the PLI Program. In the beginning of the CE initiation process, there
were several attempts to acquire more experienced engineers for the Program,
particularly for managerial positions. However, the limited number of experienced
engineers and the existence of other programs that competed for the scarce personnel
resources resulted in this situation. The company-wide shortage of competent
engineers was expressed by one of the engineer as follows:

We have 3000 [engineers] in [Technology Divisions]. They are all specialists. But only 50
[could] functioned as Lead Engineers. For [the PLI] we may only need 250 engineers. [but]
20% of them should be Lead Engineers. (Roger. Design Centre, November 1997).

In comparison to this remark, at the time of the case study, the Design Centre had
over 60 engineers, but on the basis of their involvement in previous programs no more
than 5 engineers could be considered as experienced lead engineers.
The company-wide shortage of competent engineers became a real problem for human resource allocation particularly when the PLP program experienced a massive delay, which forced Indaco to run parallel programs requiring similar specialisations at the same time. In addition, a derivative program of the PLC that was launched at the same time as the PLI Program turned out to be much bigger than expected, and subsequently required a substantial number of engineers. This problem was the main trigger of the ongoing strain between the PLI Program and Technology Divisions, as well as the trigger of some changes in the structure and working approach.

Many organisational adjustments resulted from this lack of competency. At least five management issues in the PLI Program arose from, or responded to, this lack of qualified personnel, which affected the program structures and CE initiatives:

1) changes in program structure,
2) changes in working approach,
3) a lack of trust between the Design Centre and the Operation Centre, and
4) conflicts between the Design Centre and functional design units

7.3.2.1 Changes in Program Organisational Structure

At the beginning of CE adoption, i.e. in the engineering matrix stage, the PLI Program had difficulty acquiring appropriate lead engineers for the TOP and engineering specialist groups due to scarcity of competence engineers. This led to an integration structure that merged TOP and engineering specialist groups into four design integration teams in the engineering integration stage. Even with fewer lead engineer positions, the Program struggled to acquire fully dedicated engineers for some of its design integration teams. Within these engineering matrix and engineering
integration stages, many names of experienced engineers that initially appeared in the program structures could not be retained to support the PLI Program, as one interviewee remembered:

> They were non-active, only names. At that time they were asked [to join in]. You might hear that they were fighting over names and putting those names [in the structure]. [But] [those people] did the design [for PLP]. so they could not be in [the PLI Program]. ... [The PLI Program] have a lot of new people. Top engineers never been seen in TOPs. That’s why they kept changing [the structure]. ... (Kevin, Tooling Engineering, January 1999).

Organisationally, there were two possible reasons for this situation: either the persons already occupied managerial positions in the functional design units or they could not resign from their involvement in other programs that were still in progress at that time. The Chief Engineer admitted this:

> So, I resigned from my other position in the [Technology Division] and became a manager responsible for the Design Centre. ... [Prior to that], some [engineers] were fully dedicated to the program. [but] mostly at the operational level. At the managerial level, there was just [John] and me. [Lance] was asked but he could not join because of his involvement in [the PLP]. There were a lot of such cases. [Joel] was still involved in [the derivative program]. So, they were replaced with others. (Robert, Chief Engineer, November 1997).

Engineers mentioned in the above remark were regarded as Indaco’s best engineers in their areas and had held managerial positions in functional design units. Faced with the demand from the PLI Program to be fully dedicated, these engineers opted to remain in their previous functional units in which they could support more than one program. Traditionally, their involvement in a program was indirect, via their staff as representatives, as the Chief Engineer said:

> Previously, we threw work packages over [to Technology Divisions] and they sent the representatives. But only one or two people really knew about the issue and they typically held [managerial] positions, either as head of departments or supervisors, and most of them were full time in [the PLP Program]. ... Under pressure of the [PLP] continuous delay, they panicked and took all resources to that program. (Robert, Chief Engineer, November 1997).

This led to the engineering integration structure in which most leaders of design integration teams, while they had authority to control the members, had far less
authority in design decisions due to their youth and inexperience. The move to an autonomous program division in the design-production coupling stage can be seen as an effort to secure the best available talents for the PLI Program so that they could not being disturbed by demands from other programs. The Chief Engineer explained in the interview:

Therefore, it is better for me to have a clear cut in people [arrangement] and a set of engineers. Engineers that I can control and recognise their capabilities. For sure, I would always doubt their output if they were not the best [engineers]. But, I could consult the output either back to their functions or somewhere else in the industry. (Robert, Design Centre. November 1997).

7.3.2.2 Changes in Working Approach

The working approach intended by the PLI Program Manager since the engineering matrix stage, was teamwork in which specialists from company-wide functions worked together and were fully dedicated to the Program and collocated in one area, as he stated in the interview:

CE concept is the basis to improve QCD [quality, cost, and delivery] ... CE is actually cross-functional teamwork. ... It involves not only engineering but also all functional units that involved with the product. ... The product actually integrates those organisational units. So CE is product oriented, teamwork oriented and the output is the excellent product. That is a fundamental of the [PLI] program ... The most important thing is a real team in one site. The factual integration occurs at working level in which everybody that works together and also sits together at the same room. ... If someone, e.g. material representative, is not required on daily basis, he may handle three or more parts. The space should be optimised. ... Engineering, tooling, manufacturing and production planning people, but not direct workers, have to meet on site every day. (Clive, Program Manager, June 1996)

The internalisation of design-related functions into the program structure in the engineering integration stage and later the production-related functions in the design-production coupling stage were part of the scheme to fulfil this intention. However, with the second best engineers as part of the Program team and the company-wide shortage of competent engineers to fulfil the demands from other competing...
programs, the initial intention to provide empowerment and full delegation to the cross-functional teams at the operational level could not be achieved.

Further, instead of having empowered and fully delegated engineers, the process in the design teams (TOP teams and design integration teams) remained involving managerial decisions from functional design units (albeit informally in the design integration stage) and, hence, added one more step into the process as the Chief Engineer commented:

> Sometimes [functional engineers] have worked well, but they did not have authorisation to hand out the result to us. That's the problem, they were uncertain about the result while their supervisors were not having time yet to have it checked. Should they send it to us, we could have reviewed it together. (Robert, Chief Engineer, November 1997).

The concept of autonomous division in the design-production coupling stage was intended to reduce this intervention from functional units and rely more on functional expertise within the Program, i.e. the technical advisers and the leaders of design integration teams, to provide guidance for engineers.

The removal of aeronautic engineers from design integration teams by the Chief Engineering to be put as a separate group later in the design-production coupling stage caused disintegration of design integration teams and contributed to the deviation from working approach intended by the Program Manager earlier (i.e. product-based cross-functional team). The reason behind this decision was:

> Aerodynamics could not work partially. It should be part of [aircraft] integration group. Because the responsibility of Wing Integration Team is [wing] configuration, structures and systems. [the Supervisor] may not comprehend all aspects of aerodynamics. ... So, he had to rely on his aerodynamic engineer. But, aerodynamic engineers [should] conceive aerodynamic integration as a whole. [For example] he could not see only the aerodynamic of the nacelle because there is interference between nacelle and wing. [In his analysis], he has to include the aerodynamic of wing section as well. Therefore, I merged all aerodynamic engineers together under my direct supervision. (Robert, Chief Engineer, February 1999).

Although did not explicitly point to competency concerns as the main reason, this
explanation implied that the Chief Engineer was unsure whether the design integration teams were capable of providing proportionate balance between specialisations and thorough consideration of every aspect (including the global aircraft configuration) at the outset of each component design.

In the design-production coupling stage, the Program failed to establish single cross-functional teams incorporating both design and production functions, and instead established two separate teams, the Design Centre and the Operation Centre. Despite all efforts to integrate the component-based teams from these two Centres, they remained separated. The cause of this failure was the perceived lack of experience of the designers as discussed earlier. There was a worry that the more experienced engineers from the Operation Centre would drive the design process, which, in turn, could force the inexperienced young engineers to give up product performance over the manufacturing or cost considerations. The Chief Engineer partly admitted the lack of competence in his team had put him in a defensive position in co-operating with the Operation Centre:

[Members of the Design and Operation Centres] have to be physically close each other ... It is better for them to stay nearly. It would be easier for them if they need to meet, sit and discuss together. ... [But] surely, they should have not to work too close and [design engineers] should not let the manufacturing take the drive... (Robert Chief Engineer, November 1997).

This led to the deviation in communication mechanism between the two Centres. Instead of having collaborative inter-team communication, the communication mechanism was dominated by formal communication. Even some collaborative relationships that flourished in the beginning was reduced and replaced by increasing lack of trust between the two Centres. This issue is discussed in the next section.

In the production area, operational representatives from tooling engineering and other functions that were excluded from the Operation Centre were also dominated by
young and inexperienced engineers. This also altered the intended development process. In tooling engineering, engineers assigned to the Program were required to present their work for approval from the supervisors in functional tooling department. This was because the supervisors in this department were not sure that the assigned designers had considered all matters when developing their tooling designs. In short, there was a lack of trust in the capability of the tooling engineers. Therefore, the conceptual design of the tools remained under the control of the functional tooling supervisors. One supervisor explained:

In the design process, [tooling engineers] are authorised in detail design. We provided them with a design authority to complete and to check the task but not to sign off the conceptual design. Fortnightly they have to make a presentation. ... The jig designs have to be internally presented first [in tooling engineering]. [The tool engineer] should explain his idea and we help him in [developing] the concept. ... When a tooling engineer makes a jig, the jig should be checked with the master [tool]. He has to consider how the master tools work for quality inspection. Because of the limitation of his knowledge, he focuses only to the jig.... (Kevin. Tooling Engineering. January 1999).

7.3.2.3 Lack of Trust between the Design Centre and the Operation Centre

The noticeable lack of experience of many engineers from the Design Centre had both advantages and disadvantages for the introduction of CE. One advantage was that they were willing to learn and to co-operate with engineers from the Operation Centre. These inexperienced engineers showed significant interests to the production's points of view. These design engineers welcomed and appreciated input from the Operation Centre, at least at the beginning of the design-production coupling stage. Some of them commented in the interview:

... the Operation Centre's engineers were the ones who explained things to me. ... They sent us something [to be reviewed]. When we got confused, we just made a phone call and they would explain it to us. That's good for us. We get much closer... (Susan, Design Centre, March 1998).

It is cool. ... A metal forming guy often took us to the plant. If we want to know [about
This attitude fostered the intensive interaction between the two Centres at the beginning of the stage. The expected resistance from design engineers to work together with production engineers, which could have created obstacles for CE implementation, did not happen, albeit with some concerns from the Operation Centre. This revealed in interviews as follows:

In my opinion, both parties are active. When I needed guidance, like on how to make [a part] because I could not imagine how the machine work. I phoned and asked them. I [also] provided them with suggestions on how’s if we did this by this, etc. They made an initiative to run a [familiarisation] course about fabrication. That’s good. The trainers were experts from the field. They also made a manual for our reference, such as the proper radius we should use (Darren, Design Centre, March 1998)

We provided a short course for the Design Centre on how to make manufacturing process easier. It took about three sessions. the Design Centre [engineers] was very positive toward this course. They think they really need it. (James, Operation Centre, March 1998)

There is a willingness [to co-operate]. But just the attitude is not enough. If there is willingness but the skill is not adequate, it would remain design not design for manufacturing ... I think they lack [engineer’s] intuition. ... It should be supported by experience. The experience could not be bought. ... It might be OK for now, but I don’t know how it will be after we enter the detail phase ... (William, Operation Centre, December 1997)

However, when significant design decisions began to be made, the inexperienced design engineers had to refer to the Chief Engineer or the Technical Adviser. Often, these inexperienced engineers could not defend the result of collaboration with their Operation Centre counterparts. This apparent powerlessness of the designers was derived from their status as inexperienced engineers:

There is a lot of input from [the Operation Centre]. .... As long as it did not divert the design, we changed it, but sometimes they just have to conform [to design criteria] and at the end it will go to [Chief Engineer] or [the Technical Adviser]. To date, everything should go through [the Technical Adviser]. ... One example is the window concept ... We made a study together with [the Operation Centre’s] engineers. Although [based on the study] the concept with rivet [method] is better, the bosses decided in favour of machining ones. I don’t know why... (Frank, Design Centre, March 1998).

Last time, [the Technical Adviser] said that the stabiliser front spar should become one part with the fitting. Then [Albert] said it could not be like that. He made an analysis about the difficulty, the man-hours [needed]. We discussed it together with [the Technical Adviser] and got his OK. it could be cut. Then, we put it in paper ... but [the Technical Adviser] later changed his mind (Darren, Design Centre, March 1998).
This situation dissatisfied engineers from the Operation Centre. They felt betrayed by their counterparts in the Design Centre. This dissatisfaction led to a growing lack of trust toward the Design Centre and scepticism about their commitment over operation-related issues. The Chief of Operation, in particular, expressed concerns that the Design Centre simply did not respond to input from the Operation Centre:

> We prepared producibility analysis. We sent this analysis to the Design Centre. We told them the constraints; the radius should be like this because of the machine and the cutter, the maximum movement of the machine etc. There are also assessment results, ... e.g. whether [window frame] should be machined one by one, or using forging, etc. We made assessments on both technical and economical viability. ... There is a lot of input, but there is no response. It is not clear, but I think the problem is the level of skill. There are a lot of new comers [in the Design Centre]. (Howard. Chief of Operation. December 1997).

Further more, the Operation Centre asserted that the lack of competence of design engineers was the only reason that the previously unscheduled material and technological tests of wing box and skin panel became a necessity and caused a significant delay in program schedule. The tests aimed to find the best alternative panel designs in terms of its structural strength against a certain amount of static and dynamic loads. One tooling engineer commented:

> When we were equally senior, many problems could be resolved in a short time. [We were] quick to understand [the problem]. But if our partner [said.] “what do you mean” or “we want to test it first”, it would take a very long [time]. They call it concurrent process but I call it learning process. ... Newcomers are newcomers. no experience. (Kevin, Tooling Engineering. January 1999).

This indecisiveness was even admitted by one of Design Centre supervisors, reflecting to the situation within the Design Centre itself:

> There are several factors. The first one is lack of experience; they are very young teams. They went to the left [then to] the right, but could not focus. The result is they could not complete the important ones. The DR&O never really completed; they keep changing the mission & objectives. They have dispatch & reliability but there is no structural design requirement, no system design requirement. ... That is our problem as a team. In my opinion, most problems are actually because of lack of experience that unable [us] to focus on what we should do (John. Design Centre. January 1999).

Lack of experience among design engineers also hampered the communication
between tooling engineers from functional tooling department and design engineers. This was due to the design engineers lacked of familiarity with the terminology being used and with the level of detail information required by their counterparts. This resulted in further unnecessary delays. The following incident between tooling engineering and design engineering over the master gauge information illustrated the nature of this communication problem, as revealed in the interview:

Actually, [the Design Centre] already have a significant amount of output but they did not know that we need that output. [For example,] I asked for gauge info, they did not know what gauge info looked like. They understood the term differently. After several interactions, they said, "oh that, we already have had that a long time ago. I don't know it is needed." Secondly, they do not know the need of production. ... Thirdly, some of them perceive [information] as top secret and refused to provide it. With a rough gauge info, we might proceed as many as 60% of tooling design work. ... The other 40% are the detail design after they complete the design. Then, when [these designers] agreed to provide it, they thought that they had not done it completely and hesitated to send the half-cooked information ... We do understand that such data is an estimation that might be changed later on (Kevin, Tooling Engineering, January 1999).

The situation worsened as some members of the Operation Centre discredited design engineers for using the input from the Operation Centre for their own benefit without acknowledging its source, as one of the Operation Centre’s engineers expressed:

Sometimes I could not accept that. There is a lot of work done by the Design Centre, which actually used our input. But, they put that as if it was prepared by them. It is destructive. ... (William, Operation Centre, December 1997).

On the other hand, the Design Centre viewed the Operation Centre and its assembly-focus as part of an unnecessary bureaucratic red-tape mechanism, particularly in dealing with the tooling and detail part manufacturing aspects, which were the main issues faced by the Design Centre at that moment. This led to some reservation from the Design Centre to foster further collaboration with the Operation Centre.

As a result, the communication and relationship between the Design Centre and the Operation Centre worsened under three conditions. Firstly, the lack of expertise of the Design Centre members led to hesitation from the Design Centre managers to fully
Chapter 7: Contextual Explanation of Change

collocate their members with the Operation Centre because the more experienced Operation Centre members were seen as threats that could dominated design decisions. Secondly, lack of authority in the lower level teams of the Design Centre led to increasing lack of co-operation because the Design Centre teams, even when they were able to make design decisions, were unable to defend the decisions they made together with the Operation Centre members. Thirdly, the lack of authority of the Operation Centre in tooling and detail part manufacturing issues led to a lack of co-operation because the Operation Centre could not make decisions on behalf of functional production units.

7.3.2.4 Conflict between Design Centre and Technology Divisions

As mentioned in Chapter 5, the Technology Division, a central function of design and technology had been divided into seven divisions since 1989. The development and the expansion of these functional design units (i.e. Technology Divisions) directly related to the development process of the PLP, the first indigenous 50-passenger airplane. At the beginning of the PLP Program, the Technology Division only had several departments, which then expanded in size and became relatively independent divisions. Obviously, most of the managers within this central function regarded the PLP Program as a source of pride as well as the artefact of their personal achievement.

With this background, the attitude of the managers from Technology Divisions toward the PLI Program was twofold. Firstly, they expected that a large portion of the Program would be handed over to them just like the PLP Program, particularly as they now had hands-on experience. Secondly, as the PLP was still underway, their first
priority was to complete that program. This attitude was emphasised when the top-management declared that the PLP Program should be higher priority over the PLI Program during the economic crisis.

To the dismay of those managers, the PLI Program Manager opted to establish an autonomous team that limited the involvement of Technology Divisions to merely that of "resource pools". This dissatisfaction was apparent in conversations with many functional managers. The conflict was also apparent at top management level as one member recalled:

> It seems there are different interpretations over the distribution of tasks between the Design Centre and [Technology Divisions] as resource centres. [The Technology Division] perceived that the Design Centre should only [cover] this [design aspect] only. The Design Centre perceived that [the Design Centre] also covered all other [development] aspects. As such that made the Technology Divisions commented that they themselves had no longer of any use. [The head of Technology Divisions said. "So take [the PLI] as theirs, but do not put us as the [one who] responsible". ... He also commented, "But, the constraint is we do not have enough manpower for that". While when those tasks were their responsibility, they could optimise [the use of manpower]. However, this is their opinion. It may contain vested [interests]. (Brian. Top Management Member. April 1998).

One engineer from the Design Centre who was also a supervisor in one of Technology Divisions tried to 'down-play' this conflict and stated:

> There are some [functional] managers that wanted the tasks to be handed over to them and became the ones who were responsible. But I think those are not many. [The Program Manager] and the Chief Engineer saw that as the cause [of conflict] perceiving those [functional managers] wanted to be in control. I think it was not like that (John. Design Centre. January 1999).

However, this dissatisfaction was widely recognised by the members of PLI team. In turn, these members were suspicious that the decision to give the priority to the PLP Program over the PLI Program had other reasons:

> Yesterday, it had just been decided that the number one priority is PLP [certification phase]. .... [They said] they still need 3000 designers ... What would all those designers do anyway? ... Are they redesigning the aircraft? (Ray. Design Centre. November 1997)

As their sense of belonging toward the PLP was higher than toward the PLI, it seemed
that managers of the Technology Divisions tended to put themselves and other experienced engineers into the PLP Program and allocated the less experienced engineers to the PLI Program. Many engineers from the Design Centre complained:

I cited that the qualification [needed] was lead engineer, that caused conflict [with Technology Divisions]. ... The names [of lead engineers] I asked for in my list caused the problem. They would never release them because they are key... (Roger. Design Centre, November 1997).

When we had a problem we asked these [engineers from functional units] to come and sit together in front of CATIA. That's the ideal. But, most of them were tied up with other tasks. ... The allocation of manpower to the programs remains unclear due to the limited available manpower. (Victor. Design Centre, March 1998).

Some members of the PLI Program attributed this to a company-wide lack of competence, but others attributed it to rivalry between the PLI Program and the Technology Divisions. This is confirmed in the interviews as some engineers stated:

[Technology Divisions] have numerous engineers, but engineers allocated to [the PLI Program] were not so many. We cannot complain because of this [perceived] shortage. But, it makes me wonder though, because [Indaco] do have many engineers (Victor. Design Centre, March 1998).

Have you read the previous letter from [Technology Division]? The substance was just one: in the case of [PLI], it was not [Technology Divisions] who got the experience. so [for them] there was no technology transfer (Ray, Design Centre. November 1997).

7.4 Protocols and the Effects of the Lack of Systematic Protocols

7.4.1 The Existence of Systematic Protocols in the PLI Program

One stark contrast between Westaco and Indaco was the availability of systematic protocols for program development and CE implementation. Westaco had documented and internally published procedures and manuals that systematically laid out the course of actions and deliverables for each step, as well as the objectives and benefits of the approach. The Indaco’s PLI Program entirely lacked any formal and committed protocols to support the implementation of CE and to provide detail course
Chapter 7: Contextual Explanation of Change

of actions to achieve the Program’s goals.

At Westaco, although most of the decisions in a creative process of developing the product were taken on the spot, the process itself was systematically planned at the outset. For each development program, Westaco systematically laid out all applied manuals and procedures, their integration, and their link to other relevant manuals in a written protocol specific to each program. This protocol listed and described all applied initiatives and methods for the program. The availability of such protocols provided a clear guideline on what needed to be done and how the effect of their variations resolved. The protocol provided a brief description of each development phase and the typical activities from each function. A more detailed version of the activity description was provided in a separate manual.

Ample reports revealed that team members followed the process set out in the protocols. ‘Bending the rules’ was not seemingly acceptable. Subcontractors commented that Westaco’s staff typically regarded the manuals as their ‘bible’. Indaco’s engineers who experienced the internship program at Westaco confirmed this. This attitude was also confirmed as a particular characteristic of Westaco, as noted by a representative from a European aircraft manufacturer in Indaco.

The Indaco’s PLI Program had attempted to implement the approach modelled closely on what had been adopted by Westaco, in particular the DRX program. Despite the availability of various Westaco protocols in implementing CE, there was no specific protocol to guide the CE implementation process in the PLI Program. During the field study, there was an attempt by the Chief Engineer to issue a procedure for governing

\begin{footnotesize}
\begin{itemize}
  \item Based on personal interview in the subcontractor’s site in 1997
  \item Based on personal conversation dated back to 1989
\end{itemize}
\end{footnotesize}
interactions between the PLI Program and functional design units. It was more of an
ad-hoc attempt in response to rising conflict between the Program and those units.

7.4.2 The Effects of the Lack of Systematic Protocols

CE implementation is a great leap from functional silos toward functional integration.
It involves a significant amount of organisational change and needs to be carefully
managed. Much change management literature suggests that the availability of the
standards and procedures ensure that the result of change lasts and does not bounce

In Indaco, the lack of written protocols to guide the process played a significant role
in shaping the course of introducing CE in the PLI Program. This negligence was a
result of the assumption that the Westaco model could be applied in the Indaco’s
context without much difficulty and that Westaco’s protocols could be used to guide
the implementation of CE in the PLI Program. The Westaco’s protocols on CE
initiatives were widely available in Indaco. At a later stage, the Sidina group started to
realise the need of such protocols and attempted to establish one protocol specific to
the PLI Program. However, this attempt had not been completed.

The absent of systematic protocols had four significant effects. Firstly, there were
mismatches of expectations between the PLI Program and the functional design units
due to the lack of well-defined CE concept and common approach. These mismatches
led to later disappointment, conflict, and mistrust that fuelled the conflicts over the
gradual integration of design engineers into the Program structure. Secondly, the
communication between Design Centre and Operation Centres were hindered by
three factors: (1) there were no clear exit criteria around which they could discuss and negotiate their different views; (2) there was very little clarity and mutual understanding on the roles of the participants; and (3) there were different, conflicting and chaotic forms of communication initiated by different members. Thirdly, it hindered the Sidina group from developing integrated computer support, as there were no real standards to guide them. And fourthly, the lack of working procedures and other lacks of clarity resulted in uncertainty, chaos and distrust, and provided an opportunity for some members to start imposing views and actions that were opposed to CE.

Overall, this lack of systematic protocols had a major effect in effective development of CE integration. Conflicts and tensions over CE, taking the form of organisational changes, were fuelled by this lack of protocols, as there was neither up-front discussion nor understanding on the way of implementing CE. As a result, the integration arrangements were shifted over time and more likely to be influenced by problems and issues faced later on in the process rather than overt major negotiated conflicts and differences at the outset. This lack of protocols also had the effect of freeing up individual actors to change their course of actions quickly if they wanted to, as there was no embedded CE structures and ideas to bounce off. This issue is discussed further in the following chapter.

Four major problems derived from the absent of a written guiding protocol for CE implementation in the PLI Program and significantly hampered the intended CE model to perform in the PLI Program were:

1) Lack of a well-defined CE concept and common approach,

2) Lack of commonly agreed operating procedures,
3) Lack of commonly defined exit criteria and deliverables, and
4) Lack of standard operating manuals for the enabling technology.

Detailed discussion on the effects of each of these main problems to the complex transformation process is provided in the following sections.

7.4.2.1 Lack of Well-defined CE Concept and Common Approach

At the macro level, the lack of written and systematic concepts played a role in the on-going strain between the PLI Program and the functional design units (i.e. Technology Divisions). On its introduction to the top management, CE was praised by the Program Manager as the vehicle to improve quality, cost and delivery (QCD) and to foster co-operation across functional units. However, how this CE approach would be applied in the Program had never been discussed or committed at the outset. As a result, some functional units had their own interpretation and that led to expectations incompatible with the concept intended by the Program Manager.

In the absence of protocols on CE and detail program implementation, most functional design units presumed that the Program Manager would allocate some responsibilities in product definition (work packages) to their units according to their specialisation. Therefore, some experienced engineers were parts of the program structure at the beginning of the CE introduction at the engineering matrix stage. From the persistent demand of the Program for collocation and full-dedication, these functional design units later realised that this was not the case. This late realisation triggered a sense of deception in some units that contributed to the ongoing tension between the Program and those functional design units. Expressions, such as "[the PLI Program] was too arrogant" and "If they do not need us, fine!", often expressed
by managers from those units in personal conversation. As a result, most experienced engineers resigned from the PLI Program, which left the Program with the less experienced ones. This led to several structural changes as the Program adjusted itself to this response from functional design units.

At the micro level within the PLI Program organisation, the lack of CE protocols caused anxiety and confusion in both Design Centre and Operation Centre at the design-production coupling stage. They never knew whether the way they operated was on the right track with the intended CE. In an initial co-ordination meeting with Sidina group in April 1998, engineers from both Design Centre and Operation Centre expressed this concern as follows:

Actually, we are still confused, maybe [Sidina] could tell us the lesson learned from the pilot project (Victor, Design Centre, April 1998).


Unfortunately, this co-ordination meeting that aimed to establish a written protocol for CE implementation in the Program failed to progress further.

Despite the rhetoric, such as “there is no problem in the relationship between the Operation Centre and the Design Centre” and “we always act as a single unit”, expressed by both Chief Engineer and Chief of Operation, they approached the integration issue in different ways as discussed in the previous chapter. The Chief of Operation took formal meetings as the preferred medium while Chief Engineer believed that formal meetings were “wasting engineers’ precious time” and therefore opted for on-the-spot informal meetings and discussions among engineers. Chief Engineer’s perspective was amplified by the Technical Adviser who preferred to isolate design engineers from operation engineers because “[operation engineers]
distracted [design engineers'] concentration’.

This led to chaos and contradiction in communication and decision-making mechanisms, particularly when involving inter-team relation between Design Centre and Operation Centre. The regular co-ordination meeting between Design Centre and Operation Centre was reduced and by September 1998 ceased altogether following a heated meeting concerning the progress of a technological test. Since there was no constraining regulated procedures set for the PLI Program, these uncertain, chaotic and distrustful circumstances allowed the Technical Adviser to impose his approach, which was incompatible with CE, and dominated the process. As a result, on-the-spot discussions between engineers from the Design Centre and their counterparts from the Operation Centre decreased due to the hesitation of operation engineers to come over to the Design Centre following this growing dominance of the Technical Adviser.

One engineer from the Operation Centre expressed:

When we came over [to the Design Centre], [the Technical Adviser] always looked suspiciously at us. I did not like being watched like that. It was like we were disturbing them. The worst of it, he even once said that all the output of the Operation Centre could be better off in rubbish bin. (Phillip, Operation Centre, December 1998).

7.4.2.2 Lack of Commonly Agreed Operating Procedures

In the design-production coupling stage, both Design Centre and Operation Centre attempted to establish operating procedures that would govern the interaction between them and other functional units. Within Indaco, procedures that involved more than one unit were termed as operating procedure agreements and required approval from each of the involved units before being put into practice. Some drafts of operating procedure agreement had been initiated and reviewed by both Centres (e.g. operating
procedures on Statement of Work, the Design Centre and Technology Division Working Relationship in the PLI Program, TIP Co-ordination). At the end of the case study, however, only the operating procedure agreement on the Statement of Work had been officially approved. Since the program management claimed that the PLI Program would be handled in a specific way and different to other programs (i.e. in financial management and CE implementation), the lack of the operating procedures caused uncertainty among functional units supporting the Program.

In the production area, for example, it was unclear whether the Fabrication Division would support the PLI Program in the management of raw material inventory, as was usually the case in other programs. The Statement of Work issued for the manufacturing of tooling and part specimens did not mention this particular issue. The short notice request by the PLI Program asking the Fabrication Division to store and manage the PLI's raw material was made only after the raw material had arrived. This had been seen as a 'fait accompli', which hampered the future interaction. One manager from the Fabrication Division expressed her disappointment as follows:

They are so spoilt. They seem to assume that everybody ought to support them regardless of whatever problem they might cause for other people. They just never care. (Tracy, Fabrication Division, February 1998)

This, in turn, reduced the reputation of the Operation Centre over their ability to handle the production issues in the eye of the Design Centre and contributed to the reduced communication between Design Centre and Operation Centre.

In the design area, the lack of operating procedures, particularly on the issue of human resource support from the functional design units, added to the tension between the Design Centre and the Technology Divisions. Several meetings had been carried out to resolve this issue. At best, these meetings gained some partial and
individual agreements that were mainly ad hoc in nature. In general, this ongoing tension between the Design Centre and Technology Divisions remained apparent until the end of the study due to the ad-hoc and unclear operating procedures. This contributed to the ineffective communication between the Design Centre and Technology Divisions as evident in the Configuration Review meeting described in Chapter 6.

7.4.2.3 Lack of Commonly Defined Exit Criteria and Deliverables

Although the master phasing plan of the PLI Program had been established in 1996, the deliverables of each phase were never clearly defined. These deliverables should have been in the design requirement and objectives (DR&O) as the exit criteria of the conceptual design phase. The level of detail of the DR&O was never clearly set up and resulted in a dispute even among engineers within the Design Centre. Some engineers believed that they had already achieved the target set up in the DR&O on time at the end of the conceptual design phase. Others said that the DR&O was too superficial to become a reference for the preliminary phase. These engineers argued that this level of DR&O caused more uncertainty in the design and this, in turn, reduced the speed of the development process.

The real DR&O never existed. [Not] the DR&O that I knew of. The one that has enough detail to do the design. What we got is the mission and objective. We wanted the product [to be able] to fly fast [in a certain range] and come back again [to its hangar], things like that. It is a mission & objective. A DR&O need more than that. It is not enough, far from enough. (John, Design Centre, January 1999)

The Chief Engineer admitted that the DR&O resulting from the previous conceptual design phase was a high-level one. Besides undertaking the preliminary design tasks, his team was also refining the contents of the DR&O to provide adequate detail.
Likewise, the deliverables for the preliminary design phase were never clearly defined. Many believed that these deliverables should contain the fifth level definition of the Work Breakdown Structure (WBS), as was the case in the PLP program. With the whole aircraft configuration typically referred to as the first level of Work Breakdown Structure, the fifth level would contain the detailed structure, such as the flap and the slat of the aircraft wing. It meant that the deliverables should contain definitions of all components or sub-components at those levels.

The Chief Engineer, however, had his own interpretation. For him and some members of his team, the deliverables of preliminary design phase should contain a well-defined primary structure of the aircraft (e.g. the wing and the body section that holds the wing). It meant some components might be well detailed into the sixth or seventh level as necessary. For example, there would be a detailed design of main joints, e.g. the wing to body joint. But for other components that are not part of the primary structure the third or fourth level was enough. However, none of these interpretations were documented. The understanding of these deliverables, therefore, varied. The Chief Engineers explained his interpretation as follows:

At [this] preliminary design [phase], we defined the configuration with a level of certainty to enable us to continue to the detail design. ... When we complete the preliminary design phase, the primary structure must not be changed. So we should go to the detail and define how to attach other systems. If the primary structure changes, the concept of structural strength might be affected and it would affect other configuration. For example, if wing joint must be changed, it might caused a change in landing gear position. This might affect the definition of pneumatic system of the landing gear, which in turn might affect the centre of gravity.

[The definition of preliminary design] in the [aircraft] industry varies. From my point of view, the primary structure is the wing. It cannot stand-alone. It is hold by the body; so the structure in section 44, the big frame that holds the wing should also be defined; it becomes critical. It means that I should know its structural and the dynamics calculation to ensure that my design envelope is safe. I might make some refinements, such as weight improvement in detail design [phase] later. In wing, for example, I should think about the joint between inboard wing and centre wing box. I should know the detail of the bolt diameters because we know the highest structural force is in the back. Thus detail sometimes makes people confuse about the preliminary design phase. There is a misconception that the preliminary design should not be [that] detail. In contrary, from design philosophy point of view, it should be that detail; because it could not be changed [later]. The devil is in the detail.

On the [previous PLP Program], we thought that we have defined the main hard points in
preliminary design, but, at times, we did not know whether they were the correct solutions without going into the detail. Even to date, you will get different perceptions if you talk to different people… (Robert, Chief Engineer, February 1999)

These undocumented and competing interpretations confused the younger and less experienced engineers in the design integration teams even more. As a result they became more dependent on the direction from the higher level leaders (i.e. the Chief Engineer or the Technical Adviser). This led to higher power differential between lower teams and higher teams and increasingly less authority of the lower team.

The lack of common exit criteria in each development phase created a sense of loss within the Program teams, as they could not benchmark themselves against certain criteria. At the micro level, many engineers from both Design Centre and Operation Centre understood that their tasks needed to be carried out in several stages. Without well-defined exit criteria, engineers from both Centres struggled to find a common ground in defining the deliverables at this micro level. Due to the increasingly lack of openness between the two Centres, this issue was never really resolved until the end of the PLI Program. This perpetuated the lack of openness environment despite some attempts made during the course of development process. In a group meeting between Sidina, Design Centre and Operation Centre, an engineer said:

Sometimes, we just wonder whether our line of thinking in the Operation [Centre] is the same as of the Design [Centre]. Do we have the similar approach? For example, we divided the development process from the preliminary design to the final assembly into seven stages. We broke down each stage into tasks and responsibilities. We are expecting [any] feedback from the Design [Centre]. With that, we hope our supplier [the Design Centre] can make analysis if we doing all of that, , how they could support us (Peter, Operation Centre, March, 1998).

This situation contributed to the decreasing level of communication between Design Centre and Operation Centre because the basis of negotiation between them was not available.
7.4.2.4 Lack of Standard Operating Manuals for Enabling Technology

Standard operating manuals that could guide engineers in operating within the enabling technologies, such as CATIA, Digital Product Definition, Digital Pre-Assembly, or a configuration management system, were not available for the design engineers early in the beginning of preliminary design process. Therefore, each engineer typically followed his/her own preferences, which led to the problem of compatibility even after the standard operating manuals were available. By doing this, they limited the design integration capability of the enabler technology to that of a computerised drawing board. Although the design could still individually be linked to the manufacturing area for further processes, such as tooling design and NC programming, the overall design integration capability could not be exercised.

In the design-production coupling stage, the significant feature of the enabling technology, in which the integration of all individual designs was simulated in a three-dimensional image, could not be utilised yet because this feature needed systematic compatibility, e.g. for data storage and filing system. Interference between one individual part/component and other parts/components could not be checked either. Therefore, the identification of interference between components, which would help designers to make early adjustments, could not be provided. A continuous reminder from the Sidina's technical officers on this issue did not make these design engineers aware of the importance of standard operating manuals. The technical officer responsible for the Digital Product Definition application expressed her concern:

I have talked to them again and again. I think it is too late now. I give up. It is so difficult to talk them into it. They always said that it would take so much time to revise the data all over again [in order to comply with the recently published standard operating manuals]. and they apparently did not have that time (Laura, Sidina, February 1999).
Furthermore, within the unwritten interpretation of the deliverables from the preliminary design phase, the designers drafted the main structural components and all detail designs associated with that component in one drawing to simplify their work. Apparently, this practice was incompatible with the system developed by the Sidina group and the PLI’s Configuration Management Department, which was based on a unique drawing number as part identification. This system required the consistency that one drawing (with one unique drawing number) represented only one part. By identifying the drawing as merely the attribute of the part, the part would have a single identification number throughout its life cycle. The objectives of this system were to ensure design traceability for certification purposes and to ease configuration management in tracking down the aircraft configuration at the serial production phase. With more than one part included in one drawing, the system lost its ability to trace the configuration since some parts could not be identified. Only after prolonged dispute, the Chief Engineer tried to resolve this conflict through the offer to provide a basic aircraft design course for the Sidina engineers to increase their familiarity with the design process.

7.5 Organisational Context

As outlined in the conceptual framework in Chapter 3, there are four organisational factors that influence the change process: the organisational structure and coordination mechanism, the organisational culture, the organisational sub-cultures, and the stage of development of the company. This section analyses the contribution of each factor in the process and in the shape on organisational integration and communication and decision-making mechanisms throughout CE introduction.
The detailed analysis is provided in three sections. The first section analyses the contribution of the company-wide organisational structure and co-ordination mechanisms. The second analyses the contribution of the organisational culture and the dominant functional culture. The third analyses the contribution of the company’s stage of development. The summary of these analyses is provided in Table 7-2.

Table 7-2: Influence of the Organisational Context

<table>
<thead>
<tr>
<th>Organisational Context</th>
<th>General Effect</th>
<th>Contribution to Organisational Integration</th>
<th>Contribution to Communication &amp; Decision-Making Mechanisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure and Coordination Mechanism</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Highly differentiated structure</td>
<td>- Silo effect in functional units</td>
<td>- Problems in carrying out matrix and heavyweight program at all levels throughout stages</td>
<td>- Many high power differentials between high and low level teams throughout stages</td>
</tr>
<tr>
<td>- Highly centralised structure</td>
<td>- Limited power to control activities in functional design units</td>
<td>- Increasing integration of production functions throughout stages</td>
<td>- Only a few decisions made by lower teams particularly toward the later stages</td>
</tr>
<tr>
<td>- Restructuring toward product-based organisation in 1997</td>
<td>- High power differential between high and low level managers and between superiors and subordinates</td>
<td>- Autonomous division at Design-production coupling stage but with two parallel design and operation teams</td>
<td>- Tendency to ignore lower team decisions particularly in later stages</td>
</tr>
<tr>
<td>- Merging production functions into program divisions</td>
<td></td>
<td>- Sliding back to functional arrangement in Design-production coupling stage</td>
<td></td>
</tr>
<tr>
<td>Organisational Culture and Sub-cultures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- High technological orientation</td>
<td>- Technology imperatives</td>
<td>- Changing structures to adjust to functional design units responses</td>
<td>- Focusing on computer technology to foster communication in CE</td>
</tr>
<tr>
<td>- Domination of design and technology sub-cultures</td>
<td>- Functional design units as the ‘golden kid’ prior to PLI Program</td>
<td>- Design functions in the main role for the first three stages</td>
<td>- Hampering communication between Design Centre and Operation Centre</td>
</tr>
<tr>
<td>- Strong and well-connected founder with strong orientation to design and technology</td>
<td>- Rivalry between the PLI Program and functional design units and resulted in ongoing tensions</td>
<td>- Tremendous support from production functions to the program teams since the beginning of Engineering matrix stage led to the formation of the Operation Centre in Design-production coupling stage</td>
<td>- Poor Communication between the Program and Technology Divisions</td>
</tr>
<tr>
<td>Stage of Development of the Company</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- ‘New kid’ in the aircraft industry</td>
<td>- Immaturity in terms of organisational tacit knowledge leading to lack of competence</td>
<td>- Very heavyweight Program Manager</td>
<td>- Communication difficulties across functions</td>
</tr>
<tr>
<td>- Euphoria from the success of the PLP flight test</td>
<td>- Engagement in consultancy and internship programs</td>
<td>- Difficulty in keeping heavyweight program teams at the lower levels</td>
<td>- Ability to afford a “state of the art” enabling technology specific to the PLI F’im</td>
</tr>
<tr>
<td>- Competing schedule between PLC derivatives, PLP, and PLI programs particularly due to PLP certification problems and unexpected design changes in DRI</td>
<td>- Securing financial source specific to the PLI Program</td>
<td>- Problems in acquiring delegated and fully dedicated representatives from functional design units throughout stages</td>
<td>- Poor communication between Program and functional design units</td>
</tr>
<tr>
<td></td>
<td>- Jealousy of functional design units toward the PLI Program leading to ongoing tensions</td>
<td>- Quick response of functional design units in pulling out their support to the PLI Program</td>
<td></td>
</tr>
</tbody>
</table>
7.5.1 *Company-wide Organisational Structure and Co-ordination Mechanism*

As described in Chapter 5, the organisational structure and co-ordination mechanism of Indaco were high in centralisation, high in formalisation and high in differentiation, which in general reflected both industry and societal contexts in which the company operated. Three particular organisational developments influenced the implementation process of CE:

1) The increasingly important role of the Program Manager in integrating activities across functional units.

2) The increasing number of specialisation departments in the Technology Divisions as a result of the previous PLP Program, which was the first indigenous development experience.

3) The company's organisational restructuring toward a more product-based organisation, with a flatter organisational structure in 1997.

The PLI Program was initiated within the above contextual circumstances. The Program Manager clearly wanted to smooth the interaction between the Program and functional units as he stated early in 1996:

...We are implementing CE not only to increase quality, decrease cost and speed up delivery, but also to increase co-ordination [between functions] not only among engineering [functions], but also among all other [functional] organisations related to the product. The orientation is to the product ... The product-based program actually integrates those [functional] units .... The product [team leaders] are the co-ordinators, they have to work together with other [functional] units. But the real integration is at the working level. (Clive, Program Manager, June 1996)

However, the intention of the PLI Program to attain more direct control over work done by functional units could not be fully established through the matrix mechanism adopted by the Program during the program's early stages of CE introduction, i.e. in the engineering matrix and engineering integration stages. The major problem occurred in the relationship with functions within the Technology Divisions. The
managers of the Program felt that they did not have enough power to secure the required level of control over the design activities undertaken by those functional design units to ensure that the process and product performance were within their expectations. Some reasons for this have been discussed in the previous sections, e.g. the lack of competence and the lack of systematic protocols.

The underlying cause for this problem was the 'silo effect' of the Indaco's highly differentiated structure that had been adopted since 1984 and become part of the company culture. The members of functional units tended to focus inwardly to achieve optimal solutions in terms of their own specialisation. An aeronautical engineer presented this attitude in an interview:

> In designing a wing, I want it as aerodynamic and as light as possible. I want it to be like a paper [airplane] wing the first time around. I don't want to think about what the [airframe] structure people would say. We certainly will discuss it in the next iteration and I may have to make some compromises. [But.] for the start, I will do just like that. (Ralph. Aircraft Technology Division, February 7, 1998)

This attitude remained with most functional members when they became functional representatives for the PLI design teams. Due to the high centralisation in the structure, the functional leaders were typically consulted before such a technical solution was applied. This triggered various integration and communication problems discussed in the previous chapter and led to the formation of an autonomous division in the design-production coupling stage.

The relationship and organisational arrangements with the functional production units (i.e. Production Divisions) were less complicated than the relationship with the functional design units (i.e. Technology Divisions). In part, this was attributed to the company-wide restructuring scheme that commenced in 1996 and was realised in 1997. This restructuring scheme proposed a more product-based organisation in the
company's existing production lines. Within this scheme, the production support divisions, such as Production Engineering and Industrial Engineering, were eliminated and their functional specialists were merged into the program divisions. The change of the PLI Program organisation into an autonomous division was in line with this scheme.

Unlike Indaco's other programs that maintained a matrix arrangement with functional design units, the PLI Program attempted to free itself from matrix and instead, asked the engineers to become full-members of the Program. When necessary, individual engineers were 'hired' from functional design units to work on the Program. However, as previously discussed, the PLI Program could not achieve the planned autonomous and integrated team and, instead, was divided into the Operation Centre and the Design Centre in the design-production coupling stage.

From the perspective of the Program Manager, the existence of this major partition within the PLI Program despite the initial intention towards an integrated cross-functional team, was seen as a necessary but temporary compromise to gain functional support for the intended total integration. The evidence discussed later on the politics and actions in Chapter 8 indicated that this might be seen as one necessary increment step within a 'non-threatening' change strategy employed by the Program Manager that seemingly fitted with the surrounding circumstances that were deeply entrenched into functional silos. Within this perspective, the next planned step would be the integration of Design Centre and Operation Centre, which was expected to be easier to achieve.

At first, these design-production coupling arrangement looked like as if they would work well. The combination of more experienced engineers from the Operation
Centre, who viewed the approach as a chance to ease their tasks in the production phase, and the less experienced but willing to learn engineers from the Design Centre provided the bridge for integration at the operational level as indicated in the previous chapter. However, the movement to break down the functional silos was not easy. Such organisational change has the potential to 'slide back' to the previous arrangement (Carnall, 1991), as illustrated in the following two instances.

Firstly, the Chief Engineer took out all the aeronautic engineers from the design integration teams and put them in an integrated aeronautics specialisation group that supported all design integration teams within the Design Centre. The combination of continuous design problems, the scarcity of competent human resources, and the lack of clear implementation protocols played a significant role in this movement. The Chief Engineer expected that under such isolation from other component-related design issues, aeronautic engineers would be able to deliver an optimum integrated design solution, as opposed to an optimum solution for each component design team. However, this decision modified and reduced the scope of cross-functionality of the design integration teams due to the exclusion of those aeronautic engineers.

Secondly, the Operation Centre's focus on assembly led to the exclusion of some tooling and manufacturing functions, which in turn, made the Operation Centre rely heavily on a functional production unit, i.e. Fabrication Division, that housed those functions. From the Design Centre perspective, this arrangement made the Operation Centre the unnecessary liaison that mediate the Program (i.e. the Design Centre) and that functional unit and preventing the Design Centre from directly interact with specialists from those functions. These issues caused much tension between Design Centre and Operation Centre as discussed previously, which was eventually resolved.
by an agreement that empowered the Design Centre to interact directly with those functions. However, tension was created within and between design and production functions despite the efforts to establish harmony at the beginning of the Program (e.g. through the formation of the design build process team, TIP teams, Production Co-ordinator, and Operation Centre). This incident illustrated that even between the production-related functions barriers existed, and in turn made it more difficult to break the larger barrier between design functions and production functions.

Highly centralised structure led to high power differential between superiors and subordinates because the power was typically centralised in the superiors at all levels. This contributed to the presence of a power differential between the program's higher and lower level teams throughout CE implementation stages. It also contributed to the fewer decisions made by the lower level teams and the ignorance of the decisions already made by the lower level teams in the Design Centre, particularly in the later stages when the design integration teams consisted of many younger and inexperienced engineers. This happened despite the Program Manager's best intention for a truly CE at the working level.

7.5.2 Organisational Culture, Sub-cultures, and the Strong Founder

Beside high centralisation and high differentiation, the Indaco culture was also dominated by a 'high technology' orientation. This culture was acknowledged internally and was seen as the result of the aircraft industry characteristics that continuously deal with advanced technology. However, 'hi-tech' had a deeper meaning to Indaco than the mere advance in technology. This was born out in the Indaco's mission statement, which clearly stated that the company was "a vehicle of
technology transformation” within the nation. As a state-owned company, Indaco claimed that it was expected to be “one of the nation’s Centres of Excellence” that would bring the country toward a “prosperous industry-based nation” in the future. This has led to over emphasis on technology acquisition and technology transformation. The previous PLP Program, for example, suffered from this as one engineer commented:

At [the PLP], [they said] we wanted this and that kind of technologies, and [the PLP’s] price went out of control. [The price] became so high; who wanted to buy it [at that price]. (John, Design Centre, January 1999)

Equally typical was the response given by the Ex-Project Engineer for both the PLP and PLI Programs to defend this situation, as he expressed in the interview:

There are people who argue that the cost [of the PLP] would be too high. No, it is not true. The price of one configuration is set by itself. We call it ‘the duty of configuration’ (Mark, Ex Project Engineer, July 1998)

Indaco’s vision and mission were mainly developed by its founder in the late 1970s. Beside his position as the President Director of the company, he was also an influential Cabinet member of the Government. To fulfil its mission, Indaco was equipped with billion of dollars investment in state of the art facilities for aircraft development and production process. The President Director’s position in the Government was crucial in securing the government’s direct investment to acquire such facilities.

In line with this strong tendency toward technology orientation, an immediate initiative in introducing CE in the PLI Program was to set up and invest in the computerised enabling technology. In fact, the enabler was seen as the major part of the CE adoption as reflected by the following statement by the Program Manager:

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8 Item (88) and (108), Appendix-B
[Westaco] calls it enabling technology. With this technology, they can work optimally. ... So are we in [the PLI]. There is no compromise, 100% digital. The [product] definition will be made with CATIA, 100% digital and it will also be used for the digital mock up. ... So everything can be computer simulated, part manufacturing, tool manufacturing and its interface with the part, system interface, ergonomics, maintainability, etc. For the PLI, we will use that. ... We have to totally upgrade our [human resources]. ... This month, Sidina project will go ahead. ... Other than Westaco, I don’t know ... [but] there is a prerequisite [for CE]. have to have this enable technology. (Clive, Program Manager, June 1996)

In a complex development process such as the development of PLI, the use of such technology was inevitable. It is also the typical engineering focus which remains dominant in engineering literature (e.g. Gunasekaran and Sarhadi, 1997). Nevertheless, an over-emphasis on enabling technology led to the danger of neglecting other aspects of CE (e.g. organisational and human resources), which in turn, became disastrous for the process as discussed in the previous section.

The Indaco's founder was also influential in the establishment of an engineering sub-culture as the dominant culture within the company. Trained as an aeronautical engineer and with a significant academic career in that specialisation, he enjoyed the time he spent with design engineers discussing various technical issues of the development process. He often allocated a significant portion of time during his visits to the plant for such discussion, despite his busy schedule and other demanding matters within the company. He also knew many key engineers by name. He regarded engineers, the design engineers in particular, as the company's most valuable assets. This view was expressed in various meetings and gatherings within Indaco. In order to retain these valuable engineers, the nominal value of the individual incentive was skewed in favour of engineers from the functional design units. One top management member confirmed this in the interview:

Of course [the difference] is huge. ... It is a huge [gap], but not for all. There is a gap between [design] engineers and our engineers or specialists [in Production Divisions]. At the operational level, the apprentice graduates for example, in Production they may get one hundred or fifty [thousand Rupiahs], there [in Technology Divisions] they get two hundred and fifty [thousand Rupiahs]. (Steve, Top Management Member, April 1998)
These circumstances led to the dominance of the functional design units (i.e. Technology Divisions) in the company. Top management placed design-related issues first. In the past, product features were mainly defined by capabilities and interests of the functional design units. In the development process of the previous PLP Program, for example, technology-related considerations were the main determinants of the product features and the development process rather than marketing, financial or operational considerations. Functional design units also had all the time they needed to accomplish their task regardless of the schedule, and left functional production units sandwiched between the targeted flight test schedule and this extended completion time of the design, which meant less time available to manufacture and assemble the aircraft. Within the compressed time, the functional production units also had to deal with numerous engineering changes.

Other functional units typically believed that, due to the perceived importance of their tasks, functional design units always got what they asked for regardless of the program’s budget. Some facilities they requested were regarded as unnecessary but ‘nice to have’. Any rejection by the Program Manager or the Investment Board could be by-passed by directing the request to the President Director who often over-turned the rejection. Some rumoured that the formation of additional divisions in the Technology Division was due to favouritism by the President Director as appreciation of some engineers’ contributions to the PLP Program rather than a real necessity. In short, the functional design units were often regarded as the President Director’s ‘golden boys’.

The introduction of CE in the PLI Program and, in particular, the push from the Program Manager to make the Program independent from the influence of functional
design units by asking fully delegated, fully dedicated and collocated members, created a sense of rivalry in the Technology Divisions. This was the underlying cause of the on-going tension between the PLI Program and the Technology Divisions that led to poor communication and several changes in program structure as the program management tried to adjust the Technology Divisions response to their CE concept and arrangements throughout the implementation stages.

Within this dominant culture, other differentiated and fragmented functional subcultures (Martin, 1992) eventually emerged. These were mainly based on the resentment over the domination of functional design units knowing that nobody could compete with them. Typically, this resentment was expressed by downplaying the undoubted technological achievement of the Technology Divisions. The failure of the PLP Program to meet its certification target, for example, was seen as evidence that the functional design units did not deserve undue attention from top management. This perspective was common among members from Production Divisions who typically worked on a tighter schedule and under tighter managerial control than their design counterparts. Non engineering-related functions, such as Finance and Human Resources Divisions, typically felt left out because top management favoured engineers over non-engineers. These functional units often perceived engineers as cost centres, spoilt and hard to manage.

Company-wide, these fragmented and conflicting subcultures were often seen as a lack of company culture, as one member of the Operation Centre stated:

It seemed that [Indaco] does not have a culture, so it does not have any standard [of behaviours]. Some [employees] even spread bad words about [Indaco] outside because of the lack of such organisational culture. ... That's why I've suggested splitting both the Design Centre and the Operation Centre [from the rest of Indaco]. I did not want to be exclusive, but it is for the establishment of the so-called company culture (William, Operation Centre. December 1997).
The existence of these sub-cultures with the perceived united strong technological culture of Indaco, was clearly expressed by the above member as he continued:

... At the first flight of [the previous PLP], production [people] was furious, because among four people that got patted by the President Director [in the national television] none from production. It was not fair. Did it mean there was no contribution of production [people] to [the PLP]? Then, who assembled it? ... That's why these functions do not get along; it starts from the very top and goes down to the lower levels. This incident raised some protests from [production] people who did not sleep for days to build and assemble the product; why Production [Divisions] were not represented in such event. (William, Operation Centre, December 1997)

Understandably, the announcement of CE introduction in the PLI Program was welcomed by the staff of other functions, particularly within the functional production units, who viewed CE as a means of creating a more balanced culture within the company. This expectation triggered the enthusiasm of several middle managers from functional production units to embrace the Program during its early stages and led to the formation of the Operation Centre as part of the program structure in the design-production coupling stage. In the previous PLP program, involvement in the preliminary design phase had been the sole prerogative of engineers from functional design units.

However, some of this resentment remained even after the formation of the Operation Centre and was often manifested in under-estimating the design engineers' capability. The effect of the lack of seniority among the majority of the Design Centre's members, for example, was often exaggerated by the Operation Centre's members, particularly in analysing disputes between Design Centre and Operation Centre. To a much lesser extent, the Design Centre's members sometimes expressed their doubt on the capability of the Operation Centre's members due to their relatively lower education level. This contributed to the tension, which in turn hampered the inter-team communication between Design Centre and Operation Centre.
7.5.3 The Company's Stage of Development

The PLI Program was publicly announced following the success of the first flight of the previous PLP Program. Within the company, the first flight of the first indigenous aircraft marked the success of Indaco in undertaking its third phase of development. It indicated its readiness to move on to the fourth phase, the implementation of R&D in future technology, which was to be manifested in the PLI. Indaco also enjoyed nationwide support and admiration due to this success, which was seen as a 'national pride' event and proof that the country would soon become industrialised. This led to the success of Indaco in arranging a unique financing and financial management strategy for the PLI Program with the establishment of Prico (discussed in Chapter 6). This, in turn, provided more discretion for the Program to use the allocated money, free from Indaco's financial regulations and performance. This financial arrangement contributed to the assertion that the Program had a very heavyweight management.

Meanwhile, the certification process that followed the first flight of PLP was not as smooth as planned. It dragged along due to various technical and non-technical problems that had not been fixed until the end of the field study in 1999, far behind the 1997 target and considerably over budget. Meanwhile, the sales prospects of other programs diminished during the 1990s. The only product selling was the PLC, a product co-developed with a European company that entered the market in the mid-1980s. The PLC production line also struggled to meet its delivery schedule due to technical and, later, financial problems. The value of such sales was enough to cover the PLC operational expenses but could not cover development expenses and other overhead costs. Therefore, Indaco was in financial crisis and continuously appealed to the government for additional financial support to cover the development expenses of
the PLP Program. The overall company's financial situation was in stark contrast with the secure financial situation of the PLI, at least during its early phases.

The above situation, which made the PLI Program appear as an exclusive division, created resentment and increased organisational rivalry. This contributed to the hesitation of the functional design units (i.e. Technology Divisions) to provide full support to the Program because it was they who were used to be the 'golden boys'. Furthermore, the fact that many functional design units were formed as a result of the PLP Program led to a sense of belonging toward the PLP Program, which in turn, led to some suspicions from the managers of the PLI Program that these functional design units would prioritise the PLP over the PLI. This contributed to problems of acquiring appropriate representatives from the functional design units throughout all the stages.

When the crisis finally hit the PLI Program, due to financial problems faced by Prico, and had temporarily terminated the program after preliminary design phase, the functional design units, in particular, were quick to respond by retracting some of their support. This response worried the Chief Engineer who struggled to complete the preliminary design phase. The organisational rivalry between the PLI Program and the functional design units contributed to this quick and immediate response.

In term of business and technology maturity, Indaco was inexperienced and naive within the aircraft industry. Many companies have been in operation for more than 50 years, while Indaco after approximately 20 years had just flight-tested its first 100% indigenous design. The management of the company acknowledged that they were immature, particularly in term of organisational tacit knowledge and, in order to overcome this, engaged in various technical and managerial consultancy and internship programs with renowned companies such as Westaco. For the
implementation of CE, this immaturity created a sense of anxiety in some managers, which was derived from the recognition that the company as the whole might not have enough experience. They were not so convinced that CE, the prominent concept within the aircraft industry, was the right approach, given the internal context and the stage of development of Indaco. For them, the adoption of such an approach was more of a 'technology-push' from the industry trend rather than a necessity.

The Ex-Project Engineer, who was one of the most experience engineers in Indaco, expressed his opinion in the interview:

In my opinion, the competency of [Indaco] engineers is not mature enough. The [enabling technology] system could not override the accumulation of experience. ... People who could apply CE should have 4 or 5 times experience in designing products (Mark, Ex Project Engineer, July 1998)

Considering a technical issue and relating this issue to the current attempt to model Indaco's CE on Westaco's, one Operation Centre's member recalled:

At that time, I emphasised that Westaco and us were so different. Firstly, we do not have a proper database. We started from scratch. Secondly, our competence people could not join the program. (William, Operation Centre, December 1997)

Furthermore, this also contributed to the different interpretations of the CE concept, even within the Program team, and communication difficulties and confusion across functions because the terminology had not been properly shared nor standardised.

7.6 Summary

Other than a serious attempt to acquire enabling technology similar to Westaco's, Indaco's CE initiatives in other aspects were much less developed. Even the attempt on enabling technology did not provide a significant positive contribution on the
internal organisational integration and the communication and decision-making mechanism across program teams. The significant differences from the Westaco practices were the absence of external integration (i.e. supplier and customer involvement in the program team), the absence of systematic protocol for implementation, and the lack of competence. At the termination of the PLI Program, the Indaco’s ‘specific model’ of CE was represented by a ‘frozen emergent’ arrangement, which characterised by:

1) An autonomous product development team instead of a heavyweight program.
2) Parallel design and production teams instead of single integrated teams.
3) Increasing hostile environment instead of teamwork within the Program teams.
4) Unsystematic utilisation of the enabling technology.

Detailed analysis of the rest of CE initiatives in the Indaco’s PLI Program reveals that two most significant factors that influencing the changing and final shape of organisational integration and communication and decision making mechanisms were the lack of a required level of tacit and explicit competency, and the lack of systematic protocols for CE. Further, the absence of these two initiatives contributed to the failure to effectively utilise the enabling technology set for the Program.

The lack of competent engineers played a major role in the formation of various program structures and working mechanisms as the Program struggled to adjust and fit the CE approach to reality. During the initial stage, in which the task was tackled by a small group led by an experienced engineer, this was not a significant issue. When the technical tasks grew and the size of the Program team increased, this human resource factor became more critical. It was behind a stream of structural changes in the Program. It was the root cause of the ongoing conflict between the Program’s
Design Centre and functional design units (i.e. Technology Divisions). It was also the primary cause of the increasing lack of trust between Design Centre and Operation Centre. Ultimately, this lack of competence was the major factor in the schedule overrun, as various unplanned tests needed to be undertaken and various incidents further delayed their completions.

The lack of systematic protocols caused confusion among both members and non-members of the Program team as they moved from the old sequential approach without clear guidelines towards a new one. The absence of such protocols caused the solutions taken to deal with the lack of competence were often inconsistent with the initial intention in implementing CE. It reinforced pressures to return to the previous sequential approach. This was particularly evident in various developments during the design-production coupling stage, such as the removal of aeronautical engineers from the design integration teams, discouragement to work with the Operation Centre, and ignorance over the systems developed by the Sidina group.

The transformation process of CE into a ‘specific model’ that differed from its original model was also influenced by the wider organisational context. Indaco organisation could be characterised as ‘centralistic-bureaucration’ with a strong technology culture in which a dominant design engineering sub-culture coexisted and often competed with other various functional sub-cultures (e.g. production sub-culture). It was a relatively young and immature organisation in terms of its accumulative tacit and explicit knowledge in the aircraft industry.

The silo effect of Indaco’s highly differentiated structure combined with its knowledge immaturity caused problems in carrying out matrix mechanism that led to autonomous program division cut off from functional resources. Within the Program
team, this led to the formation of two parallel centres (i.e. the Design Centre and the Operation Centre), rather than a single integrated team. This reflects the sliding back to functional arrangement that reinforced by the lack of systematic protocols. Meanwhile, the high level of centralisation infected the Program’s decision-making mechanism with the tendency to ignore the decisions and commitments made by the lower-level teams.

The strong and dominant technology culture influenced the strong emphasis on enabling technology in the overall initiatives to foster communication and interaction across functions and less emphasis on human resource readiness, such as teamwork and team building. The previous domination of design-related functions was influential in the early welcome of the CE approach by functional production units that made the early stage of implementation process ran smoothly. On the other hand, this created rivalry between the Program and the functional design units that contributed to the ongoing tension and conflicts, particularly over human resource allocation that led to the lack of competency in the Program team.

Overall, these findings emphasise the importance to consider the organisational context in the decision to implement CE to an organisation. CE initiatives implemented should suit the overall nature of the organisational context to be effective. Furthermore, the selection of the right configuration of CE initiatives at the outset plays an important role in ensuring the success of implementation.
CHAPTER 8

POLITICS OF CHANGE

8.1 Introduction

This chapter analyses the role of both individuals and groups in shaping the introduction of CE in the PLI Program from the initiation through to the elimination of the program due to financial and economic circumstances. The analysis provides important details in the organisational politics that were crucial in shaping the CE initiatives in the Program. It also shows how actions by some individuals and the decisions they consequently made or did not make, significantly affected some issues in the CE implementation process.

Using the tripartite analysis of power (Pettigrew and McNulty, 1995), this chapter reviews various actions of six key individuals throughout the CE implementation process. The review is arranged chronologically despite the inevitable overlapping. The power sources, will and skill, and context and structure of each individual were analysed in relation to their actions (or in-actions) that contributed to the changing nature and final shape of CE. These individuals were chosen because they were key players in shaping the CE in the implementation process. They are (in pseudonyms): Mark, the Project Engineer; Clive, the Program Manager; Alan, the Sidina Coordinator; William, the Production Planning Supervisor in the Operation Centre;
Lucas, the Technical Adviser for the PLI Program; and Robert, the Chief Engineer of the Design Centre.

Actions and interactions made by each of these individuals were driven by particular interests. Their behaviour and attitudes were also shaped by their experiential, contextual and cultural factors. Together, these six individuals played the most significant roles in shaping the organisational integration and communication and decision making process in the introduction of CE to the PLI Program. As we shall see in this chapter, the actions and interaction of these key individuals, both within the Program and in the broader context, contributed to the enthusiastic promotion of CE ideas which later was not adequately followed up by their implementation, the lack of integrated technology support for CE, continuing tensions with the functional design units (i.e. Technology Divisions), the lack of implemented system protocols, and the division between design and production functions in the final phase of the Program.

This chapter is arranged as follows. Section 8.2 analyses the actions of Mark, the Project Manager when the program was initiated. Mark contributed to the development of a cohesive enthusiastic group of young engineers that remained the core engineers of the Program in later stages. The actions of Clive, the Program Manager, are explored and analysed in Section 8.3. Clive was an all-powerful Program Manager who introduced CE into the Program. Section 8.4 reviews and analyses the actions of Alan and his Sidina group. Alan, the CADCAM Manager, was the adviser whom Clive relied on to establish the Sidina system, the enabling technology for implementing CE. Section 8.5 analyses the actions of William. As a young supervisor originally from Production Division, William played an important role in the establishment of the Operation Centre, the significant part of the Program.
Chapter 8: Politics of Change

that reflected its CE intention. Section 8.6 analyses the actions of Lucas and the implication of his interactions with Robert, the Chief Engineer. Lucas was the Technical Adviser assigned by Clive to assist the Chief Engineer and his teams. Lucas increasingly became more powerful and was responsible for the deterioration of CE near the end of design-production coupling stage. Section 8.7 provides summary of the chapter.

8.2 Mark: The Project Engineer at the Program’s Initiation

Mark was one of the few experienced engineers involved in the PLI Program. Trained in aeronautics, he joined Indaco at the end of the 1970s. He had been involved in the development of all two Indaco’s platform products, the co-development PLC and the first indigenous designed PLP. Starting as a new graduate, his involvement in the design process grew. By the middle of the 1980s, he became the Project Engineer for the PLP Program and was responsible for the overall engineering performance of the aircraft. He was also the Manager of New Product Development (NPD) Department in the Technology Division that was responsible for facilitating for the development of any new product or derivative. The tripartite analysis of Mark influence in the CE implementation is summarised as Table 8-1.

Mark’s power source came from his position as the Head of NPD Department, his experience and his excellent reputation as the Project Engineer of the previous PLP Program, which led to his direct and strong links to the President Director. Mark was a devoted aeronautical engineer. He was keen to involve young engineers in design exercises and believed that the company should continue to accumulate design knowledge in strict functional-based specialisation to achieve knowledge maturity.
prior to implementing an integrated approach such as CE.

Table 8-1: Tripartite Analysis of Power: Mark

<table>
<thead>
<tr>
<th>Stage</th>
<th>Program Initiation Stage</th>
<th>Engineering Matrix Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role</td>
<td>Head of NPD Department</td>
<td>Project Engineer/ Deputy Program Manager</td>
</tr>
<tr>
<td>Power Sources</td>
<td>Hierarchical position as NPD Head</td>
<td>Hierarchical position as Project Engineer</td>
</tr>
<tr>
<td></td>
<td>Reputation as Project Engineer of the PLP Program</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct link to the President Director</td>
<td></td>
</tr>
<tr>
<td>Structure and Context</td>
<td>Strong technology focus</td>
<td>Leaking reputation of the Program Manager</td>
</tr>
<tr>
<td></td>
<td>Strong autonomy within Technology Division</td>
<td></td>
</tr>
<tr>
<td>Skill and Will</td>
<td>Strong will for cohesive team</td>
<td>CE was not yet suitable</td>
</tr>
<tr>
<td></td>
<td>Emphasis on functional-based expertise</td>
<td>Not active due to other managerial assignment</td>
</tr>
<tr>
<td>Impact on CE Introduction</td>
<td>Strong fully dedicated and cohesive design team in the beginning of CE implementation</td>
<td>The implementation of CE with various problems associated with lack of competence</td>
</tr>
</tbody>
</table>

Hence, according to the tripartite analysis of power (Pettigrew and McNulty, 1995), Mark had significant power sources and structure to influence the process. Mark used both his ‘power sources’ and ‘context and structure’ capability in developing a cohesive and enthusiastic design team which consisted of various design specialisations and supporting the program to secure its financial support.

When the President of Indaco suggested developing a 100-passenger jet airplane in mid-1993, he assigned Mark to explore its possibilities. Armed with less than 20 newly-graduated engineers and a few experienced engineers, Mark carried out this task as part of the activities within the NPD Department. This task was carried out enthusiastically as expressed in various program reports. In the documents written early in 1994, for example, team members were regarded as “mostly graduated abroad in aeronautics, highly motivated, highly dedicated”1.

1 Item (4), (7) and (8) Appendix-B
Some engineers admitted that they regarded the task, at least in the beginning, simply as a hypothetical exercise, as one engineer recalled:

At that time, Mark assigned some engineers to start the PLI. I was a new (comer), just 2 months ... I just followed it through casually. Somebody worked on configuration; I helped with bits of small calculations. I calculated a bit of weight and balance, a bit of G point, a bit of payload configuration system, etc. (Frank, Design Centre, March 1998)

This attitude might have fostered influenced the enthusiasm. It was apparent that by treating this task as an exercise, Mark deliberately established a free environment for the engineers to explore all design and technical possibilities. He emphasised, however, the need for mastering specialisation and took an approach similar to the previous programs: a functional compartmentalisation approach. He explained:

I developed [PLI] in the same manner of [PLP]. I continued the capability accumulation process based on specialisation. ... A good aircraft is only made possible if each of its elements is optimised. It means it we talk about wing; it should be the best wing. To conceive the best wing, aerodynamic engineers have to assess more than 30 types of wing and only 2 or 3 will be tested in wind tunnel. This process should be done in isolation; aerodynamic engineers cannot interact with others. ... Then there is a comparative analysis, comparing one configuration with another. ...[Only] after that you could go to the next step: is it an optimum configuration? Could we optimise the process? Could we optimise the cost?

The initiation approach for the [PLI] was similar to the [PLP]. They were divided into system and structure. ... What I did in PLP and PLI was making imaginary building blocks for aerodynamics and others. but in the way they behaved they were integrated. So in aerodynamics, for example, when they reviewed the wing, it was as an integrated part that could not be separated between the structure and the aerodynamics. We usually carried out discussion and dialogue reviewing the design in the ground floor ... The PLI Program should have continued that way, but I don’t know I am not involved [any longer]. (Mark, Ex Project Engineer. July 1998)

Mark was popular among younger engineers and mixed well with them. Many engineers proudly admitted that they had worked with him. He was often seen by many young engineers across the company either as a formal or an informal mentor.

His team, at its peak consisted of 23 engineers, was loosely divided into nine groups with overlapping membership. This overlapping membership allowed technical information to flow freely among the team, which not only facilitated the development process but also increased the team cohesiveness. Within this
environment, the team presented their work at meetings chaired by Clive, the future Program Manager, between March to June 1994. During these meetings, the team not only presented and reviewed their concept of the aircraft but also suggested a way of working for the development team.

Hierarchically, the appointment of the meeting’s chair person was unusual since at that time Clive was an engineer finishing his doctoral degree in aeronautics abroad. However, it was widely speculated that he, notably a close relative to the Indaco’s President, would become the Program Manager. This might partly be explained by considering the Indonesian cultural tendency to accept high power differential (Hofstede, 1984) and leaking reputation (Trompenaars, 1994). In such culture, being a close relative of the ‘man at the top’ working in the company was typically enough for the subordinates to perceive that something further was expected and, hence, to behave accordingly.

The acceptance of Clive as the chairperson could also be related to Mark’s personality and his passion for the aeronautic profession. His egalitarian nature might make him feel indifferent towards an otherwise offending circumstance, i.e. a mere engineer chaired his team’s presentation meeting. His devotion to the aircraft development process made him always pursue excellent aircraft development over anything else. Such devotion might partly explain why the previous PLP Program, in which he was the Project Engineer, was far over budget. In the interview he expressed:

> For me, there is no airplane better than [PLP]. ... All the state of the art technologies are certainly there. It is highly appraised by others. From marketing point, it would be a success, why not? ... When [Boeing] 737 was launched to the market, no one said it was the best, and so with [Boeing] 747. They all were in doubt, in panic; they could lose their money. And so was with [Airbus] A300. ... They should think in reverse. You have invested 800 million dollars and now asking whether it is competitive. It is a crazy question that would kill the program. ... The important thing is having a room for modify. The modification cannot be one and for all, it is a pile of serial improvements. ... In a scary experience of a big flow of cash out. I know there would be a bottom line. The scare of big cash outflow caused many erroneous policies. I by-passed some of them. (Mark, Ex Project Engineer, July 1998)
Such devotion was also apparent through his continuing involvement in this PLI Program as a Vice Program Manager after the Program Manager was appointed in 1995. He played a significant role in the conceptual design phase of the PLI Program, during which the Program Manager spent most of his time abroad. He also made a significant contribution establishing the business plan of the program which secured its finances. Only after the financial scheme was established at the beginning of 1996, did his involvement cease.

As the Program Manager, Clive was handed over a rough concept of the aircraft and a relatively cohesive small team of engineers by Mark. Clive expanded the membership of the team, and announced the adoption of CE as the approach for the development team. Mark did not agree with the adoption of CE because of the lack of competence among the engineers involved. He later argued that CE involved cultural change and the introduction of enabling technology was not sufficient to successfully implement CE. He expressed his opinion in the interview:

> What they call CE [here] is first, people sit in one place. Second, that place had an integrated software and everything is computerised. ... The objective is, so they said, to increase efficiency, less cost, increase quality, less person... In my view, what they are doing in [the PLI] is not CE, the philosophy is not right. ... [Indaco] engineers are not mature enough. The system could not override the accumulation of experience. ... The [first] iteration should be specialisation-base. During my time, we still had aerodynamics, a distinct specialisation, and then we increased the communication, the interaction, the dialogue. Essentially, they need to remain in a tightly specialisation-base because they have not had experience to provide judgement yet. Dialogue involved judgement. People could not be involved in negotiation before they understand what it is; otherwise quality suffers. We are not ready yet. ... People who apply CE should have 4 or 5 times experience in designing products. ... In technology, the acculturation process is carried out through the accumulation of experience. Without accumulation of experience, there is no CE. (Mark. Ex Project Engineer. July 1998)

However, he lacked the will to use his power sources to confront the CE and Sidina concept pursued by the more powerful Clive or to create a political 'agenda' at the top management level by opening the issue of whether to use CE or not in the PLI Program. Factors in the context and structures (e.g. cultural tendencies of power
distance, his lesser degree of involvement in the Program, his new assignment) can be attributed to this lack of will.

It was strange that such an opinion from such a respected engineer as him was not taken into consideration. It is possible, however, that at that time Mark was not pressing his argument, given the cultural tendencies and his own personal traits which inhibited him from doing so. If he had clearly and openly opposed these concepts, with a 'compromised but contextually-proper' approach, a potentially successful implementation might have been obtained. The criticism of the lack of competence was widespread within the Technology Divisions and at times served as arguments to increase scepticism to the CE pursued by the Program Manager.

In summary, Mark actions and in-actions contributed to the shape of organisational integration aspect of the PLI Program. In the program initiation stage he contributed to the formation of a relatively cohesive and highly motivated design team, that later became the basis of design-related cross-functional team in the beginning of CE introduction in the PLI Program. In engineering matrix stage, although remained actively supporting the Program, he did not make significant action in shaping the organisational arrangement of the PLI Program. While having a depth understanding of Indaco's engineers' competency, he was indifference toward CE, which he believed was not compatible with such level of competency. As a result, he also contributed to the decision adopting CE and its associated organisational arrangement.

In a sense, the whole relation between Mark, the Project Engineer, and the adoption of CE approach was ironic. He had established the team that would be perfect for CE implementation in terms of its cohesiveness and openness, yet he was opposed to CE within Indaco perceiving that the engineers were not competent enough for such
approach at this time. Mark had a significant argument in his opposition in regards to the engineering competence because he had worked closely with this particular team, yet he apparently did not express his argument clearly enough. The significance of his argument became evident throughout the case study.

8.3 Clive: The Power of the Program Manager

Clive's power in promoting CE came from various sources including his close relationship with the CEO of the company and was supported by his structural position as the Program Manager of the PLI and later as the Head of the Airplane Group. This power supported the PLI Program into a heavyweight position within the company. The summary of tripartite analysis of Clive power and its contribution to the implementation of CE is provided in Table 8-2.

After being appointed as the Program Manager, Clive often flew to the U.S. to finish his internship. The daily operation of the program was run by the Manager of Program Management Office. Although he was away, the Program enjoyed the full benefit of the fact that the Program Manager was closely related to the Indaoc's President. Supports were easily secured. Statements, such as "[Clive] wants this to be...", were usually enough to acquire the necessary support from other senior managers, such as in the establishment of the Program's master phasing plan, and gaining approval for the Program's enabling technology facility.

Besides the Indonesian cultural tendency discussed in the previous section, organisational structure was another contextual explanation for this situation. Due to its delicate state as an infant development program, the PLI Program reported directly
to the President Director. Historically, the previous two programs had also enjoyed this privilege in their early stages and so there was a precedent for this arrangement. Although, when those previous programs were initiated, the Indaco structure had not been as developed. This precedent provided a comfortable justification among many top management members. Through this position, the Program gained tremendous support company-wide as it also indicated the relative importance of the Program and its Program Manager within the company.

Table 8-2: Tripartite Analysis of Power: Clive

<table>
<thead>
<tr>
<th>Stage</th>
<th>Engineering Matrix, Engineering Integration and Design-Production Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role</td>
<td>Program Manager</td>
</tr>
<tr>
<td></td>
<td>PLI Division, Program Manager</td>
</tr>
<tr>
<td></td>
<td>Chief Engineer</td>
</tr>
<tr>
<td></td>
<td>Chief Operation</td>
</tr>
<tr>
<td></td>
<td>Operation Center</td>
</tr>
<tr>
<td></td>
<td>Business Management</td>
</tr>
<tr>
<td></td>
<td>Finance</td>
</tr>
<tr>
<td></td>
<td>Design Center</td>
</tr>
<tr>
<td>Power Sources</td>
<td>Hierarchical position as the program manager</td>
</tr>
<tr>
<td></td>
<td>Closely related to the President Director</td>
</tr>
<tr>
<td></td>
<td>Young, clever, broad-minded, well-educated</td>
</tr>
<tr>
<td>Will and Skill</td>
<td>Implementing CE, but often absent and later busy with other assignments</td>
</tr>
<tr>
<td></td>
<td>Unclear description of CE as a strategy to get CE off the ground</td>
</tr>
<tr>
<td></td>
<td>Maintaining harmony in the top management council</td>
</tr>
<tr>
<td>Context and Structure</td>
<td>High power distance and leaking reputation led to respect superior relatives</td>
</tr>
<tr>
<td></td>
<td>Cultural tendency to maintain harmony</td>
</tr>
<tr>
<td></td>
<td>Dissatisfaction of production and other functions on design centric environment</td>
</tr>
<tr>
<td></td>
<td>Unique financial arrangement of the program</td>
</tr>
<tr>
<td></td>
<td>Program's position as an infant program with direct line to the President Director</td>
</tr>
<tr>
<td></td>
<td>Other assignment as the Director of Airplane Group in last stage</td>
</tr>
<tr>
<td></td>
<td>Golden boys' positions of functional design units prior to initiation of the PLI Program</td>
</tr>
</tbody>
</table>

Effect on CE Introduction

- Attract staff to join the program at earlier stages
- Gain support from functional production units but rivalry from functional design units
- Lack of detail protocols and implementation plan of CE concept
- Resistance that in turn required adjustment in organisational arrangement
- Confusion at the lower level, competing concepts, lead to conflicts and tensions
- Provide opportunity for others to impose approaches different from the intention

However, substantial support was also gained through the personality and attributes of the Program Manager. A doctorate in aeronautic engineering, he was seen as young, clever, broad-minded, well educated, and well connected both within the country and
within the global aircraft industry. One of the top management members emphasised:

Of course his name has a significant effect. He has a hotline to the President Director. But we do not look at it as a negative thing, but in a positive way. If something was not in line with the boss’s vision, we could know it straight a way. This is the positive side. ... Oh, another point, he might have his name, but he is also smart, his idea is often brilliant, his point is logical. (Brian, Top Management Member, April 1998)

Many saw him as promising a bright future for Indaco. His decision to adopt CE and the price target he set for PLI were seen as a breakthrough for Indaco’s experience and a solution to the ever present problems of cost and schedule over-run of the previous programs. One engineer expressed his support in the following way:

The driving factor is right. We have the right product and we have the right approach. ... Clive announced that we wanted to sell the product around US$ 22 million range. We got it wrong in PLP, we said we wanted that kind of technology, but in [aircraft] price we were at a mess. (John, Design Centre, January 1999)

The adoption of CE and the Program’s cross-functional team, in particular, won support from many people functional production units (i.e. Production Divisions) who had been disappointed with the design-centric environment of previous programs. These people believed that Clive could make the difference. The effect of these personal attributes was more evident at the micro level. Many engineers throughout the company applied or decided to join the Program. Some application letters were dated as late as 1998. These applicants expected that they would have a better work environment in the new program under Clive, the new leader:

The top man is great, he ran several review meeting. That is very important in encouraging us... So he knows what we are doing ... There are some superior who do not know what their subordinates are doing ... (Darren, Design Centre, March 1998)

Others who were assigned by their functional units as focal points expressed similar enthusiasm. The establishment of the master phasing plan was an illustration of this enthusiasm in resolving conflicting goals and schedules between functions. Many regarded this task as an exercise toward a truly cross-functional team and a test of
whether they were ready for it. Many focal points voluntarily put more time and effort than they were expected or required to in supporting this Program. Without such an enthusiasm, the Master Phasing Plan, which became the single reference point for the program, could have not been established. In short, during the engineering matrix stage Clive actions with all his attributes were able to attract company-wide support to the PLI Program and his CE.

At the Executive Management Council (EMC) however, this enthusiasm was lacking. There, Clive often played ‘the lack of clarity’ game providing inadequate details in order to obtain senior management commitment. For example, the Program Manager explained CE simply as an approach to effectively achieve quality, cost, and a delivery schedule without detailing its implication on functional units across the company. One senior manager recalled Clive’s presentation to the EMC:

As far as I can remember, CE has never been fully introduced [Indaco]-wide. But I might be wrong ... [Clive] informed us about the basic principle, that the core of CE is to shorten and to reduce bureaucracy between functions so that involved functions are in one place to develop the design. That is the idea, isn’t it? He told us that, but not the exact form of it and [neither] how he would proceed. [For example] I am not so sure, is it part of CE that design groups have been taken over by the Design Centre? (Brian, Top Management Member, April 1998)

Considering that the literature on CE was widely available in Indaco, this account did not indicate that those functional managers were not aware of the implication of CE. It indicated, however, that they were not sure of the Program Manager’s implementation plan. It seemed that the issue of company-wide implication of introducing CE was deliberately meant to remain unclear. Such further clarification might have opened the inevitable shift in organisational ‘balance of power’ since the implication of CE was heavily related to this balance of power across the company (i.e. between the PLI Program and the functional units). The functional design units, for example, would have a less direct role in defining the aircraft features than they
used to have in the previous programs, which in turn, might offended some top management members. It seemed that the management was not ready for such organisational-wide transformation. In this sense, all parties intentionally, although covertly, decided not to put the clarification on their decision-making agenda. Clive started this 'non-decision' by not offering the detail of his concept at the first place.

In promoting CE he was widely supported, notably by the Production Divisions who were concerned with continuous cost and schedule overruns of the development process. However, without the clarification of its implication to the top management, the political arena of CE implementation moved to the periphery and was manifested in various tensions and problems between the Program and the functional units, notably the Technology Divisions as discussed in Chapter 6 and Chapter 7. These tensions and problems became more intense in the next Engineering Integration stage when the Program adjusted the organisational structure and internalised functional specialists from Technology Divisions as members of the Program.

Clive’s decision to abandon the matrix system in favour of an autonomous system in the Design-Production Coupling stage was seemingly an effort to reduce the effect of this power struggle on the Program. However, eliminating the Program’s dependency to functional design units proved to be impossible due to the limited number of competent engineers. The PLI program remained dependent on the Technology Divisions as its source of manpower, particularly in the area of system engineering and detail engineering analysis. This manpower issue contributed to the political battleground between the Program and the Technology Divisions.

The hard-line position taken by the technology divisions can be related to the functional and organisational cultures of Indaco discussed in Chapter 7. Clive’s
intentional change from technological dominated into a cross-functional teamwork process in the strong technology oriented culture was a very difficult venture. The Program, in its later stages, suffered from this failure to change the culture. The separation of the Design Centre and the Operation Centre instead of a single integrated cross-functional team, the reliance and emphasis on enabling technology and the domination of the Technical Adviser illustrated this problem.

The continuation of this power struggle was also reflected at the operational level. Many Design Centre members simply ignored the feedback offered by the Technology Divisions in a Configuration Review Meeting between the PLI Program and the Technology Divisions mentioned earlier in Chapter 6. Some stated that the aim of the review with the functional design units was not to acquire feedback from them. Others believed this feedback was hardly necessary:

Ol', that's the comment from [one of Head of Divisions]. Sometimes his feedback is different from Lucas's ... and I trust Lucas. He is smart. Therefore, the aim of the review with functional units was to present the progress, not to gather feedback but to let them know what our design look like. At the end, we will pass it to them for detail design. (Darren Design Centre, March 1998)

Nevertheless, Clive's power sources, notably his close relation to the CEO and the cultural tendencies associated with that, prevented other senior managers to demand further clarification and hence, created a blockage for the issue to go on the management agenda. In his part, this was seemingly a necessary pragmatic political strategy to get the CE and PLI Program off the ground.

However, this blockage moved the problems into the micro level, and were manifested in particular in hesitation of the Technology Divisions to provide full support (e.g. to provide experienced engineers), which caused deterioration in the competency of the program team. His coping decision to move to an autonomous
program in design-production coupling stage, deteriorated the situation even further as most experienced engineers opted to remain in their functional units. At the end, the Program mainly consisted of inexperienced engineers who relied on the powerful Technical Adviser who was not aware of the initial intention of implementing CE as discussed later in this chapter (i.e. Section 8.6).

Lack of detailed clarity in Clive’s CE also created confusion within the Program teams in which each group pursued its own version (e.g. the Operation Centre’s mini-factory, the Design Centre’s preliminary design approach, and Sidina’s enabling technology) which were not compatible one another and caused tensions and conflicts among them. In an early interview, Clive stated his concept was not going to integrate production’s operators into the development process as in the mini-factory concept:

They have to meet everyday. But it does not include the hardware. It involves the planning, manufacturing planning, tooling engineering, but not the people from the [Production] floor. There is a concept that involves shop-floor, but we do not go to that concept ... where the design people sit in the manufacturing company as a design bureau ... I have seen it in some units of Westaco: they tried it. ... There is a small building where engineers and planners sit in one corner and the hardware workers in the other corner. So, the communication between them works well. But that’s a different concept. (Clive, Program Manager, June 1996)

However, one Supervisor in the Operation Centre had exactly this in his mind when he referred to the CE concept:

... in TIP is we divide [the program] into 4 stages. First, it is as the process integration. Then, it becomes [a design production team] that works concurrently with the design [teams]. We are in this stage now. Then, it becomes product integration and at the end it becomes a mini factory. So, the TIP members will become shop-floor people. That’s why we plotted shop-floor people there. ... That’s my idea since the beginning. (William, Operation Centre, December 1997)

This Supervisor expressed his opinion in various documents that had been submitted to the Program Manager (e.g. The 1997 Operation Management Charter). These documents had informally become references in the conduction of the Operation Centre. One TIP Co-ordinator, for example, explained the function of TIP as:
In principle, TIPs will be the incarnation of program executor. They will reincarnate to become the assembly line. In the assembly stage later on, therefore, it will be impossible that the assembler making a fuss saying it is not right or it is wrong because they have followed the process. It is possible that during the time [Phillip] will be the shop manager of the fuselage, other will be the shop manager of the centre body. TIP co-ordinator will become the assembly manager. It will be much easier, we can say, you were there at that time, so you have to be responsible. (Peter. Operation Centre, November 1997)

However, these conflicting opinions were never put forward or resolved. Even, the whole Operation Centre was seemingly unaware of the difference since the above Program Manager’ intention was never clearly documented. This apparent lack of clarity about the applied concept might simply have been the result of cultural gestures such as hesitation to express differences, face saving, or protecting harmony. But it might also be intentional as a part of organisational politics considering the Operation Centre was a significant part of the Program that differentiated it from previous programs. Any internal conflict within the Program might be seen as reducing the reputation of the Program in adopting CE.

The political action using the deliberately imprecise issue was also apparent in Clive’s decision to introduce an additional program-based reward system in his program, which was later abandoned. He did not provide the top management members the precise details of this reward system nor did the top management demand clarification on details, partly due to the separate financial arrangement, as two top management members commented:

They introduced this reward system, they said it based on the Work Breakdown Structure. [Clive]’ defence was that the good people have worked and met schedule with less cost; that people elligible for bonus. That what he said. (Brian. Top Management Member. April 1998)

The way [the PLI Program] did that would cause problem. They attached the bonus system to the Statement of Work packages. ... [Clive] felt like he and the Program owned the money because he got it directly from [Prico] for each package. He took, for example 5%, for this reward system. This is different from other programs, in which all the inflow go to [the Finance Division] and the outflow should be based on the budget. (Steve. Top Management Member. April 1998)

According to some members of the PLI Program, the actual allocation and calculation
of the system did not involve the Work Breakdown Structure nor Statement of Work package that have been completed except as a source of money. Instead, the allocation was based on the performance appraisal that, in a sense, was similar to the one that the company already had. However, after furious opposition from most senior management members, the reward system was cancelled after only a short implementation period.

These conditions that preventing CE from developing indicate that the ‘non-decision making’ in Indaco’s organisational politics played as significant role as active decisions (e.g. the move toward autonomous teams) in shaping the CE throughout the process. If Mark’s opinion in the earlier stage had been taken more seriously and a better coalition involving Technology Divisions, CADCAM, Production Divisions had been built in negotiating and setting up a detail implementation plan, CE in the PLI Program might have been more successful.

Following the introduction of a new organisational structure in June 1997, beside his position as the PLI Program Manager, Clive was also appointed as a Director of the Airplane group. In this position, he was not only responsible for the PLI Program but also for fabrication and all other airplanes. As the airplane production was the core business of Indaco, this position was very important. It provided him with tremendous power that was beneficial for the PLI program. For example, the need for tool designers and assemblers from Fabrication other divisions to support the test experiments was secured by a directive from the Director of the Airplane Group requesting all divisions to support the project and release from other tasks any member required for the Program.

However, the position was very demanding and took most of his time and made him
very busy. Particularly because of the unfolding Indonesian economic crisis, he spent less time on the Program. In a way, he lost some direct contact with the process and relied heavily on the Technical Adviser. Clive still had weekly regular meeting with the PL1 Program leaders including the Chief Engineer, Chief of Operation, Business Manager, and Financial Manager. Often these meetings were not solely dedicated to the PL1 program, but covered issues relating to the Airplane Group and involved managers from other programs. He lost almost all contact he used to have with the rest of the program members, except in the big formal meetings such as design review or operation review. He also became less sensitive toward the development of the team. One engineer stated:

The next operation review will be in 2-month time. Recently, Clive does not focus on detail ... and focuses more on the business side. I observed that he made only a few comments on technical meetings. He relies on us. So he works less on the program's side and more on the director's side (William, Operation Centre, December 1997).

Apparently, Clive was not aware of a growing anxiety among engineers over the role of the Technical Adviser, although he seemed aware of his domineering attitude. He was also seemingly not aware that with the Technical Adviser’s guidance the development process was deviating from his intention with CE implementation. The Chief Engineer could not take any action because officially the Technical Adviser was responsible directly to the Program Manager.

This situation led to the CE implementation process resembling March and Olson (1983) ‘garbage can’ model and it had difficulty sustaining “the attention of major political actors” (p.286). Furthermore, this situation allowed “less central actors to move into foreground and inject competing definitions of the situation” (Buchanan and Badham, 1999, p. 164) as represented by the Technical Adviser, who took over the development process ignoring the previous change intentions.
In summary, Clive had enough power sources, skill and will, and supporting context to initiate CE in the PLI Program, e.g. establish the matrix with the Technology Divisions, and, later, form the Design and Operation Centres; but not enough to overcome barriers and make it work. He employed a strategy not addressing the detailed concept of CE up-front in order to get the CE implementation off the ground, but this led to unintentional incremental changes: continuing integration problems with a tendency to slide back to the traditional functional-based approach.

8.4 Alan and the Sidina Group: The Power of Enabling Technology

Alan joined the company in mid 1980s as an engineer in the Information Technology Division. By the end of the 1980s, he was involved in a study that aimed to find a computer system that was suitable for supporting the development of a new aircraft platform (i.e. PLP) particularly in the area of design and manufacturing process. The study assessed various business processes across the company. Alan was appointed to assist the ex-officio leader of this study team to deal with daily operation. Following the proposal of this study, Indaco decided to implement the CATIA system, established a CADCAM Division in Technology Divisions and appointed Alan as the Head of Division. The Division provided technical support to CATIA users, provided CATIA and related systems training courses, developed the necessary software systems, and monitored the development of advance computer technology in this area.

Alan’s influence in CE was primarily based on his CADCAM Division expertise and his link to Clive, the Program Manager. The tripartite analysis of Alan is provided in Table 8-3. When the PLI Program Manager announced the intention to implement CE, he expected Alan’s division to support him in providing the enabling technology.
Although Alan’s involvement started in the early stage, the effect were mostly appeared in the last Design-Production Coupling stage where the development of computer system started to take form. Ironically, rather than eased the development process the system brought more tension in the Program particularly due to its incompatibility with the habit developed among engineers in using computer technology.

<table>
<thead>
<tr>
<th>Role</th>
<th>Engineering Matrix/Engineering Integration</th>
<th>Design-Production Coupling</th>
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<tbody>
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<td><img src="image.png" alt="Diagram" /></td>
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Table 8-3: Tripartite Analysis of Power: Alan

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<tr>
<th>Stage</th>
<th>Engineering Matrix/Engineering Integration</th>
<th>Design-Production Coupling</th>
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In providing enabling technology for CE, Alan proceeded through a similar manner as with the previous CATIA implementation. He formed a cross-functional assessment team made up of his staff at its core, convinced the Program Manager to lead the team, and put himself as the daily operations manager. The team had a weekly regular meeting and later was divided into several subgroups to tackle detail assessments. He typically oriented their actions vertically, constantly referring either to the approval from the top management on Sidina implementation or to many program directives that stated the group responsibility as system developer in the program. When the
CADCAM Division was eliminated in 1997 Indaco's restructuring, Alan moved to become an expert on the staff of the Director of Airplane Group (i.e. Clive) but all his staff remained intact as the Sidina group.

His deliberate actions in obtaining senior management commitment strengthened his position and, hence, shaped the PLI's CE to be the one that emphasised the role of enabling technology. Although never directly involved in the PLI, he was regarded as a very important person behind the adoption of CE:

CE is Alan's idea: it is not Clive's but Alan's. ... (Mark, Ex Project Engineer, July 1998)

This illustrated that Alan's actions in mobilising his power sources and contexts had created the political ground that his group to become very influential in a process in which they were otherwise only marginally involved. Alan and his team were never part of the PLI Program team, yet their Sidina system was instrumental, if not the only tangible result from the experiment with CE.

The development of Sidina system was started by running three pilot projects: concurrent engineering, knowledge-based engineering, and configuration management. The CE pilot project used the task of modifying the PLP's door as its object. During the field study, the design phase of the pilot project was completed and the modified door was in manufacturing. Despite the intention to support CE in the PLI Program, only a few PLI members were involved in CE pilot project because its timing coincided with the PLI's preliminary design phase during which most engineers were fully involved with their design tasks. The use of a PLP component naturally drew more people from the PLP program. This decision to use a non-PLI component as the object of the pilot project, while provided the opportunity to go on with his implementation plan, did not provide adequate help for the PLI team to work
with the CE concept. This led to ignorance in the Design Centre and Operation Centre of the results of the Sidina group, which in turn prevented the Sidina system to be fully utilised by the Program.

Not surprisingly, many engineers from the Design Centre and the Operation Centre were unhappy with the support provided by the Sidina group. They, ironically, argued that the Sidina group should work more closely with the PLI Program and familiarise themselves with the program environment so as to enable them to provide sufficient support as Sidina was established to support the PLI Program. They argued that the workshop and training provided based on the lessons learned from the pilot project was not enough to transfer the Sidina concept to the Program. One engineer commented in the interview:

Frankly, Sidina support was less than expected, but I cannot blame them. They are not designers: they do not have designers' experience. It was not their fault. We were fully occupied in the design process. We did not have a smooth interaction and, hence, there was less synergy between us. (Robert, Chief Engineer, January 1999)

... we haven't seen its benefit yet. It might, partly, be our fault because we were not involved due to the time constraint. But it is also a weakness of Sidina group in transferring the result to us. ... [they] should train us. Or perhaps our group should get involved then, so that the transfer process was smoother. If we only inherit the document, most probably it won't work. ... Sidina works in parallel with the program and, hence, the result cannot be implemented in the program. (Victor, Design Centre, March 1998)

In one meeting, the Design and Operation Centres both agreed to undertake a pilot project for the digital tool definition in co-operation with the Fabrication Division but without the Sidina group participation. This issue was then raised again in a review meeting with Clive the following week informing him that the Fabrication Division had its own pilot project on the digital tool definition after Sidina failed to established one for them.

The more serious conflict between the Design Centre and Sidina was a dispute on configuration management issue. It was exposed when the Design Centre carried out
the design process for two technological experimental tests (i.e. the wing box panel and the skin panel tests). The objective of these tests was to select the optimal design concept of the panels and provide the technological proof for the selected concepts. These activities were also used to check the readiness of the Program as a whole, including the systems surrounding configuration management, operation management and the enabling technology tools.

The dispute centred over the numbering system of the drawings. Together with the Program’s Configuration Management Department, the Sidina group had established a configuration management system using a unique one to one drawing number to ensure traceability. With this system, one drawing number was designated to only one part number so that the number became the property of the part not of the drawing. Alan explained in the interview:

We defined a unique single product structure. Because it is a single product structure, it should also reflect the requirement of manufacturing. The product structure is not based on designer’s viewpoint but based on the product itself, the assembly sequence, so that designers will establish the design according the structure of assembly. The drawing and its numbering system are also arranged accordingly. We established one drawing for one part concept. The unique identifier is the part, and the drawing is one of the part attributes, the container to place the shape of the part. (Alan, Sidina, January 1999)

The Design Centre violated this system by designating a drawing number to several designed parts. With support from the Chief Engineer, the Technical Adviser (i.e. Lucas) urged engineers to design various related parts on one single drawing sheet and identify them with a single drawing number. The argument for this deviation from the established system was that the prototype drawings did not need to be treated as the serial drawings. The Chief Engineer explained:

The fundamental was that we changed the design concept. For the prototype, it is impossible to draw every part of the component. The drawings will be in the form of assembly drawings. These assembly drawings have enough detail to make both assembly and detail parts. To make it work, we need a prototype group in manufacturing as a partner who have high skill and is able to interpret these [drawings] into detail drawings ... We don't have time to make all the detail drawings in the Design Centre. Later in serial phase, we will have a drawing for
each part. It is supposed to be like that to ease the configuration management. ... We are searching for the best way. The biggest problem is the Sidina people have never been involved in the design process, so their solutions did not help. They try to help but they do not help us in solving our problems. (Robert, Chief Engineer, January 1999)

However, not many people were convinced by this argument. Rather, it was a widespread awareness that the Program should make it right in the beginning to avoid complications later in the process, particularly in terms of compliance with certification process that required traceable configuration development.

The vision of Sidina is very good. They prepare the digital system to support our design process, to set up the configuration management system and, therefore to reduce mistakes in the design process and in the shop floor. The configuration control will be much better. (Victor, Design Centre, March 1998)

But, [at a development program] we don’t stop at designing the product, we should manufacture it. With this [new] way, there is a shift in our control base, from based on drawing in design to based on part in production. ... The formal reason for this backward movement from the PLI [program] was that they ran out of time. But they also mentioned that the manpower were not familiar with the system and that they aimed to make the process more flexible and faster. But, I am in doubt about the speed. It is not necessarily faster, it maybe faster in the beginning but causes more troubles in the end. It will cause problems in configuration control too. (Alan, Sidina, January 99)

These incidents illustrated the distance between the Sidina as a support group with its customer, i.e. the PLI Program. This distance was partly caused by the approach taken by Alan as the team leader of Sidina. By not seeking and, subsequently, not gaining support from horizontal peers, they, at times, lost sight of their main objective, supporting the Program, and instead focused on mastering the system as another knowledge achievement. In doing so, Alan ignored the necessary coalition with the PLI team, which was notably the main customer. This also implied that the interest was more on getting the new system the group wanted and using the PLI Program as a mechanism for this rather than toward the successful implementation of CE in the PLI Program. On the other hand, the objections from the Design Centre could also be seen as resistance to change to thing that was not ‘invented here’, given the strong domination of design engineering culture in Indaco.
After months of dispute, Alan slightly modified his approach in collaborating with the Design Centre. He asked the Technical Adviser and the Chief Engineer to provide a basic design course to familiarise support system engineers with the development process. The aim was to provide awareness of the design process that would enable computer system engineers to provide a more designer-friendly support system. This might be too late for the PLI Program. But, according to Alan the Sidina group had been directed by the Program Manager to continue with CE preparation despite the cancellation of the PLI Program and, therefore, would have plenty of time to develop a sufficient support system either for PLI or for any other program in the future.

8.5 William: The Role of Middle Management

William joined the company in the early 1990s after finishing his masters degree in France as one of Indaco’s sponsored students. He started his involvement in the PLI Program as a focal point from one of Production Divisions in 1995. His power source in the PLI Program initially came from his education level which relatively higher than other focal points from Production Divisions. The tripartite analysis of his influence throughout the process in provided in Table 8-4.

William was genuinely interested in pushing production aspects into design considerations. His influence in the process came from his ‘will’ to make a contribution in the PLI Program. During Engineering Matrix stage, he voluntarily took the initiative to co-ordinate and integrated support from all focal points from various divisions within the Production Divisions. Later, this initiative was supported by the Director of Production, who saw this as the opportunity to improve Production Divisions’ position in the development program. He recalled in the interview:
At that time, I saw that representatives from Production Divisions did not have the same view. We were not integrated. Then, I tried to get them together to make a team. The group consisted of representatives from divisions, a good [quality] people. ... I co-ordinated all of them ... We produced a lot of concepts, which later became the basis of the current system ... At the beginning, it was just voluntary, no formal assignment. ... Then we presented to [the Production Director]. After the presentation, the team was established and formalised with the Director's memorandum to the divisions. (William, Operation Centre, December 1997)

Table 8-4: Tripartite Analysis of Power: William

<table>
<thead>
<tr>
<th>Stage</th>
<th>Engineering Matrix</th>
<th>Engineering Integration</th>
<th>Design Production Coupling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role</td>
<td>Production Co-ordinator</td>
<td>- Expertise - Support from Director of Production</td>
<td>Supervisor of the Production Planning Department</td>
</tr>
<tr>
<td>Power Sources</td>
<td>- Early involvement and early idea of production integration concept</td>
<td>- Early involvement. - The 'owner' of production integration concept that became reference in the Operation Centre</td>
<td></td>
</tr>
<tr>
<td>Skill and Will</td>
<td>- Production Integration - Lobbying production's top management - Coordinating focal points</td>
<td>- Mini factory concept - Developing the concept into written charter - Assembly as the core business - Less influential due to his current position - The concept relayed to the Program Manager via the Chief of Operation</td>
<td></td>
</tr>
<tr>
<td>Effect on Introduction</td>
<td>- Formation of Design Build Process (DBP) team - Formation of TIP teams - Attract production staff to join the PLI Program</td>
<td>- Formation of the Operation Centre that had equal position with the Design Centre - Attract production staff to join the PLI Program - The concept was never openly discussed by the management of the PLI Program - Competing concepts between Design Centre, Operation Centre, and Sidina led to tensions, distrust, and conflicts</td>
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This group of focal points came from various functions, such as manufacturing, assembly, manufacturing planning, tooling engineering, process development, facility planning, industrial engineering, quality control, material procurement, manufacturing resource planning and material development. William's contribution in integrating production resources to support the PLI program was significant. The Program Manager was impressed. In the beginning of Engineering integration stage, he was appointed as Production Co-ordinator, a liaison role that interface the Program with the Production Divisions. He explained:

Then, parallel with that, I was appointed by Clive to be the Operation Co-ordinator to co-ordinate operation activities. So, I had duality in reporting, responsible to Clive and to the Director of Production. (William, Operation Centre, December 1997)

During this stage, the group of production representatives was formalised as Design
Build Process Team and production-related TIP teams aimed to prepare production aspect of the Program. Additional members were added from the relevant functional units. In the Design-Production Coupling stage, these teams were merged as part of the program organisation, i.e. the Operation Centre, which together with the Design Centre became the main part of the autonomous PLI Program.

In this sense, William was influential in promoting CE and equalising the role of production functions to the same level as the design functions. However, the position of Chief of Operation was given to Howard, a long serving manager, who was the Manager for Marketing and Customer Support Department in the previous PLI Program organisation. William was appointed as the supervisor of Production Planning Department in the Operation Centre. Most TIP members joined the Program, as members of the Operation Centre and continued their activities as in the previous stage. This made William remained influential within the Centre, as he commented:

All those [organisational] boxes are actually under the my Department. In fact, the division of tasks is not well balanced because Clive wanted to continue the previous process ... So, I haven’t changed [anything]. .... Most tasks carried out by the Facility Planning Department, for example, are based on our request. The requests about assembly facility came from TIPs under my co-ordination. It is not well balanced but it is fine by me. (William, Operation Centre, December 1997)

Even the Chief of Operation admitted his influence as he noted in the interview:

Most members of the Operation Centre] were actually part of William ‘s group back then. William was [responsible for] Design Build Process, or whatever, but it was mainly producibility. They were part of that, but we could not accommodate all of them, just part of them. Then, there were TIPs that remain functioning [now]. We involve shop-floor people from [the PLP] and [the PLC] and Fabrication. I usually rely on William for recruitment, because he was the one who ran it. Back then, he co-ordinated up to 200 people for those teams. So he knows it quite well ... He has been involved since the very beginning. (Howard, Chief of Operation, November 1997)

However, the operation concept pursued and developed by William and his group was different to the one put forward by the Program Manager and Sidina group, particularly the concept of mini factory (see Section 8.3). In this concept, the
production activities, the assembly of aircraft and major components in particular, were seen as the core business of the program. Other functions, including the design engineering functions were seen as suppliers that supporting the assembly activities. Stating that the Operation Centre’s core business was the assembly line, each of the TIPs was projected to be an autonomous mini-factory that delivered components to the assembly line.

This concept conflicted with the Design Centre’s interests, particularly with respect to the supplier – customer relationship between the Operation Centre and Design Centre. The Design Centre viewed that the objective of the Operation Centre was to assist the Design Centre in developing a sound manufacturable design, and hence the Operation Centre was the supplier of the Design Centre. In contrast, the Operation Centre was convinced that the ultimate aim of the Operation Centre was to became mini factory, as William stated:

> In the Operation Centre, we have four overlapping activities: firstly as process integration; secondly as design-production team [similar to Westaco’s], which is the role of TIP teams right now in relation with the Design Centre; then [thirdly] as production integration team [to build the prototype]; and finally to be mini-factories. That’s why we plotted shop floor staff here in the planning stage. (William, December 1997)

These conflicting views were, to a large extent, strengthened by the lack of any clear protocol in CE implementation. However, being a supervisor in the Operation Centre and cut-off from his original function decreased William’s power. As a supervisor he was not part of the program core team as he was as the Production Co-ordination in the Engineering Integration stage. His mini factory concept although internally adopted as the Operation Centre concept towards CE, for example, was never seriously discussed or considered at the program management level. Without its
original champion at that level, the mini-factory concept was prevented from being listed on the program's agenda because of its obvious deviation from the Program Manager's intentions.

Further, focusing on assembly as the core business of the PLI Program excluded manufacturing and tooling functions from the Operation Centre. Without adequate links to Production Divisions, the Operation Centre was an unnecessary bureaucratic mediator. Although the Operation Centre gave attention toward the producibility and manufacturability aspects and even provided some courses on the subjects, most of the operational tasks in detail part planning, NC-programming and tooling engineering activities were carried out by engineers from the Fabrication Division. William and the Operation Centre, hence, acted as the co-ordinating medium to channel the flow of information between the Design Centre and the Fabrication Division. Increasingly, the Design Centre felt this co-ordinating mechanism was unnecessary and even slowed the flow of information, particularly after some incidents surrounding the manufacturing process of the test specimens. These incidents indicated the powerlessness of the Operation Centre. One engineer of the Operation Centre explained:

We authorised the Statement of Work to the Fabrication Division in October 1997. Last December, a Fabrication staff reported in a meeting that some parts were completed. We believed this and told our colleagues in the Design Centre that some parts were ready. In January 1998, we went to the shop and realised not even one part was ready. The Fabrication Division had a problem with NC-programming ... We came there last Friday, three weeks after we discussed with [the NC expert], it was OK. But, it was three weeks later. ... The situation changes now because everybody involved is concerned. But, we cannot change the priority [set by Fabrication management], the [PLI] is their third priority. Right now, our parts are already in queue but not to be put into the machine ... That's why Fabrication said that the parts would be ready on the third of April. Imagine how long we have to wait. (Nathan, Operation Centre, March 1998)

The Chief Engineer expressed his concern and dissatisfaction with the support provided by the Operation Centre as the following:
[The Chief of Operation], and his group are becoming co-ordinators. It is their weakness. For example, when I have a problem in the manufacturing process of the wing, I need an expert who knows about 'wing forming' directly from the shop floor. The objective of collocation is to avoid the “men in between”. ... The problem is the Operation Centre has responsibility for operation but does not have the tool. Tooling engineering and other manufacturing functions remained in Fabrication Division. ... The Operation Centre only adds a node in the process. The procedure becomes lengthier than before. It is not right. (Robert, Chief Engineer, January 1999)

Some engineers from the Operation Centre admitted that such a structure slowed down interaction with their counterparts in both Design Centre and Fabrication:

Before, it was not too bureaucratic: we did not have to go through the co-ordinator like it is now. Before, when we were separated, we could just call a design engineer who was responsible for structure. “Could we gather in TIP-Structure to discuss this?” At that time, I was in the Fixed Wing Division. The TIP had a weekly meeting. There was no invitation memo, no nothing, just on-call basis. But now, through the coordinators ... I don’t know. (Phillip, Operation Centre, March 1998)

In the middle of 1998, this issue was raised in a PLI management meeting. The discussion was heated and ended up with an open confrontation between the Operation Centre and Design Centre. The confrontation resulted in a resolution that activities of the Fabrication Division for the PLI were not under the co-ordination of the Operation Centre. The Design Centre was encouraged to contact the Fabrication Division directly. This resolution, obviously, made William and his group very unhappy and significantly demotivated them during the whole period of the second field study. He failed to further mobilise and strengthen the production functions within the program team.

8.6 Robert and Lucas: The Role of Expertise Power

Robert was one of Indaco’s senior engineers. He joined the company in 1984 after finishing his Master degree in aeronautical engineering abroad and was deeply involved in defining aerodynamic feature of the PLP. Robert had involved in the PLI
Program since the Engineering Matrix stage as one of experienced representatives from Technology Divisions. Starting from Engineering Integration stage he was fully dedicated to the program and assumed the position as the TOP-Airplane Manager. In Design-Production Coupling stage, he became a full-member of the Program and in charge of the Design Centre as the Chief Engineer.

Lucas was an expatriate who had been hired as the Technical Adviser since the end of 1996. Together with four other expatriate advisers, his task was to assist the PLI Program in various aspects of aircraft design and analysis. He had more than 40 years’ experience in a design division of a renowned European aircraft company and an expert in aeronautics and structural design. The tripartite analysis of Robert and Lucas is summarised in Table 8-5.

Table 8-5: Tripartite Analysis of Power: Robert and Lucas

<table>
<thead>
<tr>
<th>Stage</th>
<th>Lucas</th>
<th>Robert</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design-Production Coupling</td>
<td>Political Adviser to the Program Manager</td>
<td>Chief Engineer Manager of the Design Centre</td>
</tr>
<tr>
<td>Role</td>
<td>Technical Adviser to the Program Manager</td>
<td>Chief Engineer Manager of the Design Centre</td>
</tr>
<tr>
<td>Power Sources</td>
<td>- Expatriate with 40 years experience in aircraft design</td>
<td>- Education and experience</td>
</tr>
<tr>
<td></td>
<td>- Link to the Program Manager</td>
<td>- Early involvement in the PLI Program</td>
</tr>
<tr>
<td>Skill and Will</td>
<td>- Willing to increase the quality of designers</td>
<td>- Willing to proceed according to the CE concept mutually agreed previously</td>
</tr>
<tr>
<td></td>
<td>- Strong and dominant personality to make things done according to his plan</td>
<td>- Avoid confrontation and seeking harmony</td>
</tr>
<tr>
<td></td>
<td>- Ignorance toward the attempt to implement CE-related systems and concepts</td>
<td>- Indecisive</td>
</tr>
<tr>
<td>Effect on CE introduction</td>
<td>- Experienced engineers leaving the Design Centre due to conflicts with Lucas</td>
<td>- Tensions and conflicts between the Design Centre and the Operation Centre</td>
</tr>
<tr>
<td></td>
<td>- More inexperienced engineers with greater dependency to Lucas</td>
<td>- Tension and conflict between the Design Centre and the Operation Centre</td>
</tr>
<tr>
<td></td>
<td>- Tensions and conflicts between the Design Centre and the Operation Centre</td>
<td>- Tendency to slide back to the traditional sequential approach</td>
</tr>
<tr>
<td></td>
<td>- Unutilised integration capabilities of Sidina system</td>
<td>- Unutilised integration capabilities of Sidina system</td>
</tr>
</tbody>
</table>

Within the Program, Lucas expertise was highly respected. The Chief Engineer often
referred to him as a rare ‘dinosaur’, since it was getting hard to find people in the modern aircraft industry with his combination of breadth and depth of expertise:

Typically, there are groups of people who not only know about structure but also about aerodynamics and other disciplines. But they are very rare now; they are almost extinct, particularly due to the education system. Therefore, I told you that Lucas is a dinosaur. He is part of the generation in which one person knew everything. ... His mathematical ability is very strong, so he knows aerolastics too. (Robert, Chief Engineer, November 1997)

Similarly, all engineers within the Design Centre referred him as a genius. They respected his expertise and were grateful for the technical assistance he offered. He also ran several basic applied engineering courses for the engineers to enhance their expertise. Some expressed their gratitude as the follows:

[Lucas] teaches us the very basic calculation to do the design so we have the ‘feeling’. ... Now, we have several engineers working with us and under [Lucas’s] direct supervision. That is good. Before, we had a lot of technical advisers but they were just telling us and were not as useful as him. He told us the basic of design, made us having the feeling about design. (Frank, Design Centre, March 1998)

[Lucas] is the champion. He not only knows structure, but also everything else. Whereas [Robert] is still young, hasn’t made many products, hasn’t got a lot of knowledge and experience. [Robert] once confessed to me that he and I are learning together in this program. (Darren, Design Centre, March 1998)

However, some were offended by Lucas’s manner in the Design Centre. He often raised his voice at and mocked those engineers whose work was not to his satisfaction. Most engineers, particularly the younger ones, accepted this as part of the ‘eccentricity of a genius’ and, in particular, because his help was worthy. The more experienced engineers were more offended. As one of them said:

[Lucas] is supposed to assist us only in technical matters, but he does everything else too. As a genius, his attitude is just like that. There is no democracy in here, only authoritarian. (Roger, Design Centre, November 1997)

This particular engineer, a Supervisor in the Design Centre, later left the Program after a heated confrontation with Lucas over the wingbox technological experiment. Some others felt that Lucas did not respect others, including the Chief Engineer. One engineer, a Supervisor who often had confrontations with Lucas said:
[Lucas] is weird. I have worked with many technical advisers. We know [Indaco] need them, no question about that. But, it has to be based on respect. If we respect each other we could listen to each other. But, [Lucas], he might be a champion, but has no respect for us and does not hesitate to put people down and saying bad words. It is very discouraging. Our culture cannot accept this discouraging attitude. I am not sure about his position in the organisation, but I know he does not report to [Robert]. The saddest thing is he does not respect [Robert]. That's the main problem for me. How dare he talking to [Robert] like that? As [Robert's] subordinate, I could not accept that. I don't care that he is [Clive's] people. He has no respect toward us, that's the problem. (John, Design Centre, January 1999)

Increasingly, others began to feel that Lucas had taken control of the development process. At one point, he ordered design engineers not to go to a meeting conducted by the Operating Centre. He also ignored engineers from the Operation Centre who came to the Design Centre to discuss issues with their counterparts. He often referred to them as a group who had no job other than disrupting designers' concentration.

During the financial crisis when Indaco had to let go most foreign advisers, Lucas was the only one who remained. In a sense, this reflected that the Indaco's top management respected him and relied heavily on his expertise to support the development process. This made him become more dominant in the PLI Program.

Lucas's domination became a major factor that inhibited more experienced engineers from Technology Divisions in joining the PLI program. His approach was seen as 'locking the creativity out' of the designers. Many questioned the effectiveness of his approach, particularly, in terms of building up the creativity needed in the design and development process. Inevitably, without support from more experienced engineers, the PLI Program had more inexperienced engineers in the design teams and, in turn, became more dependent to Lucas. One engineer expressed this issue:

A more driving force why people hesitate to participate is [Lucas]. Because of the absence of creativity freedom, senior engineers do not want to participate. I wanted to put the best people in the program, but I could not because they argued "my experience would be of no use there". Therefore, I put the junior ones ... No senior engineers wanted to get involved in the program on a full time basis. The lack of experience in the Program is getting worse. There is no school for designing ... It is a matter of experience and a matter of creativity. You can be creative on the basis of experience, we build our creativity based on our experience. ... It is true that Lucas has the experience, but in the aircraft development there are a lot of other disciplines. This means the development process involves the way we work and interact, a
more cultural issue. It should be a flexible environment. ... But with Lucas, it is based on his instruction; the creativity is not channelled. To be a designer we need to be creative, otherwise the designer is dead and becomes a coolie. (John, Design Centre, January 1999)

The Chief Engineer was seemingly powerless to deal with this situation and at times indecisive, particularly in the issues that previously had been mutually agreed with the Operation Centre. There were several reasons for this. Firstly, hierarchically Lucas was not under his control but reported and took orders directly from the Program Manager. Given the Indonesian cultural tendency, questioning Lucas might imply that he was questioning the Program Manager, his superior, which was not a proper behaviour. Secondly, professionally he respected Lucas’s expertise and knew that he needed him to complement his own lack of experience and expertise in some aspects of the design process. Furthermore, he knew that most members of his team were inexperienced and needed guidance that he might not be able to provide. Thirdly, personally he hated confrontation and most of the time sought compromise to avoid it.

Many members characterised Robert’s leadership as ‘soft’ and ‘need of more toughness’. Some of them illustrated his leadership as follows:

As the Chief Engineer, [Robert] knows a lot about aircraft. But in managing engineers, we haven’t heard a lot from him. We heard that from [Lucas], [Robert] once said to me, “Darren if something is going on with [Lucas], would you please tell me”. ... [Lucas] is very persistent, stubborn and tough. How could I call [Robert] [to face] with all the yelling and shouting from [Lucas]. ... [Robert] is soft and very patient. (Darren, Design Centre, March 1998)

In my opinion we need a tougher Chief Engineer. Theoretically, [Lucas] cannot make the decision; the Chief Engineer is the one who makes decisions. So the Chief Engineer must be tough. Theoretically, [Lucas] is not the Chief Engineer, but he is so dominant. (Ray, Design Centre, November 1997)

For the Design Centre’s engineers the every day design activities were characterised by juggling between the officially scheduled tasks and those given by Lucas. The officially scheduled tasks were based on the schedule established by the Operation Centre. This schedule was derived from the Program’s Master Phasing Plan and
Chapter 8: Politics of Change

consisted of target dates for the design to release the engineering data for production.

However, Lucas ignored the schedule and ordered designers to work according to his preference, Robert took no action. This situation partly explains the absence of schedule review in most meetings. A design engineer illustrated the typical every day situation as follows:

We are supposed to be schedule driven. ... But, our work is actually driven by Lucas. ... When we were doing something [based on the schedule], [Lucas] came and said, "I don't want to see this"... We want to do the official ones that based on the schedule, but there is also something from [Lucas]. He is one man show; sometimes his show sacrifices other. ... I feel pity for [Robert]. He was often caught in an awkward position. He wanted to co-ordinate us but [Lucas] is in the way. Hence, [Robert] took a compromise way, said, "You do whatever [Lucas] asks but don’t forget other things. Manage your time." At the end, it goes back to us: we have to manage the time. In the schedule we have to do the centre-line diagram. ... But [Lucas] goes directly to [for example] vertical tail and defines its hard-points. ... According to him, hard-points are the most important things for manufacturing to enable Fabrication Division preparing tools. ... It is true, but the schedule is not like that. So, we just do our best to comply with both. (Darren, Design Centre, March 1998)

The confrontation avoidance of the Chief Engineer toward Lucas cost him the trust of his team. These engineers felt they could not rely on him to back them up, even when they were right and he knew it. An incident that happened in the later stage of the field study when the skin panel was finally tested illustrates the situation created by the combination of the nature of explosive Lucas, the indecisiveness and confrontation avoidance manner of the Chief engineer, and the immature engineers.

Before the on-site static test witness meeting with the Regulation Authority officers, Robert briefly met 3 engineers from the body integration team near the test site. They discussed the current test result. Andrew, a structure analyst, said that the result was different from the theory. He also provided tentative explanation suspecting the effect of both the rubber and the aluminium flat installed between the rubber and the omega stringer. Robert seemingly agreed with the logic of the explanation, thanked him and asked him to explain that result to the authority officers in the meeting. At the meeting, the authority officer directly took over the meeting, asking various questions of documentation and conformity of the process of developing the specimen. In the area of testing installation, the officer questioned the absence of setting strain gauges and doubted that they were actually testing the critical area without such gauges. The engineers tried to response and Robert tried to support his members but unconvincingly. At the end, the engineers agreed to install at least one of setting gauge and asked the facility specialist to change the test installation who, in response said it would take about an hour.

While waiting, Robert discreetly questioned the decision not to put setting gauge on place. Andrew said that he wanted to put it on, but the facility expert said they did not have it and installing it would take time. The fact that the installation only took one hour amazed him. They discussed the discrepancies of the result. Robert then questioned the decision to put the
aluminium flat between the rubbers. Three engineers looked at each other. Andrew said that he (and apparently all) was against it at the beginning. Robert wisely asked whether it was Lucas idea, and all of them nodded. Robert said, "All right, do not finger pointing, but you have to explain this result to Lucas and that you suspect that the discrepancy was due to the flat, and suggest to remove it". He went on," you should have confidence on your own concept and convince others through various different ways, try to be more straight in argumentation". He gestured that it should include argumentation with the authority officer. Andrew said. 'yeah. 1 would feel confident explaining things that I belief, but it is hard to made argument on things you don't agree with, like the setting gage. I could not argue with the officer since I knew that he was right'.

Lucas came and asked about the result. At first, he looked at it-tentatively, did not fully understand the explanation. Seeing the chart of stress versus pressures, he said that the stress on the way back is not the same with on the way up. Something was absorbing it. Being told that they suspected the discrepancy was because of the aluminum, he asked, "why did you put the aluminum there?" and then went on and on about how stupid the idea was and provided technical reasons why it should not be there. When he comprehended that he was actually accused of being responsible of suggesting the idea, he burst out. "When you said that I told you to put aluminum there, you are insulting me." He was very angry. "I may be old, but my memory and my brain still perfect. I will remember things like this." The engineers did not respond but when Lucas went out of the circle, they said that they had proved it was Lucas idea. They still had the draft they discussed with Lucas. They have tried 3 times to convince him not to put the aluminum. More importantly, 3 of them remembered the same version against Lucas denial. Then, Robert told the engineers, not to finger pointing and calmed down Lucas and said. "It seemed there was a misunderstanding." One engineer whispered. "Look, no body stand on our side for things like this. Never!" (Field Study Journal, February 1999)

Obviously, this situation inhibited the implementation of CE in the PLI Program. The Operation Centre, in particular, was very upset at Lucas's domination and the deviation from a CE approach caused by him. Lucas's interference in the supposed to be CE process was very apparent:

The drawing was wrong. The colleague from Design Centre told me that Lucas was furious and got very angry to him. ... At that time Lucas also said that the Operation Centre should just back off and stay out of the Design Centre. According to Lucas, all assessments made by the Operation Centre could well go to rubbish bin. (Phillip, Operation Centre, January 1999)

We had a routine meeting with the Operation Centre. But Lucas said we did not need that. Only if we have problem we would run a meeting and so it is. Sometimes, we have problem but Lucas said we do not have to [have the meeting]. (Frank, Design Centre, March 1998)

Engineers from the Operation Centre became reluctant to visit the Design Centre. They blamed the Chief Engineer and his inexperience for this threat to CE. The explosive confrontation between the Chief of Operation and Lucas in a program's management meeting (i.e. September 1998) resulted in a complete breakdown in cooperation between the Operation Centre and the Design Centre. In one of his
explosive outbursts after this meeting, Lucas said that he did not want to talk to the Operation Centre any more, and instead asked an engineer from the Design Centre to explain things. Coincident with the growing anxiety over the continuation of the PLI Program, this breakdown added to the demotivation of Operation Centre engineers.

Similarly, the Sidina group was unhappy with Lucas’s domination. ‘The Lucas way of designing’ that dominated the development process was incompatible with the configuration management system they developed. On the other hand, Lucas and Robert accused the Sidina group of developing a system that was not user friendly because they were not familiar with the design process as discussed previously.

Lucas’s power came from his technical expertise and his links to the Program Manager. In design-production coupling stage, within various conditions that prevented CE from developing as intended by the Program Manager (e.g. lack of competence in design teams, lack of clarity in CE concept, the distance between the Sidina group and the Program, the failure of the Operation Centre to integrate all production functions, and lack of attention from the Program Manager), he increasingly became influential. His dominance was, in part, due to the lack of strength and power of the Chief Engineer in the face of his idiosyncratic and forceful personality. All aspects of the Chief Engineer’s power were undermined by Lucas’s power. Lucas was more knowledgeable and the Chief Engineer needed his assistance. Lucas reported to the Program Manager and not officially under control of the Chief Engineer. Cultural tendency of non-criticism strengthened Lucas’s influence. The will and skill of Robert, the soft-spoken Chief Engineer, was not a match for Lucas’s structural position and his forceful personality.

Lucas’s domination, combined with Robert’s inability to take necessary actions,
shaped the PLI’s CE to a form that deviated further from that initially intended. Under Lucas direction, the design process ignored the system developed by the Sidina group and did not use the full benefit offered by the Sidina system. He also discouraged design engineers to interact with production engineers. This interaction started to flourish at the end of the Design Integration stage and in the early of Design-Production Coupling stage. He even ignored the official schedule for the PLI. These deviations remained until the termination of the PLI Program.

8.7 Summary

The organisational politics as manifested by actions (or in-actions) and decisions (or non-decisions) of key groups and individuals, played an important part in shaping and transforming CE. The transformation of CE toward a model specific to the company was not only an adjustment process to fit the approach with its contextual factors but also a result of political behaviour of key groups and individuals in forcing and securing their own interests, sometimes through manipulation of contextual factors.

The analysis in this chapter shows that initially the Program Manager had the opportunity to introduce CE with strong support and company-wide enthusiasm, particularly from functional production units as reflected in their involvement in various program activities during engineering matrix stage. However, his lack of understanding of the sensitivity and culture of functional design units led to actions that enhanced rivalry and created tensions with those units. This led to increasingly young design engineers being assigned to the Program during the engineering integration and design-production coupling stages. Meanwhile, key individuals from production and computer support functions also had their own interests and agendas.
The functional production units longed for improving their position in the product development process, while the agenda of the computer support people was to get their hand on state of the art technology. Furthermore, the Program Manager was increasingly busy with other tasks. Combined with the lack of systematic protocols, these led to confusion and raised the opportunity to the Technical Adviser to dominate with the approach that different from CE. The result was that CE ideas were not followed up by their implementation. Instead, the organisational arrangement and mechanisms were continuously adjusted throughout four stages of change process.

It is also evident that cultural tendencies, particularly power distance and collectivism dimensions (Hofstede, 1991; 1984), influenced the actions of people involved in the process. The attitudes of Mark toward Clive's appointment as the chairperson, the ambiguousness of Clive's CE presentation in the Executive Management Council, the harmony sought by Robert in dealing with Lucas, all can be, at least partly, attributed to high power distance and collectivism of Indonesian society. These all contributed to the changing forms and final shape of CE.

The result in reality was a messy process of CE implementation in which various competing contextual factors and organisational power and politics were intertwined. The application of tripartite analysis of power (Pettigrew and McNulty, 1995) framework into the political actors' actions is useful to capture such an involved process. It provides explanations why the process made a particular turn and not another. In general, this chapter strengthens March and Olson (1983) suggestion of reorganisation as a 'garbage can' in which the course of events seem to depend less on properties of the initial concept than on the happenstance of short-run political attention, over which the implementation team typically have little control.
CHAPTER 9

THE DYNAMICS OF CHANGE: SUMMARY DISCUSSION

9.1 Introduction

The main objectives of this chapter are to provide an overview of the dynamics of introducing CE in Indaco and outline some of the ways in which the processual analysis captures its complex and changing character. The chapter is arranged as follows. Section 9.2 summarises the main stages of change chronologically through four stages of CE introduction. Section 9.3 outlines some of key drivers and barriers in the configuration of adopted CE that affected the form of organisational integration of CE. Sections 9.4 and 9.5 describe the influence of some key features of organisational politics and the broader organisational context.

9.2 Case Study Findings: Four Stages of CE Introduction Process

Although modelled to Westaco's CE that integrated all necessary initiatives, CE introduction to Indaco was characterised by strong focus on enabling technology initiatives, particularly its computer-based technology. The most important
organisational integration initiatives, such as cross-functional team and heavyweight management, were mentioned as important but never carefully prepared at the outset. Combined with the nature of Indaco’s organisational context, this ignorance created various problems and failures during the process.

The decision to introduce this kind of CE was influenced more by considerations associated with the external context rather than by requirement to find an appropriate solution for the company’s problems associated with new product development process or serious consideration on its organisational context. Both industrial and national contexts provided a push to the same direction: an emphasis on computer-based enabling technology. CE was widely used in aircraft industry. It was spread and transferred to Indaco through aircraft industry’s common practices: technical and management consulting services and internship program. On the other hand, bearing the mission as the nation’s agent of technology transfer, Indaco was interested most on the advanced of Westaco’s CE enabling technology and tried to mimic it without full consideration on its own readiness and the nature of its organisational context.

In term of its organisational integration aspect, the process of CE introduction in the Indaco’s PLI Program can be divided into four stages, each with different organisational structure and mechanism. These stages reflected efforts to find appropriate means of achieving an appropriate organisational integration within a specific Indaco’s context and organisational politics. They also illustrated the ad-hoc nature of organisational integration initiatives. The summary of the organisational integration mechanisms and the contribution of contextual factors and organisational politic in each stage is as follows:
Chapter 9: The dynamics of Change: Summary Discussion

1) Program Initiation Stage (November 1993 – August 1995)

This stage was a pre-CE stage. The PLI development was carried out by engineers of a functional department, namely New Product Development (NPD) Department of Technology Division. Consequently, the scope of the development team was limited and only involved design engineers. However, this stage provided a relatively cohesive, highly motivated team that became the basis for CE introduction and enabled CE to develop in the next stage. The formation of such a team was made possible due to the mixed of senior leader and junior engineers, overlapping membership pattern, two-way communication pattern, and extensive collaboration.

To a large extent, the leadership of Mark, the head of NPD Department and the Project Engineer of the PLI Program, contributed to the shape of such a CE-conducive team. His leadership and actions encouraged young and inexperienced engineers to tackle the obviously daunting tasks in a manner that emphasised on mastering and exploring various engineering specialisations while at the same time encouraged collaboration within a relatively unrestricted environment. Other than his personality, Mark’s approach was also influenced by his understanding on the state’s of Indaco’s technological capabilities, particularly on the level of the accumulative tacit and explicit knowledge of its engineers. His approach was also made possible by the combination of his close link to the Indaco’s President Director, Indaco’s highly centralised structure, and Indaco’s strong technology orientation, that provided the team with more than enough resources to play around.


This stage was the beginning of CE adoption. A major change from the previous stage was the upgrading of the Program’s position from a functional department led by a middle manager to become a heavyweight organisational division led by a senior
In line with CE adoption, the PLI Program involved company-wide cross-functionality although only design-related functions played the main role in the development process. The design teams were divided primarily based on integrated end product. The Program set up a matrix arrangement between its design teams and engineering specialist groups from the functional design units, which viewed as ‘resource pools’ for the Program. Due to engineers involved in the matrix were mostly inexperienced and collaboration across teams were limited, functional design units had a significant influence in technical decisions, which dissatisfied the leaders of the PLI Program as they saw it as eroding their control in the development process.

This stage was characterised by enthusiasm of non design-related functions, particularly production-related functions, to get involve in the development process. However, it also characterised by growing tension between the Program and functional design units, particularly concerning the issues of design decision responsibility and human resource allocation. To a large extent, this tension led to the change of organisational structure in the next stage.

Several factors can be accounted for the state of organisational integration on this stage. Firstly, the strong technology orientation often put other functions in ill-fated situation in the previous development programs. CE is seen as an opportunity to alter this situation and improve their status. Secondly, focusing on computer-based technology, all these major organisational changes were executed without substantial preparation in human resources or in protocols that guide the new company-wide arrangement while the intended computer-based technology required a significant time to be developed. Thirdly, in pushing his intention on CE, the Program Manager failed to build necessary coalition with experienced key personnel in functional design units. Should he, for example, have taken benefit of Mark’s understanding on
the contextual situation, he might pursue his intention differently. This cost him and the Program not only the necessity to change the organisational structure and mechanism, but also the growing rivalry and tension with functional design units in the next stage.

Fourthly, his ignorance on the need to set up the necessary protocols in undertaking CE approach did not provide the program teams with guidance to proceed according to his intended approach which were significantly different from the way most team members and other fellow employees knew and practised. This was exaggerated by his ignorance on the need of team-related training courses, such as team building and interpersonal communication skill.

3) Engineering Integration Stage (October 1996 – June 1997)

This stage was characterised by more intense tension and conflict with functional design units and continuous enthusiasm from production-related functional units in supporting the Program. Three major changes in organisational aspect occurred in this stage. Firstly, the internalisation of engineering specialists from the matrix between the Program and Engineering Specialist Groups. This made engineering specialists to become fully members of the Program’s design teams. Technical decisions, therefore, were fully in the hand of the Program. Secondly, the increasingly younger and less experienced engineers involved in the Program. Thirdly, the establishment of several Co-ordinators as fully dedicated functional representatives to perform liaison role between the Program and functional units, most notably the Production Co-ordinator.

To a large extent, the development in this stage was contributed by the fact that the Program Manager was unaware of the implication of the previous PLP Program and its subsequent first flight success on the pride of engineers in functional design units.
either as an individual or as a group. The internalisation of engineering specialists and conceiving functional design units as the resource pools not only buried the expectation of most leaders and engineers from functional design units to continue their company-wide domination through their design decisions but also directly and openly challenged this pride. On the other hand, the growing activities in production-related functions fostered by the Production Co-ordinator, who got strong back-up from the leaders of functional production units, created awareness in the Program Manager on the importance of production-related functions. These two were major factors that led to another organisational change that marked the final stage of CE introduction process.

4) Design-Production Coupling Stage (June 1997 – June 1999)

Three major changes in organisational integration aspect distinguished this stage from the previous one. Firstly, the Program became an autonomous division that cut-off from the influence and resources of functional units. Secondly, the formation of two centres, the Design Centre and the Operation Centre, which in effect provided production-related functions with an equal status to the design-related functions in product development. Thirdly, increasing number of young and inexperienced engineers and team leaders that led to increasing ignorance and disrespect toward the technical decisions made by the lower-level teams that frustrated both design and production engineers. Overall, this stage was characterised with increasing tensions and conflicts between the PLI Program and functional design units, increasing frustration among engineers involved in the Program, and increasing attempt to impose approach that clearly deviate from CE through separation of design and production functions in the Program, the lack of effective matrix organisation between the Program and the functional units, authoritarian leadership, and one-way
communication in the design development process.

At its abrupt termination due to the continuing Indonesian economic crisis, the CE introduction in the PLI Program froze at the following characteristics of its organisational integration, communication, and decision making mechanisms:

1) an autonomous product development team instead of heavyweight program team,
2) parallel design and production teams instead of single integrated teams,
3) increasingly hostile environment instead of teamwork within the program teams and between the program teams and other involved functions,
4) reduction of lower level teams' participation in design decision, and
5) failure in utilising computer technology as an integrating mechanism as suggested by engineering literature (e.g. Norman, 1990; Volk, 1992; and Fan, 1995) due to the stand alone and ad-hoc nature of the current system.

Several major factors significantly contributed to this development. Firstly, due to the development in the company and its wider context, the Program Manager tied to other assignments and could not intensively supervise the Program. Secondly, the Program Manager had not established a successful coalition with functional design units but rather increased rivalry through the autonomous program division. In response to this, functional design units pulled out most of experienced engineers from the Program. The Chief Engineer and young engineers remained in the Program became vulnerable to the actions of a domineering technical adviser who imposed contrasting approaches including discouragement to interact with the Operation Centre and ignorance toward the schedule. Thirdly, unavailability of guiding protocols on the intended CE left the inexperienced program teams off-guard upon imposed different approach. Fourthly, the lag in the preparation of the computer support system provided inadequate support for the engineers and forced them to invent their own systems, such as data storage
and retrieving system and the drawing identification system, that were incompatible with the intended support system.

During the process of the four-phase of CE introduction, there were many episodes in which aspects of CE were partially implemented; for example:

1) High level of collaboration during the program initiation stage and, at least in some part of design teams, at the beginning of CE adoption (i.e. engineering matrix stage).

2) Heavyweight management team although for most of the time it was limited at the highest level of the program management (i.e. the Program Manager).

3) The formation of matrix arrangement between the Program and functional design units and the assignment of focal points from company-wide functional units to support the Program in engineering matrix stage.

4) Active involvement of production-related functions in supporting the Program since the beginning of CE adoption (i.e. since engineering matrix stage).

5) Formal equalisation of the role and status of production-related functions with the role and status of design-related functions through the formation of the Design Centre and the Operation Centre in the design-production coupling stage.

6) High level of collaboration between design engineers and production engineers in the beginning of design-production coupling stage.

However, the final form of Indaco's CE was far from the intended Westaco model except for its equalisation of the status of production-related functions and the heavyweightness of the Program Manager. The form that emerged could hardly be called a CE process although it can be argued that the abrupt termination forced by the external context did not provide the opportunity to further shape the final form of CE in the PL1 Program.
9.3 Drivers and Barriers of Integration in the Adopted CE Configuration

The case study findings illustrate the vagueness of CE concept. CE means different things to different product development undertakings across companies and even in the same company. In this respect, assessing CE adoption and implementation through its operational initiatives become crucial. This operationalisation enables to see CE concept ‘in action’.

The case study shows the importance of not only selecting which technology or approach to adopt (i.e. CE approach), but also the selecting the right configuration of the approach (i.e. the combination of CE initiatives) (Thomas, 1994). In this respect, CE introduction in the case study suffered from five major obstacles:

1) The heavyweight Program Manager’s lack of seniority and organisational clout in driving the implementation of a CE structure.

2) The chaotic and ineffective nature of the ad-hoc character of shifting organisational arrangements to deal with ongoing problems of horizontal integration.

3) The lack of integration of the development of enabling technology with an evolving product development process.

4) The lack of competency, including necessary explicit and tacit skills and knowledge, of the Program team.

5) The lack of systematic CE protocols and plan for their implementation.

From amongst these factors, a particular feature of the case study was the way in which it highlighted the importance of competent staff and systematic protocol for organisational integration. The increasingly young and inexperienced engineers in the
Program caused both technical and non-technical problems in the development process. Other than the assignment of technical advisers to assist in solving technical problems, the PLI Program did not make significant effort to increase the competency of the program team. A technical adviser might solve the technical problems by imposing his technical opinions but did not contribute to the accumulation of internalised tacit knowledge that according to Nakayama (1997) necessary in such development. Such knowledge could only be internalised through fieldwork knowledge (e.g. intuition, experience and analogy), that helps in understanding overall circumstances and actively re-framing or integrating various technologies. Although engineering literature has mentioned the importance of tacit knowledge in the product development (e.g. Nakayama, 1997), the defining factors of tacit and explicit knowledge are mostly taken for granted and embedded in CE. It seems that the term 'skill competence' had said it all, whilst this difference between tacit and explicit knowledge has a very significant implication in the implementation process.

The necessity of systematic protocols involves two issues: What CE initiatives are carried out (i.e. CE-related manuals) and how CE is implemented in the organisation (i.e. CE charter and implementation plan). The case study shows that the lack of these two types of protocol in the PLI Program caused at least four problems include the absence of a well-defined CE concept and commonly agreed approach, operating procedures, exit criteria and deliverables, and standard operating manuals for the enabling technology. These problems caused inconsistency in management decisions particularly in dealing with the issue of lack of competency. These problems also caused confusion among those involved in the Program as they embarked on the change from traditional sequential approach but without clear guidelines for the new one and contributed to tensions within the Program teams and between the Program
teams and company-wide functions supporting the Program. Such confusion and tension contributed to the failure of CE and the infusion of contrasting approaches.

The case study also shows that organisational integration, both structurally and processually, is the most important feature of CE. Instead of focusing on initiatives in these two categories, CE in Indaco’s PLI Program emphasised on initiatives in enabling technology, particularly computer-based technology. In organisational integration aspect, the most consistent initiative was the heavyweight Program Manager, which decided at the outset and kept throughout the process. This initiative, though, had its weakness due to the relatively junior status of the Program Manager in term of his tenure that later cost the Program because of his lack of organisational clouts and thus inability to build coalition with the key individuals in functional design units. Organisational arrangement to achieve cross-functional team was continuously adjusted to fit in with the developing situation. This ad-hoc nature of organisational arrangement reflected the program management’s ignorance to the organisational aspect of CE. The Program kept changing its structure to reduce the influence from outside, which perceived as eroding the Program’s control and authority in the development process.

The communication and decision making process were also ad-hoc, according to the preference of the leader of each team. This ad-hoc nature prevented the collaboration to occur within and between teams, the information to be shared systematically, and the interlocking communication structure to exist. Further, design decisions and commitments made by the lower-level teams were increasingly disrespected and ignored. This prevented the necessary collaboration across lower-level teams. These initiatives, though, were not totally independent, but also dependent upon initiatives from other aspects. They can be seen as both part and result of CE initiatives.
In the case study, the weakness of the above initiatives was failed to be complemented by initiatives in the computer-based technology, the focus of the CE adoption in this case. The focus on this technology in effect treated CE as a tool that was indicated by over excitement in supporting computer system development. This led to the ignorance to the needs of the current development process. This ignorance to some extent was also contributed by the obvious failure of the approach taken by the PL1 Program in adopting CE: developing the computer-based enabling technology in parallel with developing the product. The success of CE initiatives in Westaco's product development programs could not be separated by the state of their in-house computer support development. But, CE initiatives in each product development program relied on the ready to use computer support systems that have been achieved rather than the support system that was in the development process.

9.4 The Significance of Organisational Politics

The empirical findings of this case study confirm that organisational politics is central to the technological change process as has been recognised by Thomas (1994). Thomas (1994) argues that innovation and change in technology and organisation may be as much products of internal political action as they are products of exogenous forces, conscious design of top leaders, or efforts of units formally sanctioned to it. In this CE introduction process, intentional actions and non-actions of key individuals significantly shaped the nature of change process. These key individuals were not necessarily the important leaders of the Program. Rather, they also included a lower-level manager within the Program, an expatriate technical adviser, and a manager from outside the Program team, all with their own sources of
power.

The case study also shows that the uncertainty nature of the adoption (Madison et al., 1980; Tushman, 1977; Hickson et al., 1971) and the interests of people involved (Thomas, 1994; Guth and Mc Millan, 1989; Wilkinson, 1983; Porter et al. 1976) were the main reasons for increasing political activities in the process. Two types on uncertainty occurred in the case study: the uncertainty due to the major transformation from traditional sequential approach to CE (Riedel and Pawar, 1991) and the uncertainty due to the absence of clear direction of CE configuration implemented.

This uncertainty interacts with the self-interest activities of individuals and groups in the organisation. The case study shows that the contribution of interests of individuals or groups of individuals were immense, particularly considering the unbalanced domination of one functional group (i.e. design engineering) over the other (i.e. production engineering). Indeed, status inequality between design engineers and production or manufacturing engineers in high-tech industries, not to mention other staff from even lower status functions, had been noted by many researchers (Kunda, 1991; Thomas, 1994).

In this case study, CE was seen as a potential vehicle by manufacturing and production engineers to show their existence, enact their worldviews, and in turn attain greater influence in the development process that previously dominated solely by design engineers. This was reflected by their effort in increasing functional involvement in the process and later imposing the mini-factory concept. The success of this effort could significantly alter the existing structural context and power relation between design engineers and production engineers as noted by Thomas (1994) in his case studies. In this case study, however, this balance of power could not
truly be achieved despite of the structural formation of both Design and Operation Centres. The effort of production engineers lose a significant back up power in relation to decreasing power sources of its main champion due to the alternation of its structural context included the cut off from the production-related functions and relatively insignificant hierarchical status of the main champion. Despite this failure, this case study clearly shows the role of organisational politics in the change process, in which CE was regarded as an opportunity to attain greater power and improve their status particularly by the production-related engineers and their functions.

In relation to the computer-based technology initiatives, the interest of a particular group rather than the integral interest of the company, or in this case, the product development process, was a dominant explanatory variable. For the computer support (i.e. Sidina) group, the PLI Program and its CE introduction were not the objectives, but rather a means that could enable them put their hand in an advanced computer-based technology. This helps explaining the ignorance of this group in building horizontal coalition with the PLI Program team. It also helps explaining the decision to use a component from other Program.

9.5 The Significance of Contextual Factors

Contextual factors influenced the shape of the changing process and the final form of CE in two ways: 1) directly, through imposing constraints and limitations to the process, and 2) indirectly, through providing a constrained arena for political actions that influences the process. It should be noted, however, that the context was not only constrained the process and political actions, but it could also be altered as a result of a process or political action. The latter can be seen in the changing nature of the
program structures throughout the process, each with different boundaries for political arena.

The case study was intended to focus on the contribution of organisational context, but the findings also show a significant contribution of the industry and national context in the process. The individual level of analysis in discussing organisational power and politics revealed the contribution of societal culture in the process that worth further discussion. These findings clearly confirm Thomas's (1994) strong recommendation for extending both organisational and temporal context.

Within the organisational context of the case study, a major significant factor was the nature of stage of development of the company, particularly in the aspects of individual and organisational knowledge accumulation. As shown in the previous chapters, most problems encountered in the PLI Program were associated with lack of competent engineers in the Program teams. In respect of the product development process, Indaco had not yet had enough knowledge, particularly the tacit design engineering knowledge. This situation is understandable since such tacit knowledge could only be accumulated through experiencing various product development processes while Indaco had completed only one co-development process (i.e. the PLC Program) and its other program (i.e. the PLP Program) was in the certification phase. Hence, the number of experienced engineers was limited and some of them had already been promoted into managerial positions hence unavailable for detail engineering tasks.

In this state of engineering competency, the PLI Program had to compete over the valuable experienced engineers with other programs, the PLP program that encountered huge engineering problems in its certification process and the PLC
derivative program that considered essential to boost PLC market after its more than 12 years field operation. Unfortunately, the PLI Program had not yet had as strong attachment to the engineers and design-engineering functions as the other two previous programs. Such a strong attachment was related to the fact that the PLC was the only selling product contributed to the company’s revenue, hence the employees’ pay-cheque, and that the PLP Program, to which most experienced engineers were previously involved with, played a crucial role related to greater domination of design engineers and functional design units.

To make the matter worse, instead of forming a coalition with key individuals in functional design units, the Program Manager dealt with such situation through limiting the Program’s exposure from the functional design units with internalisation of engineering specialists and forming an autonomous program divisions. These actions triggered a sense of rivalry in those units. As the result, the PLI Program had to cope with the increasingly less experienced engineers in its design teams that leads to conflicts and tensions within the Program between the Program and those functional design units.

Other major contextual factors were the organisational culture that had strong technology orientation and its subsequent domination of design-related functions. This was strongly fostered by the founder of the company, an aeronautic engineer who almost single-handedly built Indaco. The domination of design-related functions was not only in the design development process but also in the organisational status as reflected by the parity of the pay-cheque between design-related engineers and production-related engineers and between those engineers and non-engineering staff. As discussed in the previous section, CE introduction was seen as an opportunity by production engineers to alter their status, settle a more balance environment, and
enact their worldview or what their perceived as a better way for the company. Consequently, the PLI Program with its CE was seen as a threat to their domination by the functional design units, particularly after the Program internalised the engineering specialist group and later became an autonomous division.

By extending its organisational and temporal contexts, the case study shows that both industry and national contexts fostered such domination. In high-tech industries, the domination of design engineers is common (Kunda, 1991; Thomas 1994). Kunda’s (1991) empirical qualitative study shows that such domination often intended and carefully planted as part of organisational means to control the engineers. Thomas (1994) case studies also show such a domination that triggered production-engineers to involve in various political manoeuvrings to create an opportunity to improve their status and to enact their own worldviews.

In this case study, the domination of engineers, design engineers in particular, was also triggered by national interest. Indaco was a state-own company that had technology transfer and industrialisation as parts of its mission and contribution to national development and economic growth (Todd and Simpson, 1986). This national contextual factor also helps explaining the strong emphasis in computer-based enabling technology. The acquisition of such technology, rather than the optimal used of it, was sufficient to convince the nation that the technology transfer was in process. This national interest also helps explaining the eagerness of the Government’s official to assist the company bearing the financial burden of such aircraft development program by fostering the establishment of the private company (i.e. Prico) as the Program’s financial backer.

Another contextual factor that worth further discussion is the contribution of the
Chapter 9: The dynamics of Change: Summary Discussion

societal culture, particularly the Indonesian tendencies on power distance and collectivism dimensions (Hofstede, 1991), in the whole process of CE introduction. In contrast with the Western country in which the Indaco’s CE was originated, Indonesian culture has a strong tendency of higher power differential and collectivism. The case study, particularly from the analysis of the processual aspects of integration (i.e. communication and decision making mechanisms) and organisational politics, shows that this cultural tendencies reinforced the negative effects of competing subcultures (i.e. design and production) and hampered the problem solving communication.

The tendencies of collectivism reinforced functional compartmentalisation because functional representatives remained with strong attachment to their functional units with which they were formerly identified and were not yet ready to merge with others from different functions. Through all stages of CE implementation, the Program struggled to establish a cross-functional team with fully delegated functional representatives as its members. This strong attachment toward functional units hampered the unification of a cross-functional team. Such a strong attachment is less likely in Western countries where people are more individualistic and relatively independent from association with one another and, hence, are able to move more easily from one working coalition to another. This tendency towards collectivism reinforced differences among functions and made integration more difficult. The formation of an autonomous program team in the last stage can be seen as the decision to cope with the failure to acquire such a cross-functional team.

The acceptance of high power differential between superiors and subordinates hampered the crucial authority delegation from functional supervisors to the specialists. The managers were not prepared to delegate, while the subordinates
typically hesitated to accept delegated authority and tended to rely on their managers for direction. During the process, this cultural tendency seemed to reinforce the effect of the lack of competence. There seemed to be reciprocal behavioural tendencies between functional supervisors and their subordinates. The superiors were doubtful about their subordinates' competence and therefore often acted to directly control their detail work. They hesitated to delegate authority to those subordinates who became representatives in the Program team. Likewise, the subordinates did not have the courage to fully accept delegated authority, although this was demanded in the Program, and often relied on their superiors for detailed directions. Within the PLI Program, this tendency also explains the low level of respect showed toward the decisions made by engineers from the lower level teams and the acceptance of such a behavioural attitude by those engineers, despite all the rhetoric about full delegation. Generally, such an attitude was perceived as the superiors' prerogative, accepted and regarded as normal.

The combination of high power differential and collectivism also created a tendency to be less open in the interaction as argumentation in open dialogue between superiors and subordinates was sometimes regarded as improper and distracting harmony. This cultural tendency explains the engineers' hesitation to defend their calculations and analyses when questioned by their superiors, even when they were sure about their conclusions. Arguing with superiors was regarded as unacceptable behaviour. The incident regarding static and fatigue test of the skin panel described in Chapter 8 illustrates this hesitation and its significant effect on the development process.
10.1 Case Study Conclusion: Variation in CE Implementation

Although CE implementation in Indaco was originally modelled on Westaco's, the case study revealed that the implementation brought about a complex and dynamic change process. During this process, the 'actual' initiatives did not conform to the intended model. Different types of initiatives emerged and the Westaco model was not entirely realised. The 'realised' model specific to Indaco was not fully established due to the program's premature termination.

The complex and dynamic change process is reflected by the presence of four stages of CE introduction: (1) Program Initiation (prior to CE adoption), (2) Engineering Matrix, (3) Engineering Integration, and (4) Design-Production Coupling. Each stage could be seen as part of the transformation process of CE initiatives as they encountered, and were subsequently adjusted and shaped by, specific contextual features of Indaco and the actors involved in the implementation. Each stage had a distinctive organisational structure reflecting the struggle to achieve adequate integration. CE initiatives also varied from one stage to another. This changing nature of CE was not in a linear fashion, but revealed complex and multidimensional processes and sub-processes, each with a different but interweaving path.
This research also notes that CE practices vary not only across countries but also within an organisation as shown by different protocols across development programs at Westaco. The so-called 'Westaco model' had been developed over a period of time through several distinct initiatives in previous programs. In further contrast with Indaco's attempt, it had also been built on very extensive experience in the aircraft industry through which Westaco could draw on a vast pool of resources inside and outside the company. The implication of these findings is the classic argument of the contingency theory: there is no 'one best way' in implementing CE. Rather, both internal and external contextual factors are influential in determining which set of CE initiatives is selected and the way it is implemented in a product development program.

10.2 Conceptual Contribution of the Thesis

10.2.1 Definition and Application of an Operational Model of CE

The concept of CE started to appear in the late 1980s combining two different knowledge domains: engineering, manufacturing automation in particular, and management of technology and innovation. Early discussions on CE were dominated by conceptual development of its approach and technical development of enabling technology for its implementation. Empirical research on CE implementation started to appear in mid 1990s. But, detailed case studies remain rare, particularly concerning the implementation of CE within a particular context. This present study, therefore, is an attempt to fill this gap by specifically looking at the change process during CE implementation and providing some explanation for such a process in terms of its contextual factors and organisational power and politics surrounding the
In order to view the change process in CE implementation, this study has operationalised CE into a set of initiatives derived from a largely descriptive literature and often used as means to achieve CE objectives. This operational model of assessing CE implementation can be seen in Table 10-1. Through applying qualitative measurements along the dimensions and sub-dimensions of each initiative, this model contributes to the development of CE concept. Such measurements construct key characteristics of CE that are significantly different from the traditional product development process. This model, therefore, helps in reducing the vagueness of CE concept.

10.2.2 Definition and Application of Context and Politics of CE Process

Using a processual approach, this study is able to reveal explanation for the complex CE introduction process and for its variation from the intended model. In analysing strategy implementation process in organisations, Mintzberg and Quinn (1996) found that organisation strategies were often applied not in the way they were intended, and therefore argued for strategy formation, rather than strategy formulation. During an implementation process, other issues and approaches emerge which lead to the realisation of a strategy or an approach that is different to that originally intended. The processual approach can also be used to explain this strategy formation process: the intention, the emergence, and the realisation of strategies. The generic model of processual approach as in Figure 10-1 is proposed as a model to analyse such changes.
Table 10-1: Operationalisation of CE through CE Initiatives and Their Dimensions

<table>
<thead>
<tr>
<th>Category</th>
<th>CE Initiative</th>
<th>Dimension</th>
<th>Subdimension</th>
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<tr>
<td>Organisational Integration</td>
<td>Cross-functional Team</td>
<td>Size and architecture</td>
<td>Number of member</td>
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<td>Position at functional unit</td>
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<td>Nature of member activity</td>
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<td>Multiple membership</td>
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<td>Higher team composition</td>
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<td>Heavyweight Management</td>
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<td>Formal structure</td>
<td>Authority of program leaders</td>
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<td>Delegation from program manager</td>
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<td>Nature of delegation</td>
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<td>Communication and Decision-Making Mechanisms</td>
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<td>Collaboration</td>
<td>Interactional relationship pattern</td>
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<td>Respect to lower team decision</td>
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<td>Conflict and negotiation process</td>
<td>Power differential perception in low and high level teams</td>
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<td>Presence of collective goal</td>
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<td>Presence of shared vision</td>
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<td>Inter-team Communication</td>
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<td>Power differential perception in low and high level teams</td>
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<td>Enabling Technology</td>
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<td>Formal CE Methods</td>
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<td>Systematic Protocols</td>
<td>Formal description of CE-in-practice</td>
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<td>Implementation strategy and planning</td>
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<td>External Integration</td>
<td>Supplier Involvement</td>
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<td>Knowledge and skill parity</td>
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<td>Training on CE concept and initiatives</td>
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<td>Human Resource Policies</td>
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</table>
In this study, detailed analysis of each of CE initiatives in the Indaco’s CE revealed the importance of human resource competency and systematic protocols, particularly in shaping the organisational integration aspect of CE implementation. The importance of these two factors has been strongly indicated in various accounts and occasions throughout the process of implementation in the PLI development process. The lack of competency and the lack of CE definition and protocols, accompanied by the inability of the change agent, i.e. the Program Manager, to impose intentions and build a coalition led to a messier process and the enforcement of approaches that were incompatible with CE in the later stages.
CE literature acknowledges the importance of technical skills, multiskilling, and tacit knowledge in product development process (e.g. Riedel and Paws, 1991; Iansiti, 1993, Klein, 1994; Klein and Maurer, 1995; Volk, 1992, Nakayama, 1997). In discussions of CE, however, the defining factors of tacit and explicit knowledge are mostly taken for granted and embedded in CE. It seems that the term 'skill competence' had said it all, whilst this difference between tacit and explicit knowledge has a very significant implication in the implementation process.

Perhaps, the fact that CE originated in technologically 'mature' companies contributed to this lack of discussion because the concept was developed in the context in which tacit knowledge was not part of the concern. Hence, it is an embedded assumption in CE that some level of knowledge maturity has been acquired prior to the implementation. The stage of development in Indaco, in contrast, had not yet reached such a knowledge maturity, and hence the lack of competency became a crucial issue in CE implementation process in the Indaco's PLI. Many problems faced by the program management were associated with this issue and caused several adjustments in vertical and horizontal integration. It also caused several interaction difficulties within the Program and between the Program and the supporting functional units. This study therefore, provides rare empirical evidence on the strategic important of competency and knowledge maturity in CE adoption and therefore provides a significant contribution to CE literature.

Some CE literature have emphasised the importance of rules and procedures in CE implementation (e.g. Pinto and Pinto, 1991; Cleland, 1991). This case study showed that a lack of systematic protocols caused problems for CE implementation effort. The absence of systematic protocols was one of the primary reasons for the failure in the attempt to implement the originally intended CE. This lack of systematic protocols
caused inconsistency in management decisions particularly in dealing with the issue of lack of competency. It also caused confusion among those involved in the program as they embarked on the change from the traditional sequential approach but without clear guidelines for the new one. Furthermore, these weaknesses were not complemented by the result of computer-based technology initiatives, which were the focus of the Program. The main reason was that the development in this enabling technology was undertaken in parallels with the product development itself. Overall, this study shows the important issues are not only selecting and implementing CE, but also selecting the right configuration of CE initiatives that are compatible one another.

Applying the processual analysis in a single longitudinal case study of CE introduction process contributes to the CE literature by providing detailed empirical findings linking the CE implementation process to organisational context and politics - issues rarely addressed in the literature. This study shows the significant effect of the organisation's stage of development that relates to knowledge immaturity, and the organisational culture, which dominated by technology orientation with the dominant design engineering sub-cultures. Within this context, political manoeuvrings from individuals or groups of individuals, such as production engineers and computer support group, in pursuing their interests played significant roles in shaping the process and the final form of CE.

Extending the organisational context into its national and industrial contexts, this study notes the adoption of a 'Western' approach, such as CE, by a company from a developing country was often driven less by business objectives, such as marketing demand and reducing development time, but more by the technological development goals of the country. As the societal culture of Indonesia is different from 'Western' culture, the detailed analysis of actions and in-actions of key individuals taken to
assess the organisational politics in the process also provides some interesting tentative findings on the effect of such cultural differences, particularly in the Hofstede's (1984) cultural dimensions of power distance and collectivism. Such findings worth to be considered prior adopting an approach originated from other culturally different countries.

10.3 Limitations of the Thesis

While this study provides an understanding on the dynamics of a major transformation process embedded in CE introduction and implementation as well as the influence of organisational context and politics in such a complex process, this form of study has several limitations. Firstly, the study used a single case study and is therefore exposed to problems of generalisability to all settings. Secondly, this case study examined only one CE introduction program in the company due to earlier premature termination of another program that was initially part of the study. This eliminated the chance to compare two different CE implementation processes in a single setting.

Thirdly, even in such a complex case only partial insight into the whole picture of CE introduction could be obtained. This study only focused on organisational integration, communication, and decision making mechanism aspects of the process. Other aspects were only briefly discussed. Fourthly, the case study only represented partial introduction process and was unable to provide a full implementation cycle of CE due to the premature termination of the program under study. Thus, the results of CE implementation in term of quality, cost, and timely launching of the new product could not be provided. The above limitations have implications on the directions for
future research in this field, which are taken up later in this chapter.

10.4 Practical Implications and Recommendations

The practical implications of this case study can be summarised in the following three issues:

1) The decision to implement CE is a strategic decision that involves technological, organisational and cultural changes within the organisation. Therefore, a thorough analysis of the advantages and disadvantages of the implementation should be taken prior to the decision. Particular consideration should be given on the readiness and capabilities of the organisation and its contextual elements to engage in such changes. Various audit procedures have been developed to assist practitioners in this assessment (e.g. Couchman, 1998; de Graaf, 1996; Chiesa, Coughlan, and Voss, 1996).

2) A thorough preparation at the outset is important in ensuring the sustainable application of CE. This should include, but not limited to, top management commitment; selection of a set of CE initiatives that best suit the company's internal and external context; a detailed implementation plan; detail protocols, standard procedures and operation manuals; and the familiarisation process of the approach through training and familiarisation courses.

3) The change champion, i.e. the initiator of CE implementation, should be strongly committed to the implementation, not only to get the implementation off the ground in the early stage, but also to ensure that the process remains as originally intended and achieves its objectives. As promotion and job rotation are inevitable,
this includes a thorough briefing at the hand-over from the original champion to
the selected substitute officially assigned to follow up the process.

Furthermore, practitioners may take advantage of the operationalised CE initiatives
and their dimensions by developing a performance measurement of each initiative,
which can be used as in-progress performance measurement to assess and evaluate the
level of success of CE implementation. This in-progress performance measurement is
particularly important for new product development process that requires a long
development time prior the result and feed back in term of the product cost, quality,
and timeliness can be measured.

10.5 Implications and Recommendations for Further Research

Considering the limitations of this thesis, more CE research needs to be done on
implementation in order to capture the detailed change process in various different
contexts. This study could only focus on CE initiatives on organisational integration
in order to make the research manageable. To obtain a more comprehensive picture of
CE dynamics introduction process, the similar researches focusing on initiatives in
enabling technology, external integration or human resource management are
recommended. Furthermore, this case study could not observe the whole
implementation process due to the nature of a lengthy development time of a new
platform airplane and the unfortunate economic situation of the country. Therefore, if
future research should engage with another complex product development process,
one with a much shorter development time should be used. This would provide a
better chance for the researcher to longitudinally investigate the whole process from
its conceptualisation to market launch.
Chapter 10: Conclusions and Recommendations

Given the advantage of the processual framework, the researcher recommends the adoption of this framework for further study of CE implementation. In the aircraft industry, the investigation of the development process of various aircraft systems and equipment are recommended. Further, comparisons across development programs within a company, across industries, and across countries are also recommended, as they would increase the understanding of the inherently complicated process of introducing CE. The above researches would eventually provide a clearer operational CE model and framework. CE research with operational concerns in mind would, in turn, assist practitioners to be adequately prepared prior to adopting CE. This would immensely increase the chance of successful implementation.

Several precautions should be taken by researchers in conceptualising and operationalising the implementation of an approach in developing countries, as the national development program often drives such initiatives. These precautions involve consideration of more generic issues that often have become embedded assumptions in Western approaches, such as the level of staff competency and the consideration of market and competition issues in the decisions, as well as consideration of cultural differences between the country of origin and the adopter country.
REFERENCEs


References


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References


Janesick, V.J. (1994) The Dance of Qualitative Research Design: Metaphor,


References


Strauss, A.L. and Corbin, J (1990) *Basics of Qualitative Research: Grounded Theory*


213-219.


Appendix A

List of Meetings Attended by the Researcher during Field Studies

Meetings at the PLI Program:

1. Design Centre and Technology Divisions Coordination Meeting, October 1997
2. Basic Aircraft Design Course, November 1997
4. Design Review Meeting, November 1997
5. Operation Review Meeting, December 1997
7. TIP-Body’s Internal Meeting, February 1998
8. TIP-Body and Body Integration Design (BID) Teams Meeting (Regular, Every second Week), January – February 1998
10. Aircraft Design Familiarisation Course, February 1999

Meetings at the DRI Program:

1. Program Task Force Meeting (Regular, Twice Weekly), October 1997 – April 1998
2. Engineering Review Meeting (Regular, Weekly), November 1997 – April 1998
4. Detail Engineering Meeting: Fuselage (Regular, Weekly), January – April 1998
7. Detail Engineering Meeting: Centre Wing (Regular, Weekly), January – April 1998
8. [DRI] Program’s Schedule Meeting, March 1998
Appendix B

List of Indaco’s Documents Reviewed during Field Studies

18. [Indaco]’s Manufacturing Capabilities, [Indaco], 1995.


34. Design Factors that Minimised Production Process in Metal Forming: Assessment for the [PLI] Program, August 1996.


36. [Indaco]: Developing Nation Resilience through Aerospace Technology, 1996.


54. Minutes of Meeting: [PLI] Planning Session (Design Centre), May 1997.
57. Activity Breakdown Structure (ABS) [for] [PLI]), June 1997.


66. Structural Concept and Assembly Planning for Section 42 and 46 [Body Component], September 1997.


68. Producibility Assessment: Machining Consideration for Frame Bulkhead, September 1997.


72. SOW: Wing Box Experiment (DPM), September 1997.


76. Work Breakdown Structure for [DRI], October 1997.


78. SOW (Draft): Assessment of Automatic Drilling and Riveting Machine (ADRM) to Increase Quality and Productivity [PLI Program], November 1997.


90. OPA (Draft): Test Article Delivery for Testing, Development and Certification, April 1998.


92. SOW: Test Rig Wing Box Experiment, April 1998.

93. SOW: Assembly Jig Wing Box Experiment (Fixture), April 1998.


100. SOW: Rig Fuselage Panel Test, May 1998.


104. SOW: Assembly Jig (Fixture) Fuselage Panel Experiment, July 1998.


Appendix C

Time-Line of the PLI Program

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- Presentation from functional divisions about their scope & experience
- Industrial Engineering (IE) local point: Load projection, HR requirement from IE local points
- Manpower requirement, tooling, planning
- Design Build Process Team (DBP) Space and facility requirement
- Program requesting MH budget based on standard
- IE local point: Manpower requirement

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- Major milestone review
- Engineering Operation (ECO) meeting: Production structure discussion
- Master phasing plan review
- Preliminary assembly sequences
- Production drawing release milestone clarification
- Computer investment: Open distributed computing
- Budget plan and SOW proposals from divisions

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<td>Sidina A meeting: Manhour budget</td>
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- Manhour for door
- DBP process assessment meeting: 10 prototype
- DBP meeting: PLI assessment
- DBP meeting: Matrix TIPs & production specialist group
- Meeting: TIP & Specialist report
- Design review TIPs, engineering specialists, DBP
- DBP meeting: Review work breakdown structure (WBS)
- DBP meeting: Quality planning, space requirement, wing, WBS
- Introduction of PLI WBS (draft)
- TIP-system presentation
- TIP-fuselage progress report section 41-42
- Discussion: obstacles and lesson learned

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<td>Proposal 3 alternatives of WSP</td>
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- Decision: Procure material and use available material
- Establish tool material team
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| 1994 | RAD and Production meetings (A) 
|      | Titanium manufacturing (A) 
|      | Residual stress, clad diffusion (A) 
|      | Shot peening forming (A) 
|      | Low strain rate cold forming (A) 
| 1995 | PMO meeting: numbering system (M) 
|      | DBF meeting: design standard limitation (M) 
|      | Document: ICW guidelines (M) 
|      | Planning session: Design Centre product focus (J) 
|      | Planning session: Operation Centre assembly focus (J) 
|      | Activity Breakdown Structure (ABS) (J) 
|      | Budget Plan 1997 (M) 
| 1996 | Operating Procedure Agreement (OPA) product & process integration (M) 
|      | OPA TIP training (O) 
|      | Tooling experts: not collocated nor dedicated (A) 
|      | Design Centre and Operation Centre collocated (A) 
|      | PLI Business Process: Production planning and control (M) 
| 1997 | Certification meeting (A) 
|      | Parallel Type Certificate (TC) and Production Certificate (PC) (M) 
|      | ICW Quality system & standard (A) 
|      | Directive: Design Centre leads all development design activities (M) 
|      | Familiarization course on aircraft design process for Sidna group (J) 
|      | Skin panel test, onsite meeting with the authority (A) 
| 1998 | 
| 1999 | 

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**Appendix C**
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**Operational Level**

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**Top-Fuselage**

- Communication memo (COM): Nose mod. empennage skin splices
- COM: Random configuration concept and material
- COM: Typical fuselage structure concept
- Technical Meeting: Superplasticity forming

**TIP-Body**

- Meetings: Productivity fuselage
- Fuselage section 42, 44, 46, manhours, flow days, jigs
- Skin cutting section 48
- Skin cutting section 44

**Final project meetings**

- Assembly plan
- Task allocation

**TIP-Body/Body Integration Team**

- Skin splice section 41
- Structural concept 42, 46, 48, assembly plan
- Skin splice, assembly sequence, jig requirement

**TIP-Body/Body Integration Team**

- chem milling material, spin lathe
- Machining consideration frame bulkhead
- COM: Front spar rib machining analysis
- Document: Design practice machining assessment
- Document: Front press bulkhead proposal
- Document: Final cut analysis window frame
- COM: Vertical tail concept analysis
- Document: Keelbeam/bulkhead design evaluation

**TIP-Body/Integration Team**

- Assembly and test plan

**TIP-System**

- Meetings: SOW and plan
- Assessment: Production capability for mechanical system
- SOW for mechanical system lesson learned (draft)
- SOW for electrical system, lesson learned tubing

**TIP-System / System Integration Team**

- Assembly and test system concept
- Material testing meeting
- Expense procurement plan, alternative sources, detail schedule
- Unique format of material list, procurement flow
- Report to Program Manager
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Appendix-D

Master Phasing Plan of the PLI Program