VIABILITY OF LEAN MANUFACTURING
CONCEPTS
IN
SRI LANKAN SHIPBUILDING INDUSTRY
A CASE STUDY OF COLOMBO DOCKYARD PLC

MASTER OF BUSINESS ADMINISTRATION
IN
MANAGEMENT OF TECHNOLOGY

Captain H.C.K Ranasinghe
Department of Management of Technology
University of Moratuwa
December 2010
VIABILITY OF LEAN MANUFACTURING
CONCEPTS
IN
SRI LANKAN SHIPBUILDING INDUSTRY
A CASE STUDY OF COLOMBO DOCKYARD PLC

By

Captain H.C.K Ranasinghe

Supervised by

Dr. H.S.C Perera

The Dissertation was submitted to the Department of Management of Technology of the University of Moratuwa in partial fulfillment of the requirement for the Degree of Master of Business Administration

Department of Management of Technology
University of Moratuwa
December 2010
DECLARATION

I certify that this dissertation does not incorporate, without acknowledgement, any material previously submitted for a Degree or Diploma in any University and to the best of my knowledge and belief, it does not contain any material previously published or written by another person or myself except where due reference is made in the text. I also hereby give consent for my dissertation, if accepted, to be made available for photocopying and for inter-library loans, and for the title and summary to be made available to outside organizations.

Name of Candidate: Captain H.C.K. Ranasinghe

Signature of Candidate: Date: 20/10/2010

Countersigned by: University of Moratuwa, Sri Lanka. Electronic Theses & Dissertations www.lib.mrt.ac.lk

Name of Supervisor: Dr. H.S.C. Perera

Signature of Supervisor: Date: 20/10/2010
ABSTRACT

It has been strongly predicted that there will be a boom in the global shipbuilding industry in the near future, and a steady growth in demand at least till 2025. This gives a window of opportunity for shipyards all over the world to stabilize and expand their operations. As many large shipyards are overbooked, the small yards such as Colombo Dockyard PLC will get excellent opportunity to enter into business and expand their operations. Due to aggressive expansion programs in China and India the opportunities available for small yards will be diluted unless they build up competitive positions by improving their order winning criteria.

Sri Lankan shipbuilding industry with a dearth of natural competitive advantages will have to compete in management of resources and other geographical location factors. Lean manufacturing has been accepted as manufacturing philosophy which will deliver low cost, high quality products with low lead time. Hence, the question of this research is “How Lean manufacturing concepts can be applied in Sri Lankan Shipbuilding Industry.

As such there has not been any research on how to apply Lean manufacturing concepts in Sri Lankan shipbuilding industry. The objectives of this research are what Lean manufacturing tools are applicable in Sri Lankan Shipbuilding industry, organizational factors which should be emphasized during lean implementation and potential barriers and drivers for Lean implementation in Sri Lankan Shipbuilding Industry.

A mix of research methodologies such as questionnaire survey, unstructured interview, structured interviews and simulation were adopted during this research. As Colombo Dockyard PLC (CDPLC) being the only international level shipyard in Sri Lanka, this research is entirely based on Colombo Dockyard PLC.

Lean assessment tools revealed that scheduling, inventory, supply, layout, process and quality are areas where the current practices of CDPLC need improvements. The simulation of current process at hull fabrication workshop was able to prove that workshop layout change, use of high efficient machinery, cellular
work group structure and Pull production would improve the output parameters of current process significantly. The non quantifiable Lean tools such as 5S and Visual Control would also improve the output parameters further. The research also revealed that Lean organizational practices objectives such as standardization, Team based organization and participation and empowerment need emphasis during Lean implementation.

Unionization, organization structure, organization communication process, current leadership and management style, supply chain issues and integration of suppliers in the process, level of integration of shipyard process were found as potential barriers for Lean implementation at CDPLC. The potential drivers for Lean implementation at CDPLC would be on time delivery, labour reduction, improvement in production capacity, reduce manufacturing cycle time and production cost. The modified LAI Hypothesized model provides guideline for Lean implementation at CDPLC diagrammatically.
ACKNOWLEDGEMENT

My esteem indebtedness is first and foremost bestowed to God for granting me the wisdom, courage and health. My heartfelt gratitude is further extended to my supervisor Dr. H.S.C Perera, the Head of Department of Management of Technology, University of Moratuwa for his guidance, encouragement and valuable advice.

Special thanks go to Mr. Mangala Yapa, CEO of Colombo Dockyard PLC for his unconditional support and Mr. Godakupura, Assistant Production Manager of CDPLC for his valuable support to gather information and coordination of various activities. I am grateful to employees of CDPLC for devotion of their valuable time for filling up my questionnaire.

Lastly but equally important, I extend my deep and infinite love to my entire family for encouragement and support without which I could not make this attempt.
# TABLE OF CONTENTS

DECLARATION ........................................................................................................ iii
ABSTRACT .............................................................................................................. iv
ACKNOWLEDGEMENT ......................................................................................... vi
LIST OF TABLES ........................................................................................................ xi
LIST OF FIGURES ...................................................................................................... xii
LIST OF ABBREVIATIONS ....................................................................................... xiv

**Chapter 1 – INTRODUCTION** .............................................................................. 1
  1.1 Background ....................................................................................................... 1
  1.2 Global Shipbuilding Market ............................................................................ 2
  1.3 Sri Lankan Shipbuilding Industry .................................................................... 4
  1.4 SWOT Analysis of Sri Lankan Shipbuilding Industry ...................................... 4
  1.5 Lean Manufacturing ....................................................................................... 8
  1.6 Lean Manufacturing and Shipbuilding ............................................................. 9
  1.7 Research Problem .......................................................................................... 11
  1.8 Research Objectives ...................................................................................... 12
  1.9 Scope of the Study .......................................................................................... 12
  1.10 Significance of the study ............................................................................... 12
  1.11 Chapter Organization ................................................................................... 13

**Chapter 2 - LITERATURE REVIEW** ................................................................. 15
  2.1 Introduction .................................................................................................... 15
  2.2 Definition of Lean Manufacturing .................................................................. 16
  2.3 Lean Definition by Characteristics ................................................................ 18
  2.4 Lean as Integrative System ............................................................................ 19
  2.5 Lean Manufacturing Tools ............................................................................ 19
  2.6 Lean Frameworks .......................................................................................... 23
  2.7 Lean Manufacturing Model for Shipbuilding ................................................. 25
  2.8 Lean Production and Value Stream Mapping ............................................... 30
  2.9 Lean Assessment Tools ................................................................................ 31
  2.10 Lean Organizational Practices ...................................................................... 34
  2.11 Drivers and Barriers for Lean Implementations ............................................. 35
  2.12 Success Factors of Lean Implementation .................................................... 36
2.13 Lean Implementation Failures ................................................................. 37
2.14 Summary ................................................................................................. 38

Chapter 3 - METHODOLOGY ........................................................................ 39
3.1 Aim ................................................................................................................. 39
3.2 Colombo Dockyard PLC .............................................................................. 39
3.3 Methodology – Lean Assessment ................................................................. 40
3.4 Methodology - Identification of Lean Process Improvement Tools ............. 40
3.5 Methodology – Identification of Organization Practices .............................. 42
3.6 Methodology – Identification of Barriers and Drivers ................................... 43

Chapter 4 - LEAN ASSESSMENT ................................................................. 44
4.1 Introduction .................................................................................................. 44
4.2 Lean Assessment Tools ............................................................................... 44
4.3 Validation ....................................................................................................... 47
4.4 Aim of Lean Assessment ............................................................................. 48
4.5 Results ........................................................................................................... 48
4.6 Discussion ..................................................................................................... 48
4.6.1 Teams and Corporate Culture ................................................................. 48
4.6.2 Process and Process Technologies ......................................................... 50
4.6.3 Maintenance ............................................................................................ 50
4.6.4 Plant Layout and Material Handling ..................................................... 51
4.6.5 Setups ....................................................................................................... 51
4.6.6 Quality ..................................................................................................... 52
4.6.7 Scheduling and Production Control ...................................................... 52
4.6.8 Inventory .................................................................................................. 52
4.6.9 Suppliers .................................................................................................. 53
4.7 Conclusions .................................................................................................. 53

Chapter 5 - APPLICABILITY OF LEAN PROCESS IMPROVEMENT TOOLS .................................................................................. 54
5.1 Introduction .................................................................................................. 54
5.2 Aim ............................................................................................................... 55
5.3 Value Stream Mapping (VSM) .................................................................... 55
5.4 Simulation Support of VSM ........................................................................ 55
5.5 SigmaFlow Simulator ................................................................................... 56
5.6 New shipbuilding at Colombo Dockyard PLC ........................................... 57
LIST OF TABLES

Table 1.1 – Portfolio of Sri Lankan Shipbuilding Industry .........................................6
Table 4.1 – Results of Lean Assessment .........................................................................48
Table 5.1 – Comparison of Simulation and Actual ...........................................................75
Table 5.2 – Mean Lead Time ..........................................................................................77
Table 5.3 – Statistical Summary – Lead Time .................................................................77
Table 5.4 - Tukey Kramer Test Result – Lead Time ........................................................78
Table 5.5 - Simulation Data – Labour Utilization% .........................................................80
Table 5.6 – Statistical Summary – Labour Utilization% ................................................81
Table 5.7 - Tukey Kramer Test Result – Labour Utilization % .......................................82
Table 5.8 - Simulation Data – Working % ......................................................................84
Table 5.9 – Statistical Summary – Working % ................................................................84
Table 5.10 - Tukey Kramer Test Result – Working % ....................................................85
Table 5.11 - Sample Data – Working % ........................................................................86
Table 5.12 - Applicability of Lean Tools .......................................................................91
Table 6.1 – Operationalization of Organization Practices Objectives .............................96
Table 6.2 – Summary of Survey ...................................................................................103
Table 6.4 – Summary Results – Organizational Practice Objectives ..............................105
Table 6.5 – Summary Result – Organizational Objective Standardization ....................106
Table 6.6 – Statistical Summary – Participation and Empowerment ...............................107
Table 6.7 – Statistical Summary – Team Based Organization .......................................108
Table 6.8 Organizational Practices that Need Emphasis ..............................................110
Table 7.1 – Reported Lean Benefits ............................................................................113
Table 7.2 – Difficulty Level of Lean Implementation Phases .........................................114
Table 7.3 – Difficulty Level of Lean Organizational Concepts ....................................115
Table 7.4 – Operationalization of Lean Implementation Barriers ..................................118
Table 8.1 – Applicability of Lean Improvement Tools ..................................................130
LIST OF FIGURES

Fig 1.1- Global Shipbuilding Forecast ................................................................. 2
Fig 1.2 - Gap between Trade and Shipping Fleet .............................................. 3
Fig 1.3 - Global Shipbuilding Order Book and Deliveries ................................. 3
Fig 1.4 – Growth of Chinese Shipbuilding Capability ........................................ 5
Fig 1.5 – SWOT Analysis of Sri Lankan Shipbuilding Industry ............................. 8
Fig 2.1 – House of Lean ........................................................................................ 15
Fig 2.2 - Lean Dimensions ................................................................................... 17
Fig 2.3 – Lean Model of Karlsson ....................................................................... 26
Fig 2.4 – Lean Hypothesized Model ................................................................... 26
Fig 2.5 – Lean Shipbuilding Concept ................................................................... 27
Fig 2.6 – Lean Implementation Model of LAI ..................................................... 28
Fig 2.7 – Lean Implementation Model ................................................................. 29
Fig 2.8 – Lean Implementation Model of IHI ...................................................... 29
Fig 2.9 – Lean Ship Repair Model ...................................................................... 30
Fig 2.10 – Lean Cost Composition ....................................................................... 33
Fig 2.11 – Lean Impact Assessment Framework .................................................. 34
Fig 2.12 – Critical Success Lean Factors for SME ............................................... 36
Fig 4.1 – LESAT Architecture ............................................................................. 45
Fig 4.2 – LESAT Elements .................................................................................. 46
Fig 4.3 – Lean Profile CDPLC ............................................................................. 49
Fig 5.1 – Current VSM ......................................................................................... 63
Fig 5.2 – Process Map Existing Process ............................................................. 64
Fig 5.3 – Process Map – With Automation .......................................................... 68
Fig 5.4 – Current Shop floor Arrangement ......................................................... 69
Fig 5.5 – Proposed Shop Floor Arrangement ...................................................... 70
Fig 5.6 – Process Flow – Pull Production ............................................................. 72
Fig 5.7 – Process Diagram – All Lean Tools ....................................................... 73
Fig 5.8 – Future VSM ......................................................................................... 76
Fig 5.9 – Variation of Lead Time with Each Lean Tool ....................................... 79
Fig 5.10 – Box and Whisker Plot for Lead Time ................................................ 81
<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig 5.11</td>
<td>Variation of Labour Utilization % with Each Lean Tool</td>
</tr>
<tr>
<td>Fig 5.12</td>
<td>Box and Whisker Plot - Labour Utilization %</td>
</tr>
<tr>
<td>Fig 5.13</td>
<td>Variation of Working% with Each Lean Tool</td>
</tr>
<tr>
<td>Fig 5.14</td>
<td>Box and Whisker Plot - Working %</td>
</tr>
<tr>
<td>Fig 5.15</td>
<td>Variation of Output Parameters with Lean Tools</td>
</tr>
<tr>
<td>Fig 6.1</td>
<td>Lean Organizational Practices Objective Model</td>
</tr>
<tr>
<td>Fig 6.2</td>
<td>Organizational Objective Comparison</td>
</tr>
<tr>
<td>Fig 6.3</td>
<td>Comparison of Organizational Objective Standardization</td>
</tr>
<tr>
<td>Fig 6.4</td>
<td>Constituent Factors of Guide Line for Standardization</td>
</tr>
<tr>
<td>Fig 6.5</td>
<td>Constituent Factors of Participation and Empowerment</td>
</tr>
<tr>
<td>Fig 6.6</td>
<td>Comparison of Team Based Organization Constituent Factors</td>
</tr>
<tr>
<td>Fig 6.7</td>
<td>Team Based Organizational Practices Constituent Factors</td>
</tr>
<tr>
<td>Fig 7.1</td>
<td>Difficulty Level of Lean Implementation Phases</td>
</tr>
<tr>
<td>Fig 7.2</td>
<td>Mean Response Level – Difficulty Level of Implementation Concepts</td>
</tr>
<tr>
<td>Fig 7.3</td>
<td>Lean Hypothesized Model of LAI</td>
</tr>
<tr>
<td>Fig 7.4</td>
<td>Difficulty Level of Lean Implementation Variables</td>
</tr>
<tr>
<td>Fig 7.5</td>
<td>Lean Hypothesized Model Components</td>
</tr>
<tr>
<td>Fig 7.6</td>
<td>Lean Drivers Relative Importance</td>
</tr>
<tr>
<td>Fig 8.1</td>
<td>Proposition of Emerging Relationship Between Findings</td>
</tr>
<tr>
<td>Fig 8.2</td>
<td>Proposed Lean Implementation Model for CDPLC</td>
</tr>
</tbody>
</table>
LIST OF ABBREVIATIONS

AHTS - Anchor Handling Cum Supply Vessels
ANOVA – Analysis of Variance
APICS - American Production and Inventory Control Society
CAGR - Compounded Annual Growth Rate
CDPLC - Colombo Dockyard PLC
CM - Cellular Manufacturing
CNC – Computer and Numeric Control
DWT - Dead Weight Tonnage
GDP - Gross Domestic Product
HVLV – High Variety and Low Volume
IMO – International Maritime Organization
IMVP - International Motor Vehicle Program
IT/ITES - Information Technology and Information Technology Enable Services
JIT – Just in Time
KSLAS - knowledge base Lean advisory system
LAI – Lean Aircraft Initiative
LESAT - Lean Self Assessment Tool
LM – Lean Manufacturing
LP – Lean Production
MIT - Massachusetts Institute of Technology
MOC - Material Ordering Card
NIST - National Institute of Standards and Technology
NSRP - National shipbuilding Research program
NVA – Non Value Adding Activity
OEE - Overall Equipment Efficiency
OKP - One of a kind product
ROI – Return of Investment
SME – Small and Medium scale Enterprises
SMV – Standard Minute Value
SPC - Statistical Process Control
TMC - Toyota Motor Cooperation
TPM - Total Productive Maintenance
TPS – Toyota Production System
TQM – Total Quality Management
TTL - Enterprise Transition to Lean
VA – Value Adding Activity
VS – Visual System
VSM – Value Stream Mapping
WIP – Work in Progress