

MANUFACTURING PROCESS RE-ENGINEERING DESIGN  
IMPLEMENTATION USING COMPUTER SIMULATION MODEL

(Case study in Body Shop and Metal Finish section of Truck Assembly line)

ARYA WIRABHUANA

A project report submitted in partial fulfillment of the  
requirements for the award of the degree of  
Master of Science (Information Technology – Manufacturing)

Faculty of Computer Science and Information System  
Universiti Teknologi Malaysia

JUNE 2006

## ABSTRACT

Simulation is one of tools that have been used widely in several manufacturing areas and organizations as well as in automotive industries. Using a valid simulation model may possible give several benefit and advantages in creating better manufacturing design in order to improve the system performances. This project is concerning in implementing a computer based simulation model to design Manufacturing Process Re-engineering scenarios for performances improvement. The basic problem addressed by this project is that the current manufacturing system performances have to be improved to deal with the business environment. Project's objective is to develop/design four improvement alternatives design using Valid Computer Simulation model. Three approaches which are: Line Balancing, Facilities re-layout and process enhancement, and manufacturing process automating were applied as the foundation in creating improvement scenarios of the real system. Simulation modeling formally followed the enhanced Discrete Event Simulation methodologies. Simulation models were developed using Process Oriented Simulation Software which is ARENA version 7.1 while Statfit and Microsoft Excel software package were used for statistical analysis. Project's case study was taken from the Job Shop Manufacturing line / Intermittent Process Industries in Body welding and metal finish operations of Isuzu N-series Truck assembly line of PT. Pantja Motor, Indonesia. The project deliverable might be differ into the initial simulation model of current system and four Manufacturing Process Re-engineering scenarios that will be based on three approaches as mentioned above. Constraints and challenges in conducting the project seemed might be reduced wisely, so that the whole project outcome and deliverables are still achieved appropriately.

## ABSTRAK

Simulasi merupakan sebuah metodologi yang telah digunakan secara meluas dalam pelbagai industri pembuatan dan organisasi termasuk industri automotif. Dengan menggunakan model simulasi yang bersesuaian, ia dapat memberikan faedah dan kelebihan di dalam merancang rekabentuk sistem pembuatan bagi meningkatkan keupayaan sistem. Projek ini memfokuskan kepada pelaksanaan model simulasi berkomputer dalam proses merekabentuk Kejuruteraan Semula Proses Pembuatan bagi meningkatkan keupayaan sistem. Masalah utama bagi projek ini adalah keupayaan sistem pembuatan semasa harus dipertingkatkan untuk bersaing dalam persekitaran perniagaan kini. Objektif projek adalah untuk membangunkan model simulasi sistem semasa dan merekabentuk empat cadangan penambahbaikan menggunakan model simulasi berkomputer yang sah. Tiga pendekatan iaitu Pengimbangan Barisan, Lay-out Semula Fasiliti, dan automasi proses pembuatan digunakan sebagai asas dalam perancangan penambahbaikan bagi sistem semasa. Pemodelan simulasi yang dilakukan adalah berdasarkan metodologi Simulasi Peristiwa Diskrit. Model simulasi dibangunkan dengan menggunakan perisian aplikasi simulasi berorientasikan proses iaitu ARENA versi 7.1 manakala Statfit dan Microsoft Excel sebagai analisa statistik. Kajian kes adalah berdasarkan daripada Bahagian *Body Welding* dan Kemasan Logam, sistem baris pembuatan kenderaan trak Isuzu N-Series, PT. Pantja Motor, Indonesia. Hasil yang diperolehi daripada projek ini adalah berpandukan kepada simulasi model sistem semasa dan empat cadangan penambahbaikan. Segala kekangan dan cabaran dalam melaksanakan projek ini dapat ditangani dengan baik seterusnya objektif dan skop dapat dicapai seperti mana yang dikehendaki.

## TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	<b>DECLARATION</b>	ii
	<b>DEDICATION</b>	iii
	<b>ACKNOWLEDGEMENTS</b>	iv
	<b>ABSTRACT</b>	v
	<b>ABSTRAK</b>	vi
	<b>TABLE OF CONTENTS</b>	vii
	<b>LIST OF TABLES</b>	xiii
	<b>LIST OF FIGURES</b>	xv
	<b>LIST OF APPENDICES</b>	xx
	<b>LIST OF ABBREVIATION</b>	xxii
<b>1</b>	<b>PROJECT OVERVIEW</b>	1
	1.1 Introduction	1
	1.2 Automotive Industry Environmental Background	2
	1.3 Background of the Problem	4
	1.4 Statement of the Problem	7
	1.5 Project Objectives	7
	1.6 Project Scope	8
	1.7 Important of the Project	9
	1.8 Thesis Organization	10
	1.9 Chapter Summary	10

<b>2</b>	<b>LITERATURE REVIEW</b>	<b>11</b>
2.1	Introduction	11
2.2	Theoretical Background of Simulation System	13
2.2.1	Definition of Simulation	13
2.2.2	Type of Simulation	17
2.2.3	Advantages of Simulation	18
2.2.4	Component in Simulation Study	19
2.2.5	Steps in Simulation Study	21
2.2.6	Input Modeling	24
2.2.7	Experimental Design	25
2.2.8	Output Analysis	25
2.2.9	Verification and Validation	28
2.2.10	Simulation Application Package	29
2.3	Theoretical Background of Line Balancing	31
2.4	Theoretical Background of Manufacturing Facilities Layout and Planning	33
2.5	Theoretical Background of Automated Production System	36
2.6	Empirical Issues in Literature	39
2.6.1	Empirical Issues of Manufacturing Simulation	39
2.6.2	Empirical Issues of Facilities Planning Simulation	42
2.6.3	Empirical Issues of Simulation in Automotives Industries	45
2.7	Chapter Summary	48
<b>3</b>	<b>METHODOLOGY</b>	<b>50</b>
3.1	Introduction	50
3.2	Project methodology and flow chart	51
3.2.1	Step 1 and 2: Start and Literature Study	52
3.2.2	Step 3: Problem Formulation	52

3.2.3	Step 4: Setting of Objectives and Overall Project Plan	53
3.2.4	Step 5: Model Conceptualization	53
3.2.5	Step 6: Data Collection	53
3.2.6	Step 7: Data Validation	54
3.2.7	Step 8 and 9: Model Translation and Running the Program	54
3.2.8	Step 10: Model Verification	54
3.2.9	Step 11: Model Validation	55
3.2.10	Step 12: Experimental Design	55
3.2.11	Step 13 and 14: Output Analysis	56
3.2.12	Step 15: Documentation and Reporting	56
3.2.13	Step 16: Implementation	57
3.3	Data sources	57
3.4	Data Collection Technique	58
3.5	Project Schedule	60
3.6	Chapter Summary	63
<b>4</b>	<b>INITIAL FINDINGS</b>	<b>64</b>
4.1	Introduction	64
4.2	Organizational Analysis	64
4.2.1	Historical Background	66
4.2.2	Core Business	66
4.2.3	Organizational Vision and Mission	68
4.2.4	Problem Statement in Organizational Context	68
4.3	Analysis of Current Manufacturing Process (as-is system)	69
4.4	Current System's Manufacturing Technology	77
4.5	System Modeling and Improvement Framework.	78
4.6	Software and Hardware Requirements	81
4.7	Chapter Summary	82

5	<b>PRIMARY DATA COLLECTION AND VALIDATION</b>	83
5.1	Introduction	83
5.2	Primary data Collection	84
5.2.1	Facility Layout and Dimension	84
5.2.2	Operation Time	86
5.2.3	Transfer Time	90
5.2.4	Output Standard and Work in Process	91
5.3	Data validation	91
5.3.1	Data Sufficiency Test	92
5.3.2	Data Quality Test	92
5.3.3	Data Probability Distribution Test ( Goodness of Fit Test )	94
5.4	Chapter Summary	96
6	<b>INITIAL MODEL DEVELOPMENT AND VERIFICATION</b>	97
6.1	Introduction	97
6.2	Model Development	97
6.2.1	Application Package	98
6.2.2	Interface Design	99
6.2.3	System Modeling	102
6.2.4	Animation Modeling	104
6.2.5	Source Module	106
6.3	Model verification	106
6.3.1	Error Checking	106
6.3.2	Simulation Runs Characterization	106
6.3.3	Warm – up Period and Simulation Length Determination	108
6.4	Chapter Summary	112
7	<b>INITIAL MODEL OUTPUT ANALYSIS AND VALIDATION</b>	113
7.1	Introduction	113

7.2	Simulation Result and Analysis	113
7.2.1	Production Capacity and Input	114
7.2.2	Finish Product Cycle Time	116
7.2.3	Number of Work-in-process in Buffer Area	117
7.2.4	Workstation Utility	118
7.3	Initial Model validation	119
7.3.1	Face Validity	120
7.3.2	Model Assumption Validation	120
7.3.3	Input – Output Transformation Validation	121
7.4	Chapter Summary	124
8	<b>MANUFACTURING PROCESS RE-ENGINEERING</b>	
	<b>SCENARIO DESIGN</b>	125
8.1	Introduction	125
8.2	First Improvement Scenario	126
8.2.1	General Concept	126
8.2.2	Physical Changes	128
8.3	Second Improvement Scenario	129
8.3.1	General Concept	129
8.3.2	Physical Changes	130
8.4	Third Improvement Scenario	131
8.4.1	General Concept	131
8.4.2	Physical Changes	132
8.5	Fourth Improvement Scenario	133
8.5.1	General Concept	134
8.5.2	Physical Changes	135
8.6	Chapter Summary	136
9	<b>MANUFACTURING PROCESS RE-ENGINEERING</b>	
	<b>MODEL DEVELOPMENT</b>	137
9.1	Introduction	137
9.2	Interface Design	137
9.3	System Modeling	140



9.4	Animation Modeling	141
9.5	Source Module	145
9.6	Chapter Summary	145
10	<b>MANUFACTURING PROCESS RE-ENGINEERING</b>	
	<b>SCENARIO OUTPUT ANALYSIS AND COMPARISON</b>	146
10.1	Introduction	146
10.2	Simulation Output Result	146
10.3	System Performance Comparison	149
	10.3.1 Output Standard	149
	10.3.2 Finish Product Cycle Time	150
	10.3.3 Manufacturing Line Efficiency	152
	10.3.4 Performance Improvement Significance Determination	152
	10.3.5 Other Resources	156
10.4	Chapter Summary	158
11	<b>DISCUSSION AND CONCLUSIONS</b>	160
11.1	Research Summary	160
11.2	Conclusions	163
11.3	Constraint and Challenges	164
11.4	Further and Expansion Suggestions	165
11.5	Chapter Summary	166
	<b>REFERENCES</b>	167
	Appendices A - V	171 - 282

## LIST OF TABLES

TABLES NO.	TITLE	PAGE
4.1	Isuzu's N-Series Body welding operations	73
4.2	Number of component types assembled in each workstation based on N-Series main body Bill of Materials.	74
4.3	System modeling and improvement framework	78
6.1	Command Module Functionality in modeling the real system	103
6.2	Entity and resource animation modeling	105
7.1	Initial Model Simulation Result	114
7.2	System element and behavior modeling status	120
9.1	Modeling elements comparison for Initial Model and Manufacturing Process Re-engineering scenario	140
9.2	Additional Command Module used for Manufacturing Process Re-engineering scenario modeling	141
9.3	Additional Entity and Resource animation modeling for Manufacturing Process Re-engineering scenario	142
10.1	First re-engineering scenario simulation result	147
10.2	Second re-engineering scenario simulation result	147
10.3	Third re-engineering scenario simulation result	148
10.4	Fourth re-engineering scenario simulation result	148
10.5	Individual 95 % confidence intervals for all pairwise comparison $\bar{x}_{(2-1)}$ for output standard variable	155

10.6	Individual 95 % confidence intervals for all pairwise comparison $\bar{x}_{(2-1)}$ for output product cycle time variable	155
10.7	Comparison of whole system characteristic and performance indicator between each re-engineering scenarios and initial model	157

## LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
1.1	General step of cars assembly line	3
1.2	Isuzu Indonesia's N-series assembly plant and commercial truck model	5
1.3	Isuzu N-Series Truck General Assembly Process	6
2.1	Method for System Study (adapted from Law and Kelton, 2000)	15
2.2	A Seven-Step in Conducting Simulation (as stated by Law, 2003)	22
2.3	Type of simulation based to output analysis (adapted from Law and Kelton, 2000)	26
2.4	Transient and steady-state functions for a particular stochastic process (adapted from Law and Kelton, 2000)	27
2.5	ARENA interface and hierarchical structure	30
2.6	Manufacturing Plant/Facilities layout type: (a) Product Layout, (b) Fixed Layout, (c) Group Technology, and (d) Process Layout (adapted from Tompkins, 2003)	35
2.7	Type of departmental facilities and product flow layout; (a) End-to-end, (b) Back-to-back, (c) Front-to-front, (d) Circular, and (e) Odd-angle (adapted from Tompkins, 2003)	36
2.8	Automation Application (Groover, 2001)	37
2.9	Type of Automation (from Pisano & Hayes, 1996)	38
2.10	Flexible manufacturing system cell model by (Farahmand, 2000)	41

2.11	(a) Robotic Simulation Model (Cheng, 2000) and (b) Robotic Workcell Design (by Williams and Chompuming, 2002)	42
2.12	Simulation model in developing a new manufacturing workcell ( by Shady, <i>et al.</i> 1997) (a) Current system, (b) Final proposed workcell	43
2.13	Boeing manufacturing flow line simulation (Lu and Sundaran, 2002)	44
2.14	Improvement alternatives in car body shop assembly (by: Ulgen, <i>et al.</i> , 1994)	47
2.15	Paint Shop Operation Scheme as stated by Williams and Sadakane (1997)	47
2.16	Paint Shop Line reduction Strategy by Hee-Han <i>et al.</i> (2002)	48
3.1	Project methodology and flow chart (adapted from simulation study methodology by Banks, 2001 )	51
3.2	Data collection method characteristic (adapted from Dennis <i>et al.</i> , 2002)	60
3.3	Project 1 Work's Breakdown Structure	61
3.4	Project 2 Work's Breakdown Structure	62
4.1	Pondok Ungu assembly plant layout	65
4.2	Isuzu's official brand logo and PMI logo	67
4.3	Isuzu's Truck product portfolio	67
4.4	General Truck assembly processes	69
4.5	PMI's Truck flow processes	71
4.6	N-Series Body shop operations	72
4.7	N-Series Body shop manufacturing resources layout	76
5.1	Primary data classification	84
5.2	Current system facilities layout and dimension	85
5.3	Standard time calculation	87
5.4	Workstation's Standard Time	88

5.5	Example of Standard time calculation	89
5.6	Body Welding and Metal Finish Processes Layout	90
5.7	Transfer time data	91
5.8	Output standard and WIP data	91
5.9	Data quantitative sufficiency test	93
5.10	Example of Workstation's Standard Time control chart	94
5.11	Example of Statfit's Auto generated Histogram of the data Fitted into assigned Probability Distribution	96
6.1	Product assembly process diagram	98
6.2	ARENA Simulation package welcome windows	99
6.3	Main menu description	100
6.4	Simulation Window descriptions	101
6.5	System Performance Indicator Window view	102
6.6	Unanimated real system simulation model	104
6.7	ARENA's instant model checker	107
6.8	Initial System Simulation Run Characterization	108
6.9	Transient and Steady-State phase identification	109
6.10	Batch Mean Interval Estimation for simulation length sufficiency test	111
7.1	Daily Output Standard and number of input simulation result	115
7.2	Finish Product Cycle Time Initial Model Simulation result	116
7.3	Number of Work-in-process (WIP) in Buffer area	117
7.4	Initial Model Workstation Utility	119
7.5	Output Standard Distribution Similarity Test	123
7.6	Number of WIP Distribution Similarity Test	123
7.7	Output Standard Compare Mean T and Z-Test	124
7.8	Number of WIP Compare Mean T and Z-Test	124

8.1	Line balancing approach applied in First improvement scenario	126
8.2	Proposed Facility Layout for First Improvement Scenario	128
8.3	Parallel operations for second improvement scenario	129
8.4	Proposed Facility Layout for second improvement scenario	130
8.5	Separated automatic material handling system and process standardization for third improvement scenario	131
8.6	Proposed Facility Layout for third Improvement Scenario	133
8.7	Full integrated standardized processes with one non-accumulating automated material handling system	134
8.8	Proposed Facility Layout for fourth improvement scenario	135
9.1	First Manufacturing Re-engineering scenario's Interfaces	138
9.2	Second Manufacturing Re-engineering scenario's Interfaces	138
9.3	Third Manufacturing Re-engineering scenario's Interfaces	139
9.4	Fourth Manufacturing Re-engineering scenario's Interfaces	139
9.5	Animated simulation view for the first Re-engineering scenario	143
9.6	Animated simulation view for the second Re-engineering scenario	143
9.7	Animated simulation view for the third Re-engineering scenario	144
9.8	Animated simulation view for the fourth Re-engineering scenario	144
10.1	Comparison of output standard for each scenario and initial model	149
10.2	Comparison of cycle time for each scenario and initial model	151
10.3	Comparison of line efficiency (average resource utility) for each scenario and initial model	152

10.4	System improvement significance determination using Bonferroni paired- $t$ confidence interval method for output standard variable	154
10.5	System improvement significance determination using Bonferroni paired- $t$ confidence interval method for product cycle time variable	156



## LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Thesis Organization	172
B	Project's schedule / Gantt Chart	174
C	Isuzu N-Series truck picture and dimension	183
D	PT. Pantja Motor organizational chart	184
E	PT. Pantja Motor product profile website	185
F	Production flow process	186
G	Worker layout of N-Series production line	187
H	Bill of Material N-Series body	188
I	Example of production achievement sheet	192
J	Kanban system	193
K	Quality control process for N-series body shop	195
L	Initial system facility layout and dimension	196
M	Standard time data collection result and control chart	197
N	Goodness of Fit test summary	224
O	Product assembly process diagram	229
P	Initial model interface	232
Q	Initial model development module and source code	234
R	Initial model simulation result	245
S	Manufacturing Re-engineering scenario : Facility layout and dimension	251
T	Manufacturing Re-engineering scenario : Interface design	255

U	Manufacturing Re-engineering scenario: Source module used	261
V	Manufacturing Re-engineering scenario: Simulation result	272

**LIST OF ABBREVIATION**

BIQ	Built-in-quality
BOM	Bill of Material
CKD	Completely Knock Down
CT	Cycle Time
FSKSM	Fakulti Sains Komputer dan Sistem Maklumat
FV	Face Validity
GOF	Goodness-of-Fit
JAD	Joint Application Design
LT	Load Time
MPV	Multi Purpose Vehicle
NT	Normal time
PF	Performance Rating
PMI	PT. Pantja Motor Indonesia
PPI	Persatuan Pelajar Indonesia
PT	Process Time
ST	Set-up Time
STT	Standard Time
SUV	Sport Utility Vehicle
UIN	Universitas Islam Negeri
UT	Un-load Time
UTM	Universiti Teknologi Malaysia
WBS	Work's Breakdown Structure
WIP	Work-in-process
WS	Workstation

## **CHAPTER ONE**

### **PROJECT OVERVIEW**

#### **1.1 Introduction**

Along with the rapid growth of technology in last four decades, industrial / manufacturing enterprises confronted in the situation that improvement of the manufacturing performance is the matter which very insist to be certainly achieved. At the other hand, experimental design in existing system will give negative impact for the enterprise. This matter make many companies, finally choose not changed anything to their manufacturing system rather than take a high risk of trial and error processes in experimental design.

Simulation, as a contemporary computer/Information Technology (IT) based technology was raise to minimize that particular risk as mentioned above. In advance to develop a valid simulation model, company can conduct experimental design to get the improvement design of their manufacturing system without disturbing the working system. Computer Simulation model accommodates implementation of various Manufacturing Process Re-engineering Designs into computer based model and simulate it as well as justifying the performances.

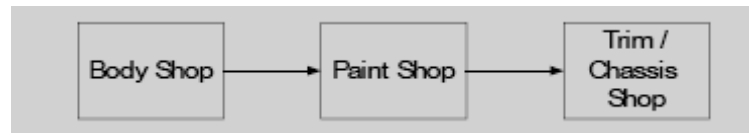
So that, conducting experimental design based on Computer Simulation Model might be the favorable solution which is collaborate the necessity of improving manufacturing performance and minimize the risk of doing direct modification to the real working system.

Manufacturing and material handling systems provide one of the most important applications of simulation. Simulation has been used successfully as an aid in the design of new production and manufacturing facilities, warehouses, and distribution centers as well as in automotive industries. It has also been used to evaluate suggested improvements to existing systems (Banks *et al.*, 2001). Engineers and analysts using simulation have found it valuable for evaluating the impact of capital investments in equipment and physical facility, and of proposed changes to material handling and layout. They have also found it useful to evaluate staffing and operating rules, and proposed rules and algorithms to be incorporated into warehouse management control software and production control systems. Managers have found simulation useful in providing a "test drive" before making capital investments, without disrupting the existing system with untried changes.

At the other side, as one of the most important sector in manufacturing filed, automotive industries also have been applying Simulation for decision support approach for more than 20 years since the rapid improvement of computer technologies. Many automotive expertises believe that simulation still will be the important decision support approach in Automotive Industries.

## **1.2 Automotive Industry Environmental Background**

As realized, automotive manufacturing system is a complex task involving several steps of machining and assembly (Hee Han, 2002). Typically, large components of an automobile such as the body, engine, etc are assembled over multiple systems. As shown in Figure 1.1, three main stages of assembly line in the automotive industry are: the body shop, the paint shop, and the trim and chassis shop. Cars flow through the assembly line from stage to stage in sequence.



**Figure 1.1** General step of cars assembly line

An automotive company will typically sequence cars based on several objectives, most dealing with line balancing and material management. In the first and last stages (the body shop and the trim and chassis shop), different cars might require the installation of different components. Such imbalance of the workload at the automotive assembly line can be due to:

1. Different options of the same car model (e.g. one car might have an automatic transmission and sunroof, while another car might have a manual transmission, but no sunroof),
2. Different types of the same model (e.g. sedan vs. wagon), or
3. Different models assembled in the same line.

This project will cover how simulation can be applied into Manufacturing Process Reengineering Design in Automotive industries sub system (which is will explained more detail in the following section) in order to improve their performances using certain manufacturing performance improvement approaches. Manufacturing Process Reengineering will be conducted using simulation based experimental design. Each design will represent the solution alternative that proposed based on particular manufacturing improvement technique.

Furthermore, one of the improvement approaches that will be used is manufacturing line balancing. Firstly, this method will determine the workload of each section in manufacturing line and illustrate the manufacturing line efficiency. Next, in order to improve line efficiency, workstation's workload imbalances will be minimizing using related algorithms which are described more detail in the following chapter.

Later on, as realized, material handling is one of the most important factors regarding to Manufacturing Performance Improvement. Optimal material handling system must drive the manufacturing flow become lean and balance. There are several techniques to increase the material handling performance, whereby one of them is determining the accurate and appropriate facilities layout that can accommodate the criteria of optimum material handling operation.

The other method that will be applied in this project to improve the manufacturing performances is automating the processes. As Groover (2001) stated that Automated Manufacturing had become a popular approach to improve the performances of manufacturing system, especially for the system that produce large number of product with high level of similarities. The common characteristic in automated manufacturing is that the system consists of automated components, such as industrial robot, automated guided vehicles, sensors, and controllers.

### **1.3 Background of Problem**

The project will be based on the case study at Isuzu N-Series Truck Assembly Plant, PT. Pantja Motor, Tbk Indonesia (PMI). PMI is an official Isuzu licensed manufacturer in Indonesia. The company is currently produce two type of Isuzu cars, which are the passenger car and commercial car. Commercial cars divide into bus and truck bases while passenger car have two main models whereby Multi Purposes Vehicle (MPV) and Sport Utility vehicle (SUV). The truck and bus assembly line is located in Jl. Kaliabang, Pondok Ungu, Bekasi – Jakarta and the head office is located about 50 kilometers from this assembly line in Jl. Gaya Motor Selatan Jakarta Utara, just next to their one another assembly plant which is for passenger car. Figure 1.2 illustrated the view of Isuzu Indonesia's assembly plant and commercial truck models.

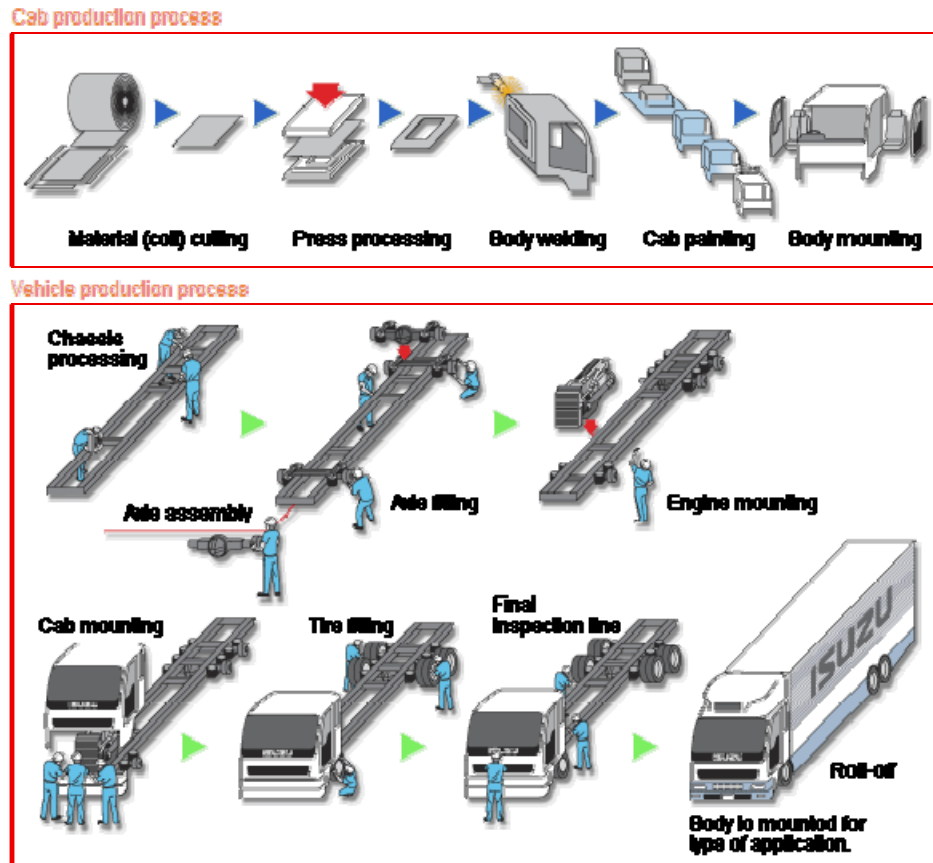


**Figure 1.2** Isuzu Indonesia's N-series assembly plant and commercial truck model

PMI's grand total production capacity of whole type is 15000 units per year, whereby the N-Series production is limited only about 6900 unit annually. Since the significant raise of product demand in the past 3 years, so the PMI is facing the problem in improving their production capacity, especially of N-series truck model which is most demanding product.

As mentioned earlier, like the other automotive type, the processes of N-series truck assembly basically consists of three general stages, which are Body shop/welding, Paint shop, and chassis and cabin shop. The appropriate performance improvement design has to be defined into the production section. Figure 1.3 indicates the general process of Isuzu N-Series assembly.





**Figure 1.3** Isuzu N-Series Truck General Assembly Process

Based on the preliminary observation and survey, it is can be concluded clearly that the processes in N-series assembly line have several opportunities to be improved because of following findings: lack of process automating, un-lean manufacturing processes, poor facility layout orientation, Work In Process (WIP) problems, and also poor line efficiency. With the appropriate manufacturing re-engineering design, using such as line balancing, facility re-layout, and automating the manufacturing process, the significant manufacturing performances may possible achieved promptly.

#### **1.4 Statement of the Problem**

Based on the preliminary study and information gathering process through documentary analysis, this project will try to overcome the problems related to the real system. The basic problem of the current manufacturing system is that the production capacity does not meet the future business environment, so the current manufacturing system has to be improved significantly. This general problem also drives several major questions that have to be answered appropriately in order to solve the problem:

1. Does the current manufacturing system is the optimal configuration in terms related to manufacturing system performance?
2. What manufacturing designs may possible significantly improve the current manufacturing / industrial system?
3. How to conduct experimental design to develop scenarios for Manufacturing Performances Improvement without disturbing the real working system?
4. How far the new design can improve the manufacturing performance?

#### **1.5 Project Objective**

Based on the case study on PMI's Body Shop N-series Assembly Line, the project will cover several objectives:

1. To analyze the current Manufacturing or Industrial Performance
2. To study what are the possible manufacturing improvement design which is able to significantly increase its manufacturing performances.
3. To develop/design several improvement alternatives design using Valid Computer Simulation model.
4. To propose the Manufacturing Process Re-engineering design for performance improvement related to the real system using three approaches: Line Balancing, Facilities re-layout and process enhancement, and automating the processes.

5. To identify the significances of improvement that achieved by implementing those three approach using computer based simulation based.
6. To implement the most valuable manufacturing re-engineering design in the computer simulation model instead of disturbing the real system.

## **1.6 Project Scope**

In case of project coverage area, the following assumption, environmental boundaries, and constraint can be mentioned in determining the project scope:

1. Primary data is collected straightly to the Manufacturing Real system by observation, interviews, sampling methods and time study.
2. Data types that used in this project are the manufacturing variables such as: process time, transfer time, set-up time, standard output, cycle time, number of work-in-process, working time, and other common manufacturing variables.
3. Secondary data are used in case of unavailability of the primary data.
4. Case study is taken from the Job Shop Manufacturing line / Intermittent Process Industries in Body shop and metal finish of Isuzu N-series Truck assembly line of PT. Pantja Motor, Tbk Indonesia (PMI).
5. Simulation modeling formally will follow Discrete Event Simulation methodology.
6. Simulation model is developed using a Process Oriented Simulation Software which is ARENA version 7.1.
7. Statfit and Microsoft Excel software package will be used for statistical analysis.
8. This project recommendations are only based on manufacturing variable aspect and assume that the real system have no constraint about anything outside the technical manufacturing aspect (e.g financial limitation, land, workforce, and technology).
9. For justifying the significance of performance improvement, the Manufacturing Process Re-engineering design will be simulated and compared to the real system.

10. Complexity of the real system, time, and the capability in making computer simulation model will be the most consideration in determining how deep alternative designs will be proposed.

### **1.7. Importance of Project**

Based on what have been illustrated before, generally this project will recommend several scenarios of manufacturing improvement design for the certain case studies. The improvement significances will be determined by a valid simulation model so that the users or clients will more easily justifying the right policies. More detail, the project potential benefits to the organization can be defined as follows:

1. Users can use the initial valid simulation model for analyzing their manufacturing process at particular stages more conveniently and efficient than studying directly through the real system.
2. With the computer based simulation model, the company may conduct the experimental design iteratively to find their best solution regarding to improve manufacturing system accurately and safely rather than do the experiment in their working system whereby definitely disrupting and deal with high risk probability.
3. Simulation model can be capable enough to predict what are the consequences and following effects that might be raised from a certain strategies implementation.
4. The result of the project will contribute the management a valuable input and consideration for supporting their decision making processes.

At the other hands, manufacturing simulation studies and research are still active and many more simulation studies are being done by time to time. So that, this project perhaps may little bit enriching the simulation studies discourse especially in applied simulation in automotives industries.

## **1.8. Organization of Thesis**

This Master Project report is consist of eleven Chapters which are describe about seventeen Project's steps as attached in Appendix A.

## **1.9. Chapter Summary**

Simulation is one of tools that have been used widely in several manufacturing area and organizations. Using a valid simulation model may possible give several benefit and advantages in creating the better manufacturing design in order to improve the performances. This project is concerning in implementing a computer based simulation model to design scenarios for performances improvement.

Manufacturing process reengineering design will be based on three approaches and principles: minimizing imbalance workloads in assembly line, improving material handling capabilities through facilities re-layout, and automating the manufacturing processes. Meanwhile, Body Shop and Metal Finish department of PMI's Isuzu N-Series assembly plant will be the base of the project's case study.

The project outcome is expected to give the significant contribution to the user or client in improving their manufacturing performances in order facing the business challenges and dealing with the problem environment.

## REFERENCES

- Altinkilinc, M. (2004). Simulation-based layout planning of a production plant. Virginia. Old Dominion University. *Proceeding of 2004 Winter Simulation Conference*. 1079-1084.
- Banks, J., Carson, J.S., Nelson, B.R., Nicol, D.M. (2001). *Discrete Event System Simulation*. New Jersey, Prentice Hall.
- Barton, R. R. (2004). Designing simulation experiment. *Proceeding of 2004 Winter Simulation Conference*. Pennsylvania. 73-79.
- Berger, M. A, Johnston, Vincent F, Hua, Jinyi. (1999). Development of simulation model for an army chemical munitions disposal facility. *Proceeding of 1999 Winter Simulation Conference*. 790-197.
- Carson, J. S. (2004). Introduction to Modeling and Simulation. *Proceeding of 2004 Winter Simulation Conference*. 9-16.
- Cheng, F. S. (2000). A methodology for developing robotic workcell simulation models. *Proceeding of 2000 Winter Simulation Conference*. 1265-1271.
- Cochran, D. S., Duda, J.W., Linck, J. (1998). *Simulation and production planning for manufacturing cells*. Massachusetts Institute of Technology: Master Thesis.
- Dahl, T. A. and Jacob, B. F. (2000). Confident decision making and improved throughput for cereal manufacturing with simulation. *Proceeding of 2000 Winter Simulation*. 1329-1332.
- Dennis, A., Wixom, B. H., and Tegarden, D. (2002). *Systems analysis and design : an object-oriented approach with UML*. New York. John Wiley & Sons.
- Farahmand, K. (2000). *Using simulation to support implementation of flexible manufacturing cell*. Texas A & M University: Ph.D Dissertation.
- Fujii, S., Morita, H., and Tanaka, T. (2000). A basic study of autonomous characterization of square array machining cells for agile manufacturing. *Proceeding of 2000 Winter Simulation Conference*. 1282-1289.

- Grabau, M. R., Maurer, R. E., and Ott, D. P. (1997). Using a simulation to generate the data to balance an assembly line. *Proceeding of 1997 Winter Simulation Conference*. 733-738.
- Groover, M. P. (2001). *Automation, Production Systems, and Computer-Integrated Manufacturing*. New Jersey. Prentice Hall International, Inc.
- Hee-Han, Y., Zou, Chen., Bras, Bret., McGinnis, Leon., Carmichael, Carol. (2002). Paint Line Color Reduction in Automobile Assembly Through Simulation. *Proceeding of 2002 Winter Simulation Conference*. 1204-1209.
- Ingalls, R. (2002). Introduction to Simulation. *Proceeding of 2002 Winter Simulation Conference*. Oklahoma. 7-16.
- Kelton, D.W., Sadowski, R. P., and Sturrock, D. T. (2004). *Simulation with Arena*. Boston: McGraw-hill Higher Education.
- Kosfeld, M. A. (1999). Warehouse design through dynamic simulation. Arizona. Intel Corporation. *Proceeding of 1999 Winter Simulation Conference*. 1049-1053.
- Kosfeld, M. A. and Quinn, T. D. (1999). Use of dynamic simulation to analyze storage and retrieval strategies. Arizona. Intel Corporation. *Proceeding of 1999 Winter Simulation Conference*. 736-741.
- Law, A. M. (2003). How to conduct a successful simulation study. *Winter Simulation Conference 2003*. Tucson Arizona. 66-70.
- Law, A. M. and Kelton, D. W. (2000). *Simulation Modeling and Analysis*. Boston: McGraw-Hill Higher Education.
- Lu, R. F. and Sundaran, S. (2002). Manufacturing process modeling of Boeing 747 moving line concept. Seattle. The Boeing Company. *Proceeding of 2002 Winter Simulation Conference*. 1041-1045.
- Miller, S. and Pegden, D. (2000). *Introduction to Manufacturing Simulation*. Rockwell Software, Inc.
- Mills, M. C. (1988). Using group technology, simulation, and analytical modeling in the design of a cellular manufacturing facility. California. McDonnell Douglas Helicopter Company. *Proceeding of 1986 Winter Simulation Conference*. 657-659.
- Mungwattana, A. (2000). *Design of cellular manufacturing system for dynamic and uncertain production requirements with presence of routing flexibility*. Virginia. Virginia State University: Ph.D Dissertation.

- Nikoukaran, J. (1999). Software selection for simulation in manufacturing : a review. In Simulation Practice and Theory. *Proceeding of 1999 Winter Simulation Conference*. 1-14.
- Park, Y. H., Matson, J. E., and Miller, D. M. (1998). Simulation and analysis of the Mercedes-Benz Production Facility. *Proceeding of 1998 Winter Simulation Conference*. 132-137.
- Patel, V., Ashby, J., and Ma, J. (2002). Discrete event simulation in automotive final process. Michigan. General Motors. *Proceeding of 2002 Winter Simulation Conference*. 1030-1034.
- Piekert, A., Thoma, J., and Brown, S. (1998). A rapid modeling technique for measurable improvements in factory performance. Munich. Siemens AG Germany. *Proceeding of 1998 Winter Simulation Conference*. 1011-1014.
- Roser, C., Nakano, M., and Tanaka, M. (2002). Throughput analysis using a single simulation. Nagakute, Aichi. Toyota Central Resercah and Development Department. *Proceeding of 2002 Winter Simulation Conference*. 1087-1094.
- Saand, S. M., Parera, T., and Wickramarachci, R. (2003). Simulation of distributed manufacturing enterprises : a new approach. Sheffield. Sheffield Hallam University. *Proceeding of 2003 Winter Simulation Conference*. 1167-1173.
- Shady, R., Spike, G., and Armstrong, B. (1997). Simulation of new product workcell. *Proceeding of 1997 Winter Simulation Conference*. 739-743.
- Shannon, R. E. (1975). *Systems Simulation – The Art and Science*. Prentice-Hall.
- Silva, L., Ramos, L. A., and Vilarinho, P. M. (2000). Using simulation for manufacturing process reengineering – a practical study. Aveiro Portugal. Campo Universitario de Santiago Portugal. *Proceeding of 2000 Winter Simulation Conference*. 1322-1328.
- Springfield, K. G., Hall, J. D., and Bell, G. W. (1999). Analysis of electronic assembly operation : longbow hellfire missile power supply. *Proceeding of 1999 Winter Simulation Conference*. 689-693.
- Stevenson, William J. (2005). *Operations Management*. McGraw-Hill International
- Tan, G., Zhau, N., and Taylor, S.J.E. (2003). Automobile manufacturing supply chain simulation in the grid environment. *Proceeding of 2003 Winter Simulation Conference*. 1149-1157.
- Tompkins, J. A. Et al (2003). *Facilities Planning*. New Jersey: John Wiley and Sons, Inc.



- Ulgen, O., Gunal, A., Grajo, E., and Shore, J. (1994). The Role of Simulation in Design and Operation of Body and Paint Shops in Vehicle Assembly Plants. *Proceedings of The European Simulation Symposium*, Society for Computer Simulation International, 1994.
- Walpole, R. E. and Myers, R. H. (1997) *Probability and statistic for engineers and scientists*. New York: Macmillan Publisher.
- William, E. J. and Sadakane, S. (1997). Simulation of a paint shop power and free line. Michigan. Ford Motor Company. *Proceeding of 1997 Winter Simulation Conference*. 727-732.
- Williams, C. L. and Chompuming, P. (2002). A simulation study of robotic welding system with parallel and serial processes in the metal fabrication industry. Memphis. University of Memphis. *Proceeding of 2002 Winter Simulation Conference*. 1018-1025.
- Williams, E. J. and Orlando, D. E. (1998). Simulation applied to final engine drop assembly. Michigan. Ford Motor Company. *Proceeding of 1988 Winter Simulation Conference*. 934-949.