TITLE:

SIMULATION & VALIDATION OF BODY FRAMING ASSEMBLY LINE USING WITNESS

PREPARED BY:

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16731

Dissertation submitted in partial fulfillment of the requirements for the

Bachelor of Engineering (Hons) Mechanical Engineering

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CERTIFICATION OF APPROVAL

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Approved by,

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UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MUHAMMAD HAKIM BIN MUHIDDIN

Abstract

Computational simulation model has been a very useful tools for most organization it's provide a cost effective, quantitative means for planning, designing, and analyzing system proposals. The problem is most manufacturing plant simulation model is unavailable. The objective of this project is to develop a simulation model of an assembly plant and validate the model. The simulation model is developed using Witness12 Simulation software and adopt project execution approach from numbers of previous technical paper. Result from this project, there is a big difference on the production output on the simulation model and the actual plant. This is due to less information sharing between institution and industry.

Acknowledgements

In completion of the Final Year Project program for eight (8) months, I would like to express my highest gratitude to all parties that involve during my final year project program very interesting and meaningful. Throughout this period, I have learned a lot of new things and gained many experiences that will be valuables for my future career path.

First and foremost, I would like to thank all staff from Mechanical Engineering Department for developing me for my future career.

I would also like to express my gratitude for the following individuals for their professionalism and contributing to the program.

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- Mr. Zamri, PROTON (Industrial Representative)
- Mr. Zuraimee (ITMS Computer Lab Technologist)
- All staff and lecturer Universiti Teknologi PETRONAS.

Last but not least, thanks to my family and friends for their support and encouragement throughout the study. I really hope that I could apply all of the skills and knowledge that I have gained during my study for my future career.

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Abbreviations and Nomenclatures

FYP	*Final Year Project*
UTP	*Universiti Teknologi Petronas*
PLC	*Programmable Logic Controller*
PROTON	*Perusahaan Otomotif Nasional Sdn Bhd*

CHAPTER 1

1. Introduction

The author has divided into six (6) sections which will be highlighted the main reason of the research is being held. At the first section of this chapter, briefly explain what are the past research development about the research topic that need to know before going into further on the project research topic. At the second section is the feature in this project research report with the current problem faced by national automobile company which is will be the research topic of the whole project. At the third section of this chapter, the author will emphasize on what are the main goal of the project, in other word what are need to be achieved at the end of this research project. At the forth section of this chapter, the author will clearly specify the scope of study of the project research because the project title is too broad and may not be enough time to finish it during specified period. The supervisor (of the author) suggests focusing on one section and research in depth in the particular section. At the last section of this chapter, the author will touch on how the project actually relevant to his studies in the UTP and how does the project research is feasible to be executed within the specified duration.

1.1 Background of Study

In this section, will elaborate about the environment of current system which the research development. First and foremost, the project research is about simulating current automobile manufacturing facilities into computational simulation software as a foundation of improvising the plant facilities. As mentioned before this project mainly will be related to national automobile manufacturing plant and facilities.

In order to become one of the successful Malaysian Automotive Manufacturer in the global arena, the company committed in fulfilling the customers satisfaction and producing the product which is competitively priced yet innovatively improving the quality of the product. The company has being produced 150,000 units of car per year. It committed to further improving the production innovation and develops deep manufacturing operation expertise.

In the late 90's, the company manufacturing plant and facilities are able to produce the various model of automobile to the customer within an acceptable waiting time. The plant capability to achieve the target of number of automobile produced per year. As the country continues develop the purchase power of the local start to arise and everyone able to own a car, thus the demand of the production increases. Reaching to a turning point where the manufacturer unable to meet the new production target based on the current demanding and production line system.

During few years back, the customers usually has to wait about 4 to 6 month to receive the automobile after they has placed the payment. After going through a lot of modification and improvisation on the system in the company manufacturing technology, it's finally come to the stage where the company starts to do research on implementing a new working system to the body framing assembly line.

Recently, the company has come to at the stage of to improving the manufacturing capabilities of the plant by changing the body framing assembly system from single model body framing assembly line into mixed model body framing assembly line. The implementation was not being executed yet as the researcher is currently analyzing the possibility of the implementation. The researcher currently on the phase analyzing whether the implementation will improve the plant production capacity or vice versa. Research collaboration between UTP and PROTON has been made as a joint force between researchers from university and researchers from industrial to bring another step forward in local manufacturing technology sector.

1.2 Problem Statement

Recently, the factor that has brought to this project is because of the unavailability of current plant simulation model caused the manager and engineer unable to detect the effective way to make improvement execution for their manufacturing plant because its involve multiple types of statistical data recorded. The first step before doing improvisation to the simulation model, the analyzer must have the current plant simulation model. The current plant simulation model has to be verified and validate in order to prove the simulation software is reliable to generating a real result.

1.3 Objective

The methodology executed is objective oriented to ensure the project is reliable and contributing to further development. There are 3 main objective needs to be achieved for this project. The accomplishment process of this project must follow the sequence.

The first objective of this project research is to develop a simulation model of existing manufacturing body framing assembly line process. The recorded raw data will be key-in into the simulation software after the author already ensure on how does the simulation works. Developed computational simulation model must be operate or behave exactly as the normal operation of existing plant. Although, in real life the manufacturing plant facing many unusual stoppage like power cut and etc. For a startup plan of developing the existing simulation model, the unusual scenario will be assumed none. Does the assumption being made affect the credibility of the simulation model final result? This question had led to the second objective.

The second objective is to validate simulation model with the existing plant. The main concern of any manufacturing plant is the production output, so the validations take place in comparing the production output of simulation model and the production output of existing plant. The purpose of validation is to ensure that necessary assumption being made has affect only small and accepted variance on the final production output between simulation model and actual plant. Thus, than only the simulation model developed can be called as the imitation of current manufacturing plant.

The last objective is to analyze the simulation model behavior for further development and provide recommendation on the model space for improvisation. Certain criteria have been highlighted in the project to establish the right simulation model. This is important for the industrial personnel to further develop a more reliable simulation model and reduce the uncertainties of the result.

1.4 Scope of Study

This project research initially is a topic with a broad scope of study which consists of several subtopic projects and the project duration is much longer. For the final year student project purpose and within limited duration of time given, this project research is the subtopic project of the initial project. In this section, it will emphasize on the scope of the subproject in detail which will make sure that there is no overlapping of project research.

This project research is an effort of research collaboration between UTP and PROTON relating to manufacturing technology research. The research will be focusing on the PROTON manufacturing plant and facilities at the PROTON City Tanjung Malim, Perak, where the 3 latest model of PROTON is being manufactured which are Preve, Iriz and SuprimaS.

Firstly, the scope of study of author in this project is to study the automobile manufacturing technology. Manufacturing technology itself is a broad topic. The author has to do research and study about the plant manufacturing sequences, including the programming and instruction or Standard Operating Procedure of the plant. This is important for the author to understand the role of each personnel in the industry that soon will be simulated in Witness12. The instruction sequence interface between one system to another system is using PLC controller, for example the interaction and sequence between robotic arm and shuttle transfer. The author must acquire adequate knowledge about IF Rules program in the PLC.

Secondly, several discrete-event simulation software has been compared based on several criteria in evaluating its capabilities and effectiveness. The example of the software is Witness12, SIMUL8, DELMIA, and etc. There is technical paper from Thomas J. which discuss about other several discrete-event simulation software like AutoMod, SLX, and Extend. The method used in developing the simulation model is the crucial part as written in the Thomas J. technical paper.

1.4.1 Limitations

There are limitations of the scope of study of the project that has been highlighted by the industrial personnel and the author's supervisor. The limitation is due to several issues that arise, one of the issues is confidential data. The industrial organization has to keep certain data confidential and only certain data that has been approved by the higher level management to be released can be used to execute in the project. It is the responsible of related member to keep the data given protected.

Due to limitations of university facilities, the Witness12 Simulation software has been choose in executing this project as per agree between the university and the industrial representative. Previous technical paper done by several automobile company also showing that the Witness12 Simulation capable to execute the project objective and it receive positive feedback from several global users.

The project will be mainly focused on the main body assembly line. There is total of 6 assembly lines, the main body line having the most mixed item within the assembly that make it classified as the challenges part in simulation modeling. If the simulation software enables to develop a simulation model as the current facilities that meet the specific criteria that need to be experiment, means that simulation software is ready to build the whole plant simulation model.

CHAPTER 2

2. Literature Review

In this chapter, will be explaining about the basic knowledge in other to understand the whole research project. Section 2.1 until 2.5 will be elaborate on the existing technology about the project, how the sequence of automobile manufacturing works, and how it relates with the current project research. The author find out as it is important to highlight the basic information that reader needs to know before understanding how this research project can be carried out. In the last two sections which are Section 2.6 and 2.7 will be explaining how previous research has led to this project research.

2.1 Simulation

Simulation is a something to be created as to make it look alike, feels alike, or behaves like something else. There is many form of simulation existed in this era. The simulation is also varied to one another. As recorded in the history of simulation already being used in the era of World War I as the military army using an artificial horse-ride machine made up of wood and mechanical gear. The horse-ride machine is designed to train the military army. At that particular era, the only exist simulation is the physical simulator.

At the point, there is simulation has being classified into 3 major types of simulation, which is physical simulation, interactive simulation and computational simulation. The physical simulation is exactly like the horse-ride machines whereby there is not human intervene toward the simulation. One of the example of interactive simulation is the military flight simulator whereby the movement of the simulator machine is based on what has being programmed and based on the controlled by the person on the simulation machine. Computational simulation is the imitation of the operation of real-world process or system over time [1] or in simpler words it is an attempt to model a real-life or hypothetical situation on a computer.

During the World War II, Jon Von Neumann and Stanislaw Ulam is a mathematician faced a problem where the hit and trial experimentation of the behavior of neutron were too costly and complicated. Hence, the factor affecting the result was known at the initial experimentation that has led to which the probabilities of separate events were merged in a step by step analysis to predict the outcomes of the whole sequence of events. The simulation technique in solving the neutron problem has been a remarkable success and starts to become commercial tools for the big scale organization and industries.

Discussing the working principle of computational simulation it is too various as it function and objective of the simulation is different to one another. The working principle of the simulation is categories based on its functions and objectives of the simulation.

2.2 Simulation in Manufacturing

In the manufacturing point of view, the present of computational simulation has been a magnificent tool for the all types manufacturing industries. Almost all section of industry is using simulation as their measure of performance and executions regardless whether the office management, manufacturing floor or even the warehouse area. The use of simulation enables the corporation to maximizing the resources and reduces the losses in order to increase the competitiveness and profit of the company. There is numbers type of simulation that being used by the manufacturing company.

The process of manufacturing a product, there are many phases of development has been done. Starting from the product design material properties until finishing of the product. Besides that, the computational simulation also being used in simulation the machine program processes regardless whether it is machining or welding process. The simulation enables to reduce human error during the machining program development. Thus, avoiding vault program from damaging the parts.

On the other side, simulation also help not just in simulating the machine process but it help the industrial engineer to observe the complex of mixed assembly line and optimize their processing capability. Some product consists of an enormous numbers of components, which has created many levels of assembly line and processes. The present of simulation enable the industrial engineer to monitor, detect the bottleneck of the manufacturing line and perform quick respond.

2.3 Automobile Manufacturing Technology

The manufacturing technology of the automobile manufacturer is based the product demand or it could be based on the type of car that being manufactured. There is two groups of automobile manufacturer, one it manufacturing luxuries and exclusive car and small numbers of car being produced during annually, and another one is manufacturing for the commercial needs where by it produce in mass production. The exclusive automobile manufacturer requires more human touch and expertise as compared to the commercial automobile manufacturer.

Figure 1(Left) the blanking process of a rear hood of an automobile. (Right)Subcomponents being placed on custom design racks.

The manufacturing of an automobile starts with a roll of material plate that soon will undergo multiple stages of gigantic stamping and blanking that turns the material plate into various shapes and patterns. The shapes that being produced is like the side structure, multiple of underbody components, the rooftop, the front hood and etc. As soon all the shapes and pattern of material plate is ready, it will be placed on its own designed rack. Various shapes of the materials plate will be transfer to body assembly area.

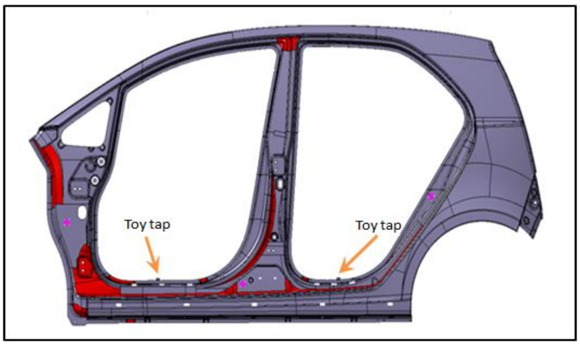

Figure 2 shows the sample of side structure.

2.4 Automobile Assembly

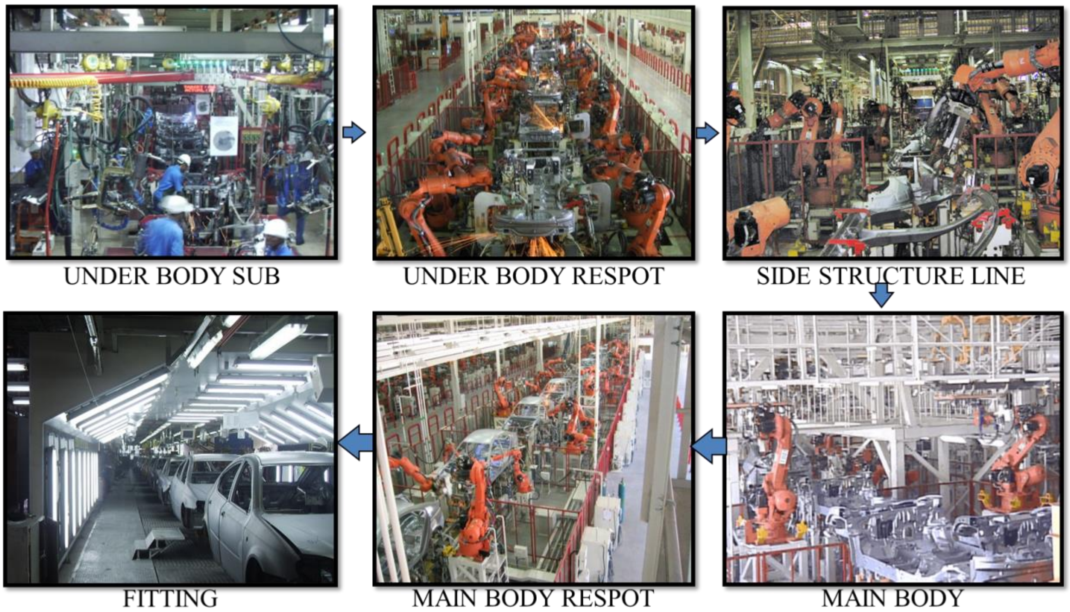

Figure 3 : PROTON Tanjung Malim Body Assembly (BA) Area.

At the body assembly area produce automobile frame structure or known as body-in-white, it consist of 6 major assembly lines whereby all the material plates will be joined together using several types of joining method as shown in Figure 3. The types of joining that has been used which is welding, riveting, clamping using toy-tap. The method controlling of joining process between the components is either by using human skill expertise or using a programmable robotic arm.

The body assembly production starts with the underbody sub assembly line, where the front end underbody sub component is mounted to the frame rail and will be mounted together with the rear end subcomponent. At the same time core structure which perform as safety factor is installed together with the structure and it is perform by experience assembler. Next, the mounted underbody frame undergoes underbody re-spot welding area, where the underbody structure undergo further spot welding performed by the automated robotic arm. The robotic arm is used to speed up the process.

While the underbody is assembled, there is another assembly line which assembling the subcomponent of the side structure parts and it is called side structure line. As soon as the underbody and the side structure are ready, it will be transferred by the overhead conveyer to main body assembly line. There are 8 substations at the main body line which at every station consist numbers of programed robotic arm. At the main body assembly line where the marriage process[1] of underbody structure and side structure including the roof top and the structure is called as body framing. After the structure has been jointed temporarily, it will enter main body re-spot line where the robotic arm will continue spot welding between structures to increase the rigidness of the body framing. The reason of the further spot welding is perform at another assembly line is because the main body assembly line space are more confine which limited the movement of the assembly robotic arm.

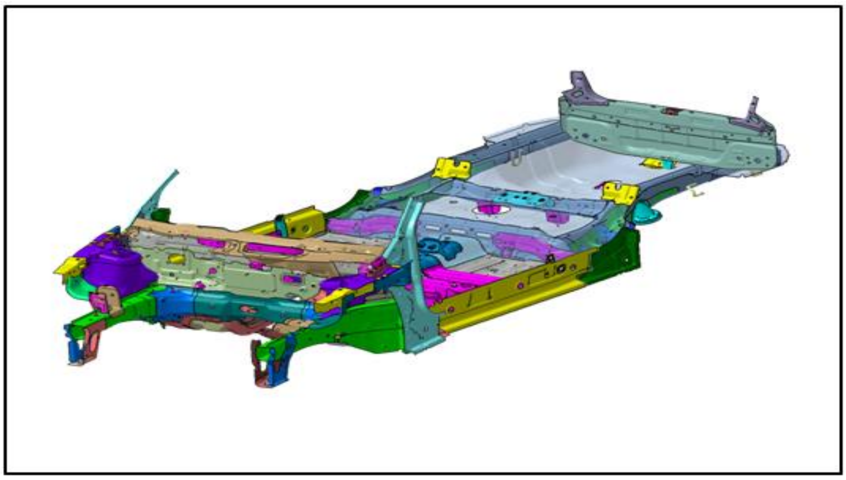

Figure 4 shows the sample of underbody structure of an automobile.

Next the body framing will enter fitting line where the front hood and bonnet is installed manually by the assembler. The part is known as body-in-white and sent the part to coating using the conveyor caring the body-in-white that dipped into white bath of primer.

2.5 WITNESS Simulation Software

WITNESS is a pedigree package of software. Lanner Group able to develop such software which became it one of the Microsoft Gold Partner, where it helps on the Microsoft Windows 7 badging. It's software that allows thousands of modelers to improve their capability. Over the past 20 years and it’s kept pace on modern software development platforms [2].

The model can be built by just using simple click and place method to place elements onto the modeling windows. Graphics play an important role to show how models are communicating and accepted. Using the WITNESS software it’s allow

[1] Marriage process is temporary attachment using only several spot weld and toy-tap.
[2] Kevin Sheehy is the senior consultant at Lanner Group, which is the company that develops the

the user to load CAD layout of the plant floor from others CAD program and it can be placed in multiple layer as representing the multiple floor of the plant [2].

In WITNESS it's involve WITNESS rules which is Push, Pull, Percent, Sequence, Least, Most and Match options. The rules than will communicating within nested multiple levels of IF, ELSE, ENDIF conditions. The software is well tested and tried by much company with assistant from Lanner Group product consultant department. It has proven in thousands of projects and the key is in the breadth and depth of element available to the modeler [2].

The machine element has being a good representation of depth the dialog offering multi tab entry of setups, breakdowns, shifts, etc. as well as the general page. It used the simple language in there Action like FOR/NEXT loops, IF/ENDIF options. It has developed similarly so that it would be much easier want come to complex logic. It is designed with full debugger integrated as it can detect fault logic and notify the user directly [2].

A great way to gain a record of the setup of all fields' logic can be seen in the WITNESS Documentor. Excel spreadsheet database can be linked to the WITNESS simulation software. The OLE DB database WITNESS offers another wizard that enables it to set up the link. It's allowing modeler to populate data into the simulation. [2]

2.6 Relevancy

In the first objective is to improve the productivity of the automotive manufacturing company, but the improvisation required a dummy model of the plant in order to avoid the experimentation is done on the actual plant. This will induce a lot of cash expenses. Simulation analysis for managing and improving productivity, which is there is a case study of an automotive company that simulate the problem in the simulation software. [3]

The result from the experimentation also was a tremendous successful to their researcher and the final result of the case study showing that 497% of Return on Investment (ROI). The simulation output for the proposed changes shoes the following:

- Increase in the body shop overall system capability;

- Increase in system uptime. Increasing the buffer allows the system to absorb downtimes with less or no impact to the body shop overall performance;
- Increase efficiency by an average of 7.5% in stages 3 and 4. The overall system efficiency improved by 2.6%;
- Job per hour increased by 8501 vehicles (body shells) annually; and
- Other changes, such as overall speed improvements.[3]

The most essential matter in developing the simulation model is having clear objectives of the project. What is the purpose of the project in other word, at the end of the project, what is the information that the modeler desire [4], for example the bottleneck of assembly and what affects directly and indirectly with the simulation modeled. This method has been emphasized by Mr. Kevin Sheehy[2] in his webinar shared in YouTube titled Good Practices for Effective Results. Although there are many point being highlighted by Mr. Kevin, only numbers of point will be used in this project.

Next, the process definition of the simulation model that needs to be build. The modeler is suggested to build the process definition chart. Process definition chart is actually the illustration of the environment of the process. The modeler requires developing the process workflow of the system or model. This gives the modeler a clear picture of the scope of experimentation that he/she required in designing the simulation model. In the process definition also helps the modeler to clearly define their problems that need to be tackle. The process definition also will clearly specify the key person involved with the simulation and their roles.

After the scope of project has been clearly defined,

In executing this project, the work breakdown structure is the technique used by the author in refining it goals and refines the step or method to achieve the setup goal. During the process of refining the goals, the number of step keep changing and increase as the author has find out a new procedure suggested from several literature materials. Below are the technique used by the author in executing this project.

[2] Kevin Sheehy is the senior consultant at Lanner Group, which is the company that develops the Witness Simulation software.

2.6.1 Internal System Condition

The internal system conditions mean the nested within multiple levels of IF, ELSE, ENDIF conditions. This will identify whether the model indicating a real working behavior or else. Modeling error can be indicated by identifying the internal system conditions [5].

2.6.2 Experiment, Replications, and Runs

The flexibility of the software requires the modeler to do multiple replication or trials on the simulation model [6]. The technique was used to study the behavior of the simulation software. The replication also must be systematically justified what the parameter changes and the result from the simulation are run. To avoid any misinterpretation of simulation model trials. All changes must be recorded and logged the changes that have been made.

2.6.3 Interactive Model Verification

The interactive model verification is actually a technique to study the behavior of the software. What does it mean by interactively is the simulation is tested stage by stage basis. The assembly plant usually consist several substation and every substation will produce the result. Interactive run technique enables the modeler to recheck model logic during model building and in troubleshooting a model when execution errors occur [6]. The process of verification take numbers of times because the verification and validation need to be perform for every changes that has been made on the model [5].

CHAPTER 3

3. Methodology

In this chapter will explain the method that has been used in executing the project. The project starts with an arrangement of industrial visit of author, author's supervisor, two technologists, and two research assistant to the manufacturing assembly plant. Discussion between author and industrial personnel has been held during the industrial visit. The objective of the discussion is to clarify between the industrial personnel about the boundary of this project and expected result by the industrial personnel at the end of this project

Before the simulation model was developed, the author has done some literature review and assessment review from the previous computational simulation software and its model. The idea of it is to identify the common strength and weaknesses of the simulation computational model. The primary project methodology flow chart is adopted from the book titled Discrete-Event System Simulation, 5th edition. The idea of this adaptation is to become the 'backbone' of overall project execution methodology. Although the project just touch until the 7th step (referring to the flow chart in Figure 3) of overall proposed execution methodology. The significant of this project is to develop the digital manufacturing plant exactly as the actual manufacturing plant.

The first part of executing this project is to highlight the problem formulation. The problem formulation is a phase where by the industrial personnel identify what are the problems that occur in the actual plant. What is currently happen in the plant or common problems occur? How does the person-in-charge react to the situation? Besides that, the industrial personnel also should highlight all possibility of problem might occur in the plant before the simulation model is developed. The simulation modeler has clearly understood the problem broad up by the industrialist. There are possibilities that the modeler or the industrial personnel has to reformulate the problem to suite the simulation software constraint.

The second step is setting up the simulation model objectives and overall project plan. Before the simulation model is developed, it is necessary to have objective on what should the simulation model achieve. This should be clearly defined by the industrial person. Then only appropriate methodology is set up to meet all the necessary objectives that can solve the problem formulation and giving a reliable result. Project planning and the method to execute the project also should be appropriately taking consideration to give positive impact to the study.

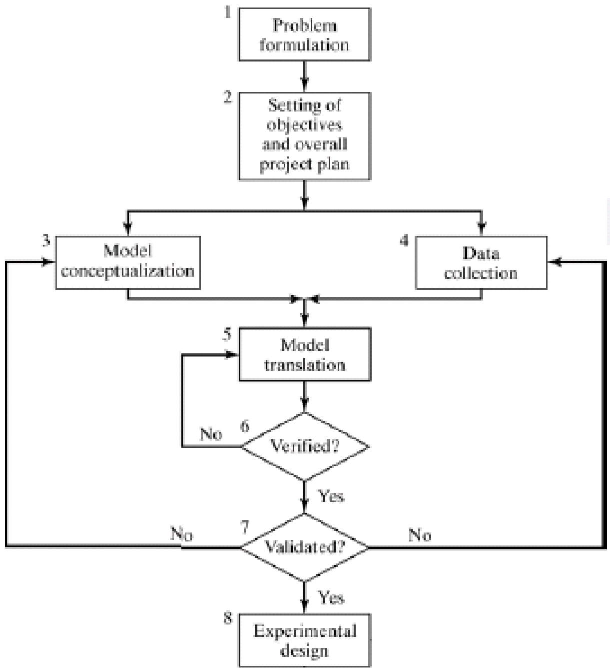

Figure 5 Simulation work flow procedure.

Source: Banks, J., II, J. S., Nelson, B. L., & Nicol, D. M., (2009). Discrete-Event System Simulation. 5th ed.: Prentice Hall.

Moving to the next step, simulation model conceptualization is being done simultaneously with data collecting on the actual plant performance. Although it is two different method of practice but somehow it has to be executed synchronously. This is because there is possibility that the data records are not completely recorded or it might need some amendment to enable the simulation to process the information. The author has developed number of individual model with different objective. This is because the author wants to observe the behavior of the simulation model on every change that has been made.

After the data is collected and the model conceptualization is done, proceed to the next process is model development where by in the model development process, the entire individual model concept is combined and tested at every level of combination. In the model conceptualization, there are 3 minor step practices by the author. First, the experiment phase where the criteria to be achieved by the simulation model. Next, the replication phase where numbers of replication is done to utilize multiple options to achieve the criteria defined in experiment phase. Lastly, the run phase where by all replication undergoes run simulation and the behavior is observed.

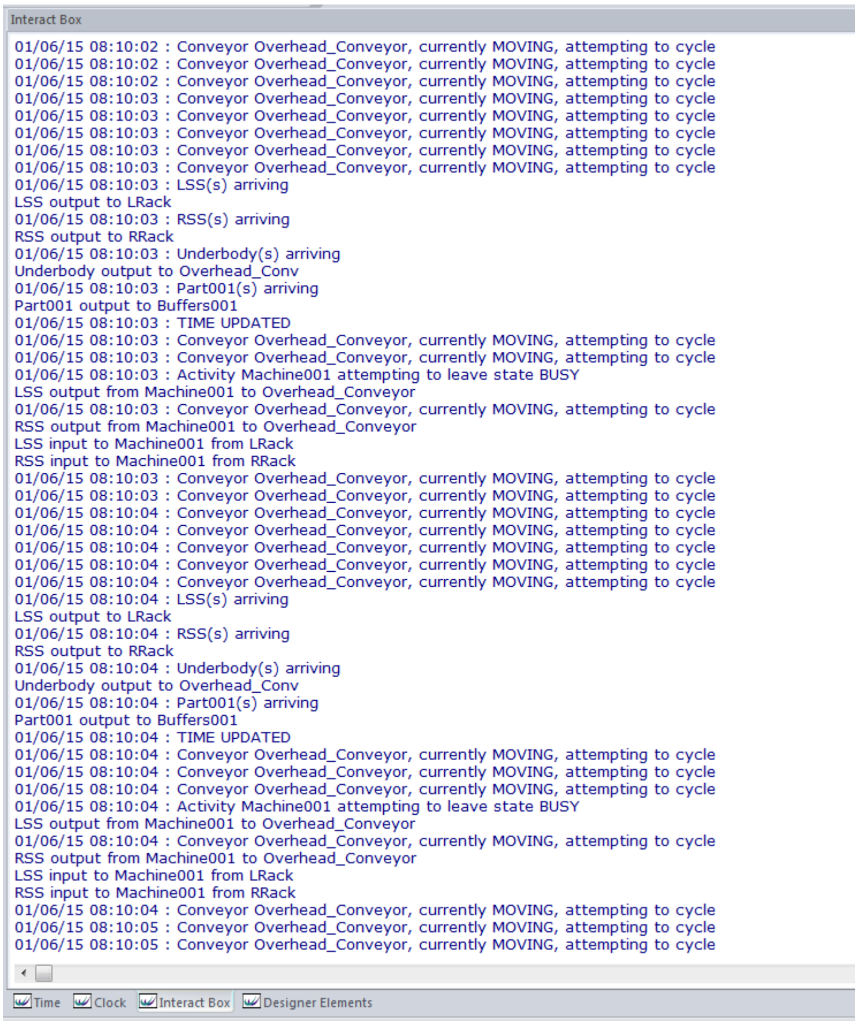

Figure 6 shows the 'interact box' window in Witness12 Simulation software.

The simulation model verification method is done by first tracing the movement of every single part in the simulation model. The part movement is traced by using interact box window. Although the interact box window can be custom made using the basic programming coding but the author choose to use available sample of interact box window due to time constraint and to reduce the time consuming in developing the interact box. Developing the new interact box might introduce new uncertainties condition of the result. Each on the case study simulation model and replication is verified using the ‘interact box’ window.

Simulation model is validated by using several methods; one of the methods is by using Microsoft Excel spreadsheet. The excel spreadsheet is used to trace the working hour functionality in the simulation software system. The production output from the excel spreadsheet is compared with the simulation performances.

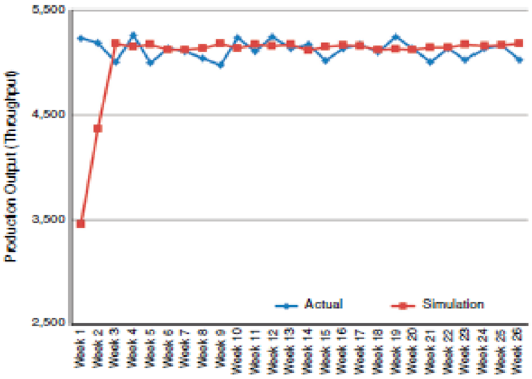

Figure 7 shows the example of actual manufacturing assembly plant recorded performance statistic and the simulation performance statistic (simulation model validation).

CHAPTER 4

4. Plant process definition and data preparation

Before the simulation model is developed it is necessary to analyze the environment and behavior of the actual model. Given to the author is the main body assembly line where there is several character of the assembly line. It is important to the author to understand the characteristic of the main body line before it is translate into simulation model. In this subtopic the author will stresses on the characteristic of the main body assembly line for the model translation phase.

Criteria 1

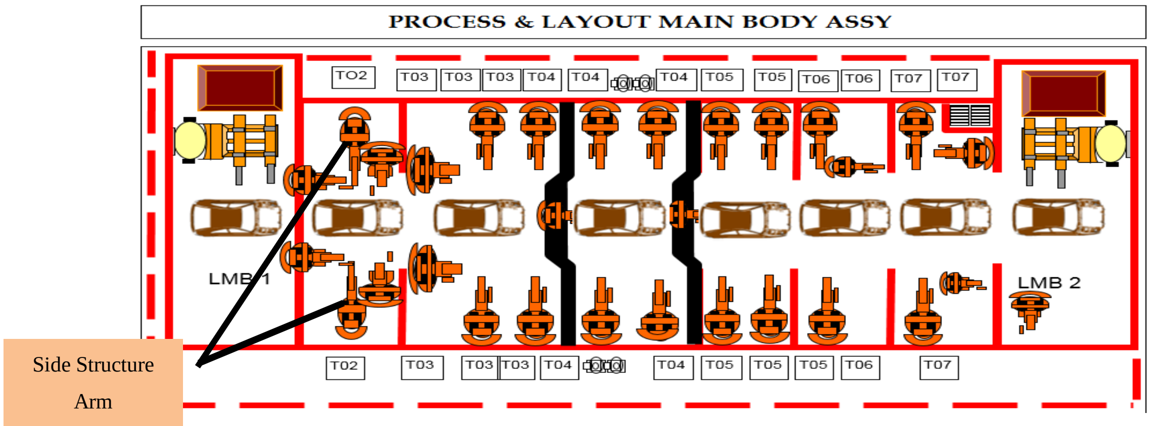

Figure 8 shows Plant layout of actual manufacturing assembly plant.

As shown in figure 4, the plant layout of main body assembly line at the body shop area. This assembly line acquires the robotic arm to marriage the underbody structure and the two side structure which is left and right. The LMB 1 signifies in the figure representing Loading Main Body 1 which placed under T01 station. The T01 is actually the process of loading of underbody structure from overhead conveyor and placed it on the assembly line. Going to next station, T02 station has total of 6 robotic arms. T02 is the process of Side Structure Arm pick up the side structure from overhead conveyor and place it at the underbody structure. The rest 4 robotic arm will perform spot welding to make the part attach together. For certain model of automobile it uses toy-tap mechanism whereby the side structure is designed to have a small left-out metal piece which will be folded with the other part of the structure.

As part continue to T03 station until T06, the robotic arm are just required to perform more spot welding to increase the rigidness of the body frame. Moving to T07 station, the roof metal plate is placed on top of the two side structure and spot weld by the rest robotic arm to ensure the metal plate is in its place. T08 station is where the body framing is unloaded from the assembly line to overhead conveyor using lift system.

Criteria 2

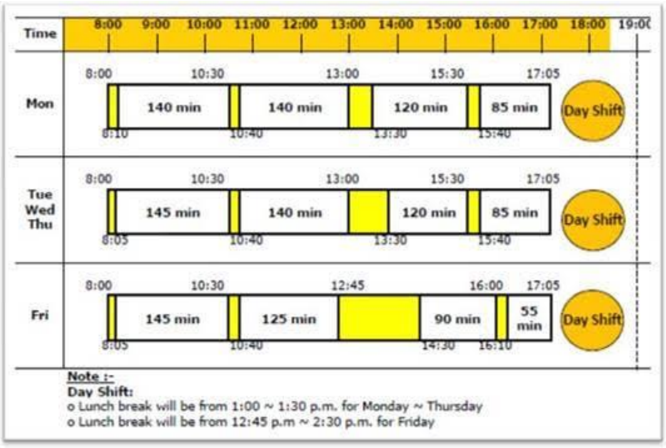

Figure 9 shows the working out of actual plant to be simulated.

Figure above shows the normal working hour of the actual automobile plant. This information required from the plant personnel to be simulated into the simulation model. It is assumed there is no any special public holiday on the day of data collecting.

Criteria 3

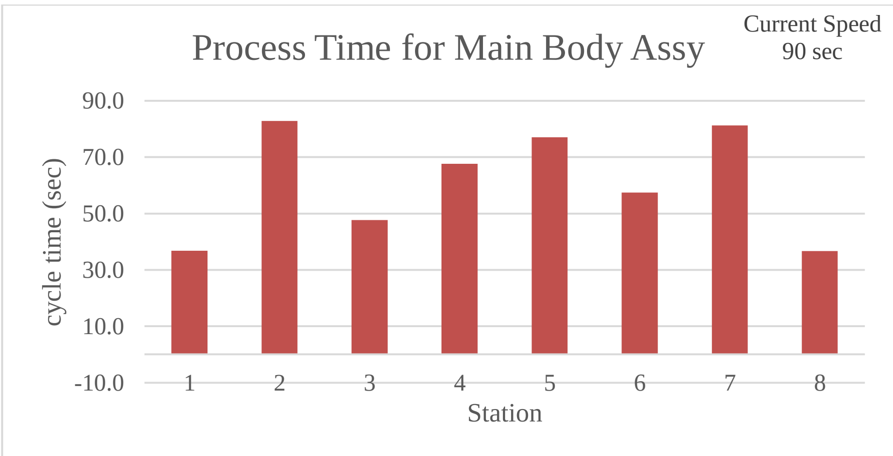

Figure 10 shows the cycle time for every station.

Chart shows the machining cycle time at each station of main body assembly line. The overall speed of the assembly line is adjustable based on the production unit required by the production manager. In this case the speed of overall mainbody assembly line is maintain at 90 second.

Criteria 4

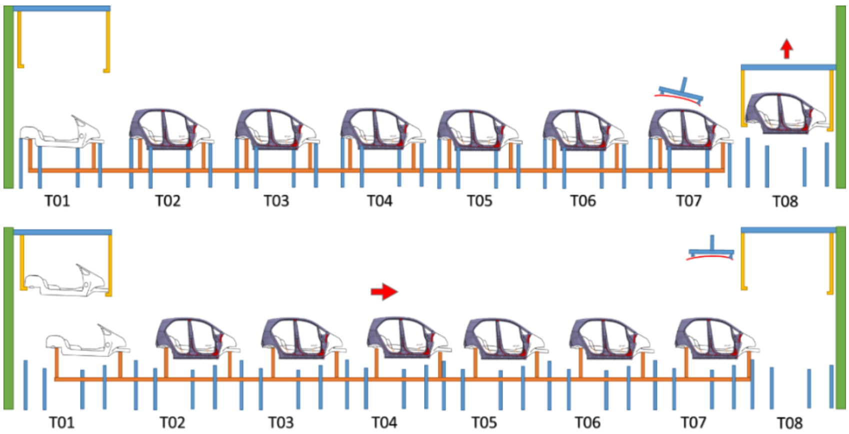

Figure 11 shows the mechanism of transfer shuttle which carrying 7 underbody structure synchronously.

Figure above shows the transfer shuttle mechanism used in the actual manufacturing assembly plant which will affect the simulation model probability of error. Transfer shuttle is frame to pick-up 7 body structure synchronously and transfer it to it next stations.

Criteria 5

Table 1 shows the production down time of actual plant to be simulated.

No.	Duration	No. of occurrence	Model	Issues	Downtime (minute)
1	Jan – Dec 2011	4	Model A	Side structure fall.	130
2	Jan – Dec 2012	5	Model A	Side structure fall.	165
3	Jan – June 2013	5	Model A	Side structure fall.	261
				Total	556

Table above shows the downtime of main body assembly line that occurs in the actual manufacturing assembly plant. The data is provided by the industrial representative to be simulate in the model

CHAPTER 5

5. Simulation Model Development

The simulation model is developed based on the criteria highlighted in previous topic. Necessary setting and adjustment has been made to increase the credibility of the simulation model. The setting and adjustment is like the Clock setting. The base time unit used in this case simulation model is in second and the plant production hour is implemented in the simulation by key-in into the ‘Periods’ tab in the Define Clock window.

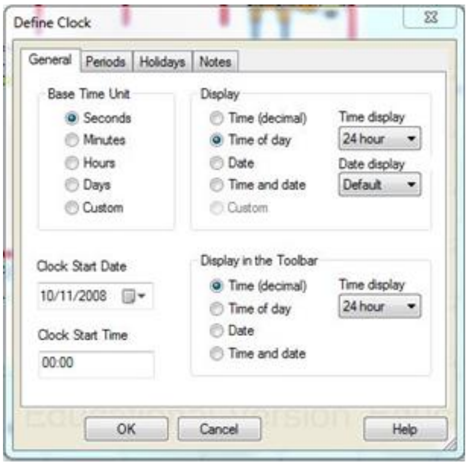

Figure 12 shows the Define Clock window to set active time for each entity in the Witness12 Simulation software.

The simulation model development starts with by:

Table 2 shows the properties of each entities present in the simulation and its profiles.

Part Name	Representation	Lot size	Arrived Interval time	Buffer Name	Buffer Size
Underbody	Underbody structure	1	30 second	Overhead_Conv	5
LSS	Left side structure	1	30 second	LRack	5
RSS	Right side structure	1	30 second	RRack	5
Part001	Roof structure	1	30 second	Buffer001	5

1. Defining the parts and buffer available in the simulation model. There for a list of parts and buffers table is developed.

2. An auxiliary machine is being setup at the side structure to instruct the machine to supply the left side structure and right side structure alternately to the Overhead_Conveyor. This conveyor will transfer the side structure in pair position, to be feed into the T02 station marriage process. The cycle time of the machine and the index time of the conveyor are flexible.

3. Define the types of machine used at every stations from the designer element. This can be found in the simulation software by double clicking the machine icon, there is several machine type on the pull bar for example, single machine, assembly machine, multi-cycle machine, general and etc. In this case the modeler chooses to use the general machine because the feature is more flexible to suite the actual plant model. The machine cycle time also has been key-in into each machine setting based on the data given by the industry personnel. Each machine has been linked to one and another using the Input Rule command. In this case the author used the Sequence/Wait Input Rule for the T02 station and T07 station to instruct the process sequence. The Input Rule instruction is "SEQUENCE/WAIT Overhead_Conveyor at Front#(2), T01#(1)".

The '#(2)' instruction means to pull 2 parts from Overhead_Conveyor (which is LSS and RSS) and '#(1)' means pull 1 part from T01 station which is the underbody structure.

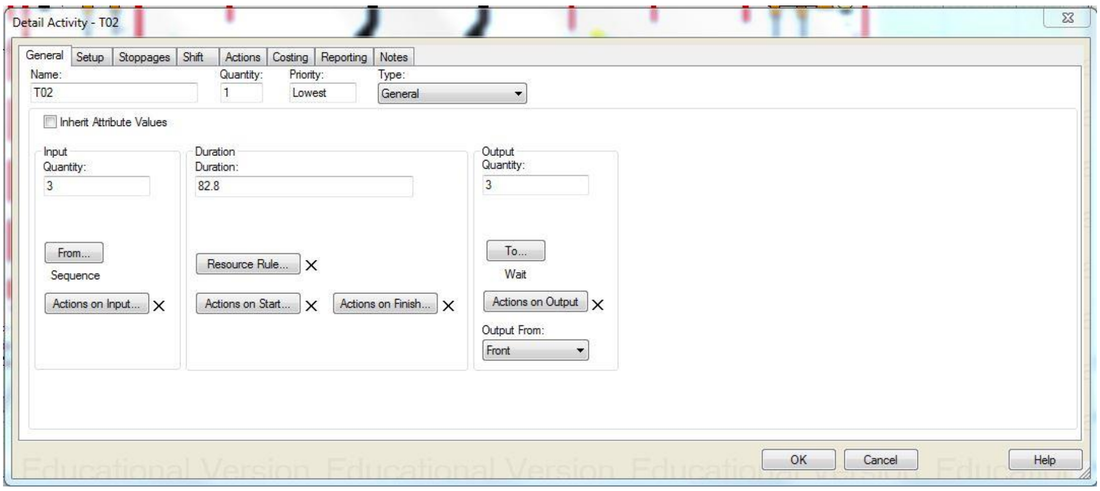

Figure 13 shows the Detail Activity window of T02 station setting.

4. Verify the entity flow in the system using the ‘interact box’ window. The verification method is performing at every point between each machine to observe the part movement. The machining cycle time is validating with calculation in Excel spreadsheet.

5. Since there is no other way to translate the transfer shuttle into the simulation model, therefore the delay time in machining cycle time is introduced. Entire machine type is being changed to multi-cycle machine. The multi-cycle machine has 2 cycle time, which the first one is the machining time and the second one is the delay time. The delay time introduced is differ from one machine to another because each machine has differ cycle time.

6. The breakdown due to side structure fall is being implemented in the simulation model by introduce stoppage tab in the ‘Detail Activity’ window of T02 station machine. This is because the side structure falls usually occur at the T02 station.

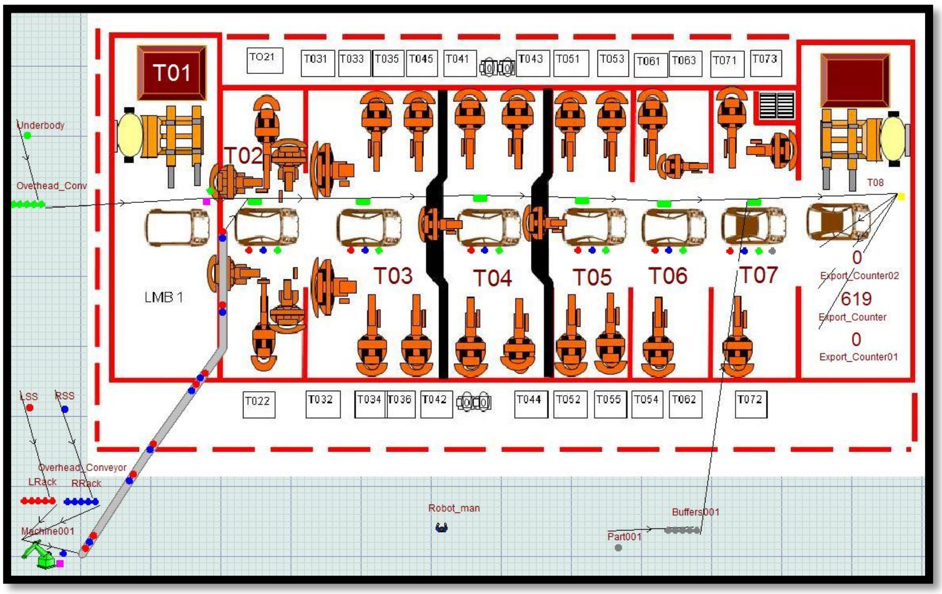

Figure 14 shows the simulation developed in the software before the output is analyzed.

Figure above show the final simulation model developed. The supply of side structure and underbody is assumed to 100% efficient. So there will be no interruption from other assembly line which is before of main body assembly line. After the simulation model is fully developed the output of the manufacturing assembly actual plant data is validated with the production output estimated in the simulation.

CHAPTER 6

6. Results and Discussion

The result gather from the simulation model and actual plant record is tabulated in the chart below. Using the Student t-test, where it is statistical hypothesis test in which the test statistic follows a Student's t-distribution. The method significantly used to make comparison between two populations.

P value and statistical significance:

The two-tailed value is less than 0.0001, by conventional criteria; this difference is considered to be extremely statistically significant.

Confidence interval:

The mean of Actual Main body Output minus Simulation Main body Output is equal 740.41 with 95% confidence interval of this difference which is from 612.6 to 868.22.

Group	**Actual Main body Output (unit)**	**Simulation Main body Output (unit)**
Mean	1617.41	877.00
Standard Deviation	1.46	258.70
SEM	0.35	62.74
N	17	17

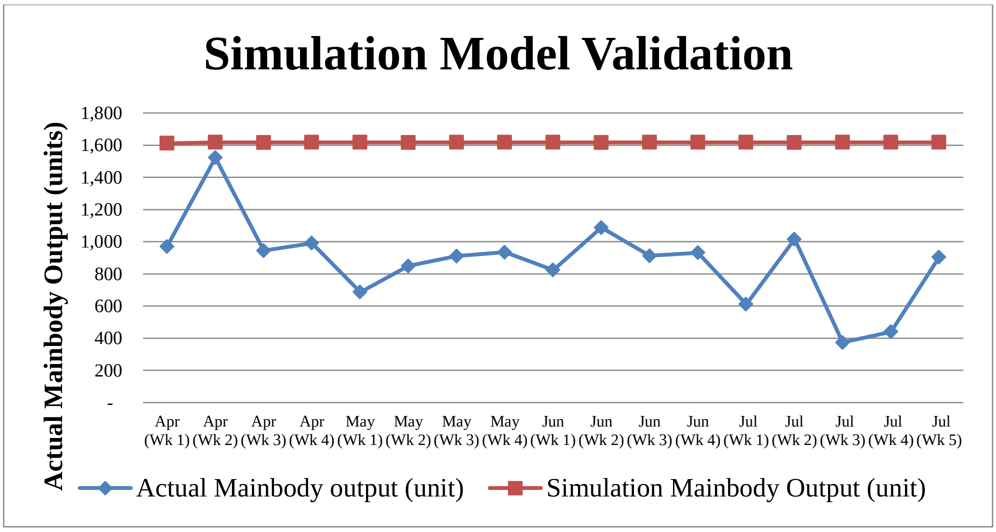

Figure 15 shows the production in the simulation verses existing plant production.

From the statistical data calculated, the result shows an extreme difference between the simulation model and the actual plant performance recorded. The initial assumption at the input of side structure and underbody structure into the main body assembly line for the simulation model was not reliable as the author makes further assessment on the simulation model. This is because the production output at the main body assembly line in the actual plant is affected by the actual performance of other assembly line before main body line.

This means that the actual production output in the chart above is not just affected by the main body assembly line but it is affected by the whole assembly line before it reach to the main body line. So the simulation model for main body assembly line should have the actual production output from underbody and side structure assembly line.

The author also identify that the information on the production downtime is not significant within the time frame of assessment. This can be seen in the **Table X**, the tendency of occurrence of side structure fall is about once in a four months but the data provided is just for three month. So the simulation model unable to show any downtime.

CHAPTER 7

7. Conclusion and Recommendation

Reaching to the end of this project there is several conclusions can be made. Some important conclusion can be drawn as follows:

1. The simulation model is successfully developed based on the information given by the industrial representative.
2. Somehow the simulation model shows an enormous different as compare with the actual manufacturing plant production output.
3. The simulation model cannot claim as validated model due to big differences from the actual output.

As a recommendation for the further development of the simulation model:

1. The form of data collection must be known at the early stage of the simulation modeling.
2. The simulation model must be developed from scratch, which means it has to be simulating from the raw materials.
3. The type of downtime must be identify first, whether it machine downtime, stations, or the whole line.
4. Explore the features of Witness12 Simulation by using Help pull bar or by clicking F1.
5. The modeler has to be very clear on to what extent the intention of the simulation experimentation.

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Appendices

Table 3 the production data recorded during simulation run and existing plant production.

No. of Weeks	Simulation Main body Output (unit)	Actual Main body output (unit)
Wk1	1612	970
Wk2	1618	1522
Wk3	1617	944
Wk4	1618	991
Wk5	1618	687
Wk6	1617	849
Wk7	1618	911
Wk8	1618	934
Wk9	1618	824
Wk10	1617	1088
Wk11	1618	913
Wk12	1618	931
Wk13	1618	611
Wk14	1617	1016
Wk15	1618	373
Wk16	1618	440
Wk17	1618	905

Figure 16 the sample of underbody structure.

Figure 17 shows the marriage process at T02 station.

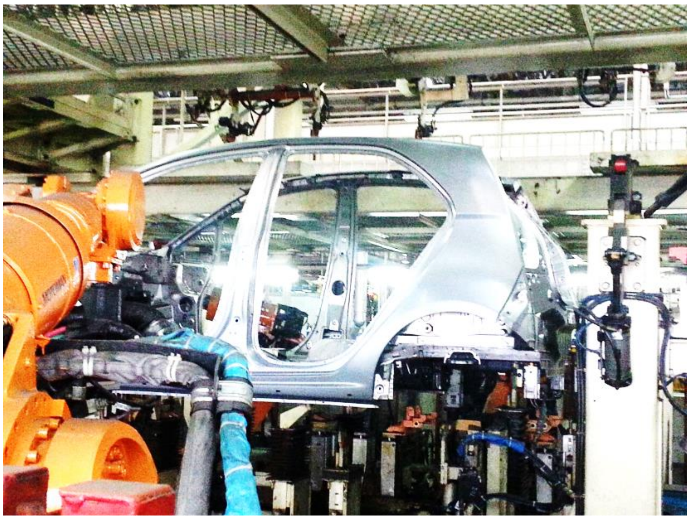

Figure 18 shows the reinforcement spot welding at T03 to increase the rigidness of the body frame.