Development of framework for armoured vehicle assembly line efficiency *improvement by using simulation analysis: Part 1*

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Abstract. Efficiencies and the productivity of the assembly line are crucial in the manufacturing sector. It is very unusual opportunity to visualise and analyse the production system, which used in defence manufacturing sector. This research study focuses on the performance of an existing production line for Malaysia's automotive defence manufacturing industry. The main issues that arise are first, the delivery is always behind the schedule and second, the human factor that contributes to the increase of rejected parts and slow down the production line. WITNESS simulation will be utilised to analyse the dynamic issues associated with the whole performance of the manufacturing system. A methodology for production layout improvement will bring into notice. DELMIA simulation can improve employee's working condition, which is to optimise the production line efficiency. The assembly line can be better in many ways, for example, the arrangement of working layout, the summit of the workplace and massive machines handling method by the worker. All of these are imperative to increase the efficiency of the employees. Continuous improvement of the proposed methodology includes progress in model design, training of operators, follow-up of implementing changes and investigations in the measurement of manufacturing line efficiencies.

1. Introduction

Plant layout is a mechanism, which implies the knowledge of the space requirements for the facilities and also involves their proper location so that the steady trend and continuity of the production cycle can take place. Plant layout design has become a fundamental base of today's industrial plant, which can influence the work efficiency, people, equipment, and procedure designed are the essential combination that drives the company's operations [48]. Facility layout designs obtained using the flow–distance metric exclusively has been criticised because they ignore empty material transfer, which increases work-in-process and equipment prices [65]. As discussed in [3], eliminate obstructions in material flow can reach maximum productivity. Manufacturers, who neglect to deliver on time, will fail to retain their customers [64]. This reality is all, the main reason why small and mid-size manufacturers must deliver the products to their clients as soon as possible [64].

The bottleneck issue in the production process creates this vision seems impossible. Bottlenecks inhibit the performance of companies [32]. On top of that, the bottleneck is inherent in a production system when it is designed and configured with several factors, such as equipment costs, space limitation, and environmental requirements [76]. An appropriate plant layout design required to position the employees, materials, autos, equipment, and other manufacturing supports and facilities.

Currently, a fixed layout of the armoured vehicles assembly line was implementing. The products stay in a place, and the workers, equipped with tools and materials come upon the product to complete the assembly process for each unit of the vehicles. This type of design layout decreases the chances of the product to be damaged since they fixed between workstations. However, this layout type does stance disadvantages. The assembly area used a fixed-position layout design operation where the thoroughly allocated time to work on the particular phase is a must in the manufacturing process. In the scheduling procedure, jobs are sequencing processing on each resource over a short-term time horizon considering the arrival time, the processing time, and the setup [38]. If one of the workers is absent or is not working in his capacity, this can slow down all other stages of the processes. The products could exceed their development deadline, and the company faces losses in overhead costs. Since workers get tired when they process jobs, their performance declines over time because of their fatigue, so that they can become slower and spend more time than expected in handling their assigned tasks [24]. Furthermore, all the devices needed for the assembly must be portable, as the fixed-position layout design operation was carried out. The mobile equipment allows the workers to position themselves within the particular workstation. The mobile machine and tools are pricey compared to the stationary because of the repair and maintenance cost. Maintenance encompasses activities including facility, vehicles, equipment, or some physical assets enabling active work [73].

Materials and equipment that arrive on specified time for use can be a disadvantage because of the excess materials. In another layout design, materials and equipment can be stocked and placed in a designated workstation and waiting for the subsequent phase of the manufacturing process. When materials and equipment have to travel for the product, only a certain number of items can occupy the working space. The excess materials result in time-consuming of the workers, as they need to move the excess materials rather than focus on the assembly process of the product. The workspace becomes insufficient depends on the number of workers needed during the manufacturing phase. The workers must not bump into each other while maneuvering the equipment, especially if the product is relatively small. Furthermore, a tense working environment will occur when they were attempting to give space to each other and slowing down the assembly process. Besides, human fallibility in working environments contributes to the majority of incidents and accidents in high-risk systems, spell it bears upon the quality and productivity in low-risk schemes [19]. If there are accidents happen during working, the production line may go dull because of the delay in assembly process due to the less workforce thus the delivery will be out of the schedule.

Consequently, the company is having problems to meet production delivery and has a high part defect, which related to employee involvement. Application of WITNESS and DELMIA simulation in these areas would improve the current situation. A framework will be developed to apply both simulation techniques to achieve optimum production layout efficiency. The research conducted on assembly line 1 in one of the armoured vehicle manufacturing company in Pahang, Malaysia. Ten assembly personnel from 6 stations in assembly line 1 will observe in human factor analysis. This study will involve data collection of production lead-time, production planning and scheduling, employee attendance and anthropometry measurement data.

2. Literature review

2.1. Manufacturing system and its sustainability

Manufacturing systems usually characterised by a stochastic and uncertain behaviour in which frequent changes and unpredictable events may occur over time [24]. The ultimate basis for all job creation is and must be the manufacturing industry. Determining the best manufacturing system configuration (MSC) may significantly improve reliability, product quality, capacity scalability, and costs in production facilities; hence, it is crucial for profitability [81]. All other services are in one way or another based on the manufacturing sector. Several other variables have to be taken into account to become successful, including, for instance: customer preferences, available resources, market supply and demand, and information flow, among others [60]. Some countries have successfully won a competitive lead due to monopolistic growth in some manufacturing sectors. Sophisticated industries are the backbone of any advanced economy. A manufacturing company must have an efficient production system to meet their delivery requirement and overall operation objective [34].

Four categories manufacturing system classified. There are cellular manufacturing layout, product layout, process layout, and fixed layout [22]. By nature, manufacturing sectors have become more and more sophisticated. Manufacturing organisations need a bit more of effectiveness, flexibility and innovation while manufacturing their products to sustain in manufacturing world [51]. The investments in new installations and production occupations are for every time increasing in monetary value and complexity. Therefore, it is necessary to have an aggressive approach to invest profitably. A systematic model for the design of the manufacturing with the help of robust computer programs, such as DES (Discrete-Event Simulation), may be one way to perform high overall productivity. This computer program is enabling knowledge elements which independently stored from its application, thus fostering the use of this knowledge across different engineering problems and provide users with a simple system which facilitates its usability and maintenance [59]. An example may be to build a virtual copy of the manufacturing line before assembled it in the real world. Computerise manufacturing scheduling tools can play an essential role in the management of industrial operations, as obtaining economic and reliable schedules is at the core of excellence in customer service and of efficiency in manufacturing companies [20]. In the past years, many losses result from the work in the manufacturing sector. Thus, the trend in many countries has been to increase the effort to produce new jobs in the service industry. Few service manufacturers feature high entry barriers compared to the manufacturing sector. Thus, the service sector is not equally substantial as the industrial sector. There is also a linkage between the military industry and the manufacturing industry [18]. Many services are in proximity to the manufacturers. If production dies, the connected service roles will travel to the new manufacturing site, maybe also in another country.

Nowadays, due to increased environmental consciousness in the world, more and more consumers would be encouraged to purchase remanufactured products [23]. The focus must shift to production planning, distribution and service logistics to achieve competitive costs [82]. Quality and delivery of manufactured goods are necessary elements for client satisfaction. Time to market and service response included as a component of the assembled system. Total production cost is another performance measure vital for manufacturing systems. Flexibility in the operations has also drawn more attention. There is also a tendency to utilise information technology systems, for example, MRP (Manufacturing Resource Planning) systems that may be considered "high-risk" systems. Companies have gone out of business following its MRP or ERP (Enterprise Resource Planning) systems [47]. Boeing was obliged to close down two of their assembly lines and bring charges against earnings in 1997 due to the complexity of their computer systems. The restricted information technology used in an industry decided by the organisation and not by the technology itself [53]. Some of the most successful production systems like TPS (Toyota Production System) chosen to not rely on sophisticated computer systems.

2.2. Human factor and productivity

Previous research studied the interaction between machine and operator. Small-scale learning, how to convey experience, and how workers can be seen to generalise their understanding within the work task have investigated. Production disturbances in manufacturing systems are a new occurrence in the chain of events leading to an actual accident. Assembly lines need the uninterrupted supply of parts at the workstations to ensure a continuous production flow, so an internal material handling system is required to periodically replenish stock along the line according to production plans [16]. The operator has appeared to be a "fixer" of immediate problems, rather than an inventor of long-term solutions to production problems. Enriched work tasks and work for the advancement of safety seem to travel hand in hand. The production disturbances improvised in a manner that promotes the development and learning of operators. At the same time, work environment and safety must be in focus.

Many engineers fail to consider the operator as a system component. As a result, work-related injuries and accidents are approaching pandemic levels [28]. The lack of design for the human user is one of the reasons why so many machines and systems are unsafe, difficult or inconvenient to use [17]. The organisation must get along to get the required operational behaviour. The scientific view focuses on how the system will serve its users. This view is establishing operating requirements for the system, how well and under which conditions the system must perform. It is hence proposed to move personnel, in gain to their technical competence, with an apprehension of human resource subjects, task planning, and change management. A survey in the U.S. established the view that besides strategic dimensions such as manufacturing lead-time, customer response time and quality, it involves and affects the organisational and human aspects of the manufacturing firm [5].

The numbers of human processing capacity limits are hard to be placed, but it can be narrowed down for at least three reasons: i) equipment design, ii) expertise and iii) working methods available. Different tasks can require various mental or physical efforts depending on the material. As an example, retrieving items from storage locations in warehouses commonly referred to as order picking, is often performed by human workers. A high amount of human work involved in order picking turns this activity into a time- and cost-intensive process step in warehouse operations [21]. When a person becomes more of an expert, they can serve a job with less mental exertion, or reciprocally, they seem to cause increased their mind working capacity. In other words, they have got the skill. The composition of the workforce, for instance, the ratio of apprentices and adequately trained workers, has an impact on a line's output and should be taken into account [52]. In the fabrication industry, usually, young workers need specialised instruments to assist them in completing their tasks. That is because they were new to the jobs that they were assigned.

In human engineering, a typical model of a cognitive process consists of a set of the sequence starting with reaction and ending with the execution. A person behaves and responds to a situation that is more likely to their general knowledge. Finally, it has proven that the different work shifts, for example, the night shift can affect the responding time. Some researchers have attempted to sort out the process by which companies select methods for improving the execution of their operations. There are two main alternatives to the learning process, which are in-process or offline [74].

2.3. Design of the manufacturing process

Numerous manufacturing companies always choose the people-oriented approach to structure their organisation. In this connection, human resource is one of the most crucial resources to manage and vital for manufacturing companies regarding customers, employees and managers [35]. The systematic design of manufacturing systems in all parts hardly can be seen where the systems often created in different steps without any strategic planning. The determining of competitive priorities forms are the core of manufacturing strategy which includes quality, cost, delivery, and flexibility [29]. In general, not a far-reaching plan is considered for new future products in the same product family and a smooth increase in output capability. In an overall purpose of manufacturing organisations, there is a need to get more systematic approaches and techniques. One of the proven ways is to disintegrate the production system into subsystems of more manageable sizes. Of vital importance is to dedicate resources requirements for layout design, fabric handling and production planning subsystems. An overall framework of manufacturing systems and their invention and valuation, with particular stress on systems analysis, systems design and systems methodology have proposed [80]. Manufacturing system design specifies physical, human, organisational and finally information and control architecture as principal areas in the design of manufacturing organisations.

An industry with the right method, which blocks the power of informatics, will gain a competitive benefit. Automation may expand rather than rule out problems with the human operator [4]. The ideal aim of automation is to replace workers with machines. The intention, however seldom completely satisfied. The system also includes the workforce, its skills and the allocation and the sequences of work tasks. The performance of the production determines by the relations among all these elements. The combined resources of engineering, workplace organisation, and skill profiles must be readily suited to each other. The principle of "organisation first, technology second" is also asserted. The development and use of technology are the results of social connections and interests that set the conditions and objectives under which technology grows.

The fast development of the manufacturing systems increases the need for a taxonomic approach to the invention of both organizations and products. The product must be appropriate for production in a suitable manufacturing system. The growth continues to obtain an improved system with a high overall yield with little tendency for production disturbances. Ultimately, the information management must be capable of giving indications if any troubles about to come. A good manufacturing system is a compounding of human interaction and output techniques.

2.4. Lean and techniques for improving manufacturing systems

Plant layout design has become a fundamental base of today's industrial plants, which can influence parts of workplace efficiency. It is required to appropriately plan and lay, employees, materials, autos, equipment, and other manufacturing supports and facilities to make the most efficient plant layout. There are many production improvement techniques. The methods mentioned here have been made by some of the most profitable companies worldwide. The fundamental ways apply in many case studies such as lean production, supply chain management, TPS (Toyota Production Systems) and TPM (Total Productive Maintenance). The improve profits and create value by minimising waste is the primary goals of lean manufacturing [12]. In a survey based on over 1000 US manufacturing plants disclosed a difference in manufacturing technologies [39]. The techniques include JIT (Just-In-Time), TQM (Total Quality Management), MC (Manufacturing Cells), and SQC (Statistical Quality Control); any new equipment is not all essential to their use but may enhance strength. An investigation studied three companies in the diesel engine sector in the US [69]. Manufacturing organisations that go wrong to recognise demand variability generate high work in process and low throughput in Multi-Product Lean Manufacturing Environment.

The companies have a different approach to manufacturing. One result seen from the survey is that the long-term implications of using buffers may be lower performance as their function may create costs and even more uncertainty through negative feedback loops. One of the most competitive manufacturing systems is the TPS (Toyota Production System). Many of its components have spread to the world as state-of-the-art of the manufacturing.

The main idea is to reduce costs by eliminating waste in different dimensions [56]. The production waste can be found everywhere in operations, for example, excessive production resources, overproduction, excessive inventory and additional capital investment. The work has to fit together with three other intermediate goals: quantity control, quality assurance and respect for humanity. All together it will establish the Toyota Production System (TPS). The effect of continued work when necessary operations should stop is overproduction. Excessive inventory designates resources for more human resources, more equipment and more floor-space for both transport and stock.

One of the fundamental approaches in the Toyota Production Systems is "Kanban". The main idea is to take control of the material flow and smooth the production flow by using physical cards.

Flexible manufacturing, shorter product lifetime and product cycle have changed the ideas of production. The concept of "lean manufacturing" has altered the way of manufacturing [50]. Lean production, on the contrary, focuses on small batches, mistakes to be shown up in a flash, continuous and incremental growth process called "Kaizen", five why's, supply chains and JIT system utilising for example Kanban. The lean plant transfers the maximum number of tasks and responsibilities to those workers, adding value to the product. Also, it bears instead of a system for detecting defects that quickly trace every problem, once found, to its ultimate cause. The automotive production has been an early adopter of lean manufacturing and lean product development, especially of the Japanese companies. The request causes random fluctuations in the manufacturing process. Conclude from that fluctuation new level will often involve some time to adapt.

2.5. WITNESS Simulation

WITNESS simulation software is one of the discrete-event simulations (DES). A DES models, the operation of a system as a discrete sequence of events in time. WITNESS simulation is an imitation of a proposed or a real-world process. WITNESS model enables a study of experiments of a complex system in a virtual world. One of the advantages of WITNESS simulation is to consider the dynamic interactions in a manufacturing system, and thus the capabilities of a machine can be set. By pressing and expanding time, the WITNESS model can speed up or slow down the phenomena such as bottleneck studies. Nowadays DES is mainly used for manufacturing systems and independent cells. The experience is that equipment efficiency will increase in a manufacturing system when WITNESS simulation is simulated. Reduction or deletion of particular production disturbances for later implementation in the real manufacturing system has shown to be beneficial. One of the main benefits of using WITNESS is the visualisation of the dynamic effects.

The WITNESS model should be sufficiently accurate compared to the real world. The accuracy is dependent on the need and purpose of the design. Although, the model has to be both affirmed and validated. The adequate quality of the input data is necessary both for the actual simulation and to draw legitimate conclusions from the WITNESS model. A fully automated collecting system is the best, but not yet a cost-effective solution according to the author's views. The simulation can achieve information sharing and reduction of total cost; thus the improvement of operating efficiency applied and competitive advantage can be enhanced [54]. Among other things, the data must be readily accessible in a "ready to use" state. The data should more or less accumulate and inserted directly into the WITNESS model. The whole idea with digital data is that it should be accessible and usable for different applications.

Computer-based manufacturing scheduling tools can play a vital role in the management of industrial operations, as obtaining economic and reliable schedules is at the core of excellence in customer service and of efficiency in manufacturing companies [20]. The obtained facts and figures about the manufacturing system are considered one of the significant advantages of WITNESS studies. Conventional measurements, such as cycle time and set-up time, are often well known but other data are not. However, there is always need to update the information about the manufacturing system. The data may be obsolete due to alterations in the organisation. There is an investment in computers, software and training of personnel before the WITNESS tool can be using. The software needs an update with all kinds of features in the software, including the knowledge of how to customise programming of specific procedures. The requisites for the person working with WITNESS are high. The provider of the WITNESS software tries to develop a program suitable for all different kinds of DES models. The development program has resulted in a somewhat unstructured and large number of instructions and commands. WITNESS programs usually include a unique software language, which further complicates the issue. Compatibility problems between the different editions of the same program have also received.

The experiment and analysis phase is one of the essential points. Various alternatives should test for relevance to finding a suitable solution to improve the performance of the model. The strength of the WITNESS software is that many variants of a model may be testing. The production data of the experiments should at all-time check for relevance. Revision of the whole task needs to be done carefully if the problem is not defined accurately, it may result in the delay of the project, thus more expensive and with possible imperfections. Other investigations indicate that the step of a model building requires less expense of time than either collecting its data or conducting experiments using the model [66]. It must emphasise the need to allocate enough time to each task in a simulation project to make the project successful. Assessing the accuracy of the model is usually tricky, especially if the model is describing non-existing equipment or line. The model is an abstraction of reality, and a perfect representation of it may never expect. There is also a correlation between the accuracy of the model and time spent on it. Therefore, the accuracy of the model must consider in the simulation results. It could be useful to evaluate how suitable time pay and the limit vary from simulation case to simulation case.

2.6. Ergonomic and DELMIA applications

Manual work and automation are the corresponding elements in modern production systems. The increasing customisation and shortening product life cycle have led to smaller stack sizes, and more products vary. A flexible component of the output operation is because from the intelligence and adaptability of human workers. Manual work requires the employee to manage several different factors, which relate to safety, task and the working environment. Efficient ergonomics in workstation design shows improves interaction between man-machine systems. The productivity of worker substantially depends upon the ergonomic design of workstations. There are a lot of research on analysing and enhancing the ergonomics of a workstation, facility layout, and tool design. For productivity improvement in manufacturing industries, the efficiency of worker plays a significant role. The productivity of worker substantially depends upon the ergonomic design of workstation. The impact of workstation design, assembly design, jig design and working postures on assembly line shows a jig designed to have the most substantial effect on an assembly line.

The workstation may operate with less efficiency if anthropometry data mismatches with workstation design. Work-related musculoskeletal disorders (MSDs) include all musculoskeletal disorders that are induced or intensified by work and the conditions of its performance [45].

The repetitiveness of work will require the workers to apply more forces, handling of heavy loads and awkward static postures expose assembly line workers to risks of musculoskeletal disorders [54]. The low back pain was the most common body region illness testified by men (34.8%); neck and low back pain by women 39% and 36.5% respectively [45]. In the fabrication industry, software that can aid, providing the fresh solution for realising ergonomic and efficient assembly processes is DELMIA [75]. The DELMIA Quest software offers tools that allow designers to achieve the results of the simulations run on the model and obtain quantitative information about the behaviour model. Due to the modern manufacturing systems which involve numerous interactions and dependencies between components, analytical and mathematical approaches limited in solving such complex maintenance problems [2]. On the one hand, DELMIA makes it possible to get statistical reports and charts (both standard and customised by the user) at the end of the simulation, on the other hand, provides the ability to display model data dynamically, updated at defined time intervals with the development of the simulation.

DELMIA software can obtain information such as average usage and cycle time machine, the number of parts processed at the end of the simulation, the percentage of use of an individual buffer. The advantages of this simulation software are it can downplay the cost of conveyance of the materials and minimise the components stored. Other than that, it can utilise the available space in the most efficient manner, and it can avoid unnecessary capital investments. Most importantly, DELMIA can efficiently use the workforce (labour). The advantages prove that DELMIA can increase the efficiency of the production line in the manufacturing industry.

2.7. Level of simulation methods

The capabilities of digital solutions or tools have opened up new opportunities and raised ambitious challenges for manufacturing systems [44]. The different methods of simulation that suitable for a manufacturing company shown in Table 1. The table illustrates the various simulation tools available for improvement work in multiple dimensions at the company. Depending on the purpose of a simulation model it has to be built accordingly [67]. The choice of the type of policies and optimisation technique depends on the situation of the company, especially the emphasis on the cost performance and the computation time [43]. DES is a tool that should be applied when it is appropriate compared to the benefits and costs. Today DES is mainly used for manufacturing systems and independent cells. One of the primary benefits to use DES is the visualisation of the dynamic effects. DES is a potent way and should be practised together with production improvement techniques for best outcomes.

Table 1. Level of simulation methods according to different tools used for different situation at the company [67]

Planning Level	Content	Method
Company	Business process	Business process

	Information flow	Modelling
	Order	
Production system	Plant layout	Material flow
	Material flow	Simulation
	Simulation	
	Control strategies	
	Job organization	
Cell	Cell layout	Movement
	Sequencing	Simulation
	NC programming	
	Cycle time	
	Collision check	
Component	Operations	FEM-simulation
	Process parameter	
	Tools	
	Auxiliary means	

The literature review was done to clarify the systems of concepts related to the research objectives, identify current practices and solutions, as well as opportunities for future inquiry. Apparently, these topics are too specific and are named considering this literature review, the study of the company and hypotheses of the author. Two research gaps identified during the literature review; there are only a few types of research on the optimisation of assembly line using the framework of WITNESS and DELMIA simulation software have been found and Less analysis showed the existence of simulation-based study in the automotive defence industry.

3. Methodology

3.1. Development of the methodology

The research methodology is a critical view because it describes how the research work, the methods and sequence of their application. Then, validation of the research outcomes is necessary because the 'right' approach delivers 'right' results. The methodology should apply a solution to the problems encountered. Based on these facts, the method should be more generalised.

3.2. Methodology for performance improvement

Method for performance enhancement in a manufacturing system was presented in different steps as shown in Figure 1.0. The method describes a DES study in various stages. Firstly, a suitable project should identify. Secondly, the input data collection phase initiated. The input data are documenting in the conceptual model in case of later reference. And so the actual DES modelling begins, followed by experiments and the result analysis takes place.

The research begins with analysing the current situation in both assembly line condition and employee's related performance as shown in Figure 2.0. The flowchart will utilise for both WITNESS and DELMIA simulation experiment. The flowchart starts from identifying the problem based on the problem statement mention in the initial stage of this proposal. The simulation objective and planning take place to grow the idea and vision of modelling conceptualisation before the execution of the simulation.

The trial needs to be designed in both, software to play the simulation. After the overall setting is made out, the experiment will be carrying several times based on objectives, which has been ready in the first place. The analysed data will undergo an improvement where this stage will also implement this flowchart to be given at specific level until the desired target achieves. The analysed data will undergo for an improvement where this stage will also implement this flowchart to be given for certain level until the desired improvement achieves.

3.3. Conceptual Framework Development Methodology
To develop the framework, which the primary aim of this research, Figure 3.0 shown the idea of the methodology. The process of developing the framework explains as follows.

3.3.1. Initial Stage
This step defines in the introduction chapter of this proposal to determine the actual problem and objective of the research. The company will support this stage.

3.3.2. Realize the Problem
This stage will further define every area of challenges, which related to the efficiency of the assembly line.

3.3.3. Simulation Experimental
Simulation experiment will do on the existing assembly line condition and human factor relationship, which contribute to the problem. After that, simulation of improvement plan will take place. Figure 2.0 shows the detail process of the simulation. Each simulation will try runs at three times to make sure the data are accurate.

3.3.4. Improvement Implementation
The analysed suggested improvement techniques in the simulation stage, which will implement for validation purposes with support from the company.

3.3.5. Framework Development
The development of the framework will develop during and after application of the propose improvement implementation to the company, which will improve the overall efficiency, performance, smoother the production flow and better working conditions. The actual data will be used to validate these research objectives.

4. Conclusion
This research will contribute to military vehicle lead time reduction by 45% hence increase at least 25% the production rate of the vehicle. The elimination of waste will reduce the production cost, which will benefit the country to produce more output with smaller cost investment. The objectives are formed based on the initial requirements mentioned in the proposal. The purposes are related to further development of discrete event simulation models capable of efficiency improvement, while DELMIA to improve the working condition as well as giving an added value to the production productivity improvement. All of these objectives work towards one aim – a framework for the armoured vehicle assembly line, efficiency improvement by using simulation analysis. A research strategy, a generic way to address these objectives, is described in the next section after the research aims and objectives. The research strategy is defined and presented in statements as follows. Taking initial agreements is a must. Actual research and research results were validated. The scope and the effect of the research have described. Thus, make each of the objectives support other and work towards the aim. It incorporates the selection of research methods among many available, descriptions of research methods used, and the overall process of this research with the final bit of analysis on elements the researcher may influence; therefore worth researching. The described methodology allows more systematic process when working with production efficiency problem. It is necessary to be skilled both in the DES software as well as assembly line improvement techniques. Improved efficiency in a manufacturing system can achieve through assembly line layout improvement. The combination of DES and DELMIA simulation techniques is beneficial. It also is shown that the performance could increase by inexpensive means.

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