A Functional Modeling and Discrete Event Simulation based approach to understand the Lean Manufacturing System

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ABSTRACT

Lean manufacturing involves elimination of waste, continuous improvement, and reduction of lead time among other factors. In order to proficiently understand and implement lean manufacturing systems, a very efficient practice has been the adoption of simulation and modeling methodologies based approach beforehand. This paper has two foci: (1) Function modeling to understand the concepts of lean manufacturing and (2) simulation techniques to design & learn some common lean tools and techniques. In this research, IDEFØ is used as a functional modeling method to model a lean manufacturing system (at desired abstraction levels) using AIØ WIN and PROMODEL 6.0.2 is used as a Discrete Event Simulation (DES) methodology to design & learn some common lean tools (like Kanban, Cellular, Push/Pull and takt time). This concurrent approach enhances the understanding of lean manufacturing concepts as well as enables the use and assessment of technology in engineering education.

Keywords: Lean Manufacturing, Modeling, Simulation

1. INTRODUCTION & BACKGROUND

Lean Manufacturing is a structured and systematic approach for identifying and eliminating waste (all non-value-added activities) through continuous improvement {1}. The objective of this research is to develop a concurrent approach which enhances the understanding of lean manufacturing concepts and tools through modeling and simulation. Specifically, in this research the use and assessment of technology in engineering education is emphasized. In order to efficiently manage and operate today's manufacturing systems, it is necessary to apply simulation methodologies to understand the behavior of a system beforehand and analyze their capabilities. Discrete Event Simulation (DES) is widely used problem solving methodology for many real world problems in manufacturing domain. It enables to study, experiment, and analyze the interactions of any system and its subsystems. The animation capabilities will provide the user an overall idea about the functioning and the plan of the developed system. Simulation using PROMODEL technology is explained by Harrell, R, C., et al {2} and simulation was used to understand the concepts of lean manufacturing {10}. An overview and tutorial in simulation modeling and control of Kanban & CONWIP pull systems using ARENA/SIMAN 3.5/4.0 is provided {6}. In this paper, PROMODEL6.0 is used as a Discrete Event Simulation (DES) methodology to design & learn some common lean tools (like Kanban system).

There are various types of enterprise modeling and analysis methods like IDEF0 to IDEF14 (and including IDEF1X), and UML are currently used by some industries. In the described research, the functional modeling method used for this investigation is the IDEFØ **(**I-CAM Definition). In the past decades, methods such as the IDEF-0 methods have been adopted as Federal Information Process Standards (FIPS 183) as well as Department of Defense standards {7}. Apart from IDEF-0 function models, there are other process representations which include the IDEF-3 process descriptions and IDEF1x data models {7, 9}. IDEFØ has proven effective in detailing the system activities for function modeling, which can be described by their inputs, outputs, controls, and mechanisms (ICOMs) {4}.The IDEFØ model enables to construct (AS-IS) models that have a top-down representation and interpretation and TO-BE enterprise can be described by a logical decomposition, which can be continued recursively to the desired level of detail. {4}. Additional information on IDEFØ can be found in {4}. This paper is organized into several sections: In section 2, a detailed IDEFØ model for Lean manufacturing system is provided. Section 3 presents a discrete event simulation model for Lean tools. Finally, section 4 highlights the need for concurrent approach and concludes this paper.

2. IDEFØ FUNCTIONAL MODEL

This section provides an A0 and first level of decomposition for target activity "Develop a Lean Manufacturing System". Using IDEFØ, the major activities involved in developing a lean manufacturing system were modeled and analyzed. At the AO level, the various Inputs, Control, Output, Mechanism (ICOM) are identified and prioritized. The temporal precedence among the activities is also captured and the tasks that comprise the AO level are identified and provided in the decomposition. Figures 2 through 4 show the top-level (A0) model and the first level of decomposition. The major principles to develop and implement a successful lean system were already developed {1, 5}. Figure 1 provides the six major activities involved in developing the lean system.

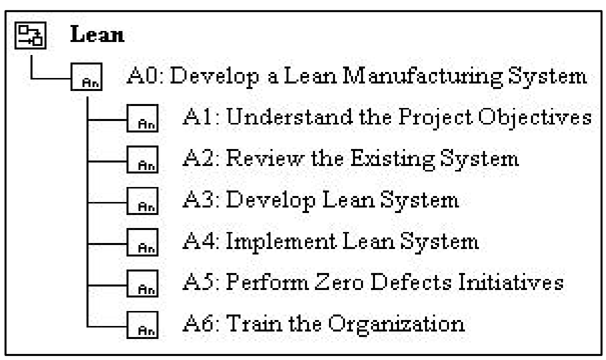

Figure No. 1: Six Phases in developing a lean system

2.1 MODEL SUMMARY

Purpose: The purpose of building this model is to enable a better understanding of the complex activities involved in developing a lean manufacturing system, which will be eventually used to implement the system.
Context: This developed model focuses only on developing a lean manufacturing system. It is assumed that the enterprise for which this model is developed have not implemented system in the past. The outputs from this model, which are of interest, include lean manufacturing system and the feedback and modifications from the customer.
Viewpoint: Viewpoint is that of an Industrial / Manufacturing engineer who has some lean manufacturing background and has worked in industry for a few years.

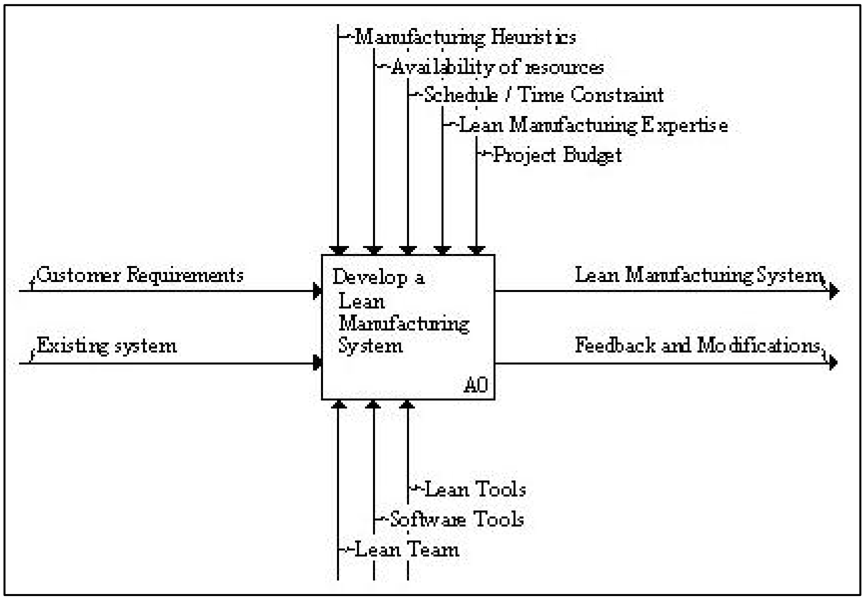

Figure No. 2: A0 (top-level) level functional model of the target activity

The functional models were built in an iterative manner; detailed glossary of the activities and the modeled attributes was also developed and due to page limitations, not all levels of decompositions have been shown. In this paper, the model illustration is limited to the A0 and first level; figure 3, 4 shows the decomposition of the target activity in figure 2.

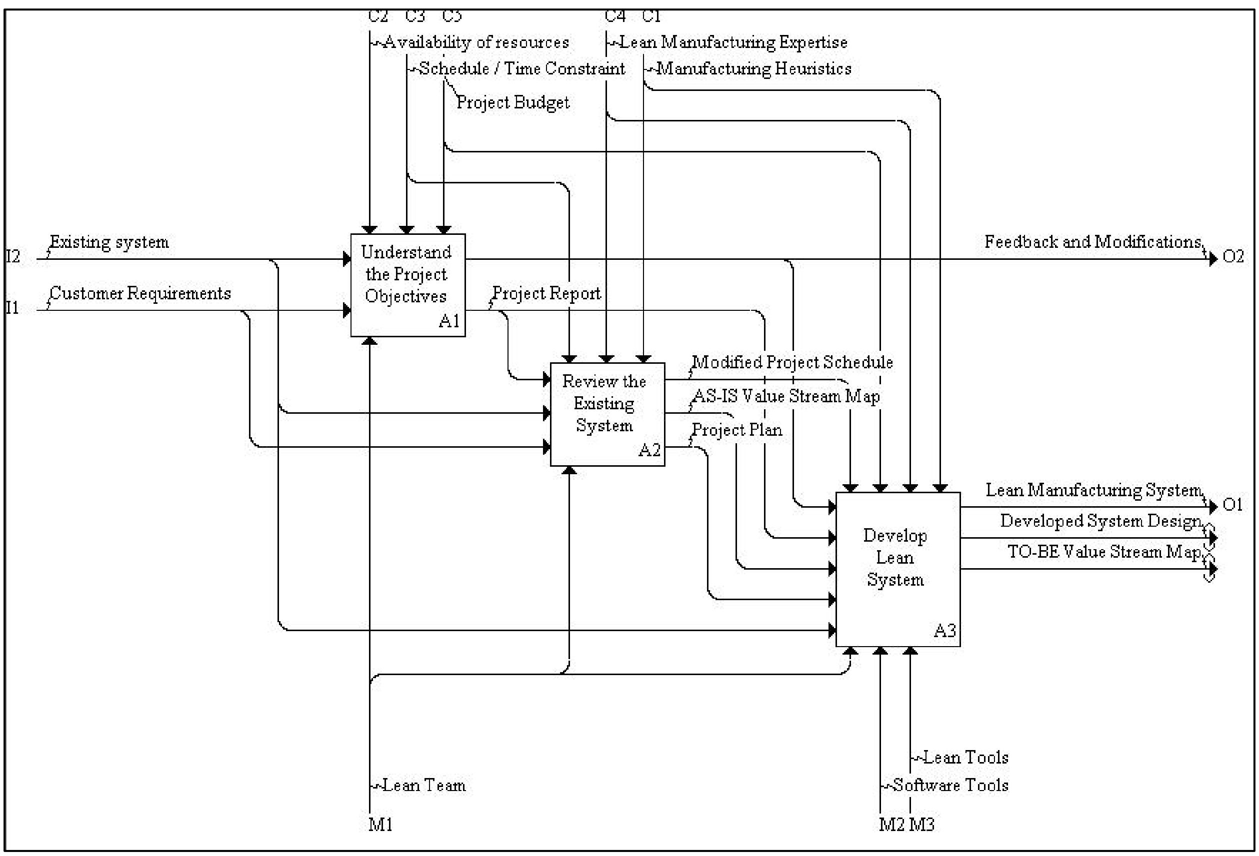

Figure No. 3: Decomposition of the target activity shown in Figure 2

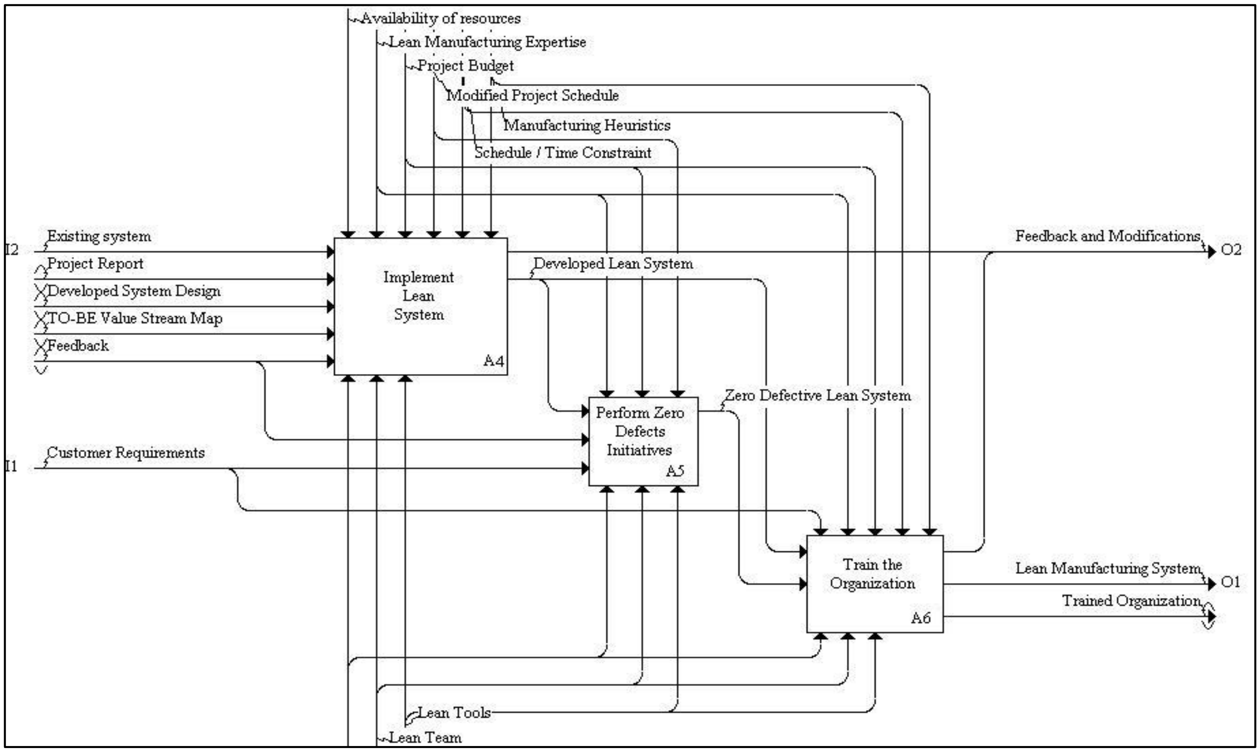

Figure No. 4: Decomposition of the target activity shown in Figure 2 (continued)

3. DISCRETE EVENT SIMULATION MODEL

Discrete Event Simulation (DES) is a simulation tool widely used for many real world problems in manufacturing domain, which enables to study, experiment, and analyzes the interactions of any system and its subsystems. In this research, DES is used as a tool to understand the concepts of lean manufacturing tools. The developed IDEFØ models enables the students to understand all the complex activities involved in developing a lean system and the DES model will help them to acquire an broader perspective of the how exactly the lean tools (Kanban system) implemented in an enterprise.

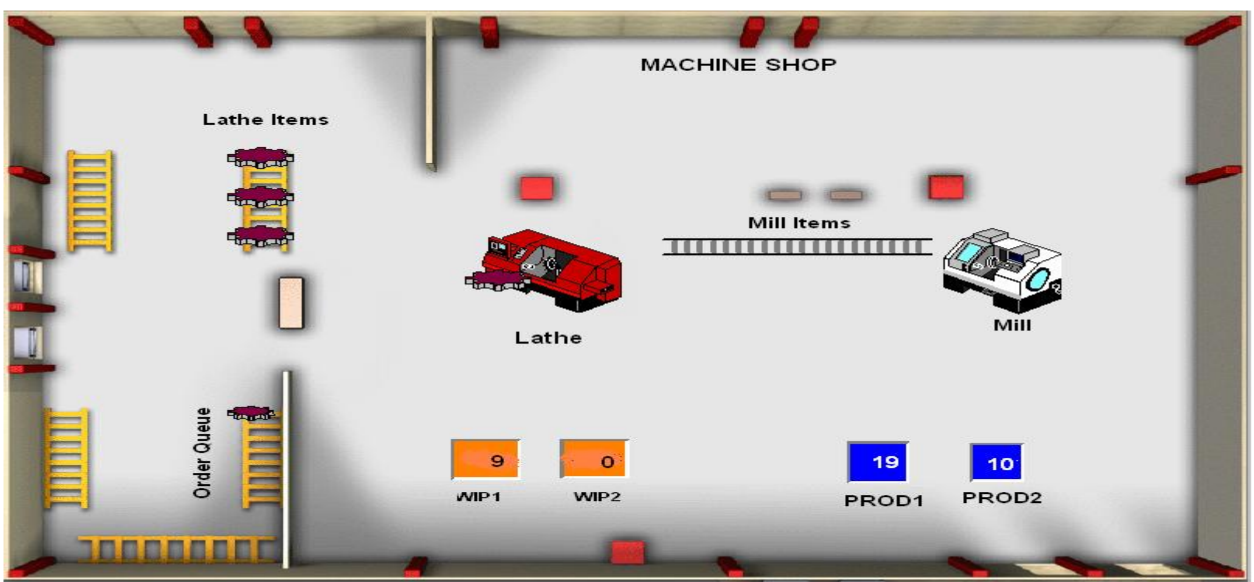

Figure No.5: DES Model of a kanban system for machine shop

In this paper, the scope of discussion is limited to Kanban system; and a DES model is build to illustrate the functioning of the system and to provide a hand-on approach for the students studying those systems. The figure 5 provides a DES model of Kanban system developed using PROMODEL 6.0.2.In general, Kanban refers to “visual record” or a signboard of a shop or store. It is one of the methods of control utilized within the Toyota production system (TPS), which contains the information that provides the work order {10}. Using the object classification in PROMODEL such as Entities, Locations, Resources, Paths the above kanban system was build. After running this model, the basic statistics provides the number of entries for each entity type at each location and how each entity type spent its time at each location.

4. CONCLUSION

This paper discussed the role of Functional Modeling and Discrete Event Simulation approach to enhance the understanding of lean manufacturing as well as the use and assessment of technology in engineering education. Using the IDEFØ models, the possibility of mapping and analyzing the complex interactions in developing a lean system is explored. It can also represent the functional activities and provides an information map for modeling 'AS IS' and 'TO BE' activities. The DES model illustrates the functioning and overview of the kanban system for the students who are familiar with the basics of simulation. Concurrent usage of both modeling and simulation in the classrooms may help the students to understanding the concepts and enables them to practice the latest technologies in education.

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