Helping Connecticut Aerospace Parts Manufacturers Become Lean

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Abstract

With funding support from the Connecticut Center for Advanced Technology (CCAT) / National Aerospace Leadership Initiatives (NALI), a *Center for Simulation Modeling and Analysis* has been established at the University of New Haven. The objectives of the Center are (1) to bring modeling and simulation techniques and tools, through faculty and student teams, to the Connecticut aerospace parts manufacturers to support their efforts in implementing Lean / Six Sigma initiatives, (2) to provide the students with industrial projects for which they have the opportunity to work on the various stages of real world projects from problem definition to final reporting and presentation, and (3) to further promote amongst the students the concepts and techniques of modeling and simulation and their applications to manufacturing. The center is equipped with the state-of-the-art computing hardware and simulation software including ARENA and QUEST as well as other modeling and computational analysis software. It is staffed by a part-time director, a fulltime graduate student, technical and secretarial support. The program was inaugurated with graduate and undergraduate student teams working on two projects provided by Consolidated Industries Inc. (a metal forging company) and Valley Tool and Manufacturing (a machining and manufacturing services company). In this presentation, we will explain in details the program, the relationship created between Connecticut aerospace parts manufacturers, CCAT/NALI and the University of New Haven, the progress made to date and the road ahead.

Introduction

For many small companies and their managers, lean is a concept that makes a great discussion topic at conferences and in meetings – it looks nice on paper and makes sense only theoretically. For them, unless the concept is put to practice in their work environment with tangible results that can be measured and are observable, the initiative to implement lean could slowly dissolve in the sea of everyday chores only to deepen the manager's skepticism. To counter the trend, the University of New Haven (UNH) and the Connecticut Center for Advanced Technology (CCAT) embarked on a program where faculty/students teams provide technical assistance on modeling and simulation to aerospace parts manufacturers in their quest to become lean.

To this end, a *Center for Simulation Modeling and Analysis* is established at UNH with partial funding support provided by (CCAT). The Center is fully student-centric: the students will be learning the concepts and techniques of modeling and simulation using the state-of-the-art software tool in the classroom / laboratory followed by a practicum where they will work on actual cases provided by area manufactures. At steady state, the Center is envisioned to produce graduates who are well-versed with modeling and simulation and who are capable of serving as resources to Connecticut aerospace manufacturers and others in their efforts to implement the Lean / Six Sigma concepts and techniques in order to improve quality, eliminate waste, reduce lead-time and generally minimize cost.

Physically, the Center is housed in a newly renovated 900 square foot laboratory space equipped with high-end PCs and seating capacity for 24 students. The instructor's station is fully equipped with computing and multimedia gears including a document camera. The students have access to a variety of software tools in this lab including ARENA and QUEST 3-dimenssional discrete event simulation software for factory modeling.

Initially, two aerospace parts manufacturers, Consolidated Industries Inc. (a metal forging company in Cheshire, CT) and Valley Tool and Manufacturing (a machining and manufacturing services company in Orange, CT), and three months later, a healthcare-medical devices company (Covidien previously U.S. Surgical) participated as the first set of real world test-cases in this experimental initiative. Each company was assigned a student team who was responsible for the total project life cycle (from definition to reporting and presentation) in which they developed a discrete event simulation model of a process from each organization. The experiment has been a success given the constraints and limitations which are inherent in most if not all real life projects. The projects are expected to be continued at varying levels as new data and refinement of models would bring new understanding and results that are valued by the sponsors.

Discrete Event Simulation Modeling

Discrete event simulation modeling refers to the mimicking of an operation (or a process) on a computer. A simulation model may be used as a decision support tool in various ways:

- To capture and quantify different measures of performance including resource utilization, throughput, queue time, work-in-process, total value-added cost, etc.
- To make comparisons of different production schedules
- To make comparisons of different crew (resource) schedules
- To identify bottlenecks in a process or a system
- To understand the interaction between components in a system
- To determine capacity and limits in a system
- To understand system behavior with changing input and/or resources

The interested readers are referred to Banks et al (2005) for a comprehensive coverage of discrete event simulation. While only the very large companies especially those with significant research and development budgets have traditionally benefited from the use of simulation modeling, the advances in computing hardware and software have made discrete event simulation modeling a more practical and affordable decision support tool which could be used by practically all firms regardless of size, budget and product mix. More recently, as a decision support tool, simulation modeling has also become an effective and easy-to-use tool in implementing Lean / Six sigma programs.

Lean / Six Sigma Concepts

The concepts of Lean / Six Sigma trace their origins in Industrial Engineering where understanding the basics of production systems for planning, scheduling, and controlling production amounts and timing are fundamental to the discipline. In its simplest meaning, Lean refers to efforts to eliminate waste in a system or a process, maintaining continuous improvement, and bringing greater efficiencies to the production operation. The paperback book by Womack et al (1991) introduces the concept in a very interesting way and coins the term "lean". Lean practices were first initiated in the manufacturing sector in the context of Just-in-Time (JIT) production system and later found their way into the business / administrative processes. Also known as the "Toyota production system", the Lean concept is centered on a plant-wide strategy, which is based on the highest quality achievable, continuous improvement, just-in-time production, waste elimination, set-up time reduction, value and utilization of human resources, proper production layout (cells), and integrated logistics. Askin et al (2002) provide a comprehensive coverage of the traditional and modern models, philosophies, and tools including lean in relation to production systems. Of the various tools, simulation is a very effective and powerful tool and in some instances perhaps the only practical tool for experimentation with various scenarios in process improvement / lean initiatives.

Lean / Six Sigma and Simulation Modeling

One of the advantages of simulation modeling (compared to the analytical methods) is its providing the means to experiment with processes/systems that do not exist or if they do exist, they should not be disturbed due to safety or financial concerns. Many Lean / Six Sigma implementation projects include situations where resources (humans as well as machinery) would be rearranged, U-shaped cells would replace long batch process production arrangements, production schedules with varying resources would replace fixed resource schedule, and many others.

In a traditional approach, the Lean project manager usually rely on intuition or on data based on static calculation, and hope that the new layout, the production schedule or resource configuration would work based on the analyst thinking, or at best, as the theoretical models may have predicted.

With simulation modeling, the project manager can actually observe the intended process with the new layout, the production schedule, or resource configuration before making the often expensive physical changes. Additionally, the project manager can experiment with the simulation model in order to verify the limits (extreme values) and see how changing the process parameters might translate to changes in throughput, resource utilization and other relevant performance measures.

History of Simulation Modeling at UNH

Discrete even simulation modeling originated in the early 1960s, but it has come to a much greater prominence since the early 1990s as faster desktop computers and more capable, easy to use Widows-based software made simulation an affordable and viable decision support tool. At the University of New Haven, simulation modeling has been offered as courses in both the undergraduate and graduate programs for more than 25 years. Beyond the first course, teams of students with a faculty advisor have undertaken numerous simulation projects at a number of Connecticut manufacturers including the Bilco Company (West Haven), Kendro Laboratory (Newtown), Remington Products (Bridgeport) and Unilever (previously known as Cheseborough-Ponds in Clinton). Simulation is also a required course in the Executive Master of Science in Engineering Management (EMSEM) program. A number of EMSEM students chose simulation related topics as their final projects while many included it as a decision support tool embedded in their quantitative analysis section of their projects. An EMSEM student (who oversees Lean project implementations for his Fortune-500 employer) in the New Haven cohort ended in November 2005, commented: "Doing the modeling really opened my eyes to some of the advantages and possible disadvantages of the manufacturing cell concept and showed me the power of modeling". Some of the project work with area manufacturers have been presented at regional and national conferences and are published in their proceedings - see Montazer et al (1999, 00, 01, 03, and 05) for project details. The three projects completed as part of the CCAT/NALI grant are briefly presented below.

The Consolidated Project

The consolidated project started out in fall 2006 with a team of seven students who scoped the scenario to be modeled, defined the problem and developed the first working simulation model in ARENA. The model was later implemented in QUEST to take advantage of its 3-D capability. The work continued with three students from the initial team who continued the work by doing model verification, validation, testing, run and output analysis. The work (model and its results) was presented to Consolidated Industries management who were extremely pleased with the project. The model output corroborated actual shop data much to the surprise but delight of the management. The project was presented in a Poster Session at the 2007 New England ASEE Conference at the University of Rhode Island. The project abstract as presented there appears below.

Process Simulation of Consolidated Industries Hammer Shop

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Advisor: M. Ali Montazer, Ph.D.

A process simulation model of the Hammer Shop at Consolidated Industries in Cheshire, CT is developed. The company forges components for the aerospace industry using steam hammers ranging from 1,500 to 12,000 pounds. Process simulation is a computer modeling technique that is used to mimic the flow of material and logic within a business entity. Various aspects of business operation are represented as computer objects that include equipment to turn the raw material into finished products, and product transfer. As a part of its commitment to continuous improvement and lean manufacturing, Consolidated Industries is interested in developing a simulation model to predict the effect of changes to improve key performance metrics, justify equipment purchases and generally performing "what-if analysis". During model development, the team visited Consolidated Industries to collect data and to build a model using ARENA and QUEST simulation software. The model is verified to closely mimic the operation of the hammer shop, is validated against production data, and can be used to make performance predictions about the hammer shop. We will discuss the approach taken to build the model, the effort to verify and validate the model, and data generated by the model for use by Consolidated.

The Valley Project

The Valley project also started out in fall 2006 with a team of four students who scoped the scenario to be modeled, defined the problem and developed the first rough working simulation model using ARENA. The work continued with two students, one new and one from the initial team who continued the work by doing model verification, validation, testing, run and output analysis. The work (model and results) was presented to Valley's manager of quality who had been closely working with us during the model development phase. He was also very pleased with the project and had much greater appreciation for the work and model results due to his closer interaction with the team. The model developed in this case was of a million-dollar five-spindle milling machine which the company was contemplating on buying for a job from a new customer. The simulation model and its results revealed facts and data that were immensely important to job scheduling and expectation of overall throughput from the milling machine. The project was also presented in a Poster Session at the annual 2007 New England ASEE Conference held at the University of Rhode Island. The project abstract as presented at that conference follows.

Modeling and Simulation of Aircraft Nose Gear Holdback Bar Production Line at Valley Tool & Manufacturing
David Gruszkowski and Enoch Ampadu
Advisor: M. Ali Montazer, Ph.D.

Our team conducted a modeling and simulation study of the fabrication process of Holdback Bars used on US Navy Aircraft Carriers. Holdback Bars are located on the nose gear of the aircraft and release the plane when it is ready for launch from the ship. Valley Tool and Manufacturing, (VTM) of Orange Connecticut is evaluating manpower, lead-time, and operational needs to produce various quantities of the bars. The model is a discrete event simulation of the fabrication process of machining and inspection operations. Using ARENA simulation software, the model successfully depicts the time and flow for all the Holdback Bar fabrication processes. By evaluating several alternative production scenarios, a Lean fabrication process using the optimum number of operators and the minimum production time was determined. The alternative scenarios include, adding operators, moving idle operators and various batch sizing implementations. The model was verified and validated to produce results that mimic those of a real production line. A predictive mathematical model has been developed based on the simulation results. The predictive model can be used by the production manager to compute the production time for a given number of bars. The simulation, model output and other findings will be explicitly exhibited.

The U.S. Surgical Project

The U.S. Surgical (now Covidien) project commenced in January 2007 with a team of two students one of who was the Production manager of the process under study at the organization. Our work started by a tour of the facility which included members of the Advanced System Simulation class (other two teams). The whole class was involved with the initial steps of model development while the core team was responsible for keeping track of ideas generated, data collection and implementation of the approaches agreed upon by the class. Upon scoping and problem definition, the team developed the first working simulation model using ARENA software. The work continued and the team made regular presentation of their progress to the class while they were engaged with model verification, validation, testing, run and output analysis. This team had an advantage due to one member of the team being the production manager of the production line being modeled, and thereby, authenticity of model results was readily and regularly checked and its fidelity continuously improved. The simulation model corroborated the suspected operation in the production line which was the bottleneck much to the delight of the production manager and his crew. The results revealed facts and data that were immensely important to the company. We were informed that abou10% improvement in throughput maybe achieved as a result of removing the bottleneck in that production line. The project was presented in a Poster Session at the annual 2007 New England ASEE Conference held at the University of Rhode Island. The project abstract as presented at that conference is presented below.

Simulation study of the Royal 35W skin stapler
Neela Ramana Rao Tamada and Hasan Tonguc Kirtan
Advisor: M. Ali Monatzer, Ph.D.

The work we are presenting is about the simulation study of the Royal 35W skin stapler production line at the United States Surgical Company in North Haven, Connecticut. The Royal 35W skin stapler, with annual production of three million units, is a device used by medical professionals to close wounds and cuts. The production line consists of automated stations followed by manual assembly. In its effort to advance lean initiatives, the company provided an opportunity to develop a simulation model to study the throughput, scrap rate and machine downtimes. Upon observation of the automated production line and with data provided by the company and expertise rendered by a team member employed at the company, our team developed a discrete event simulation model of automated portion of the production line using the ARENA and QUEST simulation software. The model closely mimics the production line in terms of both physical flow and output, as verified and validated by the operations manager. The model can be used for “what if analysis”, bottleneck identification and generally for process improvement and monitoring purposes. We will present details of the production line, data collection, modeling approach, model verification & validation, and results during the poster session.

Summary and Conclusion

A Center for Modeling and Simulation has been established. Three student teams worked on modeling and simulation projects provided by two aerospace parts manufacturers and a healthcare-medical devices company in southern Connecticut. Each project produced results that were of great value to the sponsoring organization. The concept of Lean was put to practice on a real production process in an observable and measurable fashion. Students were given the opportunity to work on real-life projects from problem definition to final presentation to the management and at a conference. The faculty was able to appreciate even more the whole concept of open-ended problem solving approach as well the value of applying knowledge, tools and techniques in real-life settings.

The support provided by CCAT / NALI has been a great catalyst to establish and enhance university – industry collaboration. Everyone benefited from the collaborative work presented in this paper. The industry sponsors of the projects especially benefited from this relationship by getting the results of the work compiled by the student teams with faculty supervision at no cost to them. In mega organizations such projects are typically done by in-house engineers/analyst on their payroll costing the company a considerable amount. In the case of smaller companies such projects do not get done or in certain cases they are done by consultants at significant cost to the company. We are proud at the University of New Haven to have been of service to the local industry free of charge. We appreciate their trust in us by letting our faculty guided student teams work on projects for them and look forward to continue the practice with other manufacturing organizations.

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CCAT - The Connecticut Center for Advanced Technology, Inc. provides services and resources to entrepreneurs and businesses, and through collaboration with industry, academia, and government, helps companies innovate and compete, thereby strengthening our nation in the global market.

NALI - The National Aerospace Leadership Initiative, created to respond to the critical needs of the U.S. aerospace manufacturing supply chain, is a partnership between U.S. industry, academia and government teams, led by consortium companies from Connecticut, Ohio and Pennsylvania - regions whose industrial capabilities are central to the aerospace industry.

M. Ali Montazer is professor of Industrial Engineering and currently Associated Dean of Engineering at the University of New Haven. He has been with UNH since 1984 as a faculty member and has served as program coordinator as well as department chair and Industry Liaison for the college of engineering. He has worked with undergraduate and graduate students on a variety of projects including projects related to lean and process improvement initiatives sponsored by the engineering and manufacturing companies in Connecticut. Dr. Montazer is a certified Experiential Education Faculty at UNH.