USING VA TO IMPLEMENT LEAN ENGINEERING

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BIOGRAPHY

James (Jim) A. Rains, Jr., CVS, is President of the Advanced Value Group, LLC and Sales Representative of Alphabrain Corporation, a Japan based company located in Tokyo. He holds a BSIE degree from Kettering University (formally General Motors Institute) and a Masters degree in Industrial Management from Central Michigan University.

His experience includes over 30 years with General Motors, having worked in Manufacturing, Manufacturing Engineering, Value Analysis, Industrial and Product Engineering. He performed these assignments in Rochester, NY, Dayton, OH and in Warren, MI.

From 1994 to 1999, Mr. Rains was responsible to improve the effectiveness and utilization of indirect labor for all of General Motors. In this assignment he was considered a corporate expert in improving worker methods and best practices relative to material handling. Over $50,000,000 per year has been saved from this effort. In August of 1999, Mr. Rains was reassigned to the Supplier Cost Engineering Group. The main function of this organization is to support the Advanced Purchasing organization to insure that GM is buying future components at a competitive price. Jim's final position while at GM was to analyze and make improvements to the engineering design process. The engineering process is one of the few remaining areas of the business that have not previously gone through the concepts of lean. Over the years Mr. Rains has facilitated about 600 teams in value analysis and synchronous improvement activities.

Mr. Rains is active in SAVE International and serves on its Board of Directors and Executive Committee, as its Immediate Past President. He is a Certified Value Specialist. He is a member of the Board of Directors, Executive Committee and the Treasurer for the Lawrence D. Miles Value Foundation. He was the Chairperson of the General Motors Corporate Value Management Committee. In addition, Mr. Rains is on the faculty at Central Michigan University and teaches a value methodology undergraduate course.

ABSTRACT

The value methodology was originated to improve the design of products or at least to determine if there were alternative and better ways for a product to perform its desired functions. Only recently (within the last 10 years), in the western world, it has been discovered that the actual design process itself must undergo the watchful eye of lean and synchronous concepts. Lean engineering is defined as the production of quality engineering deliverables with a minimum consumption of time and resources in a stable, capable process. The author has developed a new workshop format that takes advantage of the

elimination of waste concepts and has integrated them into the value analysis job plan. Workshops have been conducted using vehicle design personnel to develop proposals that eliminate waste, shorten lead time, improve productivity, and reduce manpower and cost. The design office or what is now commonly called the "engineering factory" needs to be every bit as lean and efficient as the factory that produces what these designers create. This paper will discuss how this workshop is performed, and will provide specific examples of FAST diagrams that resulted from this effort.

Introduction

"The general public has a simple and vivid mental image of automobile production - the assembly plant where all the parts come together to create the finished car or truck. While this final manufacturing step is important, it represents only about 15 percent of the human effort involved in making a car. To properly understand lean production, we must look at every step in the process, beginning with product design and engineering, then going far beyond the factory to the customer who relies on the automobile for daily living." [1.]

I believe that for a company to be truly lean, it must employ lean engineering concepts. It can be proven (and probably has, but I do not have the facts available) that the best path to a total lean enterprise, is to have a lean engineering organization. To achieve a lean enterprise the product design must lend itself to lean; what I mean is a lean design will enable a lean purchasing department, a lean finance department, a lean marketing department, a lean service organization and especially a lean manufacturing environment. A lean design will result in a quality product that meets or exceeds customer expectations and will perform the functions that the customer is willing to pay for. What I am trying to say is that "value" begins in the engineering organization. We do know that in the auto industry, approximately 80 percent of a vehicle's final cost is determined at the time of concept approval (in program timing this is 15 to 24 months prior to start of production). Little can be done to improve the cost of the final product past this point of development mainly because of the cost of change and to the delay in the program's timing. In an effort to better understand lean engineering, this paper will go into some background in lean manufacturing, for which there is more common knowledge.

Lean Manufacturing

Lean manufacturing concepts started to become popular in the western world in the mid-1980's. Competitive pressures intensified and the global economy erupted on the scene. It became increasingly clear that for companies to survive in this global marketplace that new concepts of operating a business needed to be implemented. Thus the spread of lean and synchronous manufacturing processes became the way to achieve the competitive cost structure required to survive into the 21st century. Widespread practice of lean implementation was and is predominate in the automobile industry. All the western world manufacturers began to implement their own versions of the Toyota Production System (TPS).

The TPS uses the elimination of waste as its core concept. In addition to the elimination of waste other key concepts are to satisfy the needs of the customer; provide support for the operator; reduce and eliminate process variation; ensure quality at the source; and focus on continuous improvement.

Synchronous

One definition of a synchronous organization is a systematic approach to identify and eliminate waste and non-value-added activities through continuous improvement in all products and services. Objectives of a synchronous organization are to:

- optimize all resources to produce world class products and services at the right time in the right quantities based on customer demand;
- establish an efficient and effective business system based on continuous improvement of our competitive position and finally;
- eliminate or manage constraints to improve throughput, reduce inventory and operating costs.

While working at a division of General Motors in 1992, I was responsible to implement and perpetuate the first use of what we called lean implementation workshops. They were called this because process focused workshops were conducted over a five day period with implementation happening during the five days. Lean implementation workshops took all of the known lean and synchronous manufacturing techniques and concepts learned through extensive benchmarking and applying them in our workshop. Large teams of machine operators, set-up operators, skilled trades workers, process engineers, product engineers, and quality analysts were all required to be a part of the workshop and were in fact necessary to insure its success. It was common to have as many a 30 skilled trades workers working around the clock during the workshop to disconnect equipment and reassemble it in a new improved leaner layout. We often disconnected equipment without being exactly sure where it would be re-installed. Quality analysts worked around the clock after the equipment was re-installed to verify process capability. For the first 18 workshops held at Delco, the following averaged results were achieved:

- floor space reduction of 30%,
- inventory reduction 34%,
- lead time reduction 29% and,
- productivity improvement 41%.

Please remember that these results were achieved during a five day workshop and were performed on rather large production facilities.

The Seven Types of Waste

The elimination of waste was mentioned earlier as the core to becoming a lean and efficient organization. The seven types of waste are:

<u>Waste of Over Production</u> - is producing more than is needed, faster than it is needed.

<u>Waste of Correction</u> - is the inspection or repair of a product or service required to fulfill customer requirements.

<u>Waste of Movement (material or information)</u> - is the movement of any material or information that does not add value to the process.

<u>Waste of Processing</u> - is human or machine effort which adds no value (only cost) to the product or service.

Waste of Inventory - any supply in excess of process requirements (customer's just in time demand)
Waste of Waiting - idle time that is produced when people wait on machines or machines wait on people or when people wait on people.
Waste of Motion - is any movement of people or machines which does not contribute added value to the product or service.

Based on my experience, when functional analysis is teamed up with the identification of waste to analyze processes, the results achieved can be and are astounding. Team members often surprise themselves with the results that they can achieve by applying these techniques.

Information gathered from the Arthur Andersen, November, 2000 *Automotive Best Practices Report*, it states that, "The top three causes of waste in Global Program Management (GPM) process are unclear definition of requirements, engineering changes late in the process, and poor communication of goals and progress. A 15-20% improvement in cost, lead-time and product quality can be expected through the elimination of this waste. Essentially most waste results from poor up-front planning and inefficient engineering drawing development." The report goes on to say that, "GPM systems are poor at identifying timing problems early and garnering sufficient information which may explain why 50% of the respondents frequently miss engineering drawing release, 33% miss Production Part Approval Process, and 30% miss prototype build. Only 3% miss start of production, which suggests that significant catch-up is played during the program making for inefficient use of resources." It is important to note that the respondents to this survey are the leading Tier 1 suppliers to the automobile original equipment manufacturers (OEM's). Thus it seems logical that the entire value chain is in deep trouble and plagued with an abundance of waste. (Reference Appendix A for a chart from this survey, which conveys detailed information on opportunities to reduce waste.)

Lean Engineering

Now we are going to move into the heart of the subject of my paper. The prior background was necessary to set the stage of history and terminology. In the automobile industry, as in most industries today, fast to market is essential to win against the competition. The product development cycle thus is becoming the critical, key link to an organization's success. The faster a company can develop and implement a new design the better chance it has of becoming first to market with a key new technology, appearance or clever product scheme. Moving design concepts from the "drawing board" (drawing boards are a thing of the past, with all new designs on the computer using 3-D software and math models), to the production floor and into the showroom is now where companies must excel. Quality designs have been a given for many years. Cost competitive designs have been given high consideration for many years as well, to ensure company profitability. But now so is rapid product development time. In addition to completing designs in record time, the cost to produce those designs is also extremely critical. Engineering resources are a premium expenditure. Thus it behooves an organization to make the design community as effective and efficient as possible. This is what we are calling the "lean engineering factory."

"Whenever it occurs - at central engineering headquarters or in the supplier organizations - the process of engineering a manufacturing object as complex as today's motor vehicle, demands enormous effort from large numbers of people with a broad range of skills. Therefore, it's easy to make mistakes in organizing the process."[2.] The engineering factory is complex. When I started working in the engineering factory, for me, it was like walking into a different world, and this was after over 30 years of automotive experience and after being around automotive engineers and designers that entire time. Perhaps though that the more complex a process, the less understood that process is, and the less amount of means to measure that process, then that process most likely contains a very high amount of waste. This becomes truer for large organizations like the several automobile manufacturers around the globe. The issue becomes even more profound as the auto industry continues its merger activity and will require all of its engineering resources wherever they are located to perform the same tasks in a common and efficient manner.

Since March of 2000, I have been working with the engineering design community to study its processes and systems just as we would in the production factory floor. We have a need to reduce the complexity of our processes. We have a need to commonize our processes over several engineering sites. We have a need to reduce the time it takes to deliver designs. We have a need to reduce the cost to produce designs, thus improving our productivity and throughput. The application of the seven types of waste as they apply to production needed to be revised, so that examples of waste would relate to the design community. Once these were completed, the step of waste elimination was added to the information phase of my value analysis (VA) job plan.

A comparison of mass vs lean engineering organization is summarized in a chart in Appendix B.

How It All Fits Into The VM Job Plan

The basic VM job plan stays intact. In fact, I only add a lecture and team exercise to record waste identification. One of the first lectures during the first day of my VM workshop, reviews the concepts of lean and synchronous. The seven types of waste are explained in detail to ensure participant understanding. A key pre-workshop task is to have a detailed process sequence flow chart (Appendix C). Having a sequence flow chart that is properly understood by all team members so that they are very familiar with the current process under examination is very important; actually it is essential. After the lecture the workshop participants are required to fill out on chart paper, one sheet for each type of waste, all the waste that they can identify. Usually this takes about 45 minutes to get numerous waste items identified. Team members often discuss what they have learned about waste and immediately begin to develop ideas about how to make improvements to the process being studied.

The next step is to revert back to the normal VM job plan and go through the steps of function identification, and the creation of a FAST diagram. I do not normally prepare a cost or time/function worksheet in these workshops, because I have found that I do not get enhanced results when I do. Normally a good process is only about 4% value added to start with, so the opportunities for improvement are huge.

The team then goes through the normal brainstorming by function. I always strive to develop at least 100 ideas per function brainstormed. Once the teams have exhausted their ideas, we go through the list of waste charts, which the team developed in the information phase. By going through each and every waste that was identified, the team will always brainstorm more ideas, and these are added to the appropriate brainstorming list. Then the normal VM job plan is adhered to through the implementation of the proposals developed.

Functional Analysis

To facilitate the functional analysis phase of the job plan, the value practitioner should follow the same steps that they would use in a product study or even more similar to a manufacturing process study. Again having the process detailed in a sequence flow chart is essential. The next essential step is to ensure that all the team members are familiar with the entire process. This is easier in a manufacturing process, because all team members have to do is visit the production site and walk through the steps. In a business process like designing a vehicle, one cannot actually go and walk through the process. So the expert in each area of the process must share their knowledge with the other team members to insure understanding. An easy way to accomplish this is to go through each step of the process and record the functions that are performed in that step. Or in other words, why is that step performed. Facilitator care is provided to ensure verb-noun usage and generic functions are listed. At the end of this exercise a brainstormed list of functions is normally complete and is ready to be in a Functional Analysis System Technique (FAST) Diagram. Two examples of FAST diagrams are shown in Appendix D.

Conclusion

It is my opinion that lean engineering is much more difficult to implement than lean manufacturing. Manufacturing tasks are less complex, take less time to perform (seconds vs weeks), are highly repetitive, easier to measure and have been under study by industrial engineers for over 8 decades. Engineering work is highly skilled, with technological advances happening at enormous speed. With the elimination of drawing boards and the implementation of designs totally on computer productivity enhancements are definitely happening. However, measuring the effectiveness of these changes is rather difficult. Automobile factory workers are measured to the 100^{th} of a minute using standard time data that is fairly universally accepted, but engineering work does not have any standard time data and only has estimates given by the people who do the work. Also, the engineering processes, are complex especially in the automobile industry. Thus the ability to define, review, measure and then improve engineering processes is much more difficult.

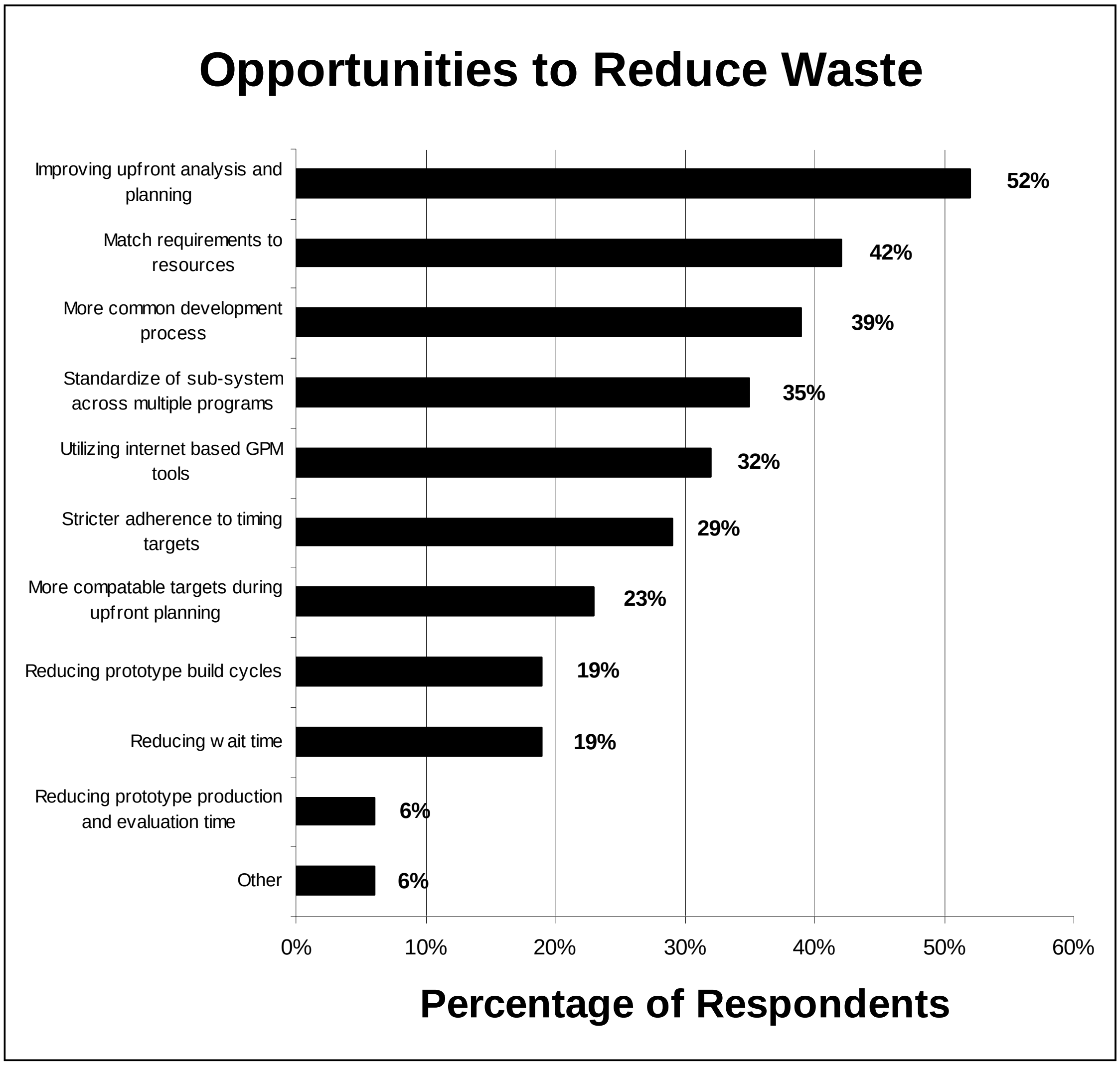
Joseph Day, CEO of Freudenberg-NOK states that auto suppliers need to adopt lean manufacturing in order to survive. He also goes on to say that, "For every supplier adopting lean manufacturing, there are literally thousands of suppliers who still just don't get it." I believe the same can be said for lean engineering. Even if a company can produce products using lean manufacturing processes, at a competitive cost, if does not have the right product developed in time to compete it will not survive.

While this paper focuses on the automobile industry, it is safe to say that the same issues, concepts and solutions can be applied to almost any type of industrial/manufacturing organization.

References

1. James P. Womack, Daniel T. Jones, and Daniel Roos, The Machine That Changed the World, Rawson Associates, Division of Macmillan Publishing Company, 1990, p. 73
2. Ibid; p.63

Appendix A



Source of graph - Arthur Andersen Automotive Best Practices Forum; Global Program Management, November, 2000

Appendix B

Product Development Performance by Regional Auto Industries, Mid - 1980's

Metric	Japanese Producers	American Producers	European Producers
Average Engineering Hours per New Car (millions)	1.7	3.1	2.9
Average Development Time per New Car (in months)	46.2	60.4	57.3
Number of Employees in Project Team	485	903	904
Number of Body Types per New Car	2.3	1.7	2.7
Average Ratio of Shared Parts	18%	38%	28%
Supplier Share of Engineering	51%	14%	37%
Die Development Time (months)	13.8	25.0	28.0
Prototype Lead Time (months)	6.2	12.4	10.9
Return to Normal Productivity After New Model (months)	4	5	12
Return to Normal Quality After New Model (months)	1.4	11	12

Source: Kim B. Clark, Takahiro Fujimoto, and W. Bruce Chew, "Product Development in the World Auto Industry, " *Brookings Papers on Economic Activity*, No. 3, 1987; and Takahiro Fujimoto "Organizations for Effective Product Development: The Case of the Global Motor Industry," PhD. Thesis, Harvard Business School, 1989, Tables 7.1,7.4, 7.8

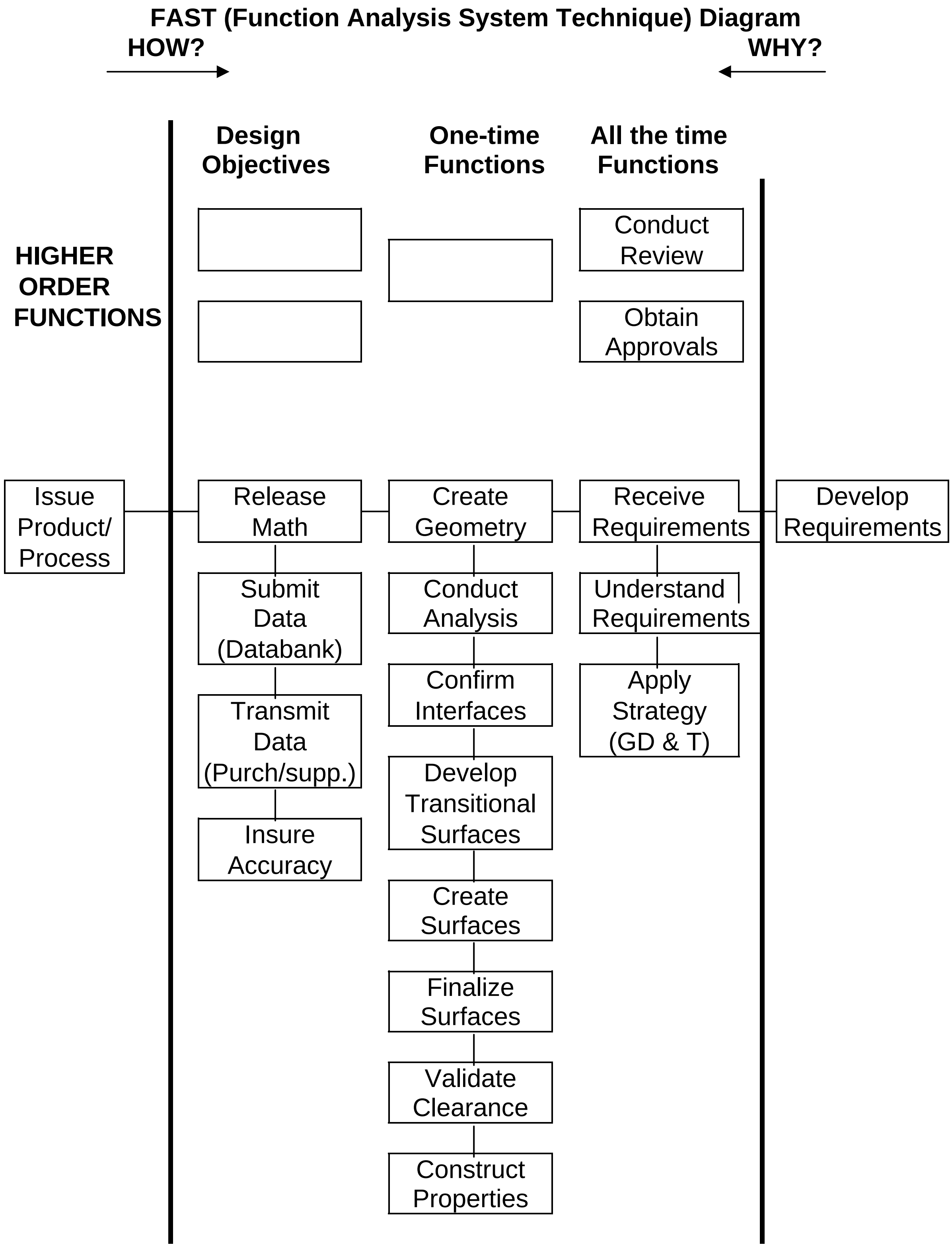
Writer's note: Global competitive pressures have made it mandatory for all regional auto industries to make radical improvements to the above stated statistics, however it is fairly safe to say that the percentage of the gaps remain approximately the same today.

Appendix C

	What? \ Who?	Engineer (GM or Supplier)	Supplier Liaison	Design (Sup-plier)	Spec	Data Mgmt.	EPC&L	Time to Perform Task (Hours)	Elapsed Time (Hours)
6	Supplier liaison reviews worksheet to acknowledge supplier drawing RCD		**R**					0.30	2.00
7	Specs reviews EWO for accuracy.				**R**			0.50	4.00
8	Specs loads EWO into Product Description System (PDS). Note PDS assigns a number. Also if necessary new part numbers are assigned.	**C**	**C**		**R**			1.00	2.00
9	Supplier liaison receives EWO via PDS		**R**					0.30	8.00
10	Engineer sends EWO to design (supplier)	**R**		**C**				2.00	24.00
11	Supplier liaison identifies the design leader at the supplier to contact for information and follow-up. At the initial contact the supplier liaison sends a copy of the EWO to the design leader and insures that the designer understands the work required and confirms the design RCD.		**R**	**C**				0.50	12.00
12	Design (supplier) implements EWO (completes math and drawing changes)	**C**	**C**	**R**	**C**	**C**		24.00	336.00
13	(Reference Step #11) If supplier liaison determines that there is a misunderstanding with the work that needs to be done and/or the assigned completion date, the supplier liaison contacts the engineer.	**C**	**R**					0.20	2.00
14	If required the supplier liaison marks up the revised ECD on design EWO work load report.		**R**					0.20	3.00
15	Supplier liaison gives new date to EPC&L to update date in system (EWO work load report) (Only required if new date is beyond Work Load Report ECD.)		**R**				**C**	0.50	4.00
16	EPC&L enters new date into system						**R**	0.20	2.00
17	The supplier liaison must contact the supplier 7 days prior to the committed date to confirm on time delivery. If supplier notifies supplier liaison that the drawing/math will be late the supplier liaison must determine when the drawing will be complete, why it is late, and make sure that the engineer is aware of the late delivery.	**C**	**R**	**C**				0.20	0.20

C = Customer
R = Responsible

Appendix D


FAST (Function Analysis System Technique) Diagram
HOW?
WHY?
Design Objectives
One-time Functions
All the time Functions
HIGHER ORDER FUNCTIONS
Conduct Review
Obtain Approvals
Issue Product/ Process
Release Math
Create Geometry
Receive Requirements
Develop Requirements
Submit Data (Databank)
Conduct Analysis
Understand Requirements
Transmit Data (Purch/supp.)
Confirm Interfaces
Apply Strategy (GD & T)
Insure Accuracy
Develop Transitional Surfaces
Create Surfaces
Finalize Surfaces
Validate Clearance
Construct Properties

PRODUCTION SPECIFICATION RELEASING PROCESS

May, 2000

FAST (Function Analysis System Technique) Diagram