

**Fast and Flexible Communication of Engineering
Information
in the Aerospace Industry**

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Fifth Quarterly Report for MIT

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Force Base

Wright Laboratories

Manufacturing and Technology Directorate
Information Technology Division

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Objectives and Goals

The objective of this project is to improve the design and production of complex mechanical assemblies that are produced in agile partnerships, with a focus on improving first time capability. Complex assemblies illustrate most of the problems of partnership manufacturing since they include many components with tight relationships to each other. Company partnerships between customers and suppliers are very common and will continue to be the dominant mode of manufacturing for the foreseeable future. New tools and methods will therefore be needed to carry out both the design and manufacture of these items and the management of design and manufacturing processes ongoing simultaneously at many companies.

The project is being carried out in close collaboration with a sister project that is focusing on the automobile industry. These industries share the characteristics listed above. Many opportunities exist for each industry to learn from the other in spite of differences in production rate and manufacturing processes.

Background

The project's approach consists of the following six steps:

1. Map selected elements of the product development process using Transactions Analysis
2. Benchmark these elements individually and as a system within and across the target industries, identifying useful metrics

3. Formulate "best practice" hypotheses based on transactions mapping and benchmarking, capturing best practices in new tools or methods
4. Create pilot projects to test, demonstrate, and customize these best practices by using the tools and testing their usefulness
5. Assess pilot outcomes using the metrics developed, and develop migratable practices within and beyond the target industries
6. Synthesize, document, and publish the findings

In conjunction with a sister project focusing on the automobile industry, we are working with several partner companies in the auto and aircraft industries:

Vought (Division of Northrop-Grumman), Boeing

Ford, Budd Company, General Motors Saginaw Division

Project activities have been selected to provide insight into a broad range of product development phases in order to grasp the whole process and determine how to affect it as a whole.

Tools Being Developed

The tools being developed or adapted for use are Transactions Analysis (a process mapping tool), Web Diagrams (for capturing the business and technical relationships between customers and suppliers), Key Characteristics (a way of identifying and structuring the critical requirements of a product, assembly, subassembly, or part in terms of deliverables to a customer), Contact Chains (for capturing the physical relationships between parts in an assembly), the Design Structure Matrix (for capturing inter-related information flows in a process and to highlight iterations and concentrated transactions), and Activity-Cost Chains (to determine the total costs of sets of related activities in a process).

Activity for the October through December 1995 Quarter:

Completion of Vought Aircraft Pilot on Precision Assembly Phase 1

Students Tim Cunningham, Don Lee, Mary Ann Anderson, and Tariq Shaukat returned from spending part of the summer at Vought, Boeing, and Ford. Krish Mantripragada did his work at MIT. Their summer work was described in the previous Quarterly Report.

Tim and Don generated and flowed down Key Characteristics for the 767 horizontal stabilizer, analyzed as-is assembly processes based on rigid fixtures, prepared alternate precision (fixtureless) assembly processes, analyzed them for their ability to deliver the KCs, and selected two feasible candidates. Mary Ann analyzed as-is task times and labor costs, and estimated new equipment costs and throughputs. She then

determined how many new machines would be needed for several scenarios and estimated investment paybacks. Tariq began a study aimed at how process and quality teams have been set up and operated. The goal is to understand what new job skills and human resources policies will be needed to support an NC-driven precision assembly process. Krish continued to develop the capability of the CAD tool ProEngineer to model assemblies and analyze assembly processes.

A separate report was prepared and sent to Vought giving detailed time, cost, and process findings. Vought has reported their satisfaction with these results.

Tariq Shaukat will continue his these studies at Vought with a one week visit in January. Due to the strike at Boeing, Vought shut down from late December to January 12, preventing his visit earlier in January.

Mary Ann Anderson is taking family leave for 6 months starting January 1, 1996.

Preparation of Papers and Reports

In the Fall we prepared three papers describing this work:

"Agile Customer-Supplier Relations In Design and Manufacture of Complex Mechanical Assemblies," which will be presented at the 5th Agility Forum in Boston in March, 1996,

"Definition, Analysis, and Planning of a Flexible Assembly Process," submitted to the 1996 ASME Conference on Flexible Automation, and

"Enhanced Key Characteristic Identification Methodology With Integrated Customer Need To Cost Analysis."

In response to an action item by Dr McGrath at the September PI's meeting, we prepared a case study report on the 767 horizontal stabilizer in tabular format and submitted in in December, 1995. We also prepared and submitted a version of the Agility Forum paper for publication in the Forum's new journal Agility and Virtual Organization.

Presentations at Technical Meetings and Conferences

The program was briefed to the Defense Manufacturing Conference in November and to the Lean Aircraft Initiative plenary meeting in December by Prof Fine.

Liaison with Lean Aircraft Initiative

Meetings were held with personnel of the Lean Aircraft Initiative to launch supplier relations studies and to help identify sites where we can carry out additional pilot studies. Lockheed Fort Worth was identified as a suitable candidate and Mr Bill Bullock has been contacted. (See next item.)

Activities to Initiate Second /ResearchPilot Site

Contact has been made with Lockheed Fort Worth (Bill Bullock contact) regarding establishing a pilot project with them. JAST and F-22 are potential target programs. A meeting was held in Fort Worth between Mr Bullock, his staff, Prof Fine and Tim Cunningham. A follow-up meeting is scheduled for January 16. Our aim is to place two students on site in Fort Worth for the last 2 weeks of January to learn the organization and focus better on a program.

Leaders for Manufacturing Internship

Mr Richard Seubert, a Leaders for Manufacturing intern, currently doing his internship at Boeing with sponsorship by this program. Mr Seubert is starting to write his thesis, entitled "Use of Key Characteristics as a Means of Improving Standard Operations". His current research efforts continue around tolerance propagation, supplier relations and flowdown of Key Characteristics through the new passenger door for the next generation 737 airplane. Boeing has identified their product keys to be incorporated on the drawings; He is now attempting to duplicate this process using the alternate methodology of identifying both product and assembly KCs. In addition, the Renton door shop is continuing its efforts to formulate its fabrication Standard Operations. He is still working with individuals from this shop to see how product KCs can act as their roadmap to improving their processes, as well as determining any possible linkage between Standard Operations and manufacturing KCs. Boeing's door parts are outsourced to a variety of foreign countries that have little experience with this kind of manufacture. It is hoped that KCs will help explain requirements clearly and improve quality. In connection with this internship, Professors Fine and Thornton and Dr Whitney visited Boeing, toured facilities, discussed KCs and variation reduction. Boeing has arranged a visit to two of their Japanese suppliers, Mitsubishi and Kawasaki, for mid January. Dr Whitney will attend these visits.

Other Activities

Don Lee and Prof Anna Thornton continue to develop methods and tools for KCs. Prof Thornton is focusing on developing tools to apply constraint based methods for the identification and management of KCs. These tools will involve the capture of relationships between KCs in the form of constraints and the ability to propagate design information through the flowdown both up and down the KC hierarchy. She recently

presented these proposed methods to the HVC (hardware variability control) team at Boeing and had a favorable response. She is looking to develop case studies to apply and test these methods. Mr Lee is continuing to develop his methods for defining Product, Assembly, and Manufacturing KCs and is seeking case studies in the Auto and Aircraft Industries to sharpen these definitions.

Renata Pomponi's research currently focuses on an exploratory case study of the three major firms in the commercial aerospace industry: Airbus Industrie consortium, the Boeing Company, and McDonnell Douglas. Anecdotal evidence suggests that Airbus is the more technically aggressive of the three, but no concrete assessment to this end has been performed. Examining decisions to adopt or bypass technology will provide both a formal answer to the question of which company is most technologically aggressive and also address the organizational basis of this stance. In order to provide a common reference point across the firms, the research will focus on the 100-seat, short-haul category of airplane, a product offered by all three manufacturers. The project will begin by defining a set of three or four technologies that will serve as the primary data sample for examination at the three sites. The selected technologies will be examined, through on-site interviews and archival data collection, to form a historical perspective of the decision-making process that led to their adoption or bypass. The focus will be on identifying organizational and technical issues that affected the decision process. The competitive response of the company, in terms of whether they were the first mover on the technology or a follower, will also be assessed. The development of each technology will be characterized as either incremental or revolutionary additions to the firm's product line, as examined through the use of aggregate project planning matrix described by Wheelwright and Clark [1992]. Observations regarding the organizational influence of the firm will be related to the technology assessment with the intent of describing the technology

strategy of the firm as either technologically aggressive or passive. Although this project focuses exclusively on the aerospace industry, it is expected that the results of the research will be extensible to other industries.