Appeared in Flexible Automation and Integrated Manufacturing Conference Proceedings 1998
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THE ENTERPRISE INTEGRATION ISSUES ENCOUNTERED WITH AGILE PROCESS INTRODUCTION

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ABSTRACT: This paper describes research that explored the issues likely to be encountered when an agile process is introduced into a traditional environment. The methodology used considers strategic, cultural, and process integration issues in the implementation of advanced technologies. The methodology is used to define upstream/downstream process integration issues and impact for the replacement of fixed tooling with reconfigurable flexible tooling for the stretch forming of aluminum sheets in aerospace manufacturing. This reconfigurable tooling technology will be key for enabling the successful production of small lots of sheet metal components at low cost and responsive cycle time in an agile environment.

INTRODUCTION

Although agility is often thought of as a strategic issue, there are areas where the benefits of agility can be realized through actionable plans on a more local level. This paper will discuss the impact of introducing an agile process into a system of existing non-agile upstream and downstream processes. The Enterprise Engineering Group at the Automation and Robotics Research Institute (ARRI) of The University of Texas at Arlington is currently working with the Northrop Grumman Commercial Aircraft Division (NGCAD) to explore these issues. The team decided to build upon previous work to utilize the Transform Enterprise Methodology (TEM). This TEM considers strategic, cultural, and process integration issues in the implementation of advanced technologies. Previous work with NGCAD dealt with the strategic and cultural issues on a company-wide basis. This project addressed the process and technology issues in a single functional area. Specifically the upstream/downstream process integration issues were identified and the impact for the replacement of fixed tooling with reconfigurable flexible tooling for the stretch forming of aluminum sheets in aerospace manufacturing was considered. This reconfigurable tooling technology will be key for enabling the successful production of small lots of sheet metal components at low cost and responsive cycle time in an agile environment.

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PROBLEM STATEMENT

Typically, a new development follows a normal trend of continuous improvement - improving the individual elements in the development and then integrating them into a well defined technique or strategy. In the early eighties, many companies had implemented factory automation in various "islands" on the factory floor. In the mid-eighties, these same companies were focusing on how to integrate these "islands of automation." A parallel can be drawn to the consideration of agile processes. Much of the focus is currently on strategic level decisions. However, agility is also enabled through shop-floor improvements such as new reconfigurable technologies. The island of automation approach may also be taken with regard to agility. Past experience demonstrates the need to take a holistic view of the enterprise. It is imperative to consider the impact to related processes in any improvement effort. This paper focuses on the problem regarding the impact of the introduction of an agile process to upstream and downstream processes. This research proposes that unless the impact is considered on relevant processes, the introduction of agile processes will provide a suboptimal solution.

APPROACH

The approach taken in this research is to use the foundational concepts of agility and to apply a proven methodology in the transformation of an enterprise, called the "Transform Enterprise Methodology" (TEM) developed at ARRI. This methodology was used to ensure a holistic approach. The IDEF0 method was used to document and understand the current and future environments of the project. The Integration DEFinition (IDEF) methodology was selected for the model creation process. Since agile processes are typically cross functional in nature, the top down approach of IDEF enables a more holistic approach to the model creation and system analysis process. This section provides overviews of agility, the transform enterprise methodology, and the IDEF0 method.

Agility Overview

The enterprise has continuously dealt with change in order to remain competitive. However, today's rate of change is increasing more rapidly than ever before. A new paradigm known as "agility" is being promoted as the solution for maintaining competitive leadership[1,2]. Agility is characterized as the ability to respond to frequent and unpredictable change. The ability to respond rapidly to changing market opportunities by utilizing agile business processes is a key attribute of an agile enterprise[2,3]. In order to establish competitive leadership, manufacturing companies are presented with the task of creating agile business processes[2,4-6]. Enhancements can be made to existing processes in order to maintain a competitive advantage as the environment continually changes. A methodology for transforming existing business processes is needed to assist the enterprise in its pursuit to engineer the enterprise for agility.

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Transform Enterprise Methodology (TEM) Overview

The Transform Enterprise Methodology (TEM) is a rigorous engineering approach to transform an enterprise from a current state to a desired future condition. The methodology integrates cultural, process and technology strategies to transform an enterprise under the guidance of a plan. It is an organized collection of activities that describes "what" must be done to change the entire enterprise. The method, shown in figure 1, is decompositional in nature and iterative in application.

The TEM is composed of four primary activities: *Develop Vision and Strategy*, *Create Desired Culture*, *Integrate & Improve Enterprise* and *Develop Technology Solutions*. The TEM begins with developing a vision of what the enterprise aspires to become and a plan to achieve it. The vision is a statement of what the enterprise aspires to become in the distant future. Strategy is the transformation plan to achieve the vision. The transformation plan is composed of cultural, process and technology strategies. The vision is achieved through processes that have cultural, process and technology components. Cultural components are the norms, attitudes and beliefs exhibited by the people involved in the process. Process components are those organized sequences of activities that transform an input into an output, provide direction for the enterprise or gather resources for the enterprise to operate. Technology components are the scientific devices that enable processes to perform. Once the vision and transformation plan has been completed, the next activity, *Create Desired Culture* begins. *Create* Desired Culture is the process of creating a culture that has the competencies to transform the enterprise[7]. A competent culture has the knowledge, attitude and skills to facilitate transformation. This culture is characterized by the constant desire of people to learn and develop critical thinking skills. Once cultural strategies are in motion, the next activity, *Integrate and Improve Enterprise* begins. *Integrate and Improve Enterprise* transforms how work is accomplished. This activity focuses on increasing the efficiency and effectiveness of all enterprise processes. As process improvement strategies are implemented, the final activity, *Develop Technology Solutions* begins. *Develop Technology Solutions* enables process improvements. Technology is any scientific device that enables a process to operate. As process improvements are made in the *Integrate & Improve Enterprise* activity, technologies are identified that enable the improvements to become reality. More details about this methodology can be found in Underdown[8].

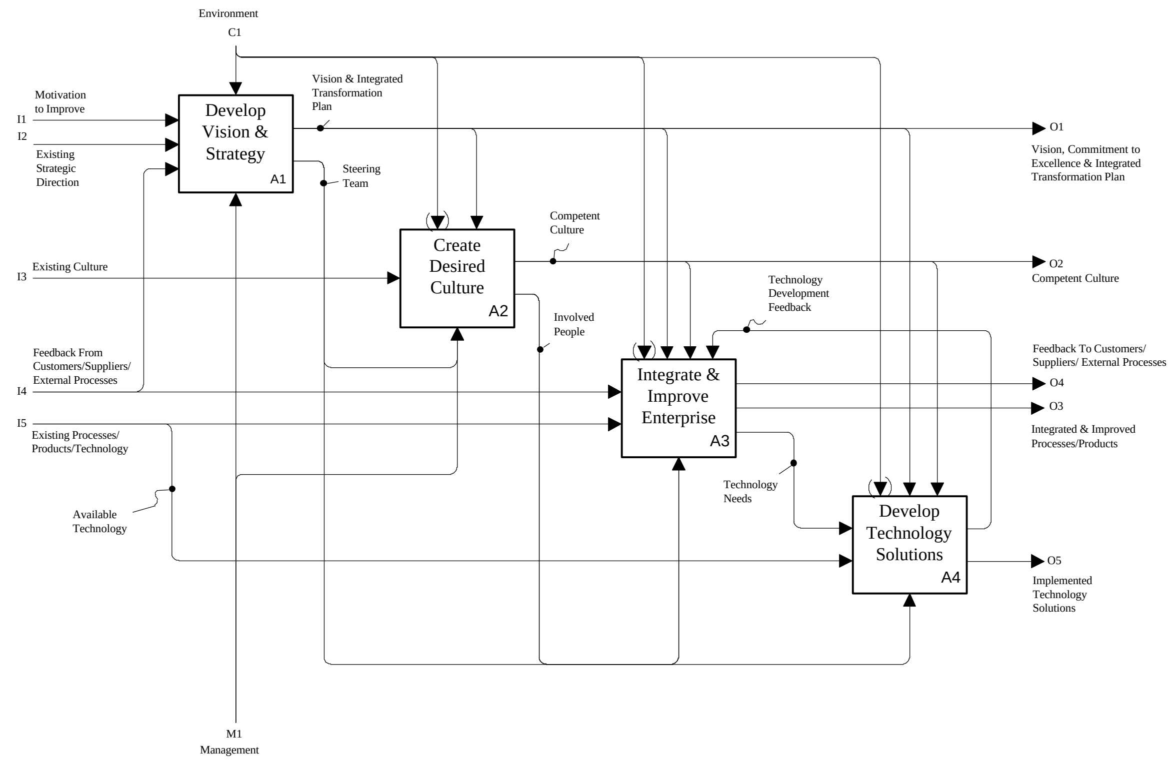

Figure 1. Transform Enterprise Methodology

IDEF Overview

IDEF (Integration DEFinition) was developed by the U.S. Air Force’s Integrated Computer Aided Manufacturing (ICAM) project in the late 1980’s. There are many different IDEF methods. Each method is useful for describing a particular perspective of an enterprise. The major IDEF methods in use are functional or activity modeling (IDEF0), information modeling (IDEF1), data modeling (IDEF1x), process description capture (IDEF3), object oriented design (IDEF4), and ontology capture (IDEF5)[9]. Although IDEF2 was intended to be used as a dynamic modeling method for simulation, the numerous simulation tools commercially available have supplanted this method.

IDEF is a rigorous methodology. The reason for the rigor is to ensure a robust and complete representation. As part of this rigor, a thorough review process is used. The review cycle is enhanced by the rigid IDEF syntax. The syntax for IDEF is very explicit. This research used one of the IDEF methodologies, IDEF0. There are five elements in the IDEF0 functional model as shown in Figure 2. The boxes represent functions such as activities, actions, processes or operations. Boxes are denoted by an active verb phrase inside the box, such as "Make Part" or "Perform Activity". Arrows indicate data. In IDEF, data can be information (like "current status") or physical objects (like "raw materials"). They are named by noun phrases such as "Raw Materials" or "Tools". The position of the arrow indicates the type of information being conveyed. Inputs are represented by the

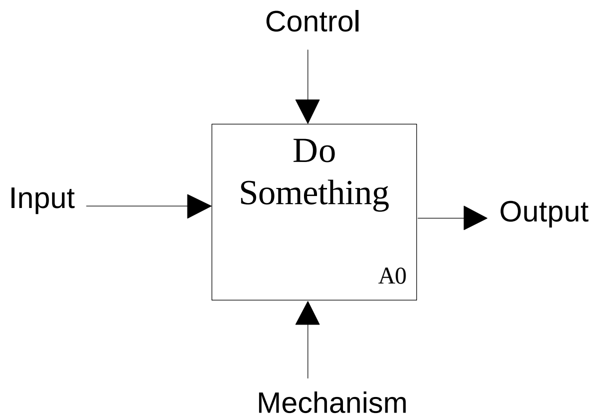

Figure 2. IDEF0 Nomenclature

arrows flowing into the left hand side of an activity box; outputs are represented by arrows flowing out the right hand side of an activity box; the arrows flowing into the top portion of the box represent constraints or controls on the activities; and the final element represented by arrows flowing into the bottom of the activity box are the mechanisms that carry out the activity[10,11]. The IDEF0 method utilizes a subordinate principle of abstraction called decomposition[12], which is the breaking down of each box (activity) into more detail in a continuous manner until the greatest level of detail is achieved[10]. An example of this is shown in figure 3.

PROCESS OVERVIEW

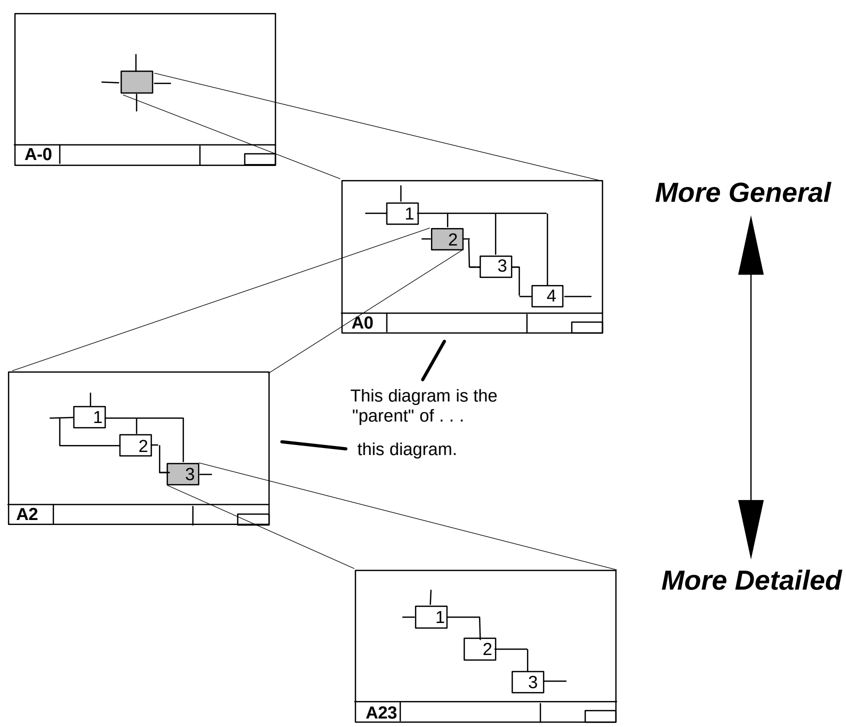

Figure 3. Functional Decomposition

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The Reconfigurable Tooling for Flexible Fabrication (RTFF) project is part of the Advanced Research Projects Agency (ARPA) Flexible Fabrication Program and is a cooperative effort between academia, industry, and national labs. The overall RTFF project is the development of a production-scale reconfigurable tool; development of a rapid large-scale shape measurement system; development of a shape control system that can include the effects of downstream manufacturing processes such as trimming; development of an accurate process modeling and simulation system that will include springback prediction; and the demonstration of this technology on the production floor. This paper focuses on the aspect of the issues relating to the implementation of the RTFF at Northrop Grumman Commercial Aircraft Division (NGCAD). A diagram of the reconfigurable tool for stretch forming is shown in figure 4.

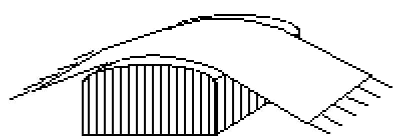

Figure 4. Reconfigurable Tool

DOMAIN KNOWLEDGE CAPTURE

A key component of any improvement effort is the understanding of the current environment and requirements for the future environment. SADT (Structured Analysis and Design Technique), the forerunner of IDEF, has developed a structured modeling process for the capture of domain knowledge. Knowledge is initially captured through interviews with various sources. These sources include people, documents, and observation of the existing system. It is important that the authors define a clear question for the model to answer. If a model does not answer a question, then the model is of no value. It is easy to try to solve too many problems with a single model. Therefore, the model must have a single subject. This is commonly referred to as 'bounding the model.' It is easy to continually add to the model leading to 'analysis paralysis', where the model is never completed. The model must also have only one viewpoint. In our research, we could have chosen the viewpoint of the shop floor operator, the stretch form manager, or the plant manager. We chose the stretch form manager. This enabled us to capture information important to the project that was outside the actual stretch form processes. From this information, the diagrams are composed and supporting text is added. All of this information forms a 'kit'. These kits are composed of a kit cover page, diagrams, text to support the diagrams, and a glossary. A kit is typically one level of diagrams in the hierarchy with the previous level diagram included to provide context. The author/reader review cycle is used to verify IDEF 'kits'. These kits are sent to the system experts who comment on the kits. We used a team of six experts for this project. The experts ranged from the shop floor foreman to the manufacturing support personnel to factory management. The author receives these comments and makes the required corrections.

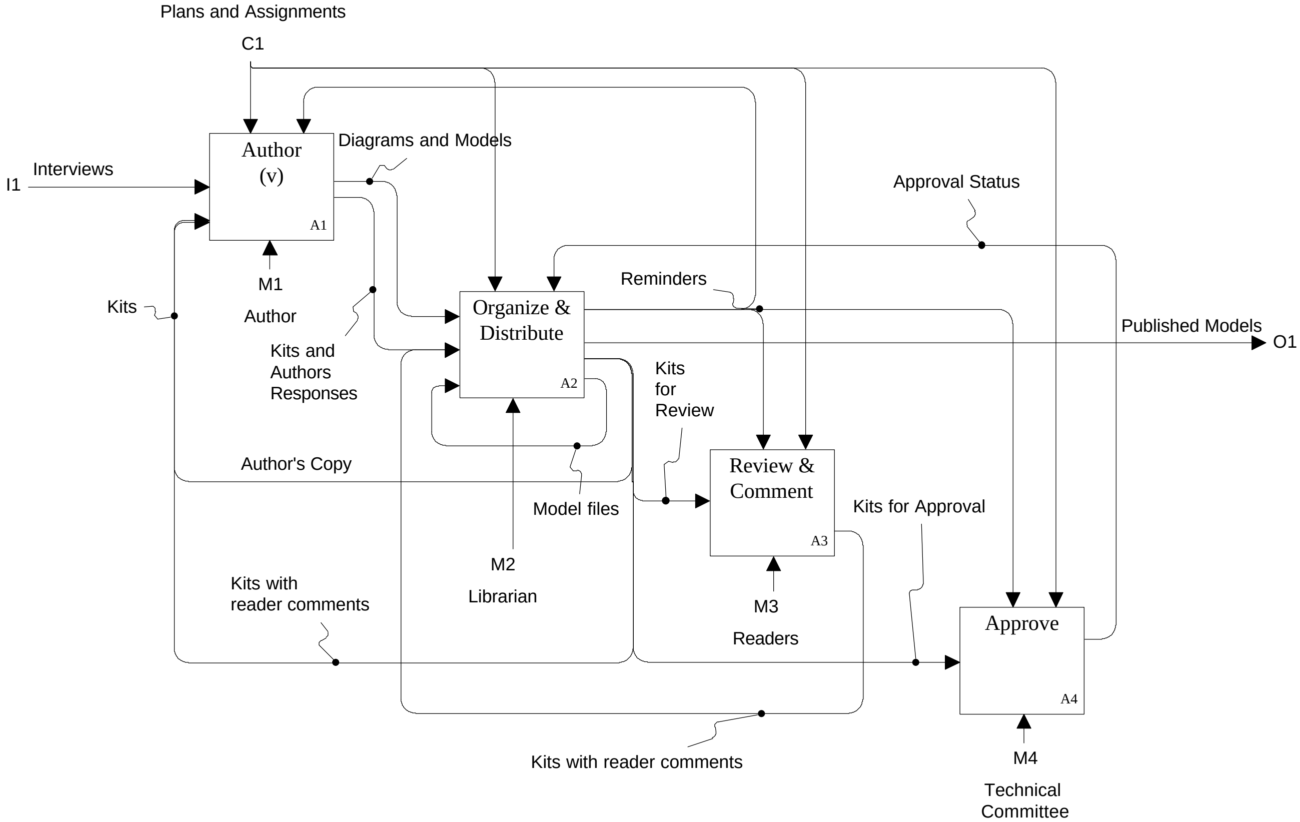

Figure 5. Review Cycle Process

The experts verify the corrections. This iterative review process continues until each kit is complete. For this project, most kits took about three iterations to complete. The cycle for each review of a kit was about a week. The next kit is then created and the review cycle begins for that kit. The kits are created and reviewed in a top-down manner until sufficient detail is captured. There were a total of twelve kits reviewed for this project. During some portions of the review, the experts were brought in a single room to review the kit which was useful for reaching consensus on some of the more difficult aspects of the model. An IDEF model of the reader/review cycle is shown in figure 5, taken from[10].

RESULTS

Although the true success of the project will not be judged until the implementation of the RTFF prototype, several benefits are already realized from this project. The primary benefit of this effort was the development of a common understanding of the environment and process for stretch forming at NGCAD. As mentioned in the previous section, the common understanding was achieved in two aspects. First, the review process required an agreement on specific parts of both the actual diagrams and the supporting descriptions and definitions. By requiring this agreement, the key players involved were forced to view the process from each others' perspective. This common understanding has been shown to be vital in facilitating improvements across functional departments. Fortunately for this project, there was little, if any, conflict in these sessions and consensus was easily achieved. The other communication benefit was providing those not involved in the daily operation of the process a more thorough understanding of the overall RTFF project. The deliverables for this project were: an IDEF0 model describing the “as-is” environment, and three “to-be” IDEF0 models. The three “to-be” models described 1) improvements to the process unrelated to the reconfigurable tooling, 2) a full-scale implementation of the reconfigurable tooling, and 3) a mixed environment with some parts using the reconfigurable tooling and some using the “as-is” process flow. Another benefit of this effort was to help identify opportunities for improvement to the current process. Several opportunities were identified and these are currently being considered for implementation. Also, the IDEF0 model was used to drive an animated simulation of the stretch form process. This was to further test other research in the use of static models to drive dynamic models. More details on this research can be found in Whitman[13].

CONCLUSION/FUTURE RESEARCH

Agility is vital to survival in todays’ mass customization environment. Processes must be able to react to unanticipated change. Due to resource limitations, agile processes will be introduced in existing traditional environments. This research has demonstrated a methodology for the consideration of surrounding processes when introducing an agile process. The smooth transition from traditional processes to a mixed traditional/agile environment is critical for survival. By using a structured methodology for the implementation of this technology which considers strategic, cultural, process, and technological issues, the transition can be eased. IDEF is a useful methodology for interacting with management and shop floor personnel. This paper provided an explanation of agility, a transformation methodology, and an overview of IDEF. Some comments on the process studied and the domain knowledge capture effort were also highlighted.

Several benefits were realized from this research. Communication and understanding was significantly increased leading to more well defined requirements for the future system. Additional opportunities for improvement to the process were identified. However, the this research will not be truly validated until the actual implementation of the reconfigurable tooling. A future task is to validate the concepts put forth in this paper after the implementation of this agile process.

ACKNOWLEDGEMENTS

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Research for this paper is funded in part by the National Science Foundation sponsored Agile Aerospace Manufacturing Research Center.

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