

Bipin Chadha
Lockheed Martin ATL
Camden, NJ 08102 USA

ENTERPRISE INFRASTRUCTURE SUPPORT FOR AGILITY

Bipin Chadha, Peter Holmes, Biju Kalathil, James Saultz, and John Welsh
Lockheed Martin Advanced Technology Laboratories
1 Federal Street, A&E 2W
Camden, NJ 08102, USA

EXECUTIVE SUMMARY

This paper describes how an Enterprise infrastructure is supporting agility on two ARPA initiatives namely, RASSP (Rapid prototyping of Application Specific Signal Processors), and AM3 (Affordable Multi-Missile Manufacturing). The two programs involve several large enterprises linked electronically to form virtual enterprises and aiming to address the issues raised by the constantly changing defense environment. The paper describes the infrastructure needs of such virtual enterprises, the existing infrastructures being used, and the technology gaps that need to be filled to support those needs. Core concepts of the RASSP Enterprise System include integration of tools and tool frameworks into an enterprise environment; program execution control through workflows; integrated data management functions; design reuse; concurrent engineering team support; and integration of design engineering and manufacturing.

INTRODUCTION

The competitive business climate and decline in the defense budget have forced defense contractors toward agile design and manufacturing approaches supported by agile, enterprise-wide infrastructures. Lockheed Martin Corporation is involved in the development of an enterprise system approach for use in the development of affordable missile systems. Three ARPA/Tri-Service programs support these efforts: The AM3 (Affordable Multi-Missile Manufacturing) program uses the results of the RASSP (Rapid prototyping of Application Specific Signal Processors) program and the AIMS (Agile Infrastructure for Manufacturing Systems) program to develop a methodology and enterprise infrastructure; the goal is to save 25-50% across the missile portfolio. These programs are examples of virtual enterprises consisting of several organizations.

The AM3/RASSP Enterprise System provides key automation support for teams of signal-processing/missile-design engineers in execution of complex development projects, thereby facilitating greatly improved productivity and efficient program control and orderly management of design configurations. Core concepts of the RASSP [3] enterprise system include integration of tools and tool frameworks into an enterprise environment, program execution control through workflows, integrated product information management functions, concurrent engineering team support, a reuse system, and integration of design engineering and manufacturing. This paper presents a strategy for use of the RASSP environment, methodology/ workflows, and information models to improve agility of signal-processor development and missile-seeker manufacturing projects.

INFRASTRUCTURE NEEDS OF AN AGILE ENTERPRISE

An Enterprise can derive agility from a number of sources including business practices, culture, infrastructure, etc. To react to new market environments and technologies, the enterprise needs:

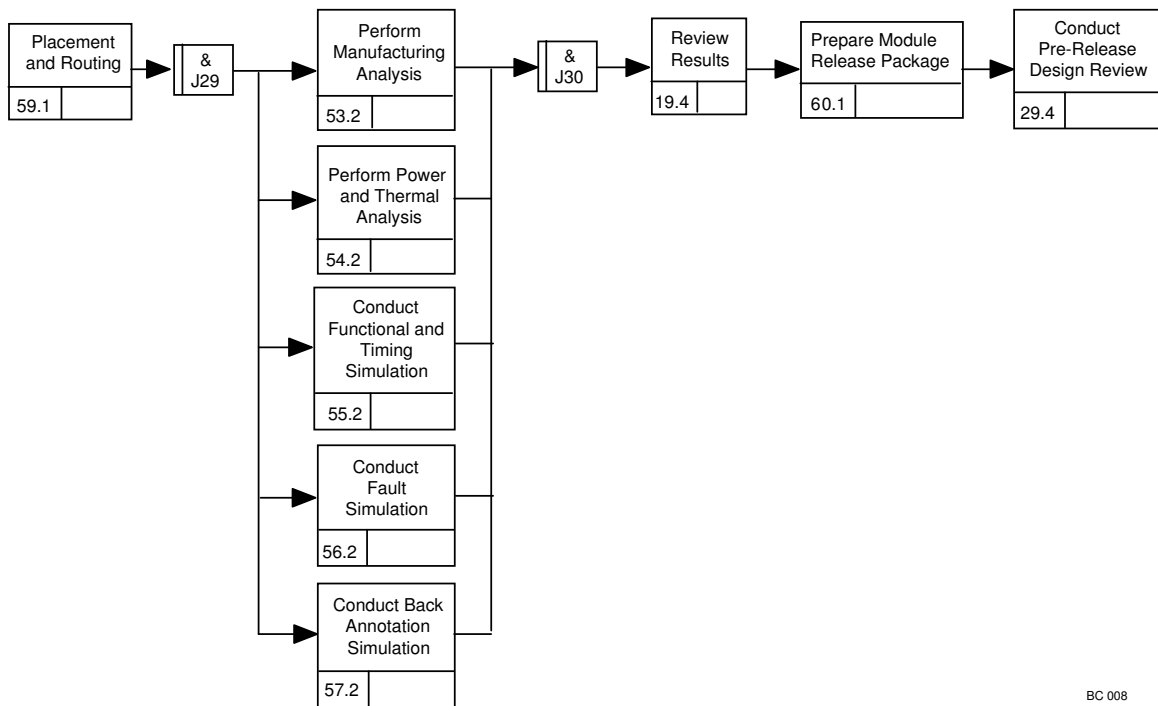
- Easy access to relevant information
- Perform tasks in a coherent manner consistent with the business strategy
- Be able to reuse earlier knowledge and experience
- Manage all its processes
- Be able to communicate across geographically distributed sites
- Provide easy ways to work with the customers and suppliers
- Support all aspects of the life-cycle from cradle to grave
- Allow collaborative work to be performed by teams.

The infrastructure should also provide the capability to plug in domain specific applications such that they support the enterprise's processes rather than program specific functions. The infrastructure should be able to reconfigure itself to the changing needs of the enterprise by easily changing processes, information, and functional characteristics.

RASSP AND AM3 INFRASTRUCTURE APPROACH

Process Engineering

Process Engineering is a methodology that supports the evolutionary and revolutionary change that is required to achieve an organization’s strategic goals through more effective, efficient, and agile business processes [1]. It involves not only process changes but also organizational changes to support the new processes. There is a significant impact on the policies and procedures of an organization. Teams are organized around processes rather than around organizational functions. Teams are empowered to make more decisions as checks and controls are reduced. Process Engineering leverages technology not just to make old processes better, but also to break the old paradigms. Once the program goals have been set and a strategy has been devised for achieving those goals, the domain processes are modeled using IDEF [2] and simulated to gain an understanding of the AS-IS environment. A process model for “module design” is shown in Figure 1.



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Figure 1. Module design process.

The processes are then reengineered using breakthrough enablers such as: RASSP concepts of model-year architecture, enterprise infrastructure, business practices, innovative organizational strategies, etc. The reengineered processes are simulated to do *what-if* analysis and to determine benefits of the new processes. These processes are then implemented via the enterprise infrastructure discussed below.

Enterprise System Overview

The core enterprise-system architecture (Figure 2) is hierarchical, integrating design tool

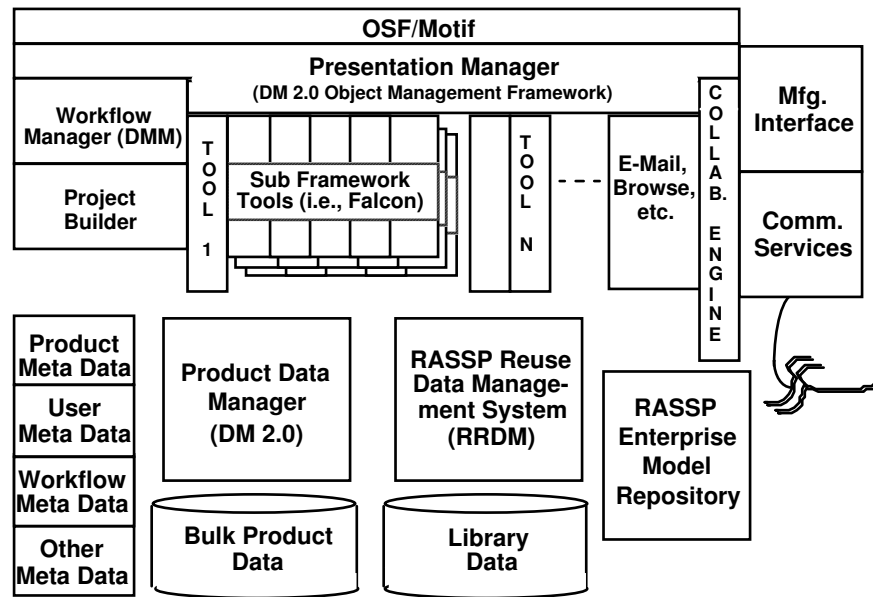


Figure 2. Enterprise system infrastructure.

frameworks and individual design tools, and it includes provisions for integrating purchasing systems and product information management. The enterprise system also includes a distributed reuse system with an object-oriented repository at the enterprise level and local framework/tool libraries managed in a coordinated fashion with enterprise level functions [4].

Integrated Process and Product Information Management

The concept of operation for the enterprise framework includes the ability to execute project plans expressed as workflows by teams of engineers. Execution of a workflow by a member of a design team, as indicated in Figure 3, initiates control commands to a CAD/CAE tool as relevant for the particular workflow step; it also initiates data transactions with the enterprise product data management system, local data management systems, and library systems as relevant for the particular workflow step. In addition, project management tools are coupled with the enterprise environment, receiving regular status updates as workflow steps are executed, thereby facilitating effective non-interfering project management.

Execution of the workflows is performed using enterprise-methodology-management tools, which provide links to tools, data-access mechanisms, and other services. This in effect removes these functions as required responsibilities for the design engineer, thereby enabling significant productivity improvement via increased focus on design tasks. Project engineers or supervisors would normally be responsible for design and implementation of project plans based on workflows using the system.

In addition to support for workflow use, the enterprise framework provides multiple workspace views for the design environment. These include tool and application workspace, data workspace for product information and reuse information, and project/workflow workspaces as described. The resources, data objects, and applications available to engineers are defined by their identity and role in an authorization hierarchy implemented in the enterprise system.

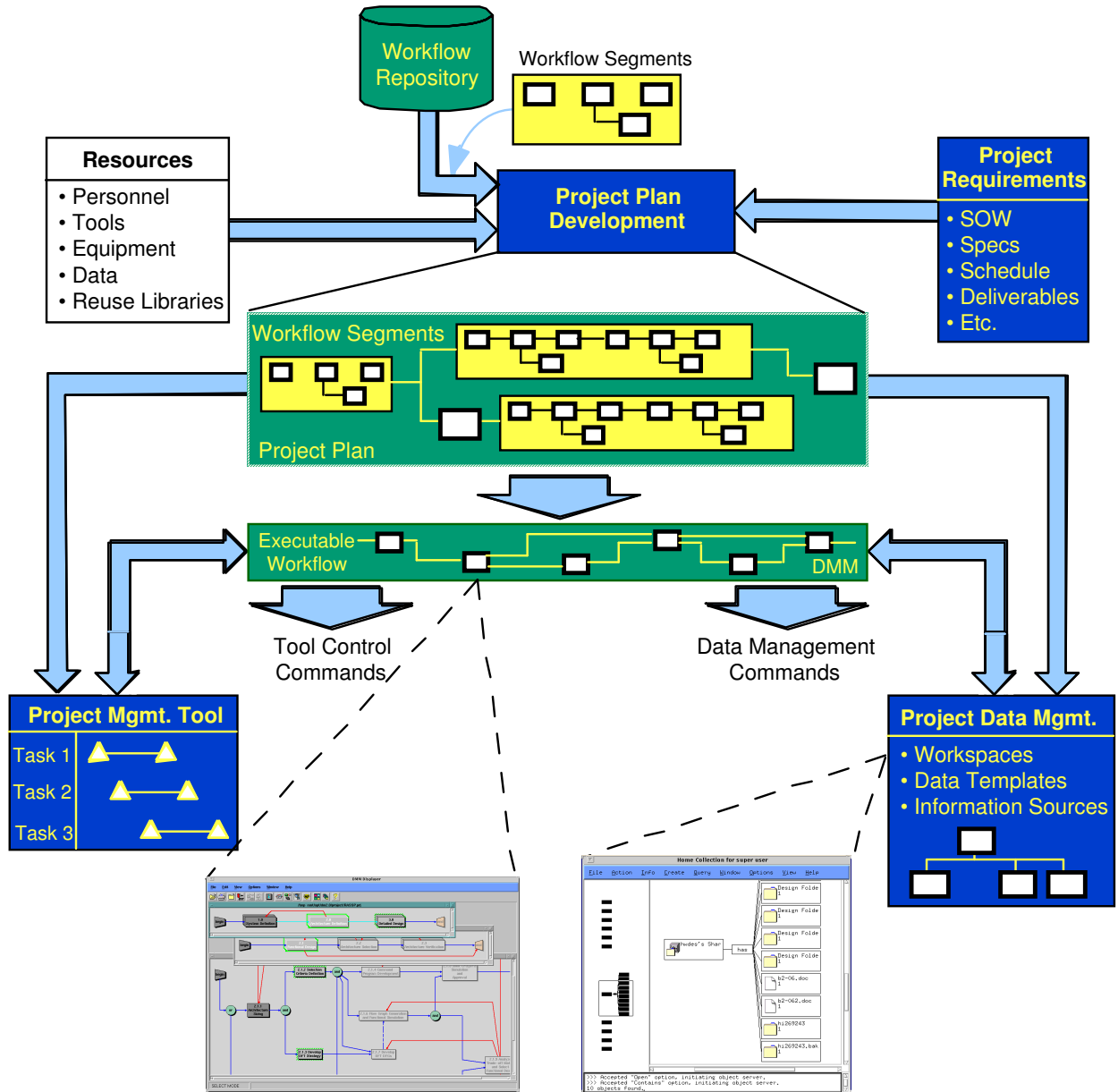


Figure 3. Project plan implementation using workflows.

The workflow captures:

- Process steps
- Their precedence relationships
- The personnel roles authorized/required to perform work
- The information objects involved (created, used, modified, destroyed, etc.) in the process step
- The tools to be launched or controlled at each step.

The information objects represent place holders for instances of objects that will flow through the workflow. The workflows are hierarchical in nature — representing the various disciplines associated with electronic design. The workflows consist of reusable workflow segments, which can be combined in various configurations to address specific project needs.

Figure 2 represents a module final design segment. These segments consist of multiple process steps, each of which are also reusable. Thus, options available to a user organization are either to make use of the RASSP workflows in current form or to develop process plans based on a combination of reuse of RASSP workflow segments, individual process steps, and possible custom user steps.

Enterprise information is a key corporate asset and will require a well planned management strategy. The RASSP team developed an enterprise data model, which specifies the metadata that the design engineers and project/system administrators need to track the product and reuse information in the system. In development of the RASSP Enterprise Data Model, several standard models were analyzed relative to RASSP-specific requirements. Models analyzed include the Product Data Control Model (which Rockwell developed on the USAF Integrated Data Strategy program), the STEP parts and protocols AP203 [6], and Part 44 [7]. The Enterprise Data Model was therefore developed based on multiple sources of product data requirements.

Reuse System

Library management in the RASSP system involves the release, cataloging, and searching of reusable design objects. The RASSP Reuse Data Manager (RRDM) supports this library management. Sources for reusable design objects in the RASSP system include:

- CAD tool libraries
- CAD-tool-independent libraries
- Component vendor data books
- Design objects created within a design organization.

In today's design environments, the ability of the design engineer to maximize reuse is impaired because there is no efficient way of searching for reusable design objects across multiple sources, and the various sources of reusable data are not coupled with the design environment. In addition, mechanisms and processes for organizing reusable design objects created within a design organization are lacking. Also lacking is the effective sharing the reusable design objects within the organization, as well as with other cooperating organizations.

The RASSP Enterprise System will include tools and methods for integrating the various sources of reusable design objects to provide a single source for searching for reusable design data and will enable enterprise-wide sharing of reuse data. The approach consists of:

- 1) Developing a design object class hierarchy, which classifies the various types of design objects in the RASSP domain and models the descriptive data associated with the design objects.
- 2) Developing a commercial library management system, which will implement the design object class hierarchy and provide mechanisms for searching for design objects across multiple libraries and across a virtual enterprise.

A methodology is also provided by the RASSP system for addition of new reuse elements and/or classes in the system. This process includes certification of the new elements, possibly to the classification hierarchy, and generation of documentation updates.

Additionally, the RASSP reuse management system will support loosely-coupled and tightly-coupled federations of cooperating organizations in sharing library data. The core library management search and browse function, which supports the RASSP design object class hierarchy, was implemented by Aspect Development. This function was released as a commercial product in May 1995. Extensions for integration of reuse library systems are currently in development. An initial version of the reuse class hierarchy is shown in Figure 4.

The RRDM extensions being developed support: capabilities to manage default and template objects, manage parametric searches, modify existing objects, modify class hierarchy, and so on.

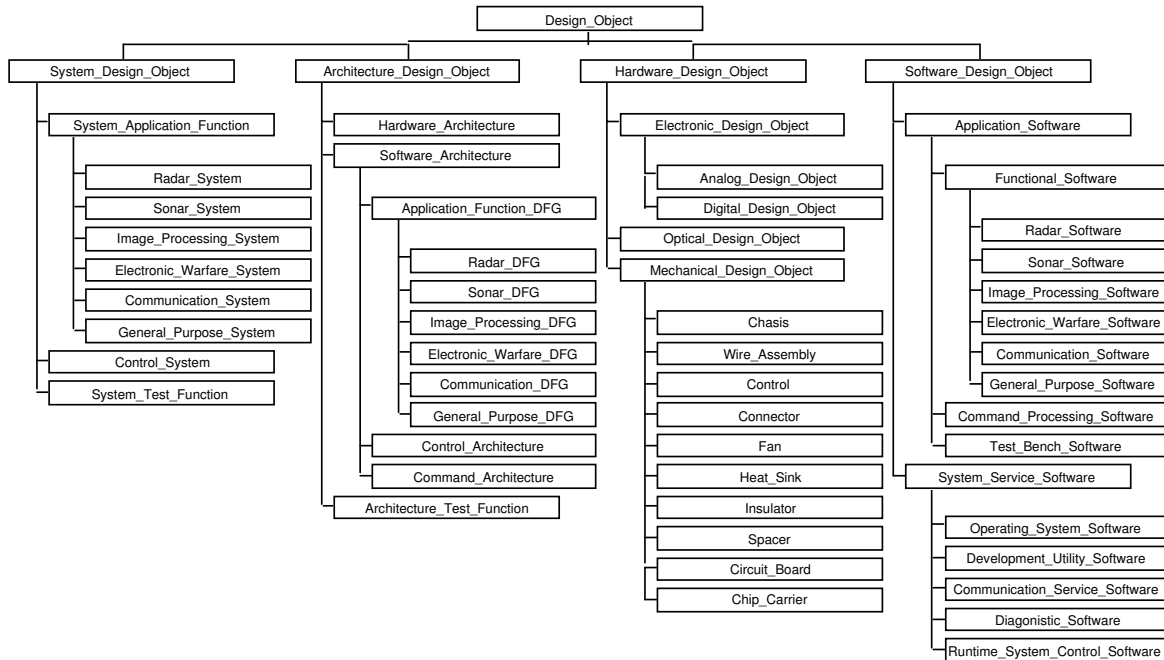


Figure 4. RASSP design object class hierarchy.

Networking

It is the goal of both RASSP and AM3 to leverage the Internet to the maximum extent possible to achieve Agility goals. A flexible, high speed Internetworking infrastructure is the starting point, upon which selective enhancements driven by program requirements are employed. Four guiding principals are used to describe the networking approach used by the RASSP and AM3 programs: speed, security, reliance on COTS, and receptivity to emerging technologies.

The first of these principals is to make maximum use of the Internet as a rapid and efficient electronic data transfer medium. RASSP and AM3 models require extensive interactions between vendors, customers, and suppliers. In many cases these participants are geographically distant from one another, yet connected to the Internet. In virtually all cases it is possible for this electronic data to be communicated in a matter of minutes from the sender to the receiver using the Internet as the transfer medium. It may be necessary, in some cases, to employ translators to ensure full compatibility between senders and receivers but it is important to exploit this capability to the maximum extent possible.

The second network principal, which is applicable to any electronic commerce but particularly to the RASSP and AM3 programs, is that of secure data transfer. Not only must the data be sent from sender to receiver quickly and accurately, it must also be conveyed in a secure fashion to reduce that the data will be intercepted and compromised. Rather than dealing with the question of which data should be secured and which should not, it is better to build an infrastructure which treats all business transactions securely. In this regard RASSP and AM3 are employing licensed Public Key Encryption technology. This is, or will be, employed in both email exchanges and in file transfer exchange.

The third principal describing the networking approach on RASSP and AM3 is one of reliance on commercial-off-the-shelf (COTS) products to the maximum extent possible. The ambitious schedules on both programs do not allow for the development of new and innovative network solutions. In this regard the two programs are using, for example, secure email and World Wide Web (WWW) client/server products which are readily available. As such, these products are accessible, and compatible, with most existing customer resources. This will make it easier to demonstrate capabilities over the Internet. However, it is important to understand that there are non-trivial implementation issues which accompany these products. Of particular significance are the large assortment of optional authentication techniques which can be used when deploying a secure WWW server.

The final consideration in the development of a network strategy in the context of RASSP and AM3 is to be cognizant of the highly volatile nature of Internet related technology (An example is the emergence of Java technology).

The development of a coherent network strategy as it applies to RASSP and AM3 holds great potential. The challenge is to identify specific mechanisms which support Agility, and then to implement and quantify them.

TECHNOLOGY GAPS

The existing infrastructure comes close to supporting the needs of an agile enterprise, however there are still significant challenges ahead. Some of the technology gaps we have identified (and are working on) to reach the proposed infrastructure are:

- Ability to capture design rationale
- Ability to interchange process information across a variety of process technology tools (Product Data Management) PDM-PDM interoperability
- Incorporation of manufacturing tools in the framework such as enterprise resource planning and finite capacity scheduling
- Provide toolkits for the enterprise to conduct business over the internet with suppliers, customers, and manufacturing facilities
- Ability to incorporate optimization engines into the enterprise to support hierarchical multidisciplinary optimization
- Ability to manage dynamic processes and exceptions.

SUMMARY

By using the principles of agility, the RASSP/AM3 enterprise system provides significant capability for enabling large productivity gains for signal-processing/ missile manufacturing teams. The development plan for the RASSP enterprise system includes four prototype build cycles. The initial prototype system, focusing on electronic hardware design, was demonstrated February 1995. Significant progress has also been achieved in the implementation of the functional design and architecture design processes, which are the focus of the Build-2 system (February 1996). Key benefits include a practical approach to apply process technology in an engineering environment; capability for planning and managing complex products; improvements in reuse implementation through an integrated, distributed strategy; and significant productivity improvements in the design/maufacturing interface.

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