Process Technology Appnote

Abstract

Process thinking is key to achieving the cycle-time and cost reduction goals that are driving product development and manufacturing today. Process issues are easily overlooked compared to product issues since process problems are not explicitly visible and typically appear as symptoms far away from problems in space and time. A problem in the design department surfaces during manufacturing several months later as a product defect. The process issues are even trickier to address since the benefits are also often observed far away in space and time of a project. For example, a good design may show up as an over budget in the design department, but it will allow the manufacturing department to manufacture it ahead of schedule at reduced cost. Result may be a penalty for designers and bonus for manufacturing department. The overall enterprise processes need to be optimized globally as opposed to local optimization forced by functional organizations and functional tools perspectives. Process thinking is facilitated by process technologies. Process technology includes tools to capture, analyze, implement, manage, and improve processes used in a virtual enterprise. Process technologies have a pervasive impact on the entire supply chain of a product, and hence it is critical that considerable attention be paid to them. The processes are incomplete without the context of information that is required to realize those processes. Tight integration of processes and their corresponding information is necessary to facilitate work. This application note contains:

- a technology description of the process work done under the RASSP program;
- methodology used for effective implementation of process technology;
- tools used to model, analyze, and implement processes;
- and further research required to realize the full potential of process technology.

The basic tenets of this work are:

- Process is as important as product
- Process and product issues are tightly integrated
- Processes need to be engineered just as the product needs to be engineered
- Process needs to be explicitly made visible to the entire team
- Design is a structured process

Purpose

The Application note describes the process modeling methodology developed on the RASSP program. Specific developments include: Process models using IDEF3 and IDEF3x methods, Process simulation models developed using WITNESS, Workflow models developed using DMM, information models developed using STEP EXPRESS, and information models implemented using AIM. The viewable parts of the model are incorporated in the RASSP Methodology Application Note as well as in the Enterprise Framework Application Note Table 2 - 1. Other information contained in the models requires specific tools in which the models were created. The RASSP models are focused on the electronics design domain, however they are generally applicable to many domains. Process models include subsystems design, architecture synthesis, detailed design for electronic modules, backplanes and ASIC devices. RASSP special case process models also address design styles prevalent in signal processor development. Examples include multiple parallel design alternatives, iteration, and management of concurrent updates. The result is a powerful top-down, reuse-based, virtual-prototyping design process and several novel process management capabilities.

The bibliography provided details a rich repository of reference materials including papers, presentations, specifications, and references to other sources of process technology information.

Roadmap

 Dennis Basara

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1.0 Introduction

Process technology is fast becoming critical to DoD and industry due to its pervasive nature in product life cycles as shown in figure 1. Process technology is a key enabler for an organization's capability to add value to its products over it's life-cycle. **Process technology/toolkits will provide an integrated environment to understand, analyze, and automate life-cycle processes.** Improved design processes and process technologies are key contributors to the RASSP goals of 4X improvements in cost and cycle time. To compete in today's environment the organization, it's tools, and it's culture need to shift from a functional mindset to a process mindset.

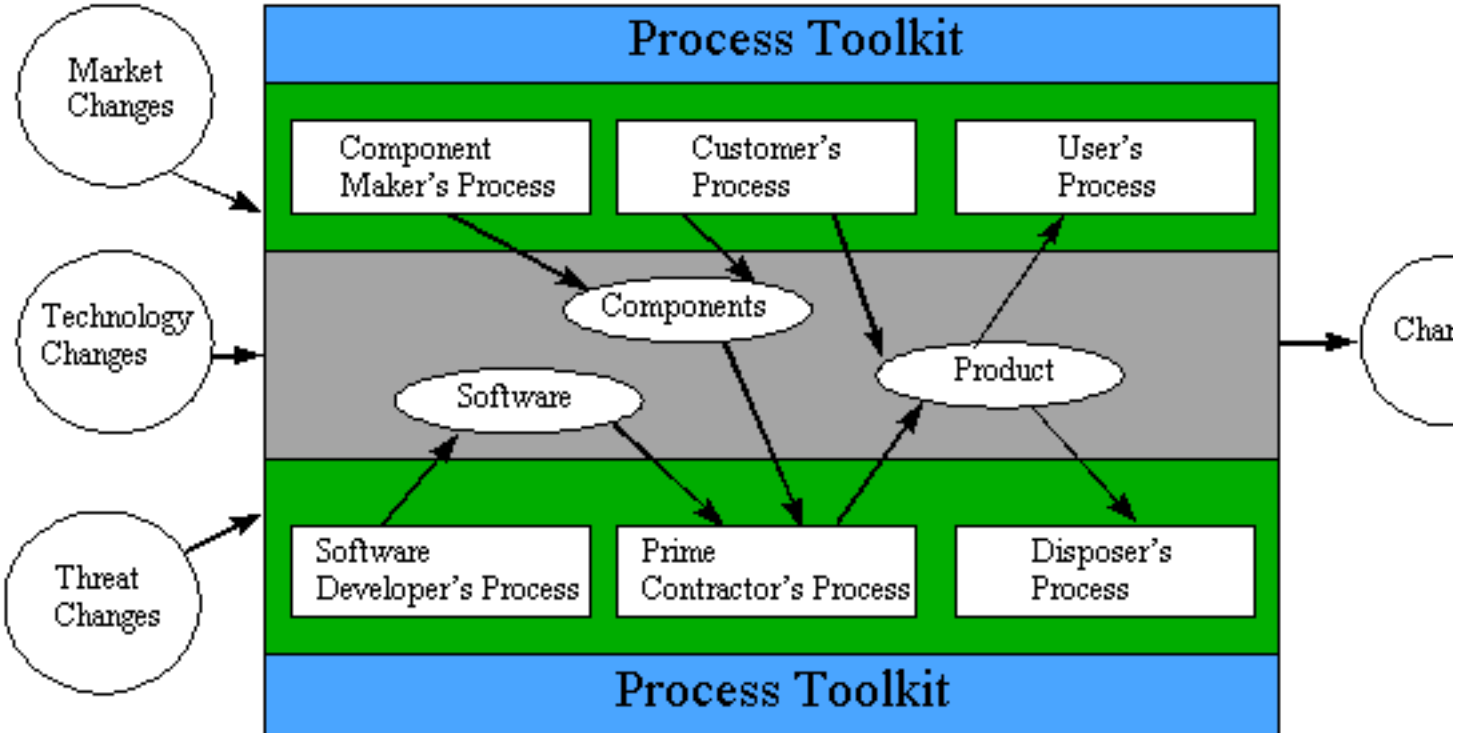

Figure 1 - 1: Process Technology Impacts all Life-cycle Phases of a Product.

In order to completely exploit design technologies and skills of the design teams the following is required:

- Product life-cycle process must be clearly understood.
- Process status must be clearly visible to everyone in the design team such that they understand the relevance, impact, and importance of what they do on the final result.
- Process and product information is seamlessly integrated.
- A clearly defined continuous process improvement strategy is put in place and acted upon.

The RASSP program developed approaches to assist organizations in addressing these needs. These approaches include a strategy for integration of process and product models, and representation of the combination as reusable segments in a standard format (IDEF). RASSP process models developed specifically for the signal processing and electronics domain also serve as reusable templates which can be customized and

applied to multiple organizations and programs.

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2.0 Problem

To successfully develop large complex systems requires users to establish and adhere to sophisticated processes throughout the program. With these systems, however, the processes are rarely preserved after system deployment - which means the processes are unavailable to organizations for maintenance and evolution over the system life cycle. Capturing and preserving these processes in a neutral representation that allows them to be re-analyzed and reused offers significant benefit. Several independent process tools are available to help develop and apply these processes on projects; however, appropriate integration and packaging of process technology could provide tremendous benefit to programs.

To support system evolution and upgrades, it is important to make the design processes used in the system available for use or adaptation. Information of particular interest for the upgrade processes includes:

- the design history (key decisions and rationale)
- development logs indicating measures of complexity associated with the original design or previous upgrades
- the rationale/intent information associated with the original process design.

Reusing the original process models in new design environment will improve productivity when users develop the processes to support system upgrades. This is often a complicated task for large systems, which should not have to be reinvented with each incremental system evolution.

These issues are complicated by the cultural issues involved in adopting process based approaches that often tend to diminish functional boundaries and demand decisions that are counter intuitive to a functional mindset.

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3.0 Methodology

The DARPA RASSP program has developed approaches and tools to assist organizations in adopting a process focus, understanding and improving their processes, and efficiently automating those processes. 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 processes. 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, appropriate process(s) are selected for application to the projects, with certain customizations and improvements as shown in figure 3 - 1. Processes are selected from a process library (specific to a group or organization), and then reengineered or customized for the specific projects. This includes identification of the information requirements, and the detailed workflow steps. These requirements drive the generation of the specific metadata used in the workflow tools and the product data management systems for control of process execution.

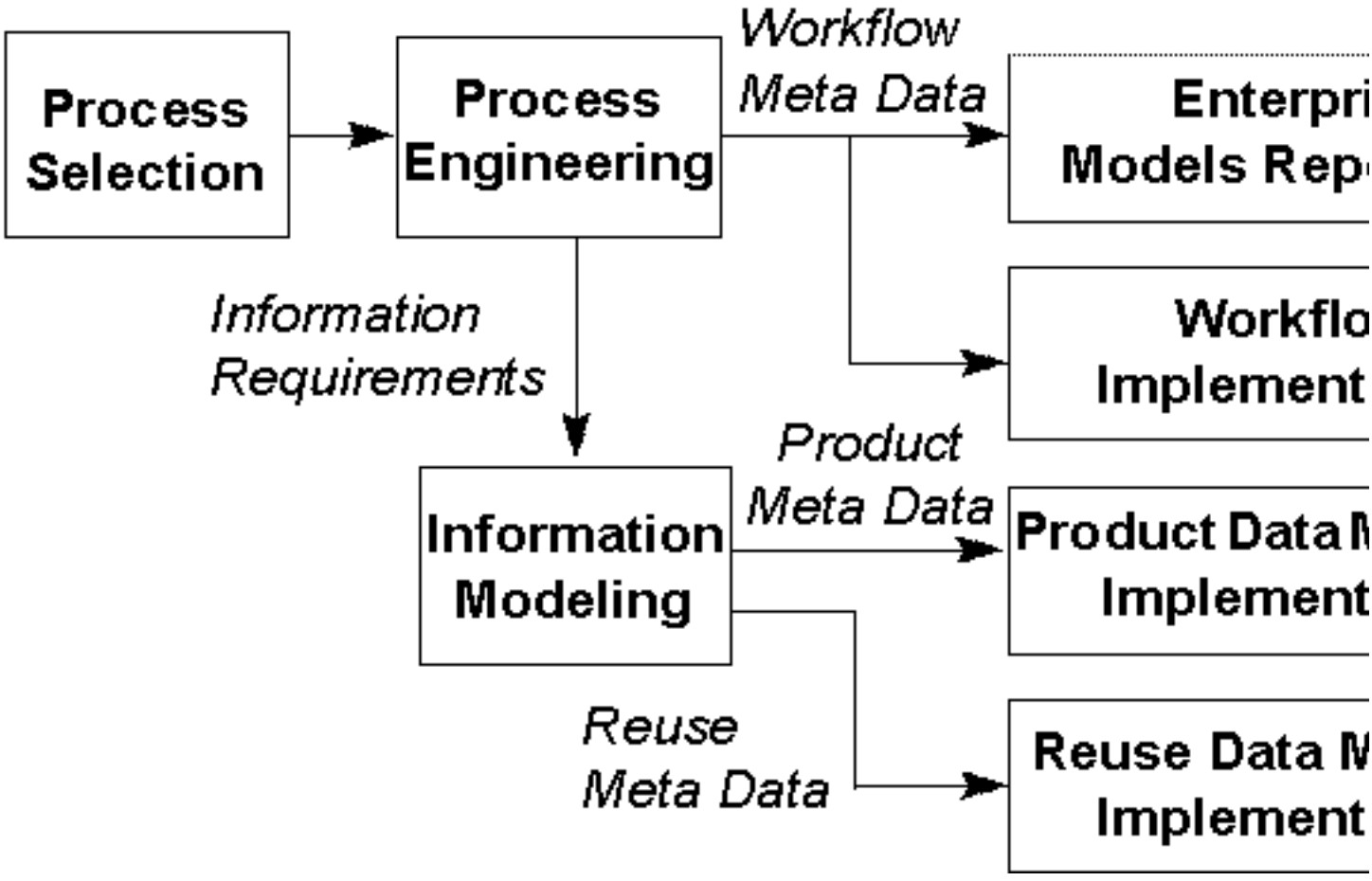

Figure 3 - 1: Process Roadmap for a Project

The domain processes are modeled using IDEF3 (figure 3 - 2) and simulated to gain an understanding of the AS - IS environment. Integrated computer aided manufacturing DEFinition language (IDEF) is a set of process and information standards developed under Air Force sponsorship, and used extensively in multiple industries for process representation. Utilization of IDEF enables representation of the process models in a neutral format - and not associated with specific implementation tools. The particular process segment in figure 3 - 2 is a final design phase for an electronics module design, reflecting parallel design analyses functions in preparation for release to manufacturing.

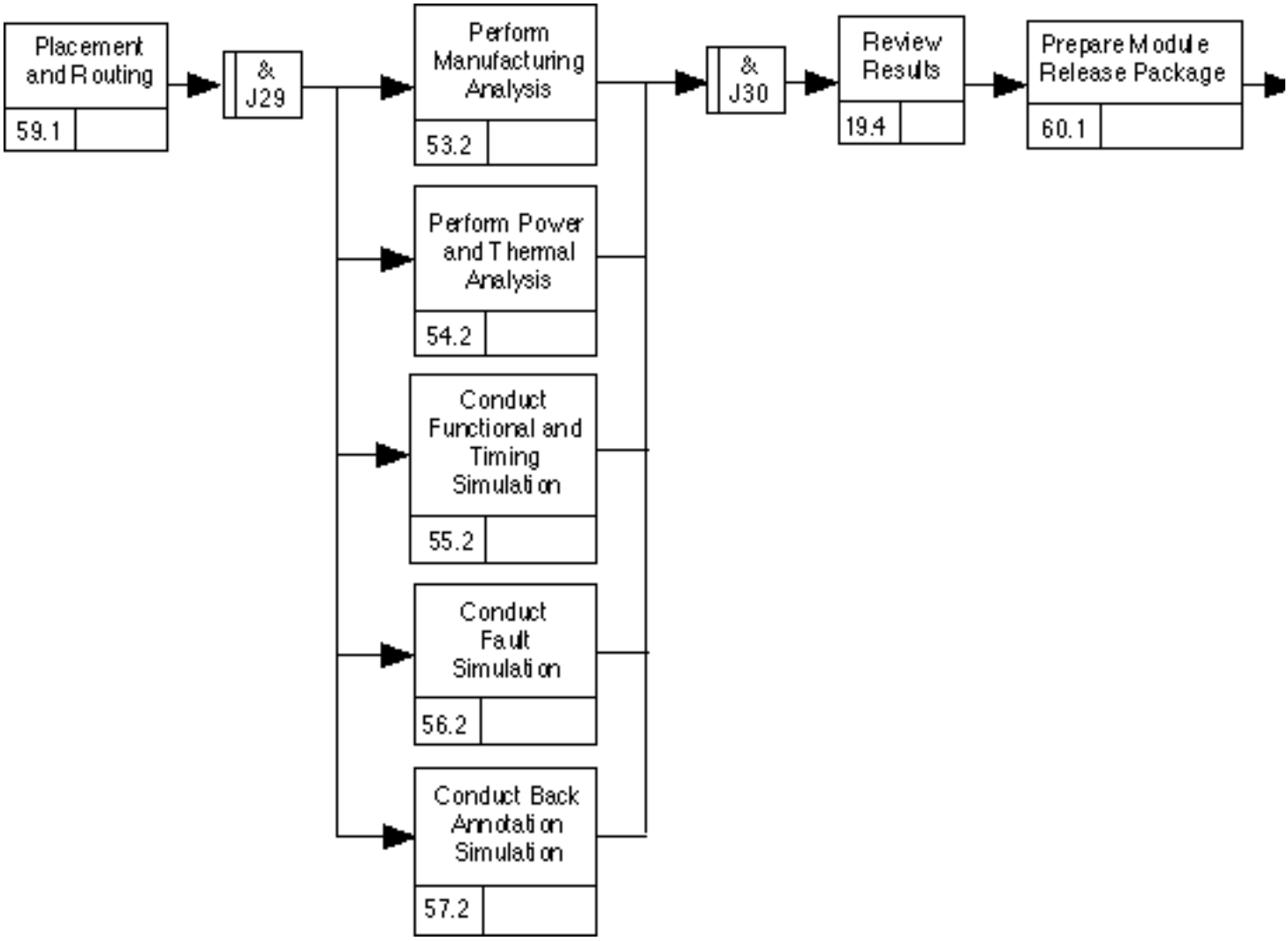

Figure 3 - 2: IDEF3 Process Model Example

The processes are 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. The simulations are performed at a level of detail suitable for program management. Typical what-if analysis determines the impacts of changes to project cost, cycle-time, and resource requirements and conflicts. Such analysis can also help an organization to determine appropriate number of concurrent projects and appropriate organization size to handle these projects.

These processes are then implemented via workflow management tools, see figure 3 - 3, that integrate with the

rest of the design and enterprise management tools to help manage a complex project. This example, Intergraph Design Methodology Manager tool (DMM), shows multiple levels of a RASSP hierarchical workflow - Functional Design as the leaf level process segment.

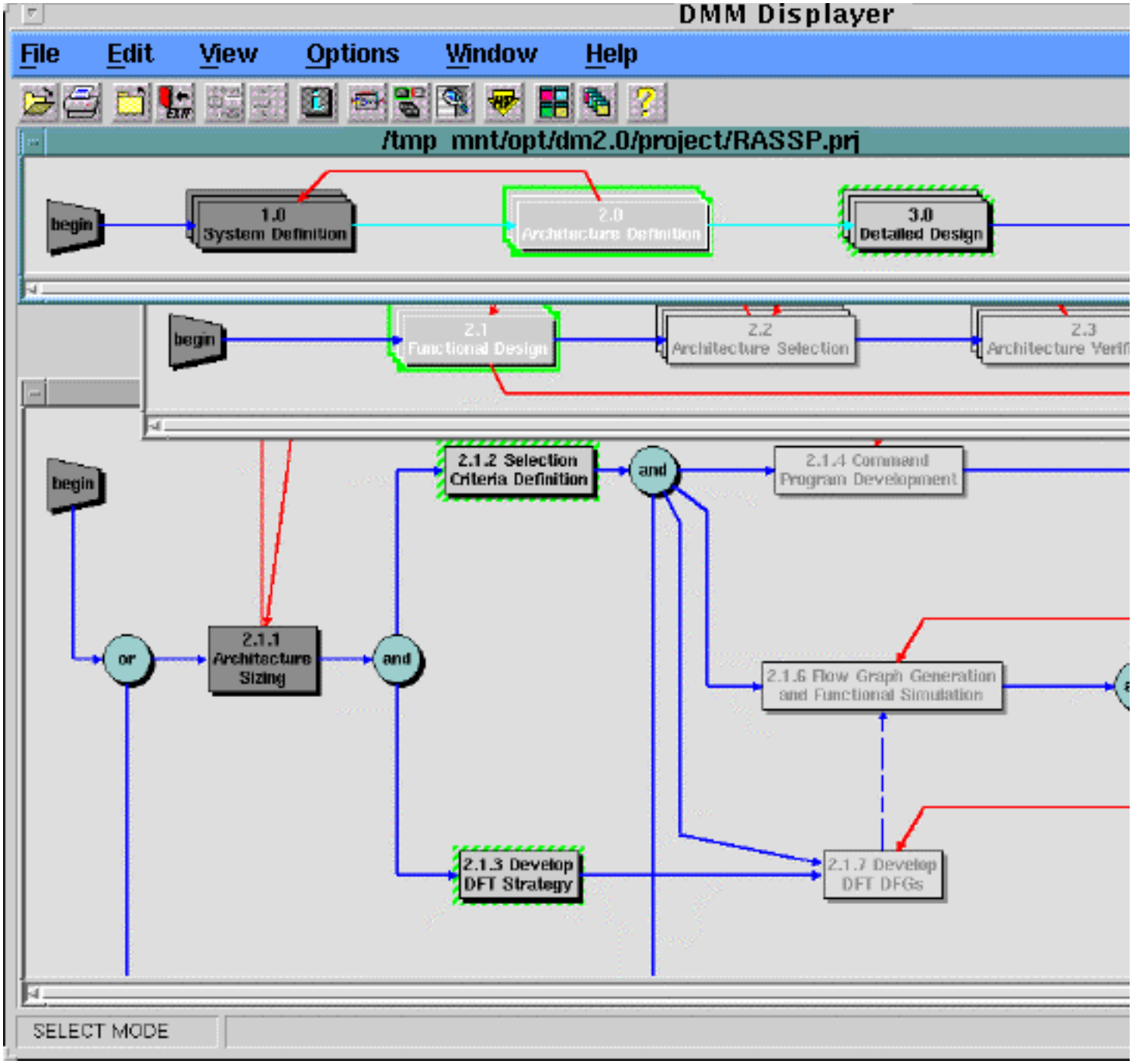

Figure 3 - 3: Workflow Example

Once the new process has been implemented and the users have been trained, the process needs to be maintained and continuously improved. Maintenance is important because the user requirements change over time and new requirements come up due to changes in the marketplace or technology. The workflow tools must provide the agility to handle these changes. System maintenance costs are significant over a system's life cycle, therefore it is critical to invest in analysis and design up front to reduce the maintenance costs.

Go to the Enterprise Framework Application Note for more information on all of the RASSP generated

workflows.

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4.0 Tools

Process engineering and supporting tools and technologies involve multiple categories, which are summarized in this section. These are available from commercial or government sources in most cases.

Process modeling and capture tools capture the user's and domain expert's knowledge into a process model. Tools define process, process steps, and corresponding objects involved in the process. Examples are Prosim from KBSI and DesignIDEF from Metasoft.

Simulation and analysis tools allow users to simulate and analyze captured process. High-end simulation tools allow complex process situations, which are dynamic and probabilistic, to be modeled and analyzed for cycle time, value-added costs, resource utilization, capacity, etc. Simulation tools also provide what-if analysis. Examples are WITNESS from Lanner, Promodel from Promodel, and EasyABC from ABC Technologies.

Workflow tools provides capabilities to assist users with their work processes by providing visual guidance through the process, launching the appropriate applications for the process steps, providing appropriate data-sets needed to perform work, monitoring process status, and tracking work history and metrics. Design tools to be used in the process are encapsulated with the data items they use. Workflow tools launch the right tools for the process step, coordinate with the data management engine to access the appropriate data items, and presents these items to the users for performance of work or restore these items on completion of the work. The workflow model 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.

Workflow tool examples are Design Methodology Manager (DMM) from Intergraph, WorkXpert from Mentor,and KI Shell from Concentus Technology Corporation.

Finite capacity scheduling tools enable users to schedule work on a tactical basis based on process simulations and actual resources available. These tools allow what-if analysis for different scheduling strategies to help determine the cost of changes. Examples are Rhythm from i2.

Project planning tools enable users to plan and manage projects, and they enable high-level task scheduling. Examples are MS Project from Microsoft. Interaction with workflow managers is also supported by project planning tools - enabling synchronization of the management and execution aspects of the projects.

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5.0 Application to RASSP

The Rapid Prototyping of Application Specific Signal Processors (RASSP) program is a multi-year DARPA/Tri-Service initiative intended to dramatically improve the process by which complex digital systems, particularly embedded digital signal processors, are designed, manufactured, upgraded, and supported. The result is a powerful top-down, reuse-based, virtual-prototyping design process and several novel process management capabilities including:

- Model Driven Approach to Enterprise Integration - the process and data models developed were demonstrated on multiple benchmark programs.
- Configurable Work Processes present the right functionality (tools) and the right information to the right users - workflows implemented in the Design Methodology Manager control tool and data access on projects.
- Dynamic code generation for data access based on process model definition - DMM enhancements support runtime generation of execution scripts enabling flexible reuse of process models across projects.
- Integration of project management, workflow management, and information management concepts was developed to achieve a complete executable project definition.
- Concurrent project /process status access to the entire team was achieved through integration with project tools and email.
- Transparent configuration management for the design team was provided with Product Data Management (PDM).
- Templates for rapid deployment of the enterprise system for new organizations or projects within the same organization.
- Support for concurrent engineering - multiple special case process models were developed to support CE design styles
- Reusable encapsulations were developed for several leading ECAD tools.

RASSP design processes have been modeled in IDEF3 and IDEF3x. The to-be processes have been converted into DMM workflows to support design process automation. The information objects modeled in workflows 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. 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 workflow templates 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.

In supporting concurrent engineering in the RASSP methodology, multiple special case workflow templates were developed and applied in domain specific workflows. These cases include:

- Mulitple concurrent tasks using parallel copies of the same dataset
- Multiple design alternatives developed concurrently with the same process
- Pipelining of datasets through a workflow
- Failback paths
- Multiple iterations in a workflow

To setup a new signal processor project, several process related activities occur (Figure 5 - 1). The project manager (PM) can make a copy of a previous project workflow and start tailoring it to the current project needs. The PM can add new workflow segments and modify existing ones based on the project requirements. Once the basic project plan is established, it is exported to a project planning software to schedule tasks and assign resources. The resulting workflows are updated with the business objects required for the project and appropriate objects are created in the PDM system. The workflows are now ready to be executed. The workflows provide appropriate configuration controlled information and tools to the users to perform a task. As the workflows are executed, appropriate project metrics are tracked and are also exported to project planning software. The workflows provide convenient mechanism for the entire project team to be aware of the project progress and status.

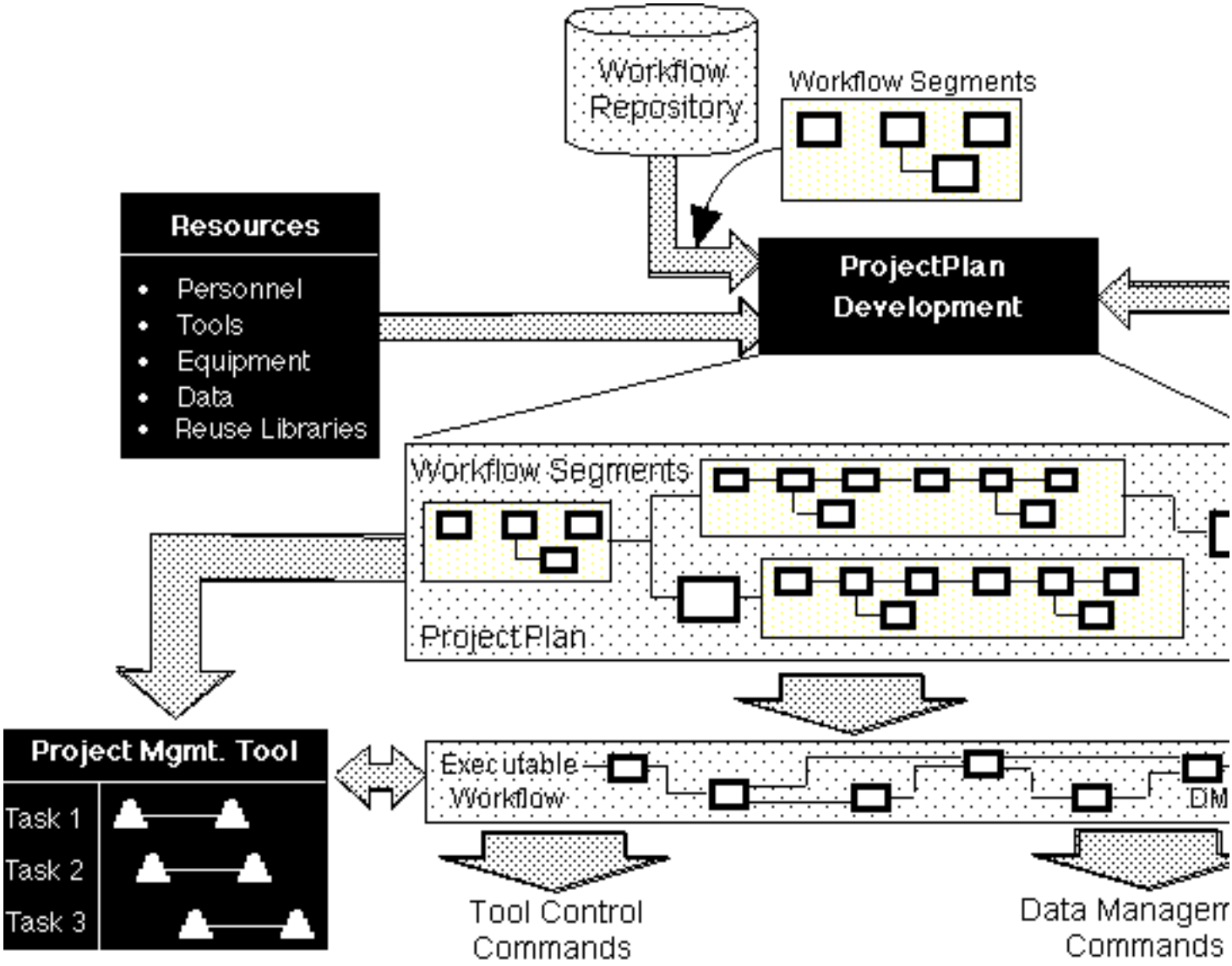

Figure 5 - 1: RASSP Process Data Manager Environment

Several useful process related products have been developed on the RASSP program that will benefit a much broader community. These products are summarized as follows:

- RASSP Methodology Document that documents the TO-BE process models.

- RASSP Enterprise Data Model defining a standards based template for engineering information systems.
- Reusable workflow segments spanning the lifecycle, such as:
  System Requirements Analysis & Refinement, Functional Analysis, System Partitioning, Functional Design, Architecture Selection, Architecture Verification, Chassis Design, Backplane Design, etc.
- Enhancements for Intergraph's DMM Workflow Management Tool including integration with PDM tools, and project support functions
- Enhancements for Intergraph's AIM Product Data Management System for engineering project support.
- High Level Models for Configuration Management and Authorization Management which are implementable in multiple information systems hence can provide a baseline rule set for environments with heterogeneous information systems.
- Various Electronics CAD Tool encapsulations with the DMM workflow tool
- Neutral Language for Process Modeling (PML) based on the IDEF standards
- Process Model Repository (REMR) for management and reuse of PML / IDEF process models

These RASSP products were used on multiple the RASSP benchmark programs.

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6.0 Conclusion

RASSP as well as other programs have made significant advances in process methodology and tools. Despite these advances, significant challenges remain to achieve a complete integrated process technology architecture. This is a result of diverse process functions, methodologies, different tools supporting these functions, rapid obsolescence of tools, limited data exchange capability between tools, and limited support for maintenance and reuse of process knowledge.

In additon to development of specific process tools and models, the RASSP program has developed a complete process toolkit concept to address these issues. This concept represents a long term process vision to be implemented on programs or internal projects subsequent to the completion of RASSP. The process technology concept includes the following components or capabilities:

- Process modeling
- Process simulation
- Process analysis
- Workflow management
- Scheduling (Finite Capacity)
- Project Management
- Exceptions
- Process Reuse Repository

This concept will be implemented using an integrated process toolkit. The architecture for this toolkit is shown in Figure 6 - 1. The toolkit leverages heavily on existing work and commercial tools to provide an integrated capability to address process information representation, exchange and reuse issues. These capabilities will be required to continuously develop faster, cheaper, better products.

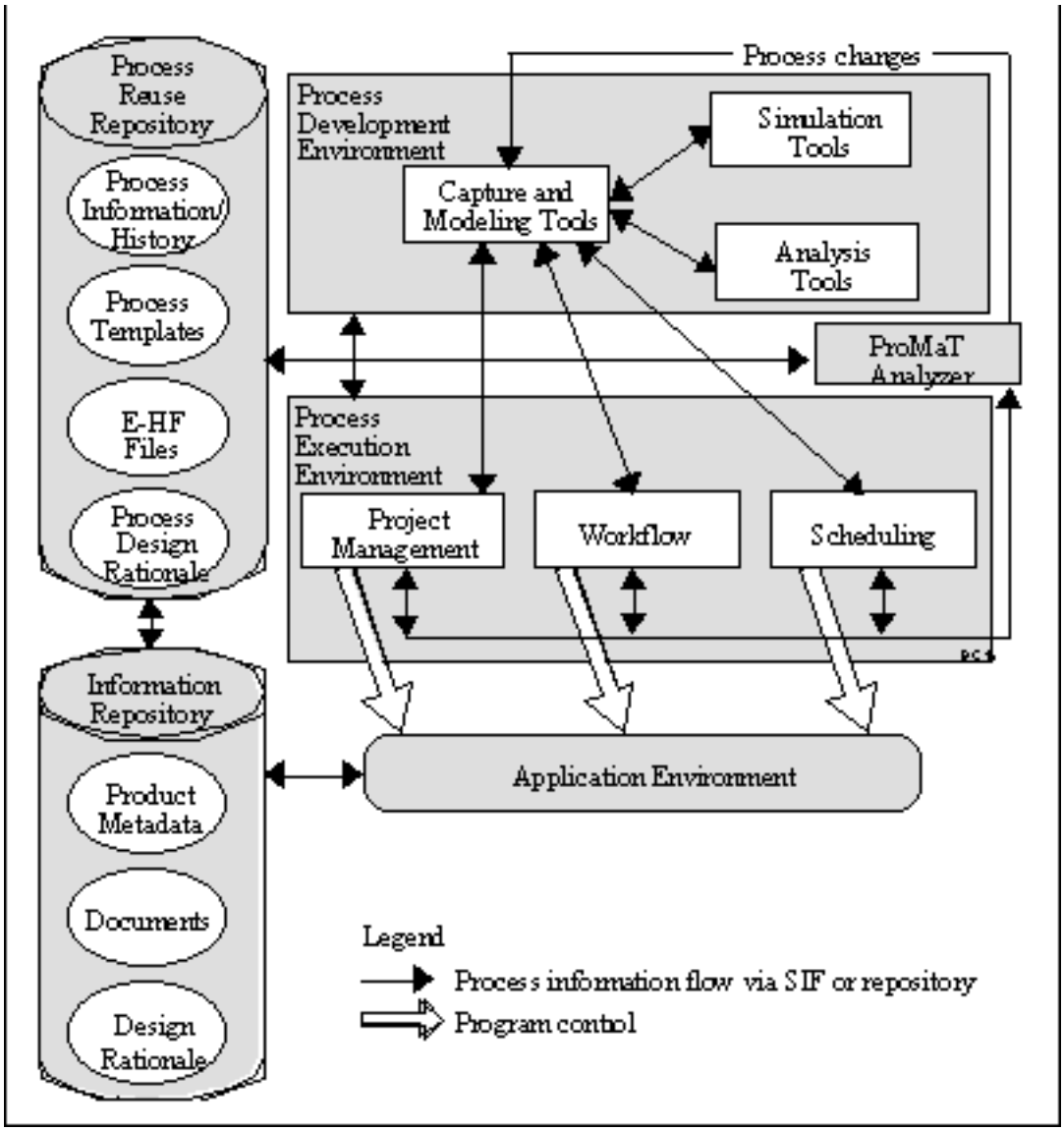

Figure 6 - 1: Process Technology Architecture to Support a Product's Life-cycle

The concept includes repositories for process information in addition to product data. A process development environment supports generation of new process plans leveraging previous models, while the Process Execution Environment supports implemention and metrics tracking on projects. A more detailed discussion of this architecture is provided in [CHADHA_95].

In summary, process based approaches provide a basis for an organization to understand its business and provide a framework to continuously improve how that business operates. This is key to understanding the current processes and developing improved business practices. Process technology toolkits allow rapid transition of process models to working systems, presentation of process integrity across applications, and capability to evaluate alternative processes for key parameters such as cost and development. RASSP has made significant progress in development and enhancement of current process tools, which will be further developed toward realization of the complete process toolkit.

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7.0 References

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7.1 Application Notes

Enterprise Framework
Methodology
