Information Systems For Shuttle Processing: An Enterprise Approach

Mark W. Edson

James E. Showalter

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INTRODUCTION

The purpose of this paper is to describe a process being utilized by Lockheed Space Operations Company (LSOC) for planning, developing and supporting an integrated information system for the Shuttle Processing Contract (SPC). This process was developed by Electronic Data Systems (EDS) to address the complex modernization and integration issues facing General Motors (GM). LSOC has contracted EDS to participate in adapting the process to the environment at Kennedy Space Center (KSC) for shuttle processing.

BACKGROUND

When NASA initiated the Space Shuttle program, a decision was made to distribute the KSC program responsibilities across multiple contracts. Although there was one set of KSC objectives, each prime contractor had the latitude to adopt the methodologies indigenous to its approach. This resulted in a multitude of different systems (manual and automated) across the shuttle program. The decision was made by KSC to consolidate the management of the shuttle program under a single contract, the Shuttle Processing Contract (SPC). As the SPC evolved, the need to integrate the existing information systems for data sharing became apparent.

The shuttle processing environment generates a tremendous amount of data which must be stored, manipulated, and eventually archived. The average shuttle processing flow requires: the use of more than 1800 Operations and Maintenance Instructions (OMI's) and Job Cards (JC's) for vehicle testing; more than 7,000 work orders to maintain Ground Support Equipment (GSE); creation and use of over 1200 Test

Preparation Sheets (TPS's) and Problem Reports (PR's) to support unplanned work,. modifications, and anomaly resolution; tracking the replacement of more than 500 vehicle tiles; analysis and review of more than 100 system modifications and other special requirements; use of over 6000 Ground OMI's to support normal GSE testing; creation of approximately 250,000 pages of documentation; reproduction of more than 31 million pages; and authorizations (stamps or signatures) totalling more than 1.2 million per flow. The administration of this volume of transactions is a monumental effort which is extremely manpower intensive today. The nature of these transactions suggest the need for automation.

The initial approach was to modify the existing systems to accommodate their requirements. After many improvements to the information systems at KSC, NASA and LSOC determined that the existing technology base could not support the data sharing requirements. With this decision a new approach was necessary to meet the program objectives of safely processing the shuttle in preparation for launch, meeting the key milestone dates for each shuttle flow, and increasing the launch rate without compromising the quality and safety requirements. After analysis of both KSC and commercial industrial solutions, LSOC decided to ask EDS to assist in the design and implementation of an integrated solution.

OVERVIEW OF THE APPROACH

Traditional information system approaches at KSC have lacked the mechanism to verify that new departmental information system requirements are consistent with the overall objectives of the SPC. This has resulted in an environment in which it is is difficult, if not impossible, to share resources, to leverage all information resource investments, and to reduce life cycle costs.

The LSOC/EDS approach provides a mechanism to migrate from the existing information systems environment to a new integrated environment which supports the principle of data integration and resource sharing for both the business and technical requirements of the SPC. Emphasis is placed on understanding SPC's strategic objectives, business practices, and information content and relationships. Current business practices must be analyzed and revised if necessary.

The LSOC/EDS approach is composed of six interrelated sub-processes: Strategic Business Planning, Enterprise Modeling, Enterprise Data Modeling, Technical Architecture Planning, Application Priority Selection Process and Application Life Cycle Process. Figure 1 depicts these processes and their relationships. The intent of this paper is to discuss the purpose and importance of these sub-processes and their relationships.

STRATEGIC BUSINESS PLANNING

The initial and perhaps the most important phase of the approach is the identification of the enterprise's strategic direction. Once this direction is known, it can be quantified into a set of guidelines for all tactical level decisions, operations and investments. Automation activities within the enterprise must also follow these same guidelines. Automation decisions should be based not simply on individual departmental needs, but rather on needs which support the strategic objectives of the enterprise. For this reason, the LSOC/EDS approach emphasizes the strategic business planning process.

Relative to strategic business planning, it is necessary to note the differences between the commercial world and the NASA environment. Where commercial enterprises formulate their business strategy based on competitive and profit objectives, NASA contractors accomplish their objectives by satisfying requirements within specific contracts. Therefore the Strategic Business Plan for the SPC is, in essence, the plan established by the SPC to fulfill the terms of the Shuttle Processing Contract.

ENTERPRISE MODELING

Enterprise Modeling utilizes the strategic business plan to construct a model representing the SPC's generic business activities required to meet its mission objectives. The Enterprise Model becomes the architecture or infrastructure for the SPC activities. It should be

ENTERPRISE INFORMATION SYSTEMS PROCESS

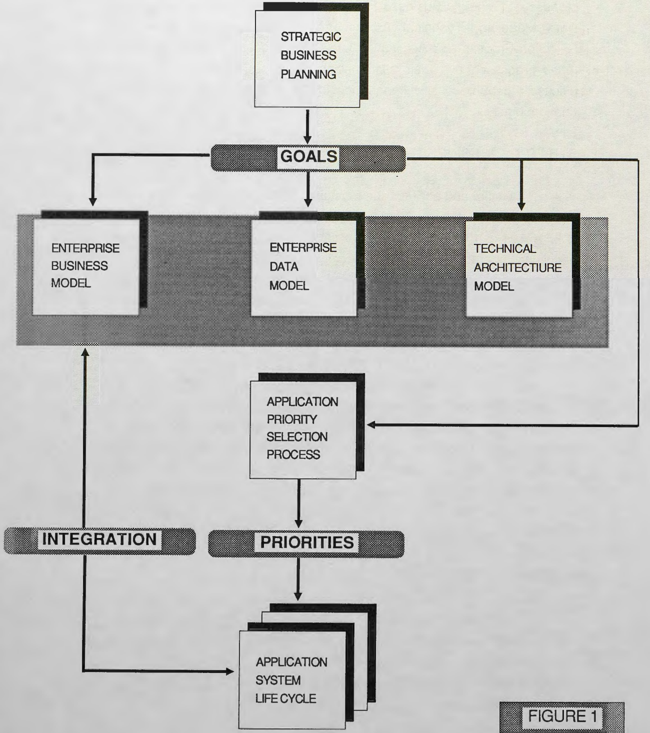

FIGURE 1

understood that the intention of the model is to understand the SPC, and will be used as a management tool for evaluating overall information system consistency. Michael E. Porter, in his two works "Competitive Strategy" and "Competitive Advantage," offers the notion of "value chain analysis" as insight into the formulation of the Enterprise Model. The scope of this discussion prevents an in-depth presentation of Porter's model. It should be noted, however, that the concept of the value chain has been the basis of our Enterprise Modeling methodology for the SPC. The attractiveness of this approach is the simplicity in classifying the key business processes within the SPC, and identifying their integration relationships.

Rather than discuss the detailed elements of the Enterprise Model, it is more useful to discuss its significance and purpose. The Enterprise Model disaggregates the SPC into its strategically relevant activities so that each activity can be analyzed to assure efficiency in meeting the SPC's mission objectives. At this point, the emphasis is placed on identifying the business activities and their strategic importance rather than their current procedural implementation. This model will be used throughout the subsequent more detailed examination of specific system implementations as a means to achieve integration consistent with the objectives specified by both NASA and the SPC.

The creation of the Enterprise Model requires functional descriptions of each of the business activities from experts in each of those fields. It is essential that the model be verified for accuracy and clarity by key NASA and SPC management.

ENTERPRISE DATA MODEL

The Enterprise Data Model is likewise a generic representation of the SPC "objects" or key resources used within shuttle processing and the key relationships between the objects. Examples of objects are parts, equipment, work instructions, requirements, employees, vendors, orders, supplies, etc.. These objects are often called entities. The Enterprise Data Model must also describe the relationships which exist between entities. There can be many different relationships among entities, but when creating the initial Enterprise Data Model, only the key relationships are identified. An example of a relationship is a part relative to a particular assembly or a work instruction relative to an implementation package. Tools and techniques are used to graphically represent the entities and relationships. An example of this is an entity relationship diagram (ERD). As in the case of the Enterprise Model, the Enterprise Data Model must be maintained at a level which the SPC user community can both review and understand. This model will perform the same functional role for SPC data integration and sharing as the Enterprise Model performs for integration of the SPC activities.

Associated with each entity is a unique set of elements which describe the entity. These elements are called attributes. Attributes are data elements such as the status of a work instruction or the weight of a piece of flight hardware. In the course of shuttle processing, the attributes may be assigned different values as the information about an entity changes. That is, a person is reassigned to a new position, a machine is activated from an idle state, or a work instruction is completed. These are all examples of an entity undergoing a change in state. In general, attributes are added to the Enterprise Data Model as part of the information modeling step within the Application Life Cycle Process. That is, as more detail is learned within the information modeling phase of a specific application, the Enterprise Data Model is expanded to include the additional attributes. In this manner, the Application Data Model (to be described in the Application Life Cycle Process) remains consistent with the Enterprise Data Model. Subsequent applications will utilize this expanded Enterprise Data Model to avoid duplication of data, thus promoting the concept of data sharing.

TECHNICAL ARCHITECTURE MANAGEMENT

Equally important to the Enterprise Model and the Enterprise Data Model is the development of a similar model for the technical architecture within which the application systems environment will be installed. The Enterprise Models (i.e. Enterprise Model and Enterprise Data Model) are representations of the SPC activities and data resources and serve as a management mechanism for integration continuity. The Technical Architecture Model is a representation of the integrated set of information resources that must similarly be managed. This model addresses four integrated layers: hardware, software, communications and application services. The scope of this discussion prohibits a lengthy description of each of these critical technical components.

For this purpose, consider these four layers forming a "platform" upon which the applications supporting the SPC are implemented. Residing within these layers are information resources. An information resource can be defined as any resource required to design, develop, and support a specific SPC application. These include hardware components (computers, workstations, communications switches, etc.), software components (operating systems, compilers, application enablers, etc.), and application services (application programs, data bases, system and data specifications, etc.). Ideally, the integrated collection of these information resources should be delivered as a "utility" in support of either an SPC user or information systems expert developing and/or utilizing a specific SPC application. The utility should be delivered such that the underlying technical complexities are transparent to the end user. Additionally, the applications should be independent of the specific technologies inherent to the information resources within the utility. To assure this occurs, the utility must be managed differently from the way in which it has been done historically. This new function is called Information Resource Management.

Within the classical system development life cycle, information systems designers have necessarily (in many cases) imbedded specific attributes of the supporting technologies within the application models. Use of hierarchical and network data base management systems are a good example of this. These systems require specific instructions to be imbedded within the programs to allow the required "navigation" through the data base. Likewise, specific hardware and proprietary operating system characteristics have routinely been incorporated into application programs to achieve functional and performance requirements. Years of this practice has resulted in systems that are highly dependent on vendor specific technologies that are extremely difficult to integrate and/or change. These technologies are changing at accelerated rates and it is not unusual to find many companies with systems that are one or more generations of technology behind. More importantly, the cost for change and support of these systems has grown and now consumes 70-80% of a company's systems staff.

The first step of the solution is the recognition of the Technical Architecture Model (similar in intent to the Enterprise Models) and that the information resources must be managed as an information utility. In the past, many projects had the authority to select the technical platform that best met the needs of the specific project requirements. This led to application specific "islands of technology." With the implementation of Information Resource Management, this practice is revised and the SPC will utilize one technical architecture model for integration consistency. In addition, there has been an assumption over the years that someone trained in programming is also qualified to design major systems. This is equivalent to saying that a carpenter is qualified to architect a major construction project. Experience has shown that system design requires skills and qualifications beyond those which are required for programming. Programmers often evolve into good designers, but programming skills alone are insufficient for competent design.

The purpose of the Technical Architecture Model is to impose a structure that can be supported by a management process for the technology investment. Information technology is so pervasive throughout the SPC and its consequences are so critical to every aspect of shuttle processing that more emphasis must be placed on all subsequent investment decisions. There are no best decisions regarding technology selection, only intelligent choices.

These choices, however, must be made by management knowledgeable about the SPC, the life cycle cost of application approaches, the technological trends, international standards, and supplier capabilities. It is likely that management will need assistance performing this analysis. This is also a role of the Information Resource Management Services provided by LSOC/EDS.

The critical factor in meeting the objective of developing a value added utility which encapsulates the technical resources transparently to the user is the adherence to international standards. It is only through the adoption of standards that integration will ultimately be achieved.

Knowledge about these standards and the vendor positions relative to incorporating the standards within their products is essential. This important task is also the responsibility of Information Resource Management. Many of the critical standards are still evolving and products with full compliance are not yet available. This issue must be carefully managed to avoid expensive future life cycle costs.

APPLICATION PRIORITY SELECTION PROCESS

The above discussions have described the three basic models (Enterprise Model, Enterprise Data Model, Technical Architecture Model), which are based upon a Strategic Business Plan, and together form the means to manage the integration consistency of specific application projects to the overall SPC information system. The next step in the process is the selection of system applications. Ideally, the selection of application system investments should be based upon the priorities defined by the Strategic Business Plan. In the past, application system priorities have been established within each individual organization rather than delineating those priorities in a Strategic Business Plan for the SPC. If the objective is to establish a manageable, integrated set of applications supporting the SPC, it is essential that the investments be made based upon the priorities set in the Strategic Business Plan. The LSOC/EDS process being described in this paper recommends that the existing application change approval board make their decisions in accordance with the Strategic Business Plan. Additionally, the LSOC/EDS process provides the mechanisms through which the application change approval boards can verify that each project is in compliance with integration consistency prior to making their decisions.

APPLICATION SYSTEM LIFE CYCLE

The next step is to develop or acquire the specific applications required by the SPC. To accomplish this a methodology is required. EDS has developed a corporate standard methodology, called the System Life Cycle (SLC). This methodology has been adopted by the LSOC/EDS team for the SPC. The SLC methodology is a synthesis of information system methodologies which have evolved over the past twenty-five years. In addition, it incorporates new concepts required for modern applications. The objective for this sub-process is to deliver an application which has been prioritized by the Strategic Business Plan and which supports the requirements defined in the Enterprise Models.

The SLC is composed of nine basic steps defined as follows:

1. Information Planning -
   If the Enterprise Data Model does exist, then this step is not required. However if it does not exist, this process produces a Data Model for the specific application. This Data Model then becomes the genesis of the Enterprise Data Model.
2. Definition -
   Process for defining a particular SPC problem and strategy for developing a solution.
3. Analysis -
   Process for defining the requirements that must be incorporated within the solution. Within this process, the Application Data Model (i.e. logical data model and ERD) for the particular application is developed and verified against the Enterprise Data Model.
4. Business Design -
   Process for aligning the SPC business practices with the agreed upon solution. Included within this process is a check to verify consistency with the Enterprise Model.
5. Technical Design -
   Process which identifies all technical specifications and application unique architecture requirements imposed by the implementation of the agreed upon solution. Included within this process is a check to verify consistency with the Technical Architecture Model.
6. Construction -
   Process which develops the program modules for the application based on the technical specifications.
7. Testing -
   Process which validates the application against the design specifications.

8. Implementation -
   Process which installs the application within the targeted environment, and validates conformance to the user requirements and to management commitments.
9. Production Support -
   Process which assures continued availability of the application. Included are such activities as: reactive maintenance, security protection, operations support, disaster recovery and configuration/version control.

In addition to these nine operational processes, there are processes that must be installed to support the entire SLC. These processes are called system life cycle support services and include project management, life cycle configuration management and software quality assurance.

SUMMARY

This paper has presented a general overview of an integrated approach for the planning, acquisition/development and support of information systems for the SPC. The process is being utilized within General Motors and other commercial clients, by EDS, and an adaptation of this same process has been selected by LSOC to address the complex integration issues facing the SPC.

The goal of this process is to provide a level of integration which the classical application development approaches have not accomplished. In any complex environment, automation must occur in phases. To achieve an integrated information systems environment as each of these phases are implemented, a well defined management process must be established. This paper addresses both the business and technical features of this management process. The process is sub-divided into six inter-related phases:

1. Strategic Business Planning -
   Phase which establishes the enterprise's prioritized objectives couched within their long term goals.

2. Enterprise Model -

   Phase which establishes the generic model of the business activities. It is used throughout the process to guide the consistency of business policies and procedure as implemented in specific information system applications.

3. Enterprise Data Model -

   Phase which establishes the generic model of the data resources used to support the Enterprise Model. It is used throughout the process to guide consistency of data definition and relationships as implemented in specific information system applications.

4. Technical Architecture Model -

   Phase which establishes the generic model of the technical resources to support the enterprise information system. It is used throughout the process to guide consistency of technical resource investments, and conformance to standards as implemented in specific information system applications.

5. Application Priority Selection Process -

   Phase which establishes the process for identifying the specific application investments necessary to support the enterprise's prioritized objectives.

6. Application System Life Cycle -

   Phase which establishes a nine step process for the conceptual, logical and physical implementation and support of specific information system applications.

The key differences of this approach from others are the emphasis on inter-relationships between all phases, integration, shared resources, the reduction of application life cycle cost, and management and user involvement. Experience has shown that automation decisions and business decisions must be made together in order to achieve the expected return on information systems investment. LSOC/EDS expect that the SPC's administration of the shuttle program will significantly improve through the implementation of the disciplined processes inherent in this approach.