INTEGRATED LOGISTICS SUPPORT DEVELOPMENT TECHNIQUES FOR SMALL SCALE SYSTEMS

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The increased cost of ownership for major systems compared against the initial procurement cost brought about DOD Directive 4100. 35, Development of Integrated Logistic Support for Systems and Equipment. Departments of the Army, Navy, and Air Force published MICOM 750-Series, WR-30, and AFSCM 37-5 respectively. Likewise the National Aeronautics and Space Administration published NHB 7500. 1 to integrate the development of their logistics requirements. These publications were all issued to insure that life cycle costs, as well as initial purchase costs, would be considered in evaluating procurement of a major system. The integrated approach outlined in these documents calls for complete documentation and full use of automatic data processing, both of which greatly increase initial development costs. These increased costs cannot always be justified for systems operating at a limited number of locations; however, the techniques called for in these DOD and NASA publications can be employed in an abbreviated manner. The abbreviated techniques are accomplished at reduced cost without detracting from the overall quality of integrated logistic support.

This paper outlines the formalized technique for development of Integrated Logistics Support Systems and compares it with a procedural model technique adapted to specific system requirements. This accomplishes cost effective establishment and management of logistics requirements which have been successfully implemented on various NASA and Air Force Aerospace Ground Equipment Programs.

INTEGRATED SYSTEM DEVELOPMENT

The Integrated Logistics Support concept promulgated by DOD Directive 4100. 35 emphasized the need for development and implementation of logistics resource requirements concurrent with the development and implementation of the operational system. The requirements established by DOD Directive were satisfied by the Navy in WR-30, the Air Force in the 375 series documents and the Army in the AR-750 series documents. NASA also recognized the need for Integrated Logistics Support and implemented it through the NPC and NHB series of documents.

Integrated system development, although described in somewhat different terms by each DOD military department and by NASA, is accomplished through similar techniques. A fully supported operational system is achieved through the approach depicted in Figure 156. The three areas requiring development are the operational system, the logistics support system and test, demonstration and deployment requirements.

The mission requirements are usually established by the using agency. Based on these requirements a mission analysis is performed to allocate the operational functions required to various portions of the total system. In addition, the mission analysis establishes the maintainability and reliability requirements necessary to assure that the desired system availability can be achieved. Reliability and maintainability are designed into the operational system; however, maintainability requirements establish goals for the development of the logistics support system. Test, demonstration and deployment requirements also are established during mission analysis.

The mission analysis results in a top level specification which provides integrated performance criteria as a set of design goals for the three areas of development. Trade study efforts and constant interchange of data between these three development areas assures development of an integrated system. Configuration Management and various Management Information System techniques are employed to provide control and visibility to the develop-

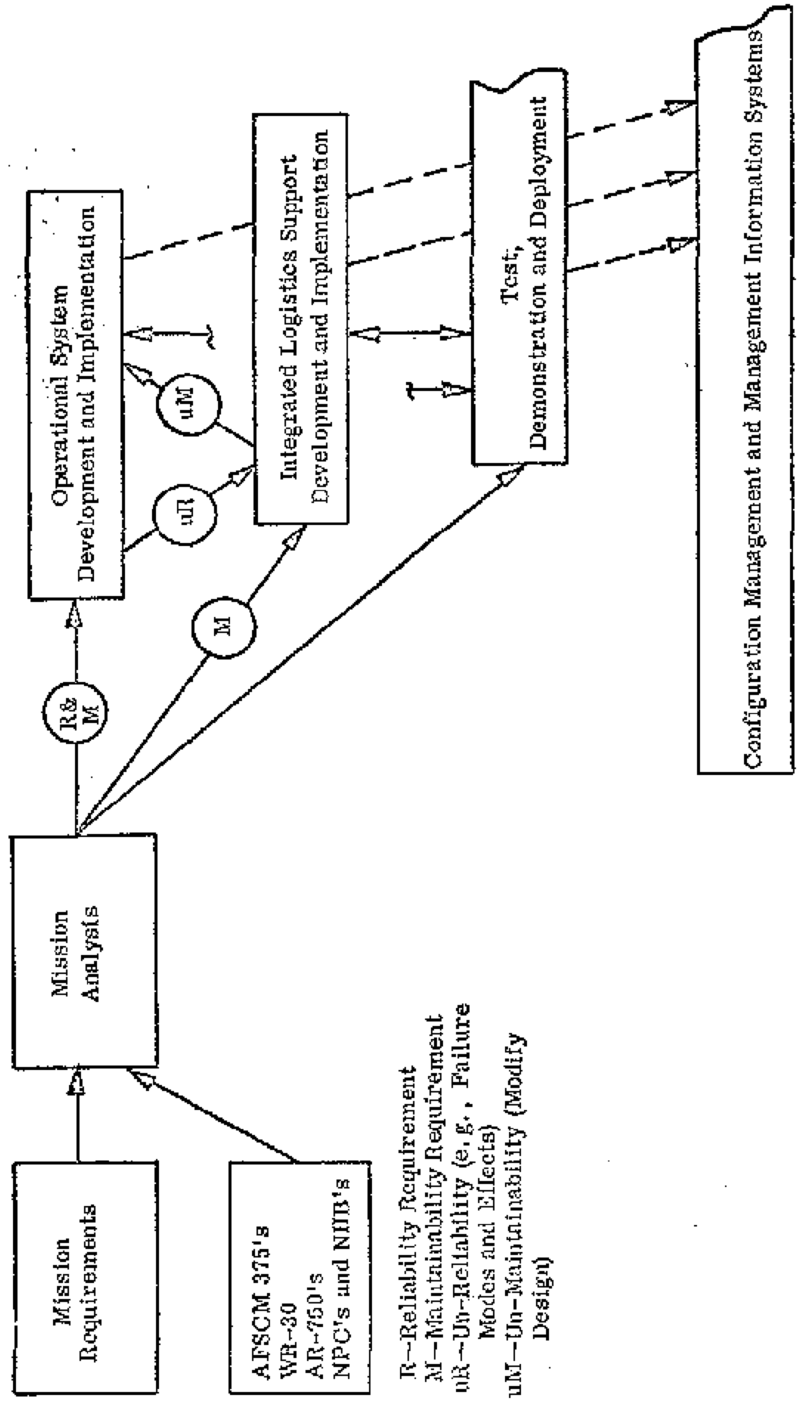

Figure 156. Integrated System Development Approach

ment and implementation program. They thus permit the separate development activities to proceed effectively in a concurrent, parallel and integrated manner.

INTEGRATED LOGISTICS SUPPORT

The process used for development of Integrated Logistics Support is shown in Figure 157. This flow diagram depicts the interrelationship of the activities required to produce integrated requirements for the logistics resources needed in support of the operational system. Mission deployment criteria and logistics support concepts and criteria are products of the Mission Analysis. (Figure 156) Product configuration data and failure modes and effects are products of the Operational System Development (Figure 156).

Mission deployment criteria of concern are the operational uses of a system which influences the logistics support resources. Operation of a system over many dispersed locations throughout the world, or even throughout the continental United States, presents a different effect on development of logistic support than operation of a system in a single location. The logistics concepts and criteria provide the basis for establishing and quantifying logistics resources at each location in the supply and maintenance complex. The concepts and criteria establish such items as the echelons or levels of maintenance and supply required, the broad functions to be performed at each level, the transportation capability available for replenishment, the pipeline factors and times introduced by the support system and specific limits placed on in-line or operational maintenance.

Product configuration is defined by end item design specifications, schematics, circuit and wiring diagrams, assembly drawings, and manufactured parts lists. The status of this data is recorded and controlled by configuration management techniques.

Failure modes and effects analysis produces the potential failure paths to be considered when performing the "Analysis of Integrated Support Requirements" commonly referred to as maintenance analysis.

The logistics resource requirements identified through the process of maintenance analysis are grouped into the major areas of spares, support equipment, technical support data, personnel and training, support facilities, and support services. This analysis also identifies potential maintainability problem areas. Possible solutions to these problems are evaluated by trade studies and incorporated into systems design as maintainability improvements.

FORMALIZED MAINTENANCE ANALYSIS

The recommended procedures for accomplishing and documenting the mission analysis and the development and implementation activities of Figure 156 are formally established by WR-30, AF 375, AR 750 and NHB 7500. The formalized approach for Integrated Logistics Support Requirements Analysis (maintenance analysis) is shown in Figure 158. The System/Equipment Design block represents the inputs to the analysis shown in Figure 157, while the Integrated Logistics Support Requirements block represents the six logistics resource areas depicted as outputs of the analysis process in Figure 157. The various forms to be completed when utilizing the formal approach are listed in Figure 159. Each maintenance activity which could be performed on an operational end item of equipment is identified on the end item maintenance sheet correlated to the specific assembly or subassembly with which it pertains. The spare part required to complete each activity is identified by specific part number.

The maintenance actions planned on the end item maintenance sheet are further analyzed to establish the support equipment, personnel, technical support data, and facilities required for their accomplishment. The requirements allocation sheet is used as a guide in performing this analysis. The requirements allocation sheet describes and documents the

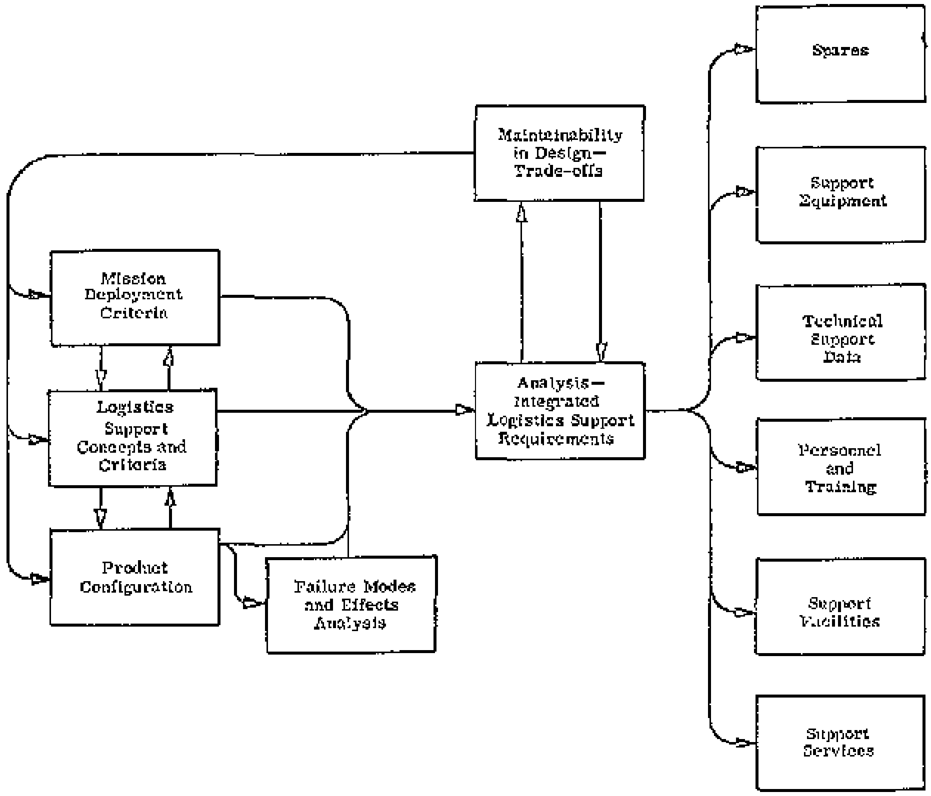

Figure 157. Integrated Logistics Support Development

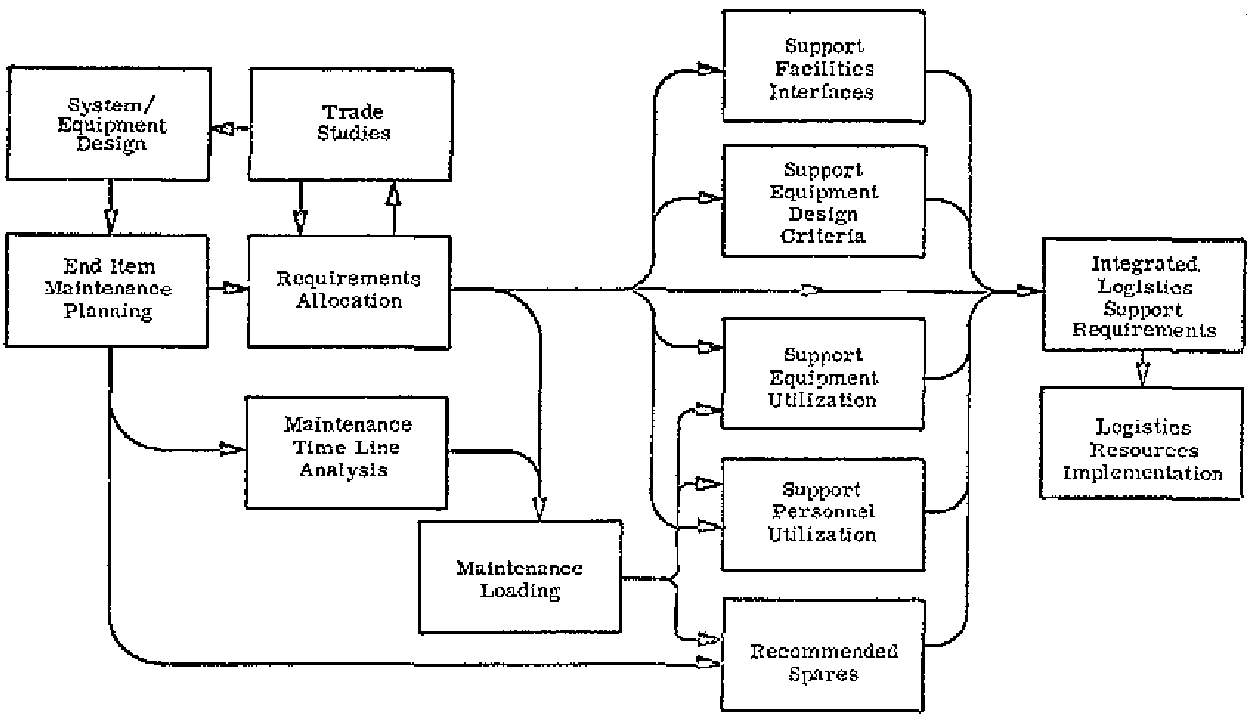

Figure 158. Flow Diagram for Formal Approach

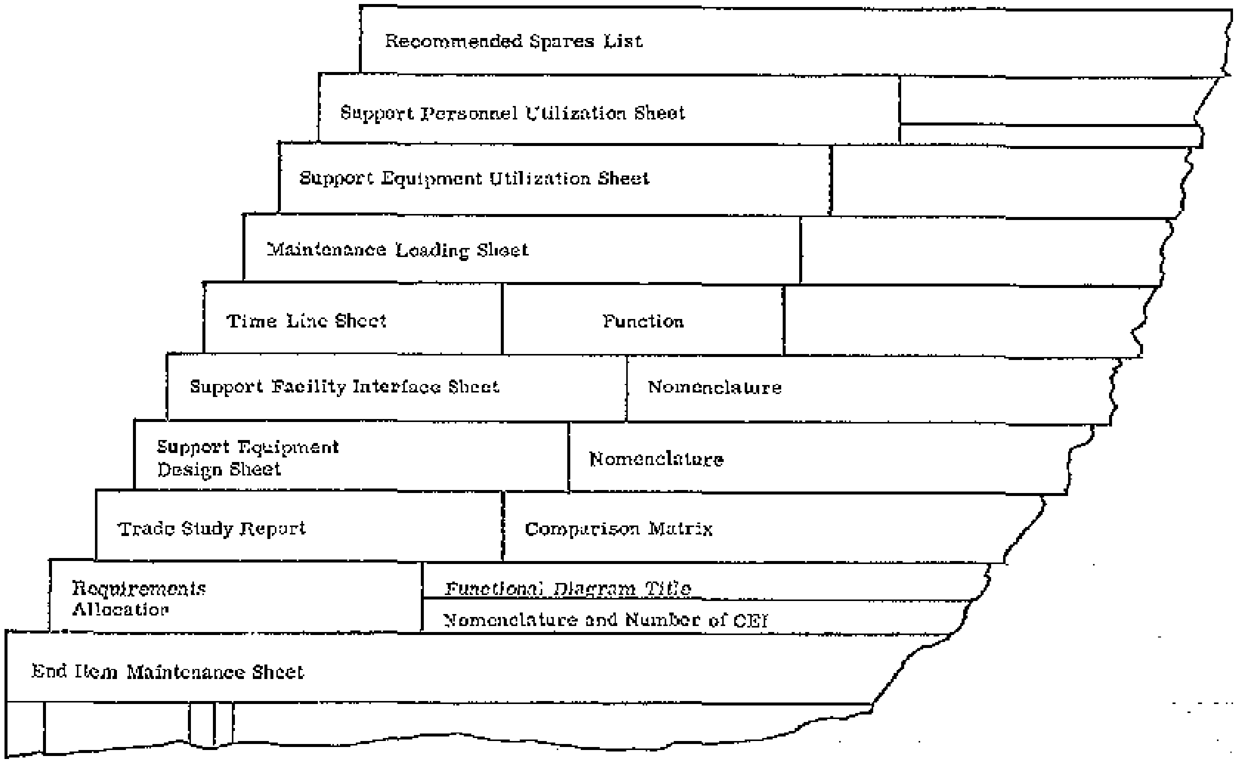

Figure 159. Formats for Formal Approach

results of the analysis. A time-line analysis of the maintenance actions is also performed and documented on the time-line sheet. Any stringent technical, cost, or repair time requirements resulting from these analyses are subjected to trade study analysis to evaluate possible alternatives for more effective solutions. These can result in modifications recommended to prime equipments, as well as changes in the functions allocated among the logistics resources. Trade study reports are used as a guide in performing these studies and for documenting results.

Engineering specifications data for support facility and equipment items are prepared based on a compilation and grouping of the requirements allocation sheet results for the individual maintenance actions. These data are prepared on the facility interface and design sheet formats of Figure 159. Personnel performance and technical support data requirements are compiled directly from the requirements allocation sheets.

A maintenance loading study is performed based on the requirements allocation sheets, probabilities of incidence for each maintenance action, and time-line analyses. This study results in estimated utilization rates for support equipment and personnel. When results from all end items are compiled, utilization rates are obtained for the entire system.

Recommended candidate spares lists for each maintenance location are compiled directly from the end item maintenance sheets. Estimated quantities of each spare for the end item being analyzed are determined from the maintenance loading analysis. The results of these analytical and processing efforts are summarized into engineering specifications for the integrated logistics support requirements for each end item. These are often compiled along with descriptive data on the end item and the logistics support concepts into an End Item Report. The compiled data serve as the basic act of technical specifications for logistics resources implementation.

The type of detailed approach is very comprehensive. It documents all major, and a substantial portion of the minor, engineering decisions throughout the conduct of the analyses. If this type of approach is carefully controlled and standardized, substantial portions, especially loading and utilization elements, are adaptable to automatic data processing methods. When these methods are implemented, they are very valuable tools for evaluating trade study alternatives and prospective modifications, as well as compiling and computing utilizations.

PROCEDURAL MODEL

The "Procedural Model" technique was devised to provide integrated logistics support development for the small scale system. Procedural model is a term selected to identify a set of forms and their applicable instructions which are used to standardize the process of performing the integrated logistics support analysis. Figure 160 illustrates the inclusion of the procedural model into the integrated systems development approach. The formal approach established in Figure 158 represented a complex procedural model developed for handling the large scale system. The formalized approach to integrated logistics support analysis is most applicable to systems with large deployment quantities which represent opportunities for substantial cost savings by optimizing large quantities of logistics resources. The expense of using this formalized approach is well justified in relation to initial procurement and anticipated life cycle costs for the system. In the case of small scale systems, use of these techniques and procedures are not always warranted since they greatly increase the initial procurement costs. These costs can be controlled through tailoring of the formal procedural model by decreasing the requirement for detailed step-by-step documentation of the analysis process used to achieve integrated logistics support. The selection of the procedural model for a particular system is based on the cost effectivity of applying the model selected.

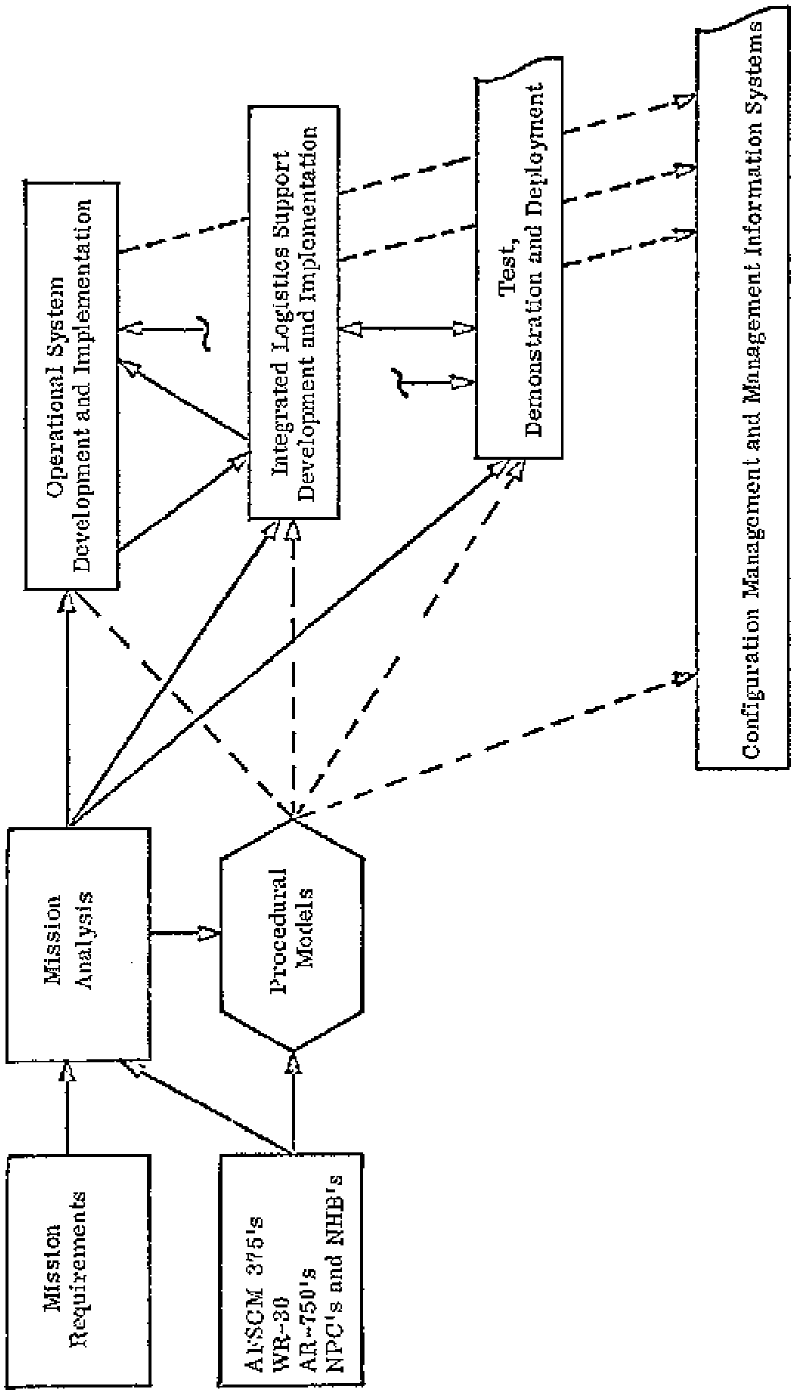

Figure 160. Integrated System Development Approach with Procedural Model

PROCEDURAL MODEL CRITERIA

The basic factors to be considered in selecting the procedural model to determine the logistics support requirements are mission operational requirements and duration, logistics support concepts, equipment complexity, deployment quantities and locations, user resources available, anticipated field modifications, development and implementation status of the system and computer-aided techniques available. Mission operating requirements to be considered are periodic short duration operations of several days once-a-month, versus long-term sustained operation for 24 hour-per-day, 365 days-per-year.

Logistics support concepts establish the maintenance activities to be accomplished at the operating facility, at local shops and at remote depots or vendor factories. Where maintenance at operating facilities is limited to removal and replacement of subassemblies, the amount of detailed analysis required is greatly reduced from that required when repair is accomplished at the same level.

As equipment operation and design complexity increase, the need for more detailed procedural models also increases in order to provide assurance that logistics support is being effectively established. The detailed analysis provides a detailed breakdown of fault isolation techniques which are more involved for complex systems.

Deployment quantities and locations provide a strong basis for establishing the level of the procedural model to be selected by the logistics engineer. When large quantities of basic system are deployed in dispersed locations, the expense involved in performing the detailed analysis can be justified, since the cost can be apportioned over the number of systems involved. The dispersed locations necessitate detailed analysis to substantiate the logistics requirements for each operating location versus those for the area support depots.

User resources available are also considered when selecting a procedural model for establishing integrated logistics support. The existing logistical establishment of repair facilities, support resources, as well as type and skill level of support personnel applied to maintain and operate a system, are key factors in the level of detailed analysis documentation required. A documented logistics system is needed as a basis for control if field modifications of a system are anticipated. The procedural model must identify the established logistics resources in order that controlled changes to these resources can be accomplished as field modifications are implemented.

As a system progresses in development and implementation, more detail are available on performance of the system and experience with maintenance requirements of the system is increased. Only limited analysis of an implemented system is required, since logistics resources in these cases are established from field data.

Another consideration in developing a procedural model is the availability of computer-aided techniques such as end item lists and spare parts lists. Preparing recommended spares lists in the format required for automation data processing facilities can reduce the documentation requirements of the model.

SMALL SCALE SYSTEM

Launch support equipment which supports the ground equipment used to launch a space vehicle can be classified as a number of small scale systems. It is required to operate with a high degree of reliability during the launch countdown cycles of the mission, thus must be rapidly restored to operation in the event a failure occurs. It is therefore necessary that highly efficient logistics support be provided during this launch countdown cycle.

The electrical launch support equipment is a one-of-a-kind system operating at a single location primarily requiring local support with a limited amount of depot repair. The development of its logistics support requirements thus typifies an approach directly applicable to small scale systems.

COST EFFECTIVITY

The selection of a specific procedural model tailored to meet an individual program need is directly related to the reduction in operating and maintenance costs which can be realized for the expenditure of funds necessary to complete the logistics engineering task. The initial procurement costs for a system are based on development and implementation costs for the logistics support system as well as the operational system. Figure 161 illustrates the relative cost effectivity for three different procedural models used to determine integrated logistics support requirements for a hypothetical program. The development and implementation costs for the operational system are assumed to be the same for the three cases illustrated. In Case A the development of logistics support has been minimized to reduce initial procurement costs. This approach can result in relatively high operating and maintenance costs of the system, with an excessive utilization of logistics resources.

An over-engineered approach to integrated logistics support is illustrated by Case C, where the operation and maintenance costs of the system have been minimized, but engineering costs during initial procurement have been maximized.

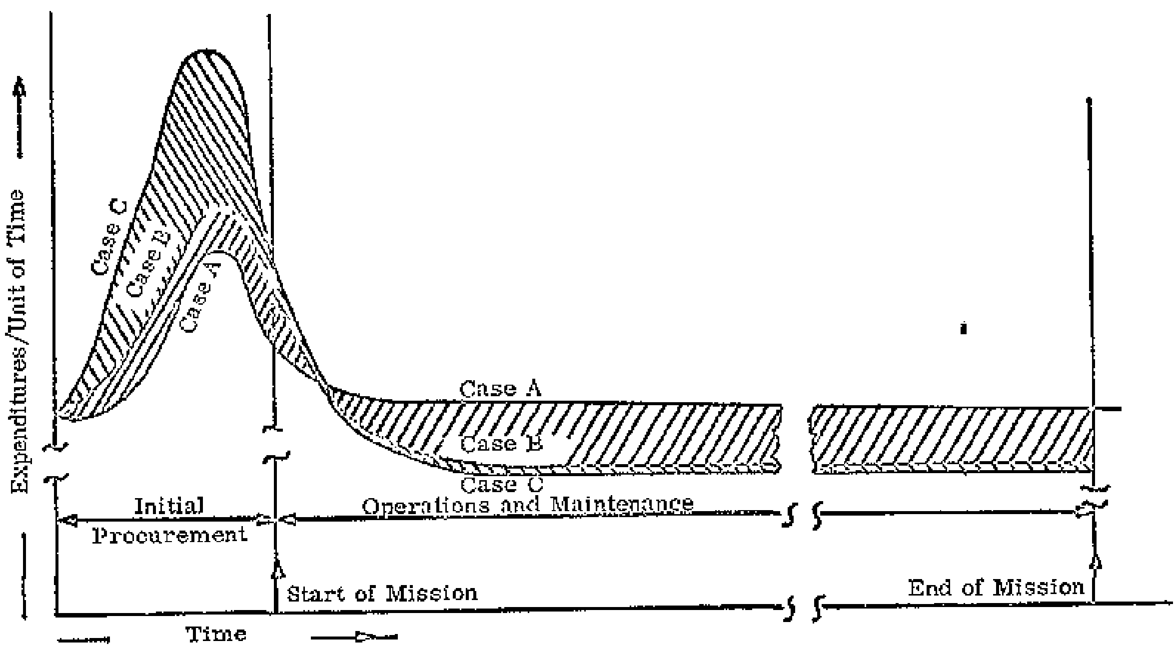

Figure 161. Procedural Model Cost Effectivity with Respect to Life Cycle Costs

Case B approaches the optimum selection of a procedural model. The decrease in operations and maintenance costs justifies the funds expended in development of integrated logistics support during the initial procurement phase.

The cost effectivity of the procedural model selected is depicted by the relative areas between the curves for the three cases illustrated.

Case B is justified over Case A by a comparison of the return in operations and maintenance dollars saved, against the initial procurement dollars expended. On the other hand, Case C cannot be justified over Case B, since increased initial procurement expenditures far exceed the return realized in reduced operation and maintenance costs.

The flow diagram shown in Figure 162 illustrates the procedural model technique approach used for the electrical launch support equipment. Considering the state of the system, the existing support establishment and the operational mission requirements, this model was developed. It produced a logistics support system satisfactory for the operational needs of the system in a cost effective manner. The entire formal process for compiling maintenance loading and utilization sheets and detailed maintenance activity sheets was eliminated. The use of the forms shown in Figure 163 combined several functions of the multiple formats of the fully detailed model previously shown in Figure 159.

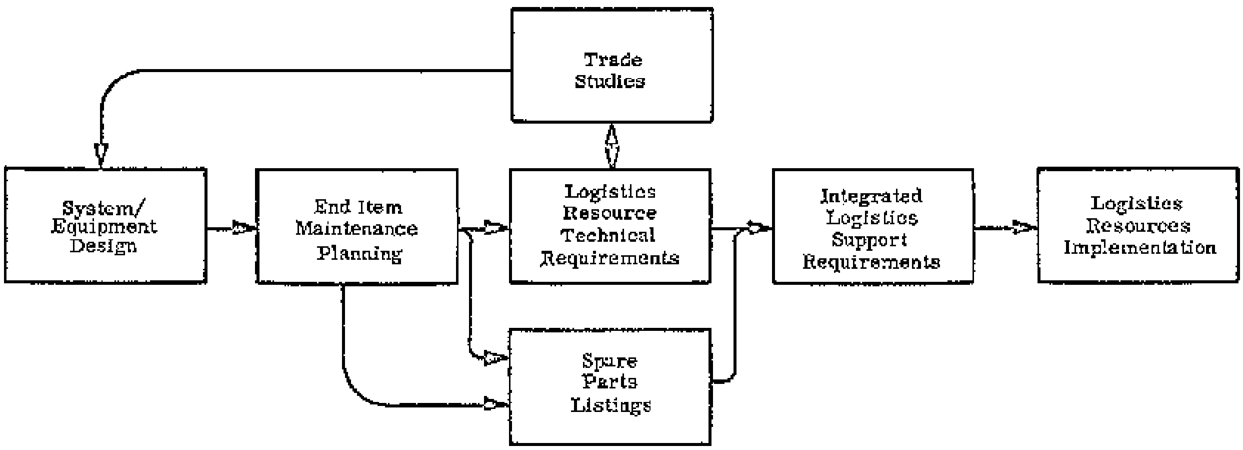

Figure 162. Procedural Model Flow Diagram for Small Scale System

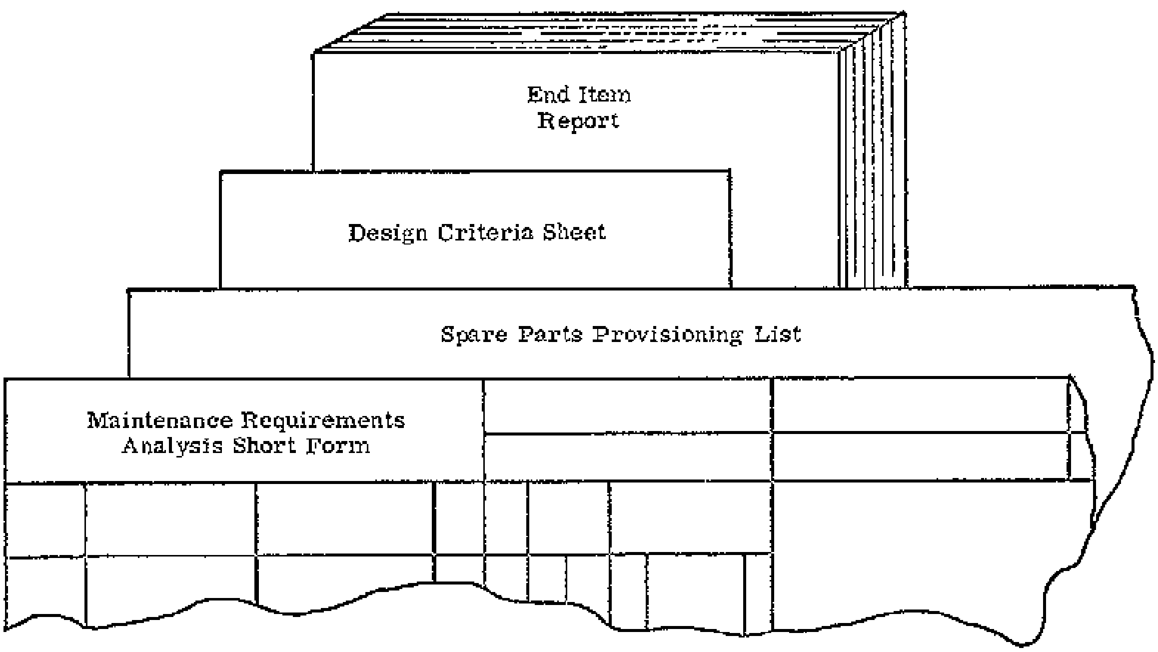

Figure 163. Procedural Model Formats for Small Scale System

The reduction of the number of separate sheets represented between these two approaches is not necessarily indicative of a proportionate reduction in the engineering content. There is, indeed, a reduction in the documentation involved. The same basic analytical processes are involved. Only the primary results of this process are documented, rather than each and every decision-step in reaching these results. This represents a considerable saving in effort. Some risk may be involved in terms of the lack of availability of detailed information for subsequent evaluation. This risk may be evidenced in fielding less than fully optimized logistics resources. The impact of this risk can be minimized by performing the engineering in a manner which gives priority to situations concerned with high value, long-lead time, and other similar program-oriented criteria.

The Maintenance Requirements Analysis Short Form identifies all the logistics support requirements for spares, MGE, special procedures, personnel and/or facilities for specific assemblies which make up an end item. The maintenance activities are analyzed but not recorded. In addition, a spare parts list is generated to provide identifying data quantities and locations in a format ready to be key punched into the automatic data processing system. The requirements identified on the MRA and the spares lists are summarized in End Item Reports (EIR's). The End Item Report provides an integrated compilation, by location, of all support items required to maintain the end item. Total integrated requirements are obtained by combining the data in these EIR's for all end items used.

The End Item Report identifies the end item considered during the analysis, specific drawings used in the analysis process, the support concepts for the end item, requirements for all logistics support areas (e.g., personnel, spares, MGE, transportation, facilities, etc.) and also lists any special items of equipment either MGE or recommended revisions to operating equipment which are required to maintain the system.

Integrated logistics support must be developed on a systematic, controlled basis. The formalized techniques presented by the DOD military departments and NASA provide a sound approach to integrated logistics requirements analysis for complex systems with highly dispersed deployment. Applying these techniques directly to small scale systems is not cost-effective; however, procedural models can and should be developed which tailor the formal approach to the small scale system. Experience has proven that use of the procedural model tailored to the system results in implementation of the desired integrated logistics support resources in a cost effective manner.