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ABSTRACT

This paper summarizes the status of management information systems with emphasis on applications to planning and management of airline maintenance and refurbishment operations. Past approaches to management of launch operations are reviewed and analyzed for their applicability to the Space Shuttle era. Factors affecting the selection of a management information system for the Shuttle will be analyzed and discussed.

INTRODUCTION

It might seem presumptuous for a paper on this subject to be submitted by an airline. Obviously, the airlines do not possess either the scientific background or the expertise in rocket technology required in existing space programs.

But as the space community has pioneered in the development of outstanding vehicle designs, extraordinarily successful programs and missions, so American Airlines has pioneered in the development of management systems for airline maintenance and refurbishment (along with leading in the development of many innovations in maintainability and reliability).

Now that the space program is approaching the era of launching re-usable vehicles (shuttles) carrying a payload (generally comparable to the airline's atmosphere - limited re-usable vehicles carrying a payload) leading to similarities in purpose and operation, some of the successful management techniques employed in the airlines might form some useful baselines for application to the shuttle program.

This paper will highlight the key factors in the maintenance and refurbishment challenges faced by the airline, review the pertinent aspects of past launch operation management and identify, in some detail, significant factors which are important to the management of the shuttle operational phase.

AIRLINE MAINTENANCE AND REFURBISHMENT

The challenge of airline maintenance and refurbishment is: to produce safe, clean and airworthy aircraft at the departure gate on time.

Maintenance

While this is complicated by the airline fleet size and routing, the major consideration is the constraint on ground time available to do the maintenance work. At the maintenance point, the local planning to identify the bill of work to be performed (planned maintenance and scheduled modifications), allow adequate time for unplanned repairs, marshall the resources and logistics support to do the required work - with work completion within an elapsed time of less than 8 hours ground time - is a major challenge.

The situation used to be simpler when components (from engines, instruments and accessories - known in the space industry as Line Replaceable Units (LRU)) were removed at fairly fixed intervals under a time or block control program. Now, however, American Airlines has led the industry in a Condition Monitored Maintenance (CMM) program where the performance of major aircraft work, engines and critical LRUs are continuously monitored. When performance approaches a critical level, the particular work is scheduled for completion. This introduced an element of variability to the planning and scheduling of work which increases control requirements immensely. But the gains in reliability and reduced costs far outweigh these complexities, so this challenge is accepted and met.

Spare LRUs and parts must flow in phase with these constantly shifting maintenance requirements. Acquisition, replenishment and distribution to removal and replacement points and the return of LRUs to the refurbishment point is a parallel management requirement.

Refurbishment

Up to now, the permutations in maintenance have been highlighted. But at times, the aircraft requires refurbishment or a modification beyond the practical limits of maintenance. Then the aircraft is scheduled for major work at the AA Maintenance & Engineering Center at Tulsa, Oklahoma.

Concurrently, the LRUs from field stations and many major units off aircraft at Tulsa flow into the refurbishment shops in mammoth volumes (200,000 units per year). The same emphasis to anticipate workload and minimize both the work requirement and out-of-service time (within the framework of good maintainability and reliability parameters) are essential ingredients in the planning, scheduling, and accomplishment of major aircraft and refurbishment shop work at Tulsa. This involves control at three levels - aircraft, engine and LRU/repairable part level, with rapid turnaround to the demand, quality, optimum productivity and performance: the management challenge.

Flowing from the maintenance point, aircraft positions at Tulsa and refurbishment shops, is a torrent of performance, reliability and cost data. These must be summarized at each level of cost and performance control - from product area involved, up through succeeding echelons - to develop cost and performance on the particular aircraft and finally, to the fleet. These must be correlated to performance goals and deviations quickly identified for corrective action.

In another interrelated cycle, refurbishment material is being planned and replenished with superseded parts being disposed of and new items acquired - all within parameters of availability and investment.

At the same time, the skillpower resources must be managed - skill, qualification, assignment, productive and lost time - goals and results. All of these impose stringent demands on planning and scheduling with a need for precision and rapid response for unplanned conditions when they occur.

Airline Management System Factors

Obviously, the foregoing does not begin to describe the full scope and depth of the maintenance and refurbishment activities. But it should be clear that there is a need for responsive interaction among all geographic locations, functions, and activities to manage the total aircraft quality and readiness successfully.

The complexity often forces airline management to attack each function separately - to design and implement independent manual or computer systems for each of the many functions. This appears to be the simple approach at the outset, especially when each organization viewed only its own parochial interests. At one time, American Airlines had twenty-one separate computer applications to service the functional needs, some of which overlapped others, processed and reported the same data from diverse sources and often produced conflicting results. The natural result of continuing this approach is to lead to an information dispersion, spreading out further and further until all semblance of management cohesion disappears.

Evolution Of The Maintenance Control System

The remedy is to reverse the trend to separation and this is what American Airlines has pioneered in the industry - the development of an integrated and interfaced Maintenance Control System (MCS) for the control of all maintenance and refurbishment activities - to plan, direct, and control the work on aircraft, engines, LRUs and service work. The Maintenance Control System is both a plan and an actuality. (Figure 1) The plan outlines the scope of the activities to be covered, encompassing all aspects of organizational and functional operations covered in the foregoing. Within this plan, there is progress. Many of the essential activities to plan, schedule and control all maintenance work are now successfully operating at maintenance and refurbishment points. Real time, correlated activities provide the means of controlling the planning and monitoring of work, labor effectiveness, and material. These have been installed beginning in 1967.

What did it take to achieve a Maintenance Control System? Skillpower, a computer, and a Master Plan for the design, development, and implementation of the Maintenance Control System in the proper priority and precedence to meet the management need.

1. Skillpower Factors

Skillpower focuses the experience and disciplines of managers, engineers, accountants, analysts, planners, logistics specialists, mathematicians, and production experts on the design, implementation and successful operation of the Maintenance Control System. The responsibility for managing the functional and product areas which involve the planning, organizing, leading, and controlling of a significant part of the operation and the analysis and judgment of staff specialists are key ingredients in the Maintenance Control System.

2. Computer Considerations

The computer is essential because of its inherent characteristics to rapidly and accurately process data, provide logical functions, and produce information in meaningful forms. Use of remote terminal devices for real time update and inquiry are applied where the requirement demands such facility. As the Maintenance Control System is planned and implemented, computer and associated requirements are kept in phase with operational needs. The computer also produces heuristic data for application of advanced mathematical techniques to enlarge the computer capability into further logical processes.

3. Master Plan

The master plan is the overall approach for the development, design, and implementation of the Maintenance Control System. Priorities, precedents, manpower estimates, costs, benefits, progress, and schedules are basically contained in the master plan. This requires some elaboration. Since this one area where American Airlines believes there is some applicability to Shuttle management, the Master plan will be discussed further in the shuttle section of this paper.

4. Typical Application of the MCS

The best proof of the success of the Maintenance Control System is to trace through an actual on-the-air example of how the Maintenance Control System tracks the work on the aircraft, starting with the line maintenance activity, through logistics, refurbishment, performance and cost functions. A typical daily process occurs as follows:

The flight crew operating an aircraft in scheduled service observes an anomaly with a cockpit instrument. This is recorded in the aircraft log. This may be reported in flight or upon arrival. The maintenance staff examines the aircraft log and notes the anomaly. Assuming this condition can continue to a subsequent visit of the aircraft, maintenance inputs the data on the anomaly using a real time terminal, to a Field Maintenance Reliability (FMR) System.

Subsequently, in planning the workload for this future aircraft check, the production planner interrogates the real time system for any pilot reports and other open work. The system prints out an immediate response displaying the FMR report on the instrument on which the anomaly was reported. This message is made part of the work planned for the aircraft.

Maintenance requests a serviceable instrument from their supply point, installs it on the aircraft and returns the unserviceable unit to supply. The FMR record is closed out with a final action taken message (FACT).

Labor expended is reported through a terminal to the Maintenance Control System computer. The unserviceable instrument is routed to the refurbishment point on a tag which references the pilot report data. A copy of this tag is also input by the station to the Maintenance Control System computer to request logistics replacement from the refurbishment point, rebalance the station inventory and build the main computer record. From this message, the computer system automatically produces a shipping document to replenish the station supply and concurrently produces the documents outlining the necessary steps to refurbish the instrument. The shop order contains the pilot report information, station removal information, and master work specifications.

Labor and progress are reported in real time and the shop order is used to route the work through the cycle. Progress, delay, and performance reports are produced on exception or summary bases. Labor and material costs are also accumulated both from maintenance and refurbishment shop reportings.

The result is that by the single primary inputs, initially built from maintenance, the computer system automatically distributes the data through logistics, refurbishment, reliability, cost and performance processes, producing the information for the diverse management control needs.

The complete history of the incident is also available and may be correlated to other like instruments, aircraft or fleets.

By further accumulation and analysis, both maintenance and refurbishment skillpower and logistics requirements are controlled and a baseline for forecasting future requirements provided.

Technical and management performance are reported against parameters and proper controls are applied to reduce costs and improve maintainability.

Results of The Maintenance Control System

These goals, and more, have been achieved in the AA Maintenance Control System. However, the system has not been fully implemented in some areas because of lower priority. The master plan had provided a planning basis for the implementation against the priority, economics and precedents. keeping the management system from disintegrating into separate processes but on the right path to serving multiple needs from few inputs. The important factor is not that we have arrived, but with this plan, we know where we are going. Use of the master plan also has given us the capability to improve the existing system and future design areas to take advantage of improved software, periphal equipment and computer capability.

RELATION TO PAST LAUNCH OPERATIONS

An understanding of airline operation and how American Airlines continues to solve the management challenges may have some interest within itself, but in comparing the requirements of an airline to those of the past space programs and vehicle management, the conclusion might be reached that there is no comparison.

Under the direction of NASA at the Kennedy Space Center, American Airlines made a study of the Optimization of Operational Processing and Management Systems for the Operational Phase of the Space Shuttle. In the course of that study, American Airlines recognized some salient differences in past space programs, primarily Apollo, which will be highlighted here from the viewpoint of the requirements of a management system:

First, we believe it is generally correct to view the past programs as primarily scientific and to some extent, experimental in nature. Each program, mission, and vehicle had differing goals and differing physical characteristics. The management of each required different emphasis from many organizations involved. In some cases, tailor-made procedures were unique to the specific mission. From a management system standpoint, this type operation is analogous to a research and development effort where the system needed to be constantly adapted to the unique need. Consequently, management by project teams and manual procedures seemed more reasonable throughout these programs. This operation is vastly different than the airline environment where more stable fleet operations prevail.

Another factor in past programs was the long time spans planned for accomplishing a mission and the delay tolerance allowed. Only one vehicle was in process for the most part. This permitted the use of manual interaction and coordination, with provisions for uniqueness and variability which were adequately (if not ideally) served by the manual management systems. As stated earlier, short ground times and high volume activity are inherent in the airline.

The fact that launch and space vehicles essentially did not require refurbishment, maintainability, or correlation between vehicles reduced the complexity of the system requirement - this is dramatically opposite to the airline where these are major operational elements. There are other factors in past programs related to contractor, intercenter responsibilities, and national implications which influenced the management system requirements.

In the Apollo program, had it continued, some evidence of stability was beginning to form in some of the functional areas which indicate a pattern which the American Airlines study found useful for future space programs. But the test of all management systems is not how well they provided for the past effort but how well they will provide for the future.

FACTORS FOR SELECTING SHUTTLE MANAGEMENT SYSTEMS (SMS) FOR THE SHUTTLE OPERATIONAL PHASE

If we look ahead to the future of space programs, the reusable vehicle (not only the initial shuttle) is undoubtedly the regularly scheduled transportation mode of the future, taking a prominent place in the spectrum of passenger and cargo transportation. To assess the requirements of the shuttle management system required for such an endeavor, four major points must be considered:

1. Operational Requirements

In terms of operational requirements, the following key points appear to apply as either fact or valid planning premise:

The orbiter and booster systems will be reusable. This will require additional activities such as recovery, safing, and refurbishment. Further, maintainability, multi-flight reliability, and the need to track vehicle and major assembly performance on successive missions is required. New models of orbiters and boosters will follow the initial vehicles. Modifications to existing vehicles will have to be managed. Launches frequency will continue to increase requiring optimum definition of work and minimum spans for accomplishment. It is a conceivable goal that the two-week turnaround ground time in the initial shuttle program will be shortened either by management demand or better still as a result of the shuttle management system utilized. As the shuttle fleets increase in size and models, matched by escalations in costs, there will be internal and external pressures for reducing funding requirements and improving management.

2. Definition of Responsibilities

As to responsibilities, specific reference is outside the scope of this paper. However, it is evident that with the increased emphasis on the operational requirement, new or changed functions and an organization for regular processing and launch operation will have to be considered. Policy and organizational decisions which result will have to be incorporated in the shuttle management system plan.

3. Functional Requirements

Both from the operational requirement and delineation of responsibilities, the functional areas involved in recovery, safing, maintenance/refurbishment, handling, meeting, servicing, and launch will evolve. It appears that in this respect there will be many analogies between the shuttle operational phase and the airline. (The distinction will exist in technology, processes and safety factors) but a management control system for a reusable vehicle which takes off (or is launched), flies (or orbits), lands (and/or is recovered), and requires refurbishment, reliability, cost, and performance control is made up of many of the same ingredients. In either case, the management system must provide for:

Open endedness to accommodate differing depths of control based on the emphasis on the activity being controlled.

Responsiveness to the operational requirement.

Correlation of data progressively tracking the activity to serve the varied purposes for overall management.

We have identified the following requirements in a well planned maintenance and refurbishment management control system:

A. There should be an OPERATIONS PLANNING function to provide the central source for technical requirements of all kinds (test, support, refurbish, etc.). Master data on work processes and sequences, skillpower and other resource requirements, technical procedures and the basic maintenance and refurbishment plans are formulated as part of this function. Specification documents from various sources are translated into specific work requirements on a time, mission or other basis. Operations Planning provides work specifications to Scheduling, indicating the specific tasks to be accomplished, when they are to be accomplished, and the material required.

B. A SCHEDULING function should utilize the work specifications, manning and material resource requirements data furnished by Operations Planning to produce total work packages (bills-of-work). The bills-of-work sequentially order and time-phase tasks for maximum resource utilization and transmit work document requirements to the work control function. Scheduling also reschedules those tasks that were rejected by Problem Identification and Resolution during or after task completion.

C. There should be a well developed series of WORK CONTROL DOCUMENTS to provide the work instructions which specify to the technicians what is to be done to accomplish specific tasks. These include shop orders (many tasks), job orders (few tasks), and test/check-out documents applicable to two levels of work accomplishment - orbiter refurbishment/launch processing; and LRU/manufacturing (fabrication shops). The work control documents refer to manual procedures when more detail processing instructions are required to perform a task. Trigger data is utilized to report accomplishment of work tasks. Work control provide for standardized work instructions in similar functional areas and a single work control system - open-ended and capable of tracing work through all levels of maintenance or refurbishment.

D. WORK ACCOMPLISHMENT should report the work delineated in work control documents according to schedule. It also reports labor expended, task progress, additional resource requirements, problems encountered, schedule changes, and document changes authorized through the Feedback function. Work Accomplishment maintains the work-in-process (WIP) file. The WIP file is the single source of active data on work in process for both vehicles and shops. WIP data is utilized, in general, to report status of unusual events and vital normal events.

E. A system of FEEDBACK should record in real time, technical and operational processing data reported by Work Accomplishment or vehicle monitoring systems against work control documents and system criteria. The data is edited and validated against system parameters. Error response is directed back to the input point for correction of unacceptable data. Feedback processes validated data to the appropriate function for file update and further processing within the applicable function.

F. There should be a PERFORMANCE AND COST function to compare actual work accomplishment costs to standard. For each task performed: Operations Planning will provide the requirements including the labor standard and work position; Work Accomplishment will provide the actual accomplishment and/or reject data; Feedback will provide the actual labor and material expenditure data; Performance and Cost accumulates and analyzes accomplishment data for labor performance, workmanship, and labor and material cost effectiveness. If actual labor or material varies from standard beyond established limits, the system produces exception reports. Trend data is developed and required information is made available on an inquiry basis and by regularly scheduled action documents.

G. A STATUSING function should provide real-time (CRT or printed notice) or other timely status on work accomplishment to Scheduling and other appropriate functions and data users. Reports indicate planned versus actual work accomplishment status by task, LRU and project. Reasons for delays, impact factors and rescheduling requirements are also provided. It also reports deferral of non-mandatory work to Scheduling for rescheduling. Statusing will vary with reporting requirements which are functions of criticality, time in schedule, etc.

H. There is a requirement for a MATERIALS MANAGEMENT function to provide integrated and centralized inventory control and distribution of materials (spare parts, equipment, tools, and supplies) required and used in maintenance and refurbishment optimized overall funding level commensurate with mission goals and program objectives; uniform initial provisioning with concurrent action on facility readiness; control of tools and test equipment to permit pooling; and more extensive use of optimum storage and bench stocks.

I. A PROBLEM IDENTIFICATION AND RESOLUTION function should provide integrated data packages containing all direct and related findings and effects to facilitate identification and resolution of real-time and recurrent type problems; utilize teams to handle recurrent type problems using quantitative problem impact ratings and pre-established performance standards; provide for a pre-planned, organized approach to troubleshooting and establish an organized process for origination and revision of vehicle scheduled maintenance requirements.

J. A CONFIGURATION MANAGEMENT function would provide a decision making process for proposed modifications to vehicles; consultation during the design and pre-delivery phases; procedures for the design, scheduling and accomplishment of modifications; currency of configuration documentation; revisions to interface control documents and uniform configuration management procedures.

K. There is a requirement for a FORECASTING function to provide projections of skillpower, facility and material resource requirements to guide management decisions in the areas of: initial operating capability; routine planning; reaction to significant program changes; determination of fiscal year funding requirements; and resource requirement options, trades, and simulations as required for selected time periods.

L. OPERATIONAL RELATIONSHIPS AND QUALIFICATIONS MANAGEMENT should encompass the functional and people-oriented relationships of formal and informal organizations; revise the formal organization to accommodate the additional functions of recovery, safing, and vehicle refurbishment; standardizes work accomplishment sign-offs and provides a technical personnel development program covering certification, training and qualification. For the most part, this will result in definitions of management responsibility to be applied to all functional areas.

M. Requirement for COMMAND MEDIA should provide for the documented, standardized and stratified communications of management. This includes administrative policies, directives, systems, procedures, technical specifications, and criteria which apply to both the formal and informal organizations.

These requirements arrayed to show their interrelationship (Figure 2) provide a model of the shuttle management system from which the framework of computer and manual system design can be developed.

4. System Control and Development Plan

A. Separate Versus Interfaced Systems - A control and development plan is required to undertake the coordinated design of a shuttle management system of the required magnitude to encompass these functions. There is a natural tendency to be awed by the total requirement and retreat into system separateness by withdrawal into independent systems or apply a "pick-and-choose-the-best-piece" syndrome rather than study the total requirements as a whole. However, it would seem that an industry which recognized the need for technical interfaces between stages in the launch and space vehicles would most clearly appreciate the same need for precise and timely interfaces in the management of the shuttle operational phase.

This is exactly what American Airlines had to achieve in conceiving, designing and implementing the Maintenance Control System. This paper has illustrated one result of the interfaced and integrated approach. The instrument might well have been in an orbiter rather than in an airplane. Essentially the same process and correlation would be required.

So to achieve the total relationship, the solution for shuttle management would have to be the development of a system encompassing all the organizations and functions of the organization. Once the functions and interrelationships have been defined as suggested in Item 3, then the commonality of data elements in functions and communication between the data elements will be recognized. This identifies the requirements of an integrated, interfaced management control system.

An integrated system is one in which the activities within a function are so closely related that together they form the whole. An interfaced system is one in which the activities between functions are so related that the output of one becomes the input of the other. These can be designed and implemented in time frames separate from each other, but the integrity of communications between them must be determined in advance and preserved.

B. Data Bank - It becomes evident as initial system planning gets underway, that more than one function uses some of the same data. Data on an LRU, for example, is needed by configuration, material, operations planning and problem identification functions. Following the principle of an integrated and interfaced system, separate data on an LRU cannot be tolerated but the data on an LRU must be in a common bank of data. This leads to the definition of a master data bank, containing related data for a given function, with an identified responsibility for control of the data and as many functions as needed drawing upon the data (multi-user).

C. Need For Control - Finally, as the individual applications are analyzed, the common data base identified, and the interfacing and integrating takes shape, there is a realization that the management of the system design and implementation will require direction and control. There must be an overall plan. Decisions must be made on how to divide parts of the system into design packages, and establish the priority order in which the system must be installed. Definition of the activities best suited for manual control or computer processing must be done for each function as organized and defined. While the computer provides much of the basic data processing, proper and rapid interfacing and response, all the functions involve analysis, judgment and decision making within the manual, analytical or management sphere.

The information which follows outlines a Master Plan concept through which development of both the manual and computer systems are controlled and the requirements to efficiently phase in the entire system are defined.

D. The Master Plan Approach

SEGMENTS - The essential ingredient of the master plan is the concept that systems are conceived, designed, programmed and implemented in steps called segments. A segment must solve a problem. Sometimes this solution will be the establishment of portion of the data base; not, in itself, a contribution to cost reductions but usually a significant solution that will make possible other segments that are contributors to cost reduction or required performance.

Once the segments are identified, they can be grouped together in logical relationships of functions applied to major work flows or processes. For example, the initial system segments may be applied to orbiter refurbishment and subsequently applied to launch operations and LRU refurbishment continuing through the entire gambit of responsibilities. In some respects, this definition also generally indicates the portions of the system which may be implemented in a priority order.

TASK GROUPS - An approach used successfully within American Airlines for this definition is to use a task group composed of representatives from the organizations with major involvement with the segment along with representatives from the management systems and data processing organizations. The task group is totally responsible for the design of the segment, defining both manual and computer processes. They act as an interface between the task group and their own organization, informing their organization, and conveying ideas from the organization back to the task group.

THE SEGMENT ABSTRACT - The first step in developing the system is for the task group to prepare an abstract of the segment. The purpose of the segment abstract is to state briefly what problem the segment must solve, the environment that must be created to support the solution and the benefits of bringing the problem under control. Precedents between segments must also be established at this time. It is then time to arrange the segments in order of the precedents which have already been indicated in the segment abstracts. (Figure 3)

This then leads to a general approach to identify options for applying the system effort and a logical sequence of segment development. Each segment abstract is a convenient document for the resolution of expected benefits and costs. The total assessment provides an organized manner in which it is possible to make a financial evaluation of the costs and benefits.

DEVELOPMENT AND IMPLEMENTATION STEPS - After the whole system has been visualized, integrated, interfaced, segmented, and sequenced, it is necessary to establish a means for planning, leading, and controlling its design and implementation. When a segment has been established by the abstract, then estimates and progress measurement start with a series of milestones; an outline, functional specifications, program development, system test, implementation and installation. The segment outline is a description of the general objectives, scope, and major development tasks of a segment. Functional specifications are a detailed description of the segment, including precise definition of such factors as input, output, models, data elements, procedures, special equipment/facilities, and implementation and installation plans. Computer programs represent the conversion of functional specifications to computer processing procedures and instructions, and may involve such activities as program specifications, flow charts, program coding, and program testing. System testing is a thorough test of the elements of the system, such as forms, procedures, programs, terminals, and outputs conducted by the user under simulated operating conditions, prior to acceptance of the system.

The installation will involve activities such as training, conversions, and the operational use of all elements such as procedures, forms, and programs. Support continues until all initial problems are resolved and the segment operates smoothly.

Using the master plan concept and the milestones, schedules can be developed, resources determined and allocated, progress can be monitored, and status can be reported in a consistent manner for all segments.

PLANNING AND CONTROL - No project the size of an integrated, interfaced information system for shuttle management can be successfully designed and implemented unless it is subject to strict controls. The master plan approach included production control features that should be put in the form of a critical path network. There are many alternative choices that must be considered during such a project and it is vitally important to maintain performance on schedule, respond to alterations of plans, and that there be a tool selecting the best alternates according to the need. There are any number of programs available for this purpose and the use of a version with manpower leveling provides the planning tool for American Airlines. Use of this technique can forecast resources for system design (Figure 4) and implementation schedule (Figure 5).

This paper has covered the master plan approach in some depth. Control is the key ingredient in the development of a management system of the magnitude required for the operational phase of the shuttle.

SUMMARY

In the experience of American Airlines, the concept of an integrated and interfaced system has produced many meaningful results, permitted the incorporation of activities such as contract work, reorganizations and the need for finer controls without substantially affecting the system design or operation. Not all activities have been included nor are all possible improvements incorporated but the important factor is that it permits continued development (in a sense the management system design may never be finished) and also provides the management tool for the control of priority and resources. In the tenuous days ahead in planning for the reusable vehicle program, an equal control is also needed so that the management control system is comprehensive, flexible and responsive to the operational demands of the shuttle era.

The scope and depth of this paper addresses many broad principles and may appear conceptual or idealistic in nature. But, given the analogy between airline maintenance/refurbisnment and shuttle maintenance/refurbishment, a coordinated management control system plan exists and works successfully for the airline - there is no reason with the proper commitment why the shuttle management system won't work for the shuttle.

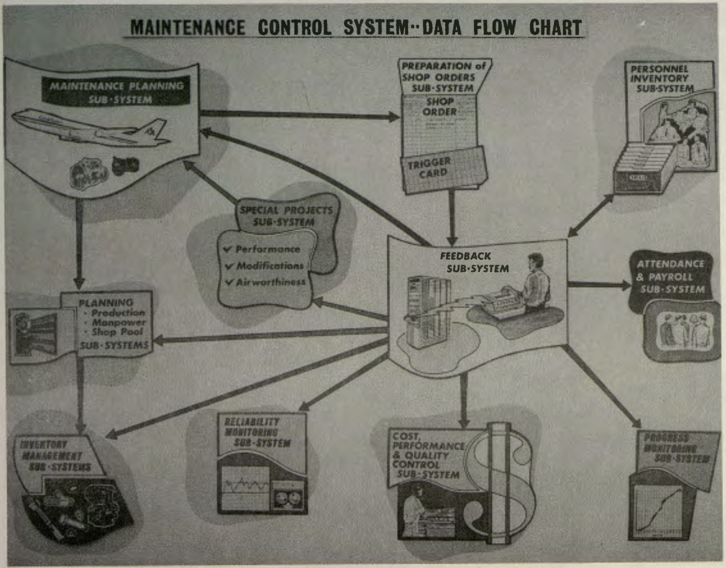


Figure 1 - AA Maintenance Control System

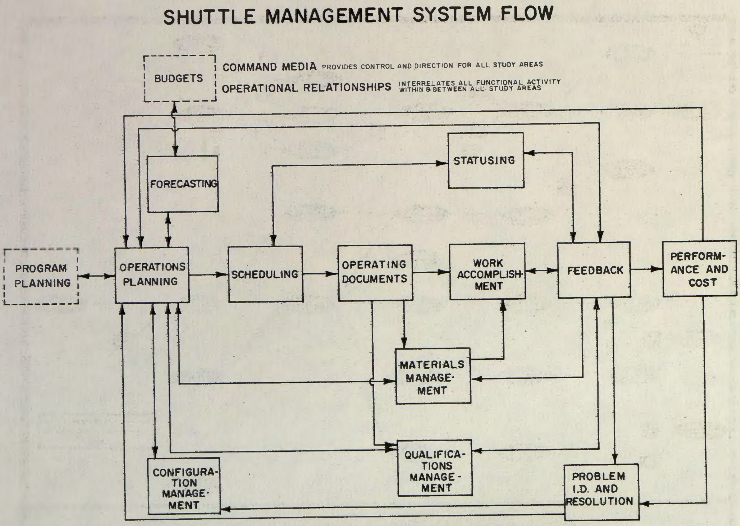


Figure 2 - Shuttle Management System Model

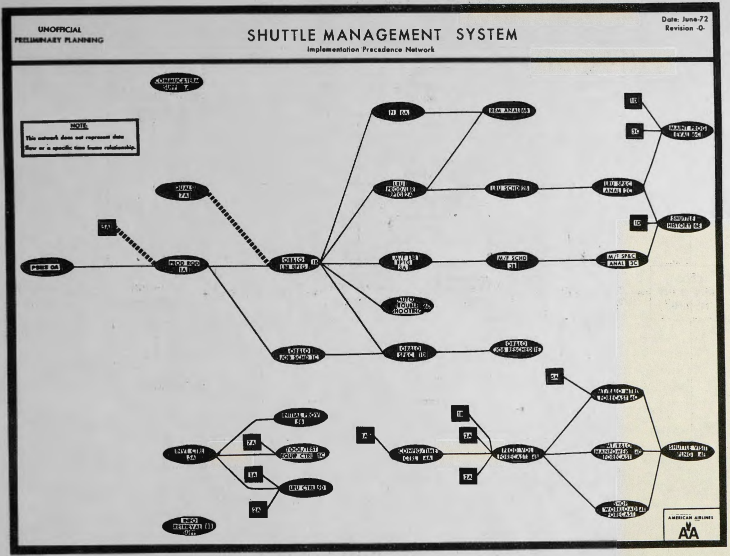


Figure 3 - Implementation Precedence Network

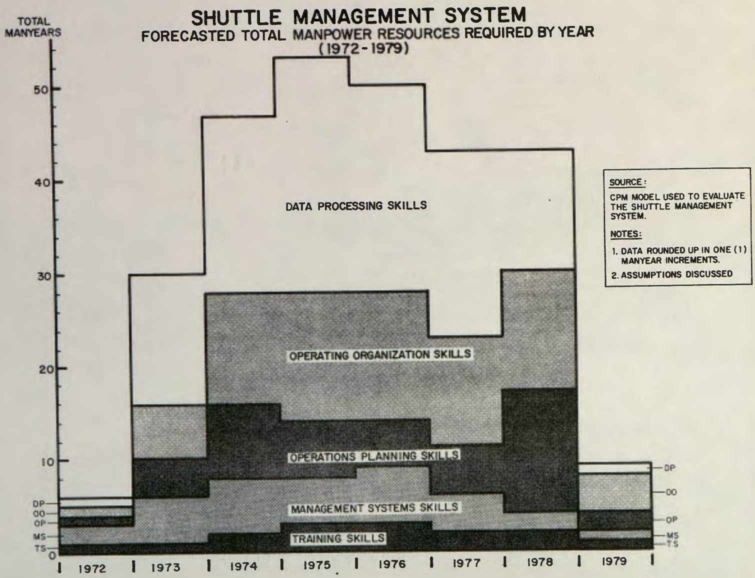
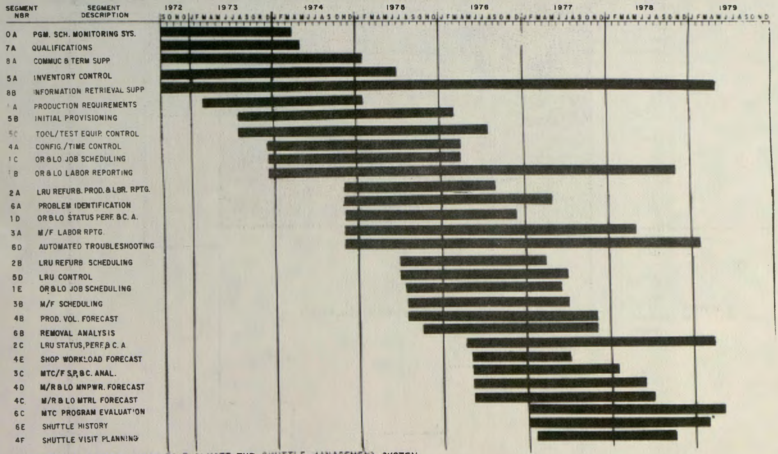


Figure 4 - Forecasted Manpower Requirements For System Implementation

SHUTTLE MANAGEMENT SYSTEM
IMPLEMENTATION SCHEDULE BY SCHEDULED START DATE



SOURCE: CPM MODEL USED TO EVALUATE THE SHUTTLE MANAGEMENT SYSTEM

Figure 5 - Implementation Schedule Plan