Improved Techniques for the Management of Launch Operations

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The application of automatic computers to business management integrates science and art and contributes directly to the advancement of management as a vital and creative force. This paper discusses improved techniques applied to the management of launch operations and the development of an automated management reporting system, citing some of the advantages and disadvantages over manual reporting systems.

The original schemes were developed and evaluated during the checkout and launch of the Gemini Launch Vehicle. The system can be applied to any major integration task involving numerous interfaces and different hardware configurations. Further developments are being considered for possible use in Titan III-C and Apollo Applications launch operations.

Introduction

The most striking characteristic of launch operations, in the true management sense, is its irreversible nature. After all systems readiness has been satisfactorily assessed and the hold-down devices have been actuated, the liftoff of an unmanned planetary probe or a manned space vehicle represents an extraordinary expenditure of national resources. The success of the venture is immediately reflected in the prestige of our nation and, on a less grandiose scale but nearly as vital, in the level of interest toward development of more advanced systems. Conversely, the effects of failure are immediately recognized in those factors which retard progress and orderly development.

As launch vehicles and spacecraft increase in size and complexity, it becomes of paramount importance for all levels of management to know the status of activities for adequate and timely test and checkout of airborne and ground systems. The ability to assess, on a frequent basis, the magnitude of effort remaining to meet milestone dates and to recognize problem areas and schedule conflicts must be maximized in order to achieve critical launch dates and specific liftoff times. Contingency-planning requirements can be recognized and expeditiously applied so as to accommodate test milestone slippages.

Assessment of status and readiness was considered to be of singular importance during the Gemini program. To this end, an Integrated Management Reporting System was developed, using automated techniques, to provide each level of program management with a daily assessment of progress and problem-status and resolution. The Integrated Management Reporting System evaluated schedule performance, documentation status, configuration management, hardware open work, failure analysis, and corrective action as several of the major parameters involved in managing a launch operation.

Section I

Need for Progress Assessment

It is obvious to the working manager that assessment of progress toward an assigned goal is one of his major challenges. The ability to control his organization is a direct function of his early participation in the definition and planning phases preceding the initiation of the work task. It must be assumed, for purposes of this paper, that the manager has been given the necessary authority to execute the responsibilities associated with the task.

A. Ability to Achieve Scheduled Commitments

Statusing work progress is vital, then, for two primary reasons: First, the manager can evaluate the adherence to plan. Second, the manager can determine the probability of meeting milestones established by the original plan or define the need for alternative courses of action required to accommodate anomalous performance.

Statusing is analogous to the feedback loop of a simple servo-mechanism, as can be observed in Figure 1. The steps required to reach task completion must be based upon a flow of events. Each event must be defined, with respect to resources and time, so that the manager can ensure achievement of work to be performed within the allotted time. The summation of the events is represented by the schedule.

The schedule must be updated on a periodic basis so as to accurately reflect the level of effort required to meet the task objective. Typical sources of work assignment will be discussed in Section II.

B. The Launch Operations Department

The Launch Operations Department has been used to evaluate the effectiveness and efficiency of the departmental work-status system.

1. Organization. Figure 2 is an illustration of the organization of a typical launch operations activity.

The department manager is responsible for all work activities involving preparation of the launch vehicle for flight. He is assigned trained personnel to direct and implement discrete work efforts. These personnel are divided into system groupings, such as the propulsion and propellant systems and the instrumentation system. Each system group is supervised by a group engineer, who reports to the test conductor. The test conductor provides the direction and supervision required to conduct shift activities within the Launch Operations Department.

2. Functions. Inasmuch as the Launch Operations Department is the organization responsible for preparing the launch vehicle, its functions include directing specific work tasks in accordance with the approved schedule. These tasks define work required to:

a. receive the launch vehicle at the test site
b. erect the launch vehicle on the launch complex
c. validate all systems in accordance with approved procedures
d. conduct the launch countdown
e. evaluate flight performance
f. repair launch-site damage
g. prepare to receive next vehicle
3. Other Departmental Support. The Launch Operations Department requires support from other departments to conduct daily and launch activities. (The application of the project organization and the line-staff department relationship will not be discussed in this paper.) Typical of this support are:

a. Engineering
b. Quality
c. Safety
d. Materiel
e. Contracts
f. Finance
g. Administration
h. Planning
i. Configuration-and-data management

Engineering provides the technical support required to evaluate launch-vehicle system performance, design hardware changes needed to correct anomalous operation of vehicle equipment, and develop special engineering tests needed to investigate equipment problems.

Quality performs inspection of work being accomplished on the launch vehicle to ensure that it is in conformance with approved procedures. The Quality function maintains a status of open work items generated during the conduct of checkout procedures. This listing also includes those failed items which have been referred to special testing or failure analysis.

The materiel function provides component and supply support. This effort must maintain inventories of critical components, ensuring their availability when needed.

Contracts, finance, and administration perform business support functions. The responsibilities of these activities are well recognized, e.g., contract work authority, cost control, and personnel availability. The importance of the business operations is emphasized due to the use of fixed-price and cost-incentive contracting of launch operations support.

Planning and configuration-and-data management represent two major activities affecting status determination. Planning, as an organizational unit, must coordinate all work required to prepare the launch vehicle, present a preliminary schedule (plan) for management's approval, and publish the approved schedule for use by all departments. Follow-up (or statusing, or controlling) provides the vital closed-loop operation needed to achieve the desired goal. Configuration-and-data management provides a second, comparative tool by which management ensures conformance of work accomplished to standards, such as procedures and engineering drawings.

In summary, the preparation of the launch vehicle requires the concerted efforts of a number of technical and support organizations. The Launch Operations Department must perform as the focal point, coordinating the support tasks in accordance with the approved schedule.

Section II
The Manual Statusing System

The ability to determine the status of work progress, and thereby exercise control, depends upon the understanding of the scope of work to be accomplished. Any system developed to provide status information for the manager must recognize two principles which define the purpose and nature of control. These principles are:

Principle of Assurance of Objective: Controls must contribute to accomplishment of group objectives by detecting deviations from plans early enough and in such a manner that corrective action is made possible.

Principle of Efficiency of Controls: Controls are efficient if they effectively detect deviation from plans with a minimum of unsought consequences.

Like the other functions of management, controls do not exist merely to create activity but must have as their essential purpose the attainment of objectives or goals. Another function of management is to direct, or exercise control, upon the understanding of the scope of work to be accomplished. Any system developed to provide status information for the manager must recognize two principles which define the purpose and nature of control. These principles are:

A. Sources of Work Assignment

Of the many sources which can generate work for the Launch Operations Department, three major categories are considered for the purposes of this paper. These categories are:

1. Test Procedures. Test procedures define the specific steps to be used by the systems personnel when operating launch-vehicle systems. These documents define equipment requirements, prerequisite testing, and provide means for recording deviations or anomalous performance. These documents are in booklet form and provide a record of steps performed, each step being verified by a quality inspector and approved by a supervising engineer. Test procedures are scheduled by number and title and are allotted time spans based upon past experience. Each procedure is authorized for conduct prior to the scheduled period by having the system's supervising engineer, test conductor, and quality inspector sign a preprinted work-authority form. As the procedure is conducted, the engineer records deviations or component-failure information within the procedure. After completion of the testing the procedure, together with the original work-authority form, is returned to a central data center. Anomalies are recorded on a preprinted form classed as a trouble report and presented to the quality activity for recording as an open item. Resolution of the problem by redesign, replacement, or repair will satisfy requirements to close the work item.

The control function as applied to test procedures is illustrated in Figure 2-1.

2. Engineering Directives. The engineering activity provides technical support and direction to the Launch Operations Department. For example, test procedures are generated using as a basis a system-test specification. A change in the technical content of the specification will necessitate a change in the appropriate test procedure. This represents an added work element for the Launch Operations Department.

Another engineering action requiring additional expenditure of time and resources is the development of a special test. This task is usually required to evaluate anomalous performance of a component or system or to achieve additional confidence in a system which has been modified in some way.

The activities which the Launch Operations Department must conduct are illustrated in Figure 2-2.

3. Other Sources. In addition to the two categories discussed above, other sources of work
Several of these sources are component replacement, modification, special inspections, and delays in schedule due to outside influences. A summation of these factors must in actuality be made before accurate work status can be determined. However, for purposes of this paper, only the two major categories of test procedures and engineering directives will be used to evaluate the manual statusing system and to compare it with newer and perhaps more efficient techniques.

Jerome Kanter emphasizes the need for developing an understanding of the integrated-systems approach to systems analysis: "An integrated system approach recognizes rather than ignores interrelationships. The system may begin with automation of a specific function, but only after the total picture is studied. This permits the later addition of subsystems with minimum effort and duplication."^4

B. Manual Statusing Methods

Status of work, as the controlling function, is provided to the management of the Launch Operations Department in several report forms. Status, of course, is based upon a schedule of work events and must be provided for management assessment at periodic intervals. This section will discuss the manual process of status reporting, including schedule development, status reviews, and documentation. As stated previously, the test procedure and engineering directive subsystems will be analyzed.

1. Schedule Development. Development of work elements for launch-vehicle checkout is based upon two factors: First is the number of test procedures and engineering directives required to make an adequate assessment of systems readiness. Second is an estimate of time required to conduct each work element. Inputs to the schedule are provided by the management of the Launch Operations Department, specifically the test conductor and the system group engineers. Supporting data, such as test-tool availability and special material support, are provided by the supporting departments. The scheduling function is performed by the planning activity whose responsibility it is to coordinate, develop, publish, and monitor the actual performance. The output of the planning activity is in the form of a "waterfall" schedule, for gross reference, and a detailed work schedule defining the work elements to be accomplished by each system group during each work shift. Figure 2-2 provides an illustration of the sequence of events for the scheduling function.

2. Daily Status Meetings. A daily meeting is held by the test conductor, at which time each system group engineer presents a verbal status of the following:
   a. Work completed during the previous day
   b. Estimate of percentage completion of work in progress
   c. Work to be conducted during the day
   d. Problem areas, interference with the systems, and support-department support requirements.

   The planner updates the daily work schedule based upon the progress reported by each system engineer. The information provided by a through d, above, provides the planner with data needed to ascertain progress. Three courses of action are possible: First, if the work events are reported to be on schedule, the published schedule will suffice for future use. If events are behind schedule, the published schedule must be modified in order to attempt to achieve the next major milestone on the overall "waterfall" schedule. An assessment of the probability of meeting this commitment is based upon the professional knowledge and experience of management and the planner. Should work events be ahead of schedule, management and the planner must modify the schedule by revising time estimates and readjusting contingency periods in order to meet the next significant milestone.

3. Major Status Reviews. Yet another technique for assessing progress in a multi-element project operation is the major, or periodic, status review. It is during this event that all factors pertaining to support of launch-vehicle checkout activities are discussed by management. By restricting this analysis to test procedures and engineering directives, one can sense the magnitude of the problem involved in determining the status of work progress. For example, the manager must decide upon the adequacy of work conducted based upon two inputs:
   a. Verbal presentation by the system engineer
   b. Review of documentation maintained by the quality activity.

   Documentation generated during tests leading up to the major status review can be recognized in Figures 2-1, 2-2, and 2-3. In summation, these are the following:
   a. Master schedule ("waterfall" schedule)
   b. Daily schedule by system
   c. Test plan
   d. Test procedures and special test procedures (engineering directives)
   e. Work-authority form
   f. Problem report
   g. Recapitulation report.

   While the above-listed reports present to the manager the status of test procedures and engineering directives, a management information system must be capable of providing a concise and accurate picture of all services supporting the launch operation. As an example, the Gemini system reviewed the status of the following support tasks at critical review points during launch-vehicle checkout:
   a. Configuration management
   b. Problem summary (failure analysis)
   c. GSE and AGE acceptance summary
   d. Specification compliance of airborne and ground systems
   e. Critical component availability
   f. Personnel certification
   g. Engineering support plan
   h. Data acquisition and report plan
   i. Preventive maintenance of airborne and ground equipment
   j. AGE and GSE calibration status.
Section III
Integrated Management Reporting System

This section will discuss the Integrated Management Reporting System developed to support Gemini Launch Vehicle checkout operations. The analysis will be concerned with the status of work progress as outlined in Section II. Management and decision-making processes are, at best, complex in nature. Consequently, where a complex problem is being investigated, it is useful to start with a radically simplified version of the system.

A. Objective of the System

The Integrated Management Reporting System has as its primary objective the presentation of status data concerning launch vehicle checkout and resources availability. These data are designed to combine and simplify information previously assembled by manual techniques and present these data in a form readily available for decision-making purposes. The data presented were selected to provide both current status as well as trends so that future performance could be predicted.

B. Output Requirements

The automated reporting system is designed to provide top and middle management and line supervisors with status reports needed to assess work progress. Output requirements imposed upon the system are as follows:

1. Daily Reports. The system provides daily reports defining the percentage of completion of test procedures, activity recap of open work items, and a scheduling index defining work to be accomplished during the two-shift work period. These reports are produced on standard EDP paper and provided in sufficient copies to satisfy both internal company management and external customer review requirements.

2. Special Reports. Special reports describing open work remaining to be accomplished, i.e., exception approach, are prepared for scheduled milestone reviews. Again the system provides printouts of data concerning schedule progress, test procedure completion, and open work items. From these data, management can assess the status of work completion and evaluate readiness to proceed to the next program milestone, whether it be further testing or launch.

3. Periodic Report. In addition to the reports listed previously, the system provides a biweekly report to the program director. This report outlines, in brief summary form, an image of the overall schedule of each system in percentage of completion.

C. Input Requirements

Inputs to the reporting system are generated as follows:

1. Schedule Development. Line supervisors, such as the systems engineers and the test conductor, coordinate the listing of test procedures required to prepare the launch vehicle. The test-flow sequence is developed from these discussions and modified as necessary to include additional engineering tests of a special nature. Time estimates for each test procedure are provided by the systems engineers. This information is used to establish total elapsed test-flow time, as well as to permit evaluation of test-procedure completion for each 24-hour period.

Daily meetings are held by the test conductor, at which time corrections to the shift schedule are made available as input to the system. This function provides performance feedback and permits further adjustment of scheduled work items and reassignment of program resources needed to meet the major milestone dates.

2. Activity Recap. Inputs to this report are acquired during the conduct of test procedures and include a listing of all open work items resulting from anomalous behavior of the system, failure of components, or retests required due to lack of satisfactory data.

D. System Analysis

Caution must be exercised in approaching the analysis of an integrated management reporting system. Kanter reports that "neither is such a system a panacea--whereby management may merely convert its hitherto unsolved problems to some mis­ understood series of binary numbers, sit back, watch the lights flash, and receive an answer. Management does not become a passive participant, given the luxury to sit back and wait for results. This concept of 'problem in--solution out' can often result in 'problem in--greater problem out.'

The overall system is designed to provide batch processing of schedule and activity data so as to make reports available for management's use at the beginning of work hours or the following day. The system is illustrated in Figure 3-1.

All input data are prepared in a similar format, using a form designed for ADP use. Data are transmitted to a punched paper tape and transmitted via telephone lines to the remote computer laboratory. A Model 2B Teletype machine produces a five-channel punched paper tape for accumulated data. In the computer laboratory, data are received by another Teletype machine. At the end of the workday, all tapes are introduced into the computer for update processing.

1. Schedule Development. Experience has shown that the best method of communicating information to computer personnel is by means of a written question-and-answer format, supplemented by an adequate description of all the points involved. Consequently, development of the schedule system data flow requires the use of eight programs:

   a. Schedule Master Update Program
   b. Sequence Time Generator Program
   c. Merge Program
   d. Schedule Program
   e. Directors' Report Program
   f. Daily Schedule Report Program
   g. Index Report Program
   h. Worksheet Program.

The Schedule Master Update Program accepts new activity data, which updates the master tape. This program produces two work tapes. The first is an error tape which is used to verify and correct programming errors prior to update of the Schedule Master. The second work tape contains information required for the Sequence Time Generator Program.

The Sequence Time Generator Program integrates
activity start and completion times into the Schedule Master Update work tape. A new work tape is generated and used as an input to the Merge Program.

The Merge Program is used to merge information obtained from the updated work tape produced by the Schedule Master Update Program with the work tape obtained from the Sequence Time Generation Program. The output of the Merge Program is a schedule work tape, containing a description of activities and span times, which is used as an input to the Schedule Program.

The Schedule Program uses the schedule work tape as an input to develop the Schedule Update work tape. This program adjusts time sequences for each activity as required by manpower and resource changes or limitations. These adjusted activity sequences are produced on the Schedule Master Update tape.

The Directors' Report Program uses the Schedule Update work tape as input. This top-management-level report requires two additional inputs, however. These are the original Schedule Update work tape, which serves as the basis for comparison, and the Activity Recap Master tape.

The Daily Schedule Report Program uses the Schedule Update work tape as input. This program produces daily work schedules for varying work spans, usually for periods between major milestones. If the subsequent milestone slips, new daily work schedules are printed out to the rescheduled milestone date.

The Index Report Program uses the Schedule Update work tape as input. This program produces a listing of each activity sorted by prime systems.

The Worksheet Program uses the new schedule master tape as input. On the initial run, worksheets are produced for each activity. The subsequent runs produce worksheets for those activities which are conducted during the period but not completed.

Figure 3-2 provides an overall view of Scheduling System data flow.

The Schedule Program utilizes several additional considerations in order to provide accurate daily worksheets to the Launch Operations personnel, thereby contributing to the accuracy of progress assessment. These are concerned with manpower and resources and continuous or noncontinuous activities. The program integrates manpower-availability limitations into activity scheduling. Changes in resources, testing environment, availability of services, and hard failures necessitating extension of activity time can be accommodated by the Schedule Program.

This routine also accommodates the overtime scheduling by adjusting times for start of subsequent work activities affected by the slippage. This condition is immediately flagged for management review and approval, due to the added costs involved in overtime operations.

2. Activity Recap. The Activity Recap report is used to record the status of open work items required to successfully complete testing and checkout of the launch vehicle. The recap lists items of hardware failure, anomalous system performance, etc., which can have an effect upon meeting program schedule milestones. Anomalous behavior can affect the conduct of a test procedure, thereby affecting the work effort of a particular vehicle system. This item becomes more significant should it occur during periods of integrated systems testing. The Activity Recap provides a complete historical recording of items of this type.

The system developed to produce the Activity Recap report is less complicated than that developed for scheduling. Each work item or anomaly is recorded on a standard form and assigned an identification number. A master file is maintained on each number and on each test-procedure number. The master file is updated on a daily basis by means of the punched-paper-tape transmission system. Reports are produced daily during the period of 10 days prior to launch and on a biweekly basis for the remainder of the checkout period. Figure 3-3 provides an illustration of the Activity Recap report.

3. Directors' Report. In The Computer Age, Gilbert Burck summarizes the hopes of management when he states: "The great achievement of the computer is that it is enabling the executive to clear away some of the uncertainty that surrounds him, to subtract some of the variables from the circumstances that fret him, to convert many ill-structured and inherently insoluble problems into well-structured and partly soluble ones, to rely less on hunches and intuition and more on analysis, to behave less like an artist and more like a scientist in disposing of routine matters, and to save his creativity and imagination for more important work."1

The Directors' Report serves to provide management with a summary which depicts the status of total project operations and is concerned equally with the progress of launch-vehicle checkout and with the efficiency and readiness of support-department activities.

The Directors' Report Program uses outputs from both the Scheduling Program and the Activity Recap to display graphically the overall schedule in a condensed format, comparing the original planned schedule against actual progress to date.9 The report is further subdivided into an appropriate number of systems, in order for a comparison to be possibile for specific checkout and support tasks.

In this manner, management is able to ascertain possible critical areas which might inhibit schedule progress and an ability of the entire organization to achieve major program milestones.

In addition to the graphic display of schedule performance, the Directors' Report also includes a graphic presentation of items, by total numbers, reflected as an open work or problem item on the Activity Recap. This technique provides management with the immediate intelligence to investigate specific systems which represent an excessive number of open items remaining to be worked.

The flow of data for the Directors' Report is illustrated in Figure 3-4.
the experimental approach and the analytical approach... If you can make a model of the physical situation, subject this model to specific inputs, and interpret its behavior in meaningful terms, then you are on the right track in using analysis rather than experimentation to achieve your results.\(^6\)

The analytical approach offers an immediate benefit when applying computers and automatic data-processing to the management process. The procedure required to perform systems analysis demands that the manager and line supervisor understand the exact details involved in planning, organizing, acting, and controlling a job. Many managers become intensely aware of their superficial knowledge of program operations, as well as the specific functions of their departments. The educational process is of immediate importance and can result in an improved organization and deletion of redundant or unnecessary functions.

When evaluating the automated status system or, more professionally, the Integrated Management Reporting System, one should be guided by the thoughtful questions outlined by Chaplin. These questions are as follows:

What are the weaknesses of the present system?

Why is management dissatisfied with the data it now receives?

What data would be of more value to management?

What data are required for adequate control and for the maintenance of control?

In what way is the present system deficient in meeting these data needs?\(^2\)

The weakness of the original system was in its inability to present program status in an accurate and responsive fashion. Manually generated reports were varied in format and required an unacceptable amount of personal interpretation. Judgment was required in either system; however, the basis for decision-making was based largely upon experience and less on factual status data. As concerns the manipulation and presentation of data, Sattinger states: "Primarily, the computer provides an efficient and economical method of handling the vast amounts of numerical data and other information involved in the performance of many of the complex tasks undertaken in government, business, and industry. The computer is thus a fast and highly efficient servant capable of relieving its masters of much routine computation and record-keeping."\(^6\)

Management dissatisfaction with the data it received was once again concerned with its ability to execute its fundamental processes. The manually generated reports included numerous iterative, filtering operations. Reports were cumbersome and necessitated that top management become intimately familiar with details of the program.

Decisions required to modify launch-vehicle systems, for example, could not be made without an extensive knowledge of system design parameters, test specifications, component performance, and failure history data. Decisions to modify equipment would reflect immediately upon work schedules, activity records, personnel assignments, and cost. The objective of the automated system was to present these elements affecting program control in a manner which would meet the needs of top management as well as provide the added details required by line supervisors, such as the test conductor or the system group engineer.

A pertinent comment on the foregoing thought was expressed by Burck: "This new mastery of (computer) operations gives— or should give—top management more time for its 'strategic' work, such as long-range planning, policy making, choosing staff, deciding on new products and capital investments, financing, and public and labor relations. All computer-systems men worth their salt have learned that top management does not need the detailed, day-to-day information that is proving so valuable to subordinate managers. To keep their top executives from being inundated with useless (if interesting) paper, they are striving to provide them only with the 'exception' operating information that demands or justifies action.\(^1\)

What data would be of more value to management?

Of course, the level of management directly affects the level of detail. In the manual system, scheduling data were provided on flow charts and page-and-line schedules. In the automated system, these data were reduced to graphical displays depicting percentage of completion for top management and a printout of scheduling information for line supervisors. The latter tab-run provided detailed information concerning tests to be accomplished, estimates of manpower by type and quantity, duration, start and stop times, constraints, and equipment requirements. Completion of work sheets at the end of the work shift provided feedback which indicated test completion, need for reschedule, and numbers and types of problems, all of which affected status determination and forecasting. The volume of "paperwork" was of reasonable proportion. Therefore, new techniques for displaying schedule data would be of inestimable help to all levels of management. The system should be capable of displaying gross qualitative information for periodic progress assessment, yet permit the manager to obtain the details involved in critical-path tasks. Again, the data provided by the automated system is satisfactory; its presentation must be improved.

Control, as a fundamental factor in successful management, can best be served by the automated system. Status of work, as a part of the control function, is achieved if data from the many operating elements supporting the program are integrated into a single, common, and simple information system. Since each manager and line supervisor must understand more thoroughly the specific steps required to complete their assignments, they can readily recognize anomalous behavior of their activity and institute appropriate changes to correct the condition. The Integrated Management Reporting System provides them with the means to record, calculate, and outline the alternatives necessary to execute a decision and provide trend data upon which to base approval of present performance or initiation of program changes as necessary. Finally, crisp and accurate presentation of schedule plan, performance, and trends reduces the level of conflict which management faces between fact and opinion, knowledge and habit.

The present system is deficient in meeting data needs of management in several ways: First, the presentation of the data introduces problems to the line supervisor, as well as to management. This condition is alleviated by the institution of training programs serving to indoctrinate management in the fundamentals of the system, its input requirements, output capabilities, and overall limitations. For this particular application, it was necessary to extend the training program into the technician level. Accurate feedback data could only be realized by proper and accurate performance in accordance with work-sheet instructions. Second, the system was limited to the

16.1-6
use of an ADP facility at a location somewhat remote from the central data facility and the work areas. Consequently, processing of data required several added operations to generate and transmit punched-paper-tape information to the remote facility. Report printouts were made at the remote processing facility and distributed manually. No printout capability was incorporated at the central data facility adjacent to the launch complex due to funding limitations.

In summary, the automated system demonstrated significant advantages over the manual statusing technique. Development of the Integrated Management Reporting System resolved many problems associated with the manual system, simplified and standardized reports and work-authority forms, and reduced administrative costs ultimately by reducing administrative personnel levels.

Sattinger summarizes the challenge of opportunity for the future: "The businessman has gradually come to realize that he has at his disposal a powerful tool for both monitoring the activity of his business and optimizing its operation. The growth of these computer applications, especially that of monitoring business activity, depends heavily upon the rapid accumulation and transmission of data from the field. The necessary equipment is just becoming economically feasible."

Bibliography

Figure 1-2

Organization of a Typical Launch Operations Activity
Figure 2-1. Test-Procedure Control
Engineering Requirement

Component Failure, etc.

Prepare Engineering Test Directive

Schedule

Prepare Special Test Procedure

Approval

Open Work Authority

STP

Schedule Work Sheet

STP

Start STP

Similar to Figure 2-1.

Figure 2-2. Special Test Requirements
Figure 2-3. Manual Scheduling of Test Procedures and Engineering Direction
Figure 3-1. System Diagram
From Launch Operations

Updated TP Schedule Work Sheets

Paper Tape Punch

Paper Tape Data

Teletype Central Data Center

Teletype Receiver Computer

Paper Tape Data

Paper Tape Conversion

Error Listing

Sched. Master Tape

Sched. Daily TP Activity Tape

Schedule Master Update Program

New Sched. Master

Work Tape

Error Listing

Sequence Time Generator Program

Work Tape

Merge Program

Sched. Work Tape

Work Sheet Program

Work Sheets

Reports

Directors' Report

Daily Schedule Report

Index Report

To Launch Operations

Figure 3-2. Scheduling System
Figure 3-3. Activity Recap Data Flow
Figure 3-4. Directors' Report Data Flow