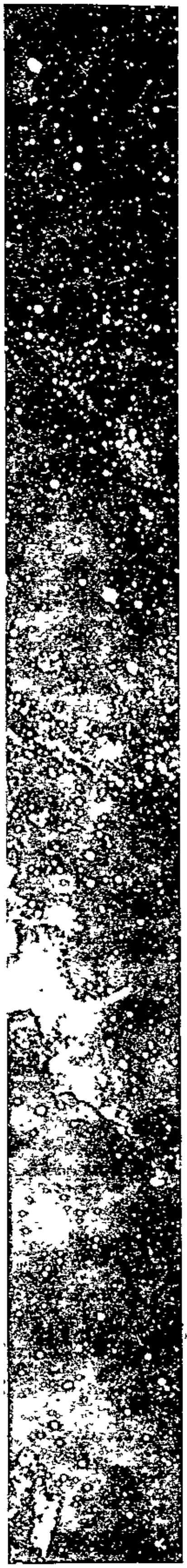
SPACE SYSTEMS



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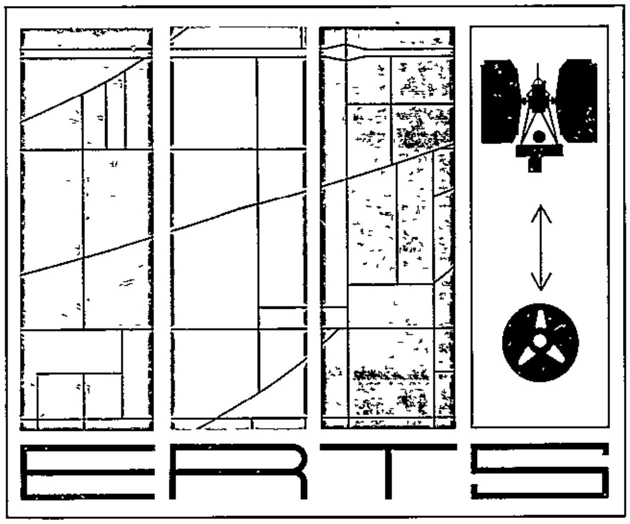
17 April 1970

EARTH RESOURCES TECHNOLOGY SATELLITE
OPERATIONS CONTROL CENTER
AND
DATA PROCESSING FACILITY
FINAL REPORT

SYSTEMS STUDIES

BOOK 1



Prepared For
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

GENERAL ELECTRIC

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EARTH RESOURCES TECHNOLOGY SATELLITE OPERATIONS CONTROL CENTER AND DATA PROCESSING FACILITY FINAL REPORT

SYSTEMS STUDIES

BOOK 1

PREPARED FOR:

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771

UNDER

CONTRACT NO. NAS 5—11529

GENERAL ELECTRIC

SPACE SYSTEMS ORGANIZATION
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17 April 1970

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SECTION 1
INTRODUCTION

This final report of the Earth Resources Technology Satellite Ground Data Handling System (GDHS) design studies is submitted in accordance with NASA Contract Number NAS 5-11259, Article II, Item 5a, and in accordance with the ERTS contract milestone schedule.

The primary objective of this study was to develop a Ground Data Handling System capable of meeting the performance requirements of the ERTS mission and the requirements delineated in NASA Study Specification S-701-P-3.

This Phase B/C study for the GDHS has been successfully completed with the establishment of a GDHS design meeting specification requirements.

In addition to this Phase B/C Study Report, a Phase D Proposal for the GDHS has been submitted in separate volumes which provide a detailed definition of the proposed GDHS system, together with its design, performance, capability, and implementation plans.

The Final Study Report presented herein presents in detail those analyses and tradeoffs required to arrive at a cost-effective design meeting all requirements. A summary of the GDHS design resulting from these studies is presented in Section 2, and significant study results are presented in Section 3. Section 4 provides an overview of the functional analyses, requirements, and specifications resulting from GDHS system level studies.

OCC system design studies, subsystems, installation/test and operations studies are presented in Sections 5 through 8.

NDPF system design studies, subsystems, installation/test and operations studies are presented in Sections 10 through 13.

Automatic Data Processing (ADP) equipment, which has a significant role in the GDHS, has been defined and an ADP Applications (Feasibility) Study has been completed. A revised version of this document, together with ADP Procurement Specifications, ADP Evaluation Criteria, and the final ADP Evaluation and Selection Report are submitted under separate cover.

Also submitted in separate volumes are preliminary specifications for the GDHS, its subsystems, and all components. In many cases, these specifications have been developed to a level of detail ready for final release pending NASA approval, and will permit immediate go-ahead on development of critical hardware and software items.

SECTION 2

GDHS OVERVIEW

The ERTS System includes a spacecraft in a near-polar sun-synchronous orbit, carrying a payload of a Multispectral Scanner System (MSS), Return Beam Vidicon Cameras (RBVC), Wideband Video Tape Recorders (WBVTR) and a Data Collection System (DCS) for the acquisition of data from earth-based sensing platforms. As shown in Figure 2-1, data acquired by the spaceborne system are transmitted to designated STADAN and MSFN ground sites, and forwarded through NASCOM to a Ground Data Handling System (GDHS) at GSFC.

Within the GDHS, the payload data are routed to the NASA Data Processing Facility (NDPF) for processing conversion to a format consistent with multiple user requirements for further processing, analysis and action. The NDPF also provides for processing of correlative data, storage and retrieval of data, and special processing on request. As a result, the NDPF must provide for the handling of a wide range of data products and workloads.

In addition, within the GDHS, the Operations Control Center (OCC) performs the functions required to plan, schedule, operate and evaluate spacecraft and payload operations, as shown in Figure 2-1. The OCC provides the command and control feedback to the spacecraft for accomplishing specific payload data collection requirements.

The OCC and the NDPF, as co-located facilities comprising the GDHS, are able to share common equipment or are able to use similar equipment as operational back-ups. However, because of the simplified interfaces between the OCC and NDPF, operation in physically separate facilities is easily achievable by means of a communications tie for voice and data interface.

Design of both the OCC and the NDPF are based on maximum utilization of standard or off-the-shelf hardware and software with emphasis on modularization whenever feasible to permit graceful growth. In the case of the OCC, this objective will be achieved by taking advantage of the experience gained in design of the Nimbus Control Center. The design of the NDPF capitalizes on hardware and software developed for other applications, such as the National Space Science Data Center and various military programs.

Many of the operations performed by the OCC and NDPF must be automated to meet mission requirements and therefore require Automatic Data Processing (ADP) equipment. However, the proposed design also provides a back-up capability using manual procedures and alternate modes of operating equipment.

In addition to the ADP equipment required in both the OCC and NDPF, ADP equipment is also required to perform spacecraft and sensor test functions both at the contractor's test facility and at the launch site. Because many of the functions required to perform system testing are identical to those required for flight operations, the Systems Integration Test Equipment (SITE) and software utilized for spacecraft testing will be identical to or compatible with, equipment and software required for the OCC. For this reason, the computer configurations and software for both OCC and SITE have been designed to be nearly identical, with differences only to account for specialized interfaces and computational requirements.

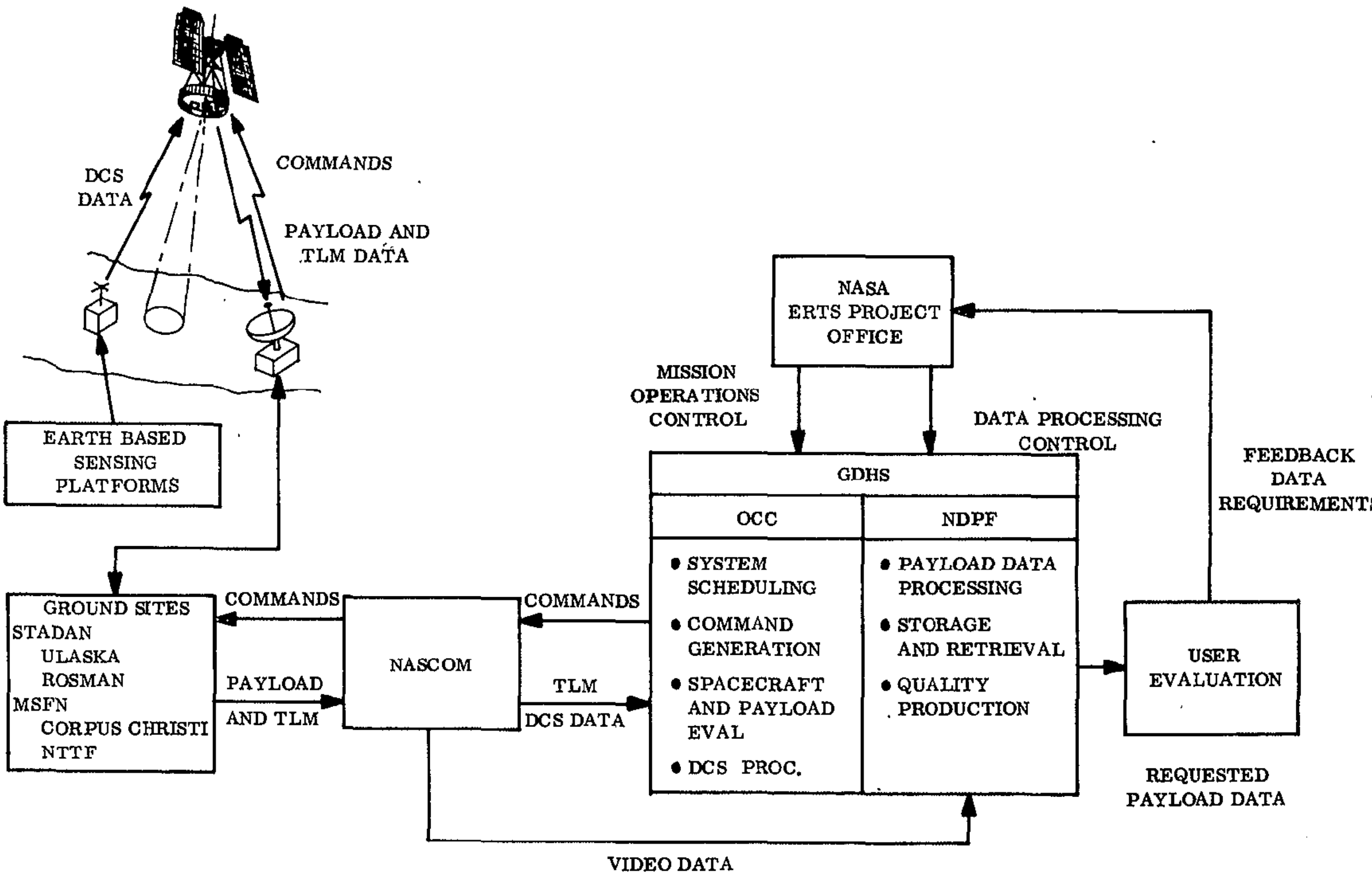


Figure 2-1. ERTS System Overview

SECTION 3

SIGNIFICANT STUDY RESULTS

Several of the studies performed during the Phase B/C period have provided results which have significantly impacted our proposed system design. These studies, together with the applicable results are discussed in detail in subsequent sections of this report. A summary of these significant study results is provided below and consists of the following topics:

OCC

1. OCC Operational Reliability
2. PCM Processing Design
3. OCC Operations Consoles
4. Commonality of OCC/System Test Hardware and Software
5. OCC/NDPF Independence

NDPF

1. NDPF Computer De-centralization
2. NDPF Workload
3. EBR Selection
4. Bulk Image Processing Throughput
5. RBV On-line Corrections to Bulk Imagery
6. Hybrid Image Processing Approach
7. System Accuracy and Ground Control Point Use
8. High Density Digital Tape Applications
9. Feature Enhancement Study
10. Microform Techniques
11. NDPF Information Retrieval System

3.1 OCC OPERATIONAL RELIABILITY

The OCC is the focal point for all ERTS unique project operations, and is designed to provide positive command and control over all spacecraft and payload operations. A major factor of this design approach is the ability of the OCC to preserve and maintain its real-time operational capability, even in the event of a major equipment failure. This is accomplished in several ways:

1. Selected equipments which perform critical functions are duplicated within the OCC. In almost every case the duplicate equipment has been integrated into the normal operational configuration and contributes to routine operations. In the event of failure this equipment can be switched into the critical flow or can be configured to operate in a contingency mode. This provides several real-time back-up modes within the OCC, itself, even in the event of an OCC computer failure, without the need for NDPF or other support.

2. Emergency backup is also available to the OCC for real-time spacecraft command and control in the event of network failure or other major contingency. In this mode the OCC will direct command activities by voice communication with the remote stations. This mode is initiated by the OCC itself and carried out under prescribed contingency procedures. The remote stations will command the spacecraft at OCC direction, transmitting individual commands and predefined contingency command sequences established in advance by the OCC.

3. In the event that the CCC should lose its computer facilities for an extended period, the OCC processing functions can be performed in the NDPF. Both of these computers are common, and OCC applications software will operate on the NDPF computer. Reconfiguration will be simple and will require only peripheral switching, for the most part. This mode need only be employed off-pass, since real-time operational backup is already provided within the OCC, itself, as described above.

3.2 PCM PROCESSING DESIGN

The purpose of this study was to assess the impact on the GDHS design resulting from processing the narrowband PCM playback data in the OCC, the NDPF, or both. Several factors entered into the study. The OCC requires the playback data shortly after it is acquired in order to perform an in-depth assessment of spacecraft performance and health. The real-time PCM data only covers an average of 10 to 12 minutes per orbit and cannot describe events programmed to occur outside the range of the station. These events could be unique to non-real time activities in which case a malfunction might not be readily apparent in the real-time data. Immediate post-pass analysis of this data would permit the malfunction to be identified and corrective action taken in the shortest possible time.

The NDPF requires selected information from the playback PCM data for generation of the Image Annotation Tape (IAT). This data defines the payload operating times and correlative spacecraft attitude for non-real time sensor operations. Since the payload video tapes are mailed to GSFC, the timing was not critical. NDPF also requires all of the PCM data received for generation of the Master Digital Data Tapes (MDDT). Here again, timing is not critical since the MDDT serves primarily as a historical archive.

An assessment was then made of the impact of this processing requirement on software development and computer sizing and loading for the OCC and NDPF. It was readily evident that the real-time software already required in the OCC could be easily adapted to perform the basic playback processing functions. In addition, the OCC real-time software could easily be utilized to provide the IAT inputs to the NDPF for real-time sensor operations. This again could easily be done for the playback data. Hence, the impact on OCC software appeared minimal. The impact on NDPF software development is minimal only if the OCC and NDPF computers are identical or software compatible. In this case, of course, it was assumed that the OCC real-time software could be carried over to the NDPF and modified.

In terms of sizing, it is evident that the OCC computer is sized for the real-time requirements of telemetry processing, commanding, and display. The size requirements of playback processing do not exceed those of real-time processing. Hence, there is no impact on OCC computer size, nor on OCC loading.

The effect of these requirements on the NDPF computer was significant if the NDPF was to process the data for the OCC. This would require much greater loading of the NDPF and would require increased core memory and random access storage to maintain throughput

As a result, it was decided to design the OCC to process both real-time and playback PCM data and to provide the necessary inputs to the NDPF routinely for the generation of the IAT and MDDT.

3.3 OCC OPERATIONS CONSOLES

The design concept for the OCC operations consoles is based on the need to provide the flight operations team with the information necessary to make rapid command and control decisions and the means to implement these decisions in an effective and timely manner. The consoles are designed as functional work stations. The primary display medium is a CRT display mounted in each console and driven by the OCC computer. Each console is also equipped with a standard input keyboard and set of programmable function keys which permit access to the computer. In addition, the consoles are equipped with a spacecraft time clock and pass time clock, communications panel, and a small matrix of status and alarm indicators also driven by the computer that can be programmed according to each console's function. The operations supervisor console and command console are identical to the other consoles but also contain a command entry panel which affords direct access to command generation software in the computer. Console design prevents commanding from both consoles simultaneously through positive lock-out.

During real-time operations each console operator may access any one of approximately fifty or more displays for immediate call-up at his console. Display requests are made via the keyboard. The display software in the computer will also notify the operator of any alarm conditions that have been identified in data which he is not currently viewing.

During the off-pass periods the consoles provide multi-user access to the computer. This permits the console to be used for spacecraft performance analysis, anomaly investigation, or processing required in preparation for the next orbit.

This approach permits the design of a single, standard operations console which has the flexibility to satisfy virtually all operational needs and also functions as a work station for both on-pass and off-line mission phases, including mission planning and anomaly investigation.

3.4 COMMONALITY OF OCC AND SYSTEM TEST HARDWARE/SOFTWARE

A significant aspect of the OCC design study effort has been the definition of the common requirements of the OCC and System Integration Test Equipment (SITE) for spacecraft command, control, and performance evaluation. This has resulted in a design approach in which all SITE software can be defined and developed as a subset of the OCC software, and where the critical elements of the SITE hardware are common to, and compatible with, the OCC hardware.

The OCC software development can be time-phased to produce the required SITE programs at the necessary points in the in-house test sequence. This design approach presents an extremely cost-effective solution to the development of OCC-SITE software and provides a timely test-bed from which to gain confidence in the performance of the OCC operational software and of the OCC computer configuration.

3.5 OCC AND NDPF INDEPENDENCE

The OCC is keyed to the schedule of the spacecraft and must operate 24 hours/day for 7 days/week, and is required to support each station pass, while the NDPF is oriented toward production line operation and, as defined by later design, operates 1 to 3 shifts/day for 5 days/week. The design of the interfaces between the NDPF and OCC, then, determines the schedule dependency between the two segments, and since the spacecraft is fixed, schedule dependency would restrict the NDPF to the OCC schedule. This restriction, in turn, imposes requirements on subsystem schedules, operating modes, reliability and throughput rates.

Independence of the OCC and NDPF, on the other hand, allows flexibility in NDPF subsystem design and scheduling, as they can be designed against standard items such as rolls of film, reels of tape, etc., instead of a satellite schedule. Quick turn-around processing can still be done, either by scheduling the NDPF in anticipation (on infrequent intervals) or by interrupting the job-oriented processing flows. Independence also allows separation of the OCC and NDPF without serious impact on the GDHS operation.

The obvious advantages in independence led to the design of simplified, "physical item" interfaces between the OCC and NDPF.

3.6 NDPF COMPUTER DECENTRALIZATION

Analyses of the functions to be implemented in the NDPF demonstrate the need for digital computer equipment for a number of computation and control functions. These include:

1. Image Annotation Tape Generation
2. MDDT Generation
3. Information Storage and Retrieval
4. DCS Processing
5. Digital Tape Reproduction
6. Bulk Process Control and Image Annotation Control
7. Precision Processing Control
8. Computer-Readable Tape Generation
9. Thematic Processing Control

Design and tradeoff studies have shown that the first five of these functions (1 to 5), which are "computational" in nature, can most efficiently and cost-effectively be implemented on a single medium-scale general purpose computer having standard peripherals, simple interfaces and nominal capabilities. However, the remaining functions (6 to 9), which are primarily "process control" in nature, are most effectively accomplished by small devices dedicated to their process control function.

As a result, we recommend the use of three small general purpose control computers as key components of the bulk processing (function 6), precision processing (function 7), and special processing (functions 8 and 9) elements of the Image Processing Subsystem. It should be noted that the computers proposed for bulk and precision processing are part of integrated hybrid systems in which the computers are used only as control devices, rather than for the "processing", manipulation, or correction of image data.

These proposed computers are of a common model with common peripheral equipments (with some exception). The use of three common process control computers for Image Processing is strongly recommended, in comparison to a system employing a simple larger scale computer, or small computers of different manufacture, for the following reasons:

1. Operational backup in the event of serious maintenance down time is provided by interchangeability between the three computers.

2. Costs and efficiency of operation and maintenance are optimized by the use of common systems. Spare part and service availability is part of this..

3. Software generation and modification costs and manpower requirements are minimized with the use of three common systems.

4. The development and modification costs for production software are less with three parallel processors for these functions, in comparison to a time sharing system. This is particularly applicable to the types of control computer support within Image Processing where I/O byte rates and memory cycle times have a higher importance in comparison to other computer parameters.

5. Interface costs are less expensive, and maintenance problems will not be catastrophic, for the system with three individual process control computers.

6. Additional avenues for system growth are open because of the flexibility inherent in the dedicated, and interchangeable process control computer concept.

3.7 NDPF WORKLOAD

Mission simulation studies have shown that operation of the sensor systems for Case B coverage will produce an average of 78 minutes of data per day as discussed later. At 25 seconds per scene (RBV frame or MSS equivalent frame) and seven spectral bands per scene, 9212 individual images will be obtained each week (188 scenes/day or 1315 images/day). Precision processing and color processing is based on percentage of the data gathered, and adds 460 images per week to the total number of images to be processed. There is little justification for significantly reducing the data input based on cloud cover estimates since the usefulness of partially obscured images is yet to be determined, the distribution of cloud cover over 100 x 100 nm areas is insufficiently known, and collection of useless data can be avoided by proper mission planning.

Production of 10 copies each of negative transparencies and positive transparencies and positive paper prints then must be sized at 96, 720 of each, per week (9212 + 460) (10). It is believed that the most useful item will be the positive transparencies and the standard 9-1/2 inch format. Positive prints are also most useful in the 9-1/2 inch size. As the costs for 9-1/2 inch and 70 mm photographic materials differ by an order of magnitude and processing speed differs by a factor of 6, an obvious significant savings in throughput cost as well as equipment and labor costs can be realized by proposing 70 mm instead of 9-1/2 inch materials. For this reason, it is recommended that the bulk negative transparencies be produced in a 70 mm format, as this is useful to users, assuming the availability of the 9-1/2 inch positive transparneices and prints. However, the precision processed data, negatives as well as positive, and the positive transparencies and prints are considered unacceptable if supplied in the 70 mm format, and such a system would not be responsive to user requirements.

Flexibility in equipment use and staffing is included to allow latitude in responding to changing throughput and formats. Microform techniques are strongly recommended to allow a more tailored throughput, responsive directly to user requests.

A most important feature of the recommended design is the throughput achievable in the Precision Processing Subsystem. The subsystem can throughput 5 percent of the RBV data and 5 percent of the MSS data in approximately 40 hours per week. The subsystem produces registered, rectified and photometrically corrected 9-1/2 negative transparencies and, simultaneously, can record the corrected images in digital form on high density tape for later conversion to standard computer-readable tape. That is, operating at 75 percent efficiency to allow for set-up and routine maintenance, 15 percent of the total data could be produced as registered, rectified, photometrically corrected images in a three-shift operation. This is the same amount of bulk data expected to be used to make color composites.

The Bulk Image Processing Subsystem can throughput the Case B load in approximately 60 hours per week. This figure includes a 75 percent efficiency factor for set-up and routine maintenance. Therefore, the ability to handle a large increase in load due to more data collection or regeneration of first generation images is a strong feature of this design. This throughput results partially from the innovative approach to MSS framing.

3.8 EBR SELECTION

An electron beam recorder (EBR) is proposed for the high resolution film recorder (HRFR) in bulk processing. The tradeoff studies leading to the selection of an EBR for the HRFR are discussed in detail in Section 11.1.

The selection of an EBR over a laser beam recorder (LBR) was a result of the unique capabilities possessed by the EBR. Both EBR's and LBR's can reproduce RBV and MSS data with minimum degradation of the final imagery. However, it is the integration into the bulk processing system that brings out the important differences in the two alternatives for the HRFR.

If an LBR is used for the HRFR, system interfacing becomes more complicated than with an EBR. An LBR requires that the RBV and MSS data source timing be slaved to the LBR time base. An EBR does not require this. Annotating the imagery requires more computer capacity with an LBR than with an EBR. Significant system cost benefits are thus available when an EBR is used for the HRFR.

Two significant capabilities emerge from the selection of an EBR for bulk film recording:

1. The beam scan can be shaped electronically on-line. Thus, geometric corrections determined in the precision processing section can be introduced into the bulk imagery produced from video tapes which will permit registration of triplets (to within 6 scan lines rms). Although this registration correction will not significantly improve the ability to locate the imagery on the ground, it makes

possible the production of color composites from bulk imagery. Throughput is not compromised using this technique. The value to the user of receiving improved bulk-processed imagery is obvious. The value of this capability to NASA is also obvious in that the bulk processed RBV images will now satisfy a larger fraction of potential users without an intermediate registration-processing step.

2. On-line framing of strip MSS imagery can be accomplished by multiplexing the beam over two portions of the film being exposed. Thus, the 10 percent overlap sections on adjacent framed images can be written at the same time. This technique has twice the throughput of any known technique for electronic framing, and significantly minimizes mechanical wear on the video tape recorder, since it is not required to be cycled.

3.9 BULK IMAGE PROCESSING THROUGHPUT

The Bulk Image Processing lines are designed to provide high quality, high reliability throughput. With two EBR's, the Case B load will require about 60 hours per week. With one EBR, the time required becomes 80 hours per week. These times allow time for set-up and maintenance, as well as 25 hours per week for the logistics and handling operations. Thus, with one EBR, 86 hours each week are available for coping with additional loads or unanticipated problems.

Reliability is provided in the design. With the two-EBR system, the obvious redundancy is available in the film recorder. The backup video tape recorders from the OCC may be used when not supporting a NTTF pass, and both the Special Processing computer and Precision Processing computer are available to replace the Bulk Processing computer. Additionally, Image Annotation Tapes can be made on the OCC computer using the NDPF software, should the NDPF central computer not be available.

Similar redundancy is provided in the Photographic Processing subsystem to assure continuous production of bulk imagery.

3.10 RBV ON-LINE CORRECTIONS TO BULK IMAGERY

The use of Electron Beam Recorders in the Bulk Processing Subsystem allows on-line corrections in both the x and y image directions. The system proposed to implement the corrections performs differential corrections, the same correction method used in the Precision Processing equipment.

Without the bulk image corrector, using a bulk printing control technique that could make only first-order corrections, the bulk registration errors for RBV images would rise to a maximum of 67 RBV 145-foot picture elements and an rms error of 16 elements. These numbers, over one-third of a nautical mile rms registration error, probably exceed the limits of practical utility for serious investigators of earth-resources phenomena.

Moreover, misregistration of this size would be clearly visible to the unaided eye viewing a color composite photograph at 1/1, 000, 000. The rms misregistration would be about 1/32 inch.

The proposed system, using differential correction, removes all systematic errors and yields spectral triplets which can be registered to about 6 RBV 145 foot picture elements (rms), and this level of misregistration cannot be detected by the unaided eye.

Thus, 100 percent of the Bulk Imagery will be corrected to satisfy most user requirements.

The errors are identified and corrections computed in the Precision Processing element. Correcting the bulk data does not decrease bulk throughput at all.

3.11 HYBRID IMAGE PROCESSING APPROACH

The hybrid approach used in the NDPF design for Bulk and Precision Image processing yields an integrated, high throughput facility that can handle Case B requirements on a regular 40 to 60 hour/week basis.

The techniques used for precision processing maintain the data in analog form, while using digital techniques for computation and control. Therefore, extensive digital processing is not required to perform corrections. These corrections can be performed by shaped scanning and film writing techniques without loss of information inherent in digitization or coarse scanning. Moreover, these corrections can be performed on the various spectral bands in parallel. Digital techniques can still be performed where appropriate, for such "picture element-level" items as reseau removal, dropout compensation, etc., but these are not recommended for the correction of the total number of picture elements per RBV triplet or MSS quad (about 50 million).

The hybrid approach provides statistical error data which can be used to perform significant correction to the bulk data. This will yield imagery which is registered to about three to six picture elements.

The inherent throughout afforded by hybrid processing and the efficient method of framing MSS data allows growth or additional processing to be done by both Bulk and Precision processing. This permits growth on the order of three times the Case B requirements, without affecting the ability to correct bulk data.

3.12 SYSTEM ACCURACY AND GROUND CONTROL POINT USE

In summary, studies performed indicate that precision processed data will be located and registered as follows:

	Precision Location Errors		Precision Registration Errors	
	99.7%	68.3%	99.7%	68.3%
MSS	691	245	406 ft	171 ft
RBV	586 ft	213 ft	442 ft	206 ft

The corrected bulk data is located as:

Bulk Location Errors

	99.7%	68.3%
MSS	1.64 nm	0.52 nm
RBV	1.82 nm	0.55 nm

In addition, the corrected bulk RBV can be registered to 934 feet rms error.

The geometric corrections performed to the RBV precision processed data from reseau measurements will leave a mean residual error of 0.4 picture elements (0.4 picture element standard deviation).

The error determination is performed via automated reseau recognition and routine use of ground control points. The use of ground control points obviates the need for precision sensor location and attitude data to perform precision location. These ground control points are any features recognizable in an ERTS image and locatable on the earth's surface. It will take, at most, one day to prepare the ground control points for a precision location problem, as 60 to 80 points can be identified and entered into the precessor in one man-day. After approximately three man-months of effort, sufficient ground control points will have been identified for all precision location for the United States coverage, and only routine maintenance of the ground control point file (and expansion to world coverage) will be required.

3.13 HIGH DENSITY DIGITAL TAPE APPLICATION

The use of High Density Digital Tape (HDDT) Recorders is covered in detail in Section 11.1 of this report.

The system design considerations leading to the generation of computer-readable tapes have resulted in a uniform and convenient method of storing precision processed RBV and MSS video data in a practical way on HDDT. In addition, this same tape can be used for producing computer-readable tapes simultaneously with other production without introducing throughput problems.

For producing computer-readable tapes from raw RBV and MSS video information, the use of the HDDTR and its wide ranges of speed has provided a convenient and practical way of dealing with the high and incompatible data rates between video tapes and computers. The result is that the methods of handling the different data formats within the system are uniform. From the user point of view, the use of HDDT has allowed a desirable and uniform scheme of spectrally and spatially interleaving of the registered data as the output format on computer-readable tape.

Use of the HDDT also provides most efficient storage for digitized image data as well as a transfer media internally between analog equipment operating at video speed and digital computer equipment.

3.14 FEATURE ENHANCEMENT STUDY

An analysis of the application of multispectral processing for feature enhancement was conducted during Phase B/C. The equipment to accomplish this enhancement, a "Thematic Processor", would operate as an integral part of the ERTS Image Processing Subsystem.

The results of this analysis indicate:

1. A thematic processor which processes digitized video from Bulk Processing of MSS video or Precision Processed video can be integrated into the Image Processing System.

2. This processor should also provide for the extraction and analysis of manually and automatically selected samples of multispectral video. These data are used to "train" the Thematic Processor to enhance or classify designated features.

3. Thematic processing capability can be added to the recommended Image Processing System with a minimum of additional equipment. This capability would share: the High Density Digital Tape recorder-reproducer for input and output of raw and enhanced video, the process control computer, and Control and Display Console of the Special Processing Element with other functions. The thematically enhanced or classified imagery would then be produced on film by the Bulk Processing Element, and produced in a color-coded image format when required by color registration printing equipment.

4. The incorporation of a Thematic Processing capability within the ERTS-NDPF is recommended because it will allow all principal investigators and experimenters involved with multispectral data to perform much of these experiments without unique spectral processing equipment of their own.

3.15 MICROFORM TECHNIQUES

In considering the scale and format requirements for a montage catalog, a replica montage was constructed using Nimbus and Apollo photographs. Because of cloud cover changes between adjacent swaths and the fact that above 55°N, there is a 50 percent overlap between adjacent swaths, it is difficult to construct a montage catalog which may be correlated to a geographic overlay and which, at the same time, can give a useful indication of ground obscuration. An alternate approach of reproducing independent swaths was also considered. It was felt, however, that the number of pages necessary to produce an acceptable scale for image recognition would require a montage catalog that would be expensive and of only marginal utility.

It is therefore proposed that the most effective way of providing an overview of satellite coverage and image quality to the user would be through the distribution of a microfilm catalog. This catalog shall consist of three sections:

1. Outline maps with each image-producing swath drawn in several shades of gray to indicate level of ground obscuration and image quality. Separate maps would

be provided for MSS and RBV imagery; for clarity and ease of reading, individual maps would be provided for the Unites States and other major geographical areas. These maps could be generated from the Information Retrieval Data Base and converted to microfilm by a COM device.

2. Computer-generated listings of available data ordered by geographic area covered and/or time of observation. Each image will be referred to by its position (i.e., "page number") in the microfilm catalog.

3. High quality microfilm images of all ERTS data of acceptable qualtiy. These will be collected into 18-day coverage cycles and broken into volumes (i.e., reels) according to area covered (e.g., U.S. only, Europe only, etc.)

It is estimated that an 18-day coverage catalog containing all of the useful U.S. images (all spectral bands with acceptable ground obscuration) may be supplied in a single roll of microfilm. The first of these sections may be provided in either hard copy or in microfilm. Hard copy sections will be of sufficient utility to warrant distribution without the microfilm images. Since these two sections will be computer-generated, it will be a trivial matter to produce catalog materials for any coverage period.

The microfilm images will be available within 1 day of the generation of the bulk images. Because of the high quality and the low relative cost of microfilm, consideration should also be given to the daily distribution of several microfilm copies to user agencies for perusal prior to ordering images for analysis.

3.16 NDPF INFORMATION RETRIEVAL SYSTEM

The requirements of an information retrieval system were considered and an integrated system design has been proposed that combines the various functions of information retrieval, production control, catalog generation and management reporting into a modular set of programs that utilize a single segmented data base. The advantages of these design concepts are:

1. Data maintained in the data base is available to all user programs, thus minimizing mass storage requirements.

2. All computer data generated in the NDPF is directly linked into the data bank, thus eliminating the costs and errors associated with a manual entry system.

3. Time sharing query responses are provided for information retrieval; because of modular systems design, time sharing query responses will also be available for production status and management reporting.

4. Commonality of applications systems routines will allow considerable flexibility and growth potential at virtually no additional cost.

5. Full logical selection (or searching) algorithms will be required for information retrieval functions. The same algorithms will also support selection of data for

generation of production control reports, catalog materials, and management information for either internal or external use.

6. No additional software will be required if access to portions of the information retrieval system is provided to telecommunication processors at remote sites.

SECTION 4
GDHS SYSTEM DESIGN

The design of the GDHS requires careful attention to the major system level tradeoffs which must be performed prior to detail design of its major segments or subsystems. These tradeoffs are required to:

1. Allocate functional requirements to various segments or subsystems

2. Establish the degree of commonality and/or sharing of equipments and software desirable throughout the GDHS design

3. Establish the appropriate operational concepts required to achieve reliable spacecraft operations and rapid throughput, high quality payload data processing.

These tradeoffs and their results are described throughout this Section and in Sections 5.0 through 13.0 for the segment (OCC and NDPF) and subsystem levels.

In addition, this section provides a review of the resulting GDHS system design (Section 4.1) and its key features as listed in Table 4-1, a discussion of the GDHS functional and subsystem design (Section 4.2), a summary of the major GDHS requirements (Section 4.3), and a tabulation of the GDHS specifications which have resulted from the design studies presented in this study report.

4.1 GDHS DESIGN OVERVIEW

The ERTS GDHS is composed of two major segments: The Operations Control Center (OCC) and the NASA Data Processing Facility (NDPF). These segments and the functions proposed to be performed in each segment to accomplish the ERTS mission are shown in Figure 4.1-1.

The OCC performs the functions of system scheduling, command generation, PCM processing, spacecraft/payload evaluation, and system scheduling. The system scheduling function determines the sensor operations which will effectively utilize the data collection capability of the spaceborne observation system, and schedules necessary system operations such as tracking, orbit maintenance operations, wide band tape recorder operations, and ground station contacts. The command generation, PCM processing, and spacecraft evaluation functions are performed to monitor the state of the system and implement the operations requested to accomplish the mission. These functions provide real time support of the operations control function where the actual control of the spacecraft and mission resides.

The NDPF is not constrained to the real time, around the clock spacecraft support as in the OCC, but must process, store and disseminate the collected sensor data on a dependable, high quality basis. Conversion of the video signals to film, and precision film processing, are required to produce usable quality imagery. Computations performed on telemetered data are required for DCS processing and/or location and annotation of the images to permit maximum data utilization by the users. Special processing must be provided to prepare the sensor data in digitized computer readable form.

Table 4-1. Key GDHS Design Factors

Motivating Design Factor	Proposed Design Approach
Interfaces between OCC and NDPE should be minimized to permit easy relocation of either facility; to simplify hardware and software design; and to minimize interdependency of schedules and operating modes.	Interfaces between OCC and NDPE consist of hand carried magnetic tapes (for spacecraft, DCS, and video data) or hand copy data (coverage priorities data volume estimates, ephemeris data, etc.).
All PCM processing should be performed in the OCC to assure timely information for spacecraft operations.	OCC design permits processing, analysis and display of all spacecraft/payload PCM data and generation of the SPDT. PCM processing in the NDPE, based on SPDT input is performed only to acquire parameters required for image annotation and to generate the MDDT for archival storage.
DCS data acquisition, decoding, and preprocessing should be accomplished in the OCC to capitalize on its existing NASCOM interfaces.	DCS preprocessing performed in the OCC to generate computer readable table utilizes the existing PCM decommutation capability and network interfaces. DCS final processing is performed in the NDPF to utilize the available processing and distribution capabilities.
OCC design must assure fail-safe backup modes for spacecraft operations in the event of computer failures.	OCC design provides redundant or alternate processing paths to permit continued real time command and PCM data display in the event of critical hardware failure. For extended OCC computer down-time failures, NDPF backup can be used.
The ability to backup OCC computer operations by the NDPF in at least a "degraded mode" is desireable to protect the spacecraft during long term OCC computer failures.	Choice of an NHPF computer identical to or compatible with the OCC computer has been assured by proper balancing of computational workload. OCC and NDPF co-location will permit hardware backup through peripheral switching and manual software transfer.
Checkout and validation of OCC operational software during spacecraft test activities is desireable. Conversely, software used for spacecraft testing should be designed to exercise and evaluate flight operational modes and conditions.	Spacecraft test software is designed as a subset of OCC operational software with a minimum of modifications or additions uniquely required for testing.
Constant and reliable throughput is required in the NDPF, especially in the bulk image processing lines.	All key items in the bulk processing lines are redundant. Allowances for maintenance, normal working efficiences, and realistic throughput are provided thruout the system. No single critical component failure can cause stoppage of bulk data flow.
Maximize quality of bulk processed image data to minimize need for precision processed data.	Corrections made to bulk data are implemented identically as in precision processing. All systematic errors are removed from 100 percent of bulk imagery using error identification from precision processing. All RBV spectral images are registered to 3-6 scan lines by bulk processing.
Flexibility in production should be provided to allow response to changing requirements or special request.	An information retrieval system integrated to provide production control via work orders allows fast response to each particular production requirement.

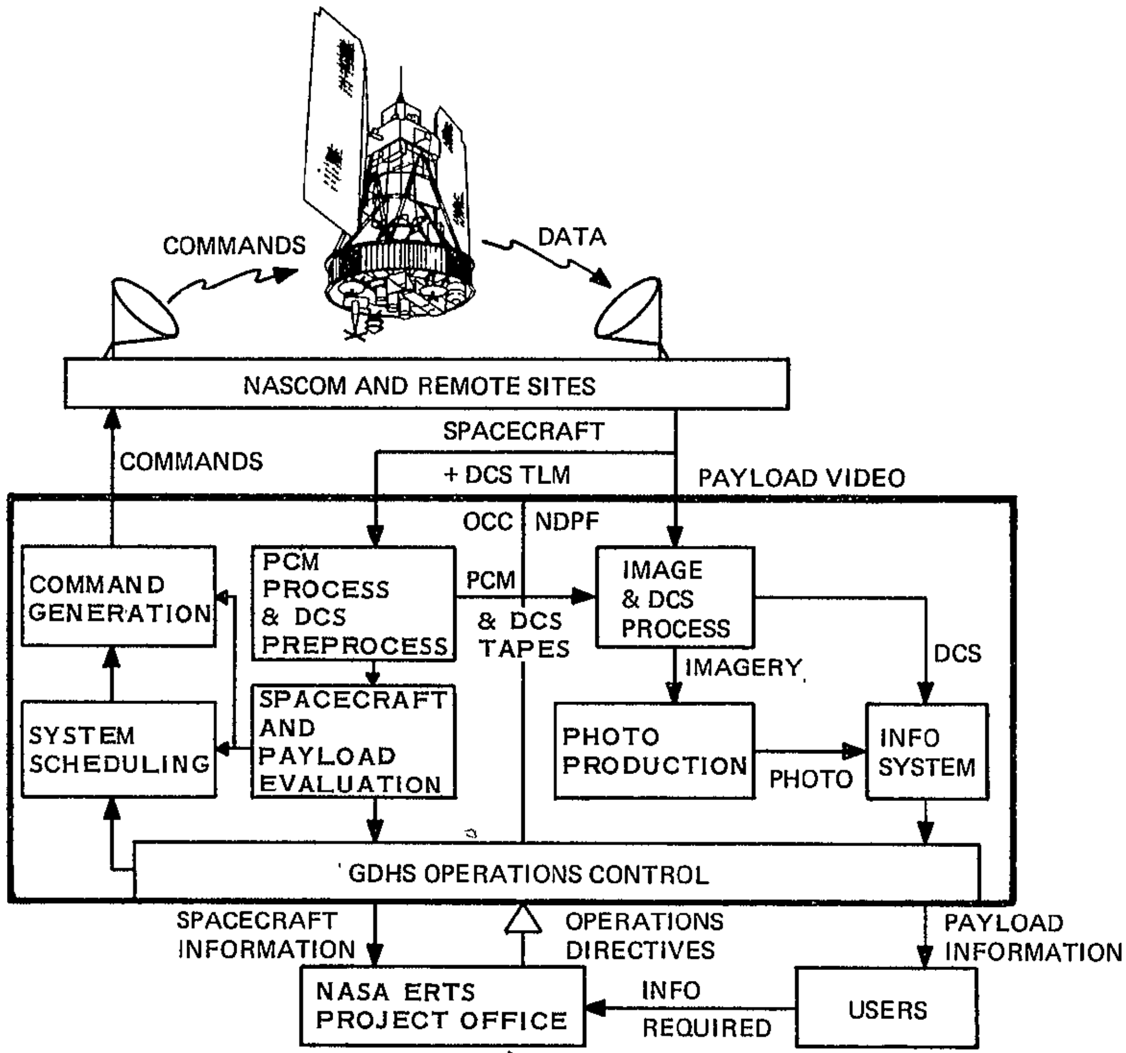


Figure 4.1-1. ERTS System Functions

The images produced must be copied and processed to yield high quality output, yet the system must throughput a large amount of photographic materials and computer tapes in a reasonable amount of time. Hence, quality control and efficient process specification and control are needed. Processing control must schedule special orders as well as maintain control over bulk data flow. With the large amount of data which will be available from the ERTS system, the library type functions of classification, storage, retrieval, and query response must also be performed efficiently. In addition, the logistics and accounting necessary in maintaining and monitoring the GDHS must be provided.

4.2 GDHS FUNCTIONAL AND SUBSYSTEM DESIGN

The GDHS consists of the Operations Control Center (OCC) and the NASA Data Processing Facility (NDPF). As these segments are functionally and operationally dissimilar, the detailed analyses and designs are covered in Sections 5 and 10, respectively. Paragraph 4.2.1 summarizes these designs; Paragraph 4.2.2 describes the resulting subsystem design and configuration.

4.2.1 GDHS FUNCTIONAL DESIGN

Figure 4.2-1 illustrates the design and interfaces for the GDHS.

4.2.1.1 OCC Functional Design

To meet the specifications, the OCC must perform the following functions:

1. Planning and Scheduling - Establish payload (RBV, MSS, DCS and WBVTR) operations desired and the necessary mission supporting ground activities.

2. Command Generation - Generate the commands required to operate the payloads in accordance with the mission plan and to maintain the spacecraft.

3. Spacecraft and Payload Performance Evaluation - Preprocess DCS data and to evaluate the status and operation of the spacecraft and payload systems via telemetry, raw DCS data and payload imagery. Also produce the spacecraft performance data tape.

4. Operations Control - Control the activities in the OCC, serve as the focal point in the OCC, implement mission operations, and maintain interfaces with the ERTS Project Office and the remainder of the system (NDPF, NASCOM, Orbit Determination Group, ESSA, etc.).

4.2.1.2 NDPF Functional Design

To meet the specifications, the NDPF must perform the following functions:

1. Platform Processing and Data Location - Produce the processed DCS final output, the Image Annotation Tape containing the information necessary for film annotation, and the Master Digital Data Tape containing non-video archival digital data.

2. Master Image Generation - Produce the annotated first generation film images from RBV and MSS video data.

3. Precision (Photogrammetric) Processing - Remove geometric and radiometric distortions from the RBV and MSS imagery and to produce accurate mapped photographs.

4. Special Processing - Produce edited computer readable digital tapes from the video sensor inputs, and to perform digital image and (optional) thermatic processing.

5. Photo-Optical Processing - Perform the photographic processing not directly involved in production processing, such as enlargement, etc.

6. Production Photo Processing - Provide the high volume, quality photographic production capability, information system maintenance and computer services required in the NDPF, including positive and negative transpariencies, paper prints, etc.

7. Working Storage - Provide storage, retrieval, shipping and receiving of the materials handled in the NDPF.

8. NDPF Control - Provide for NASA Project Office interface and other external interfaces, control production processes, maintain quality standards, and provide publication services for the GDHS.

4.2.2 SUBSYSTEM DESIGN CONFIGURATION

The studies documented later in this report have been used to determine an implementation which will perform the functions specified above in a cost-effective manner. A summary is provided here.

4.2.2.1 OCC

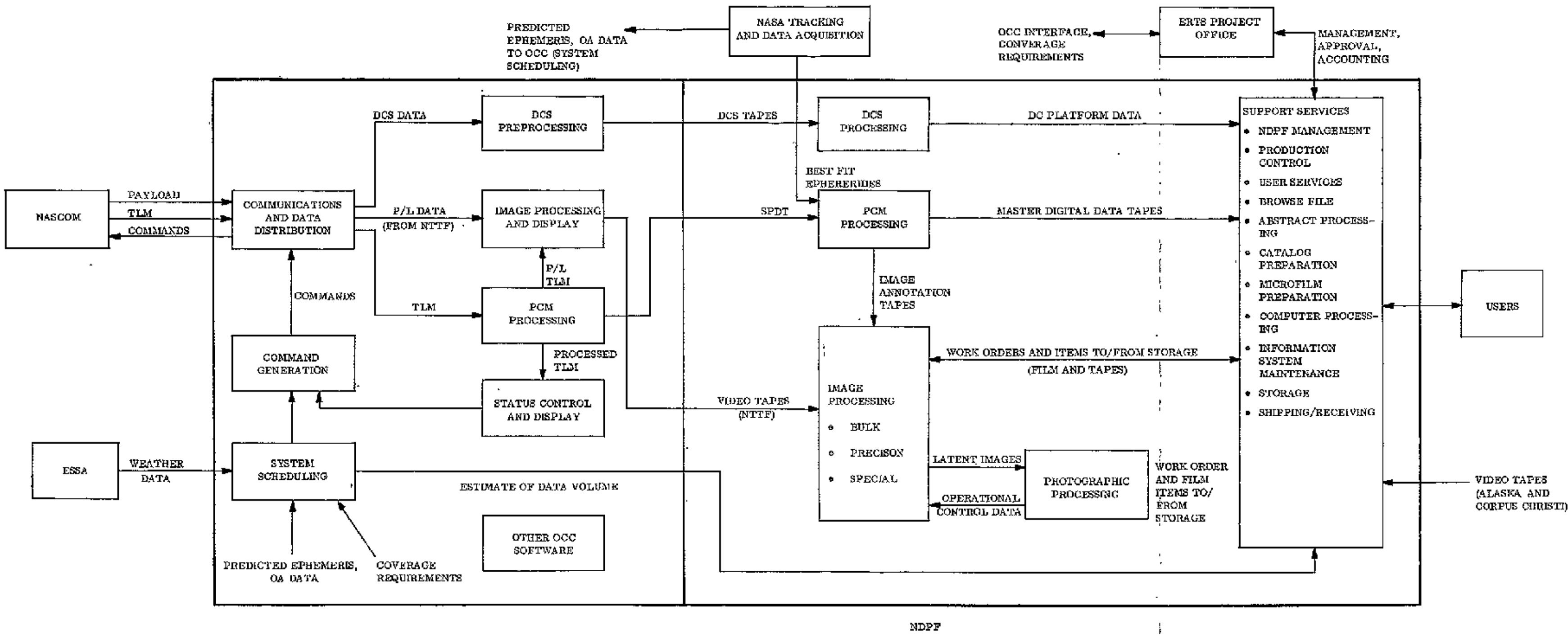
The central theme in the OCC is the evaluation and control of the observatory system. This is reflected in the central OCC computer and operation consoles design which is dedicated to evaluation and commanding while in contact with the spacecraft and makes full use of the computer and consoles for time-shared, multi-job processing between contacts with the spacecraft.

Several of the subsystems in the OCC are comprised chiefly of software which operates entirely within the OCC computer. The subsystems shown in Figure 4.2-1 include the following:

1. PCM Data Processing - Accepts and processes spacecraft and payload telemetry data for command and control and performance evaluation. DCS preprocessing is also performed. This subsystem consists entirely of software which operates on both real-time and playback PCM and DCS data.

2. Image Processing and Display - Provides for the recording and quick look display of RBV and MSS data.

3. Command Generation - Compiles the spacecraft command list and manages the formatting, transmission, display and verification of real-time and stored commands during real-time spacecraft acquisition. All command functions are performed under the control of the command operator stationed at the command console.



FOLDOUT FRAME 1

FOLDOUT FRAME 2

Figure 4.2-1. GDHS Functional Design

4. Status Control and Display Subsystem - Consists of the OCC operations consoles, strip chart and event recorders, and display generation software which operates in the OCC computer. Each of the operations consoles contains a CRT display and entry keyboard which permits operators to individually select any display in the display library. The keyboards also permit multi-user access to the full computer capability for the variety of processing functions routinely performed within the OCC.

5. Communications and Data Distribution - Provides a centralized interface between the OCC and NASCOM. This subsystem performs all of the necessary input/output patch and switching, signal conditioning, recording, time translation, and data flow management required within the OCC.

6. Computing Services - Performs all of the processing and computation required within the OCC. This subsystem consists of the OCC general purpose computer, its peripherals, and its operating system software.

7. System Scheduling - Consists entirely of software which accepts orbit and weather data inputs together with spacecraft and payload status information to generate schedules for payload operations, WBVTR read and write operations, tracking station coverage, and orbit maintenance schedules.

8. Other OCC Software - Consists of all other software required within the OCC. This includes:

    a. Applications executive software

    b. OCC test and diagnostic software

    c. Data base management software.

4.2.2.2 NDPF

In the NDPF, the goal is achievement and maintenance of high quality throughput. As various products are produced, the processing lines need to be as independent as possible to isolate each production line from any perturbations in another line. Likewise, the entire NDPF is oriented toward throughput and needs to be isolated from the 104 minute cycle schedule of the OCC. To these ends, the interfaces between the OCC and NDPF are physical items (as opposed to signals requiring schedule coordination), the processing lines are parallel and independent, and realistic flexibility is provided to allow adapting to varying loads. It should be noted that some equipments are shared where throughput allows such sharing. This is the case where the film printer functionally required by the special processing function is actually the printer implemented in the bulk or precision processing function. The use of high density digital tape as interface media between the processing lines also permits this sharing without perturbing throughput schedules.

The NDPF subsystems, shown in Figure 4.2-1 are:

1. Image Processing Subsystem. These provide for generation of all master images and consist of:

   a. Bulk Image Processing Element - Converts RBV and MSS video data tapes to annotated 70 mm film, using the Image Annotation Tape produced in the PCM Processing Subsystem; implements corrections derived in the Precision Processing Element; provides high density digital tape containing digitized raw RBV and MSS data; and converts digitized data from high density digital tape to film.

   b. Precision Processing Element - Uses bulk processed 70 mm imagery, the Image Annotation Tape and ground control points to produce radiometrically and geometrically corrected imagery on 9½ inch film and on high density digital tape. Also, it produces a world-wide ground control point library from ERTS imagery; converts digitized data from high density digital tape to film; and determines the corrections to be applied to the bulk processed data.

   c. Special Processing Element - Edits and converts data between computer readable and high density digital tapes; provides the software for performing digital image processing; and performs thematic processing (optionally).

2. PCM Processing Subsystem. Provides the software to perform attitude determination, image location and annotation data processing. This uses ephemerides tapes from NASA and the SPDT from the OCC containing calibrated and converted telemetry to produce the Image Annotation Tape and the Master Digital Data Tape.

3. DCS Processing Subsystem. Provides the software to process the DCS data received, calibrated and converted on the SPDT from the OCC to user oriented output.

4. Photographic Processing Subsystem. Provides for the enlarging of 70 mm bulk imagery to 9½ inch color composites, and the photographic copying and processing necessary to produce the quantity and quality of imagery required.

5. Computing Services Subsystem. Provides the ADP equipment used throughout the NDPF and software not specified under other NDPF subsystems, such as system software and tape duplication.

6. Support Services Subsystem. Provides for image assessment, quality control implementation microform processing, publication services, storage, shipping and receiving, user services and NDPF interface service.

4.3 GDHS REQUIREMENTS

4.3.1 GDHS MISSION REQUIREMENTS

The characteristics of the ERTS GDHS are defined to satisfy the requirements of the ERTS mission. These mission requirements are specified below in terms of:

1. Mission Data

2. Mission Support

3. Mission Phases

4.3.1.1 Mission Data Requirements

The ERTS mission data is defined as that data acquired by the Observatory payload and consists of:

1. Return Beam Vidicon (RBV) Camera data

2. Multispectral Scanner (MSS) data

3. Data Collection System (DCS) receiver

4.3.1.1.1 Mission Data Sources

Mission data will be acquired at every opportunity over the continental United States, plus one hour of payload operation per day over the rest of the earth.

The RBV and MSS data will be received and recorded on magnetic tape at the STADAN Alaska ground station and the MSFN Corpus Christi ground station and physically transfered daily to the GDHS. The RBV and MSS data will also be received at the GSFC NTTF ground station, transmitted in real time to the GDHS via NASCOM facilities, and be recorded there on magnetic tape.

The DCS data will be received, recorded and pre-processed at the Alaska and Corpus Christi ground station and will be transmitted to the GDHS via NASCOM facilities to the GDHS in the post-pass period. The DCS data will also be received at the GSFC NTTF ground station, transmitted in real time to the GDHS, via NASCOM facilities, where it will be further pre-processed and recorded.

4.3.1.1.2 Mission Data Processing

The GDHS will convert all video data collected from the RBV's and MSS, as discussed in Section 4.3.2.1, to annotated imagery on black and white film. The RBV imagery is produced as framed imagery representing ground coverage of 100 by 100 nm. The MSS data is returned as continuous strip imagery which is converted to frame imagery with 10 percent overlap to correspond to the RBV data.

The GDHS will also produce high density digital tape containing digitized, raw sensor data. The GDHS will generate geometrically and radiometrically corrected imagery in both film and high density digital tape form, and will precisely locate the imagery to within 213 ft and 245 ft (15 errors) for RBV and MSS data, respectively. The GDHS will have the capability to convert the digitized image data from high density digital tape to computer-readable tape and vice versa.

The GDHS will produce copies of the RBV and MSS data generated as a result of the above specified processes and distribute these data to designated users. User agencies. The DCS data will be processed and the DCS data products will be distributed to User agencies. The GDHS will publish catalogues, corresponding to an 18 day coverage cycle, containing information concerning the availability of mission data.

The GHDS will respond to special requests for available data and the special processing thereof, and will provide a liaison service for the User for the purpose of aiding in the User utilization of the GDHS capabilities.

4.3.1.1.3 Mission Data Throughput

The RBV and MSS data throughput requirements will be in accordance with the specifications shown in Table 4.3-1. The GDHS will be capable of processing that DCS data received from the interrogation of 1000 data collection platforms at the rate of 18,000 interrogations per twelve (12) hours. The GDHS will record and archive all mission data products and be capable of reproducing any desired item contained within the archives. The archives will provide for the storage of 9000 tapes, 150,000 units of 9 inches of 9 inches imagery, 1500 cans of 70 mm roll film, 50,000 70 mm aperture cards, and 50,000 computer punch cards.

4.3.1.2 Mission Support Requirements

The GDHS ERTS mission support requirements are defined as those not specified in terms of mission data, as defined in Section 4.3.1.1, but, nevertheless necessary to satisfactorily accomplish the ERTS Mission.

4.3.1.2.1 Observatory Orbit and Station Coverage Characteristics

The GDHS will provide mission support as specified herein for the ERTS Observatory, which will be placed in Earth orbit with nominal parameters listed in Table 4.3-2. The Observatory will make approximately 14 orbits per day, 12 of which will nominally produce ground station contact, and 2 of which may be "dead" and back-to-back. Nominally, four orbits per day will produce overlapping ground station coverage and, thus, will require rapid and coordinated ground station hand-over. Station contact will nominally be 10 minutes duration.

4.3.1.2.2 Mission Support Data Sources

The GDHS will receive all telemetry data, as discussed in Section 4.3.2.3, from the Observatory containing all information concerning the operation and status of both the Observatory and its payload. The telemetry data will consist of both real time and dump data in PCM format. The real time data will be received continuously during a station pass, and is a real time description of the Observatory and Payload status and operations. The dump telemetry data consists of the history of Observatory and Payload status and operations which have been recorded on the Observatory narrow band tape recorder since the last station

Table 4.3-1. GDHS Throughput Requirements of RBV & MSS Mission Data

B-W	Black and White
C	Color
+	Positive transparency
−	Negative transparency
+ Prints	Positive paper prints
C Prints	Color Positive Paper prints

RBV Input
188 Scenes/Day — 1316 Scenes/Week
564 Images/Day — 3948 Images/Week

MSS Input
188 Scenes/day — 1316 Scenes/week
752 images/day — 5264 Images/week

Input	Branch	Scenes Per Week	For Each Scene	Items Per Week
RBV Input	100% Bulk	1316	3 B-W masters	3,948
			30 +	39,480
			30 −	39,480
			30 + prints	39,480
	20% Bulk Color	263	1 C−	263
			10 C prints	2,360
	5% Precision	66	3 B-W masters	198
			30 −	1,980
			30 +	1,980
			30 + prints	1,980
			1 C−	66
			10 C prints	660
			Computer Readable	≈ 238 Tapes
	1% Digitized	13.2	3 copies Computer readable	≈ 158 tapes
MSS Input	100% Bulk	1316	4 B-W masters	5,264
			40 +	52,640
			40 −	52,640
			40 + prints	52,640
	20% Bulk Color	263	2 C−	526
			20 C prints	5,260
	5% Precision	66	4 B-W masters	264
			40+	2,640
			40 −	2,640
			40 + prints	2,640
			2 C−	132
			20 C prints	1,320
			Computer Readable	≈ 238 Tapes
	5% Comp Readable	66	3 copies Computer Readable	≈ 713 tapes

Table 4. 3-2. Nominal Orbit Parameters

Orbit Parameters	Nominal Orbit
Altitude*	492.35 nm
Inclination	99.088 deg
Period	6196.015 sec
Eccentricity	0
Time at ascending Node	21:30
Coverage Cycle Duration	18 days (251 revs)
Distance Between Adjacent Ground Tracks	86.06 nm
*Altitude Defined as: Semi-Major Axis Minus Equatorial Radius	

pass. During a station pass the dump telemetry data is transmitted at a rate 24 times the real time telemetry rate.

The GDHS will receive orbital data as discussed in Section 4.3.2.5, from the NASA Orbit Determination Group describing the orbital behavior of the Observatory; the GDHS will be the respository of, and respond to, specific requests for mission data acquisition requirements; and the GDHS will receive current and projected cloud cover information as discussed in Section 4.3.2.6, from the Environmental Science Services Administration and other appropriate sources as required.

4.3.1.2.3 Mission Support Functions

Utilizing the above specified information, the GDHS will perform all functions required to generate and be the source of all commands, as discussed in Section 4.3.2.4, transmitted to the Observatory to control the in-orbit operations of both the Observatory and its payload. The commands consist of real time and stored commands. The real time commands are exeucted in real time as received by the Observatory. The stored commands are stored in the Observatory memory for delayed execution. The Observatory memory has a capacity of 30 stored commands which may be recycled at fixed intervals.

The GDHS will schedule all station pass activities, as discussed in Section 4.3.1.2.1 and implied by Table 4.3-2, sufficiently in advance to coordinate and confirm with NETCON, OPSCON, and MSFNOC the availability and operational readiness of all required STADAN, MSFN, and NASCOM facilities.

The information specified above will also be utilized as appropriate in the processing of mission data, as specified in Section 4.3.1.1, and to compile and make available historical Observatory and payload performance data in a form that may be directly correlated with the mission data.

4.3.1.3 Mission Phase Requirements

Those GDHS mission requirements specified in Sections 4.3.1.1 and 4.3.1.2 are concerned with steady state mission operations as herein defined. In addition, the GDHS will be capable of supporting other mission phases as defined below.

The GDHS will, in the prelaunch time period, participate in and perform such functions and activities as necessary to establish the operational readiness of the GDHS and the ERTS system at the time of launch.

During the period of Observatory launch and orbit injection the GDHS will acquire information and initialize its operations as necessary to assume control of the Observatory and engage in steady state mission operations at the first available station pass after orbit injection.

The GDHS will anticipate failure modes within the Observatory and its payload, internal to the GDHS and within the other elements of the ERTS system, and will be capable of continuing operations in such a manner that only mortal and irremedial failures within the Observatory and/or its payload will cause mission abort.

4.3.2 GDHS INTERFACES

The GDHS must interface, directly or indirectly, with all elements of the ERTS System, shown in Figure 4.3-1 and itemized as follows:

1. The ERTS Observatory

2. A complex of ground-based remote stations which are part of the Manned Space Flight Network (MSFN), and the STADAN Network

3. The NASCOM Network that transfers data and communications to and from these remote sites

4. MSFNOC, NETCON, and OPSCON that provide scheduling and control for the MSFN and STADAN sites and the NASCOM facilities

5. The NASA Orbit Determination Group to determine the Observatory orbit and orbit maintenance requirements.

6. ESSA to provide cloud cover information

7. The NASA ERTS Project Office to provide project control and requirements

8. The User community that is the recipient of all mission data

9. Remote Data Collection platforms making on-site measurements that are transmitted to the Observatory.

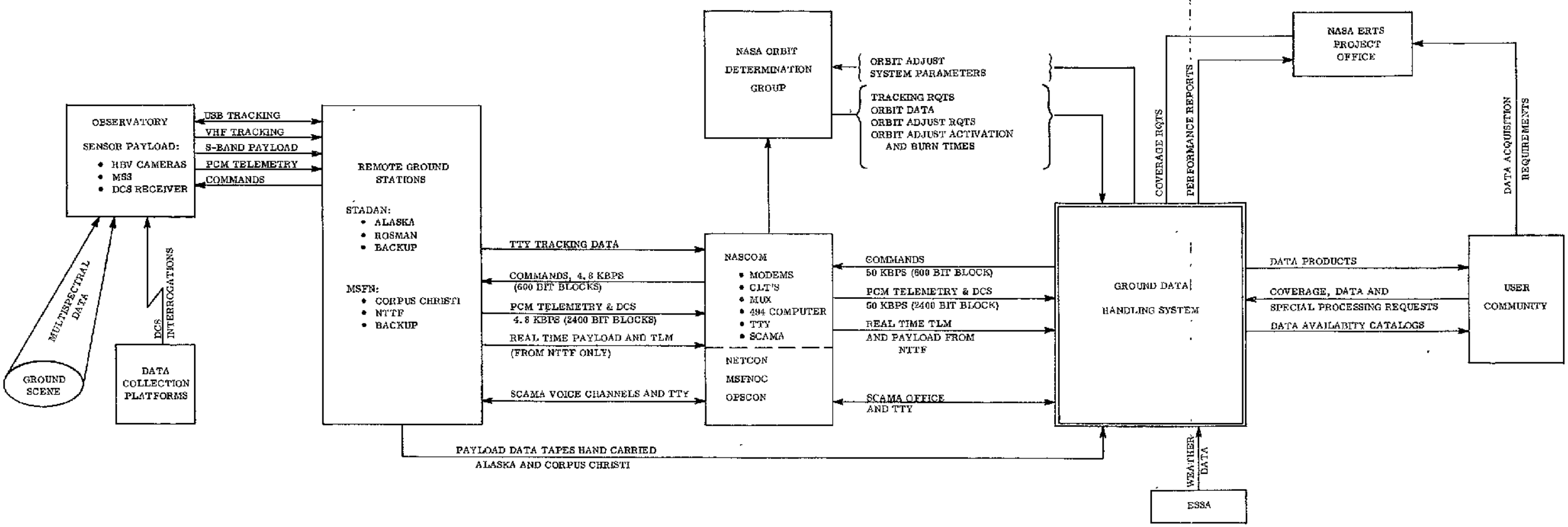


Figure 4.3-1. System Configuration and GDHS Interfaces

FOLDOUT FRAME 1

FOLDOUT FRAME 2

The GDHS interfaces with the other ERTS system elements, and are described in the following paragraphs in terms of the major types of information flow, which includes the following:

1. Payload (RBV/MSS) Data
2. Payload (DCS) Data
3. Telemetry Data
4. Command Data
5. Tracking Data
6. Weather Data
7. User Data

4.3.2.1 Payload (MSS/RBV) Data

Payload data is capable of being received at three remote facilities: Alaska, Corpus Christi, and NTTF. The video payload data transfer from Alaska and Corpus Christi to the GDHS will be via physical transfer of tapes. The NTFF will relay MSS and RBV data in real time to the OCC, where it will be recorded.

The wideband imaging sensors for ERTS consist of three return beam vidicon cameras and a 4-channel (5 for ERTS B) multispectral scanner. Two tape recorders, each capable of recording either MSS or RBV data, are included in the payload. The Observatory will provide two parallel S-band payload data communication links. Any two tapes of data from the combinations of real time, playback, MSS or RBV data may be transmitted over these two links simultaneously. The nominal configuration of downlinked payload data will be RT MSS/RBV data or WBVTR playback MSS/RBV data over the two assigned S-band frequencies. 100-pps ERTS clock signals consisting of 40 bits in ten 4-bit BCD format will be recorded on auxiliary tracks of the WBVTR's and downlinked in real time and during WBVTR dump for time correlation purposes. MSS data will be in the form of PCM data downlinked at a 15-mbps rate, while the RBV data is in the form of FM video data.

On the ground, either at the remote sites or the GDHS, selected patching configurations will route the MSS and RBV data, concurrently with the 100 pps clock data, to the ground wideband video tape recorders and to MSS and RBV quick look displays. Thus, the MSS or RBV recorded data on the ground WBVTR will contain the video of each sensor on a main track(s) as well as the time code data on the auxiliary track, similar to the spaceborne WBVTR's.

Other payload correlation data contained on the narrow band PCM downlink will be relayed to the GSFC directly in real time. This data will be used for image annotation tape generation and other data required for final MSS-RBV processing once the tapes arrive at GSFC.

4.3.2.2 Data Collection System (DCS) Data

The DCP's will be located in remote locations throughout the continental United States. These platforms will uplink on an assigned UHF frequency of 401.9 MHz to the ERTS vehicle. Each DCP will transmit data to the ERTS vehicle asynchronously with data burst of 38 milliseconds approximately every 90 or 180 seconds. Mutual interference from two or more DCP's transmitting is, thus, possible depending on the number of DCP's and the accuracy of their transmission frequency.

The Data Collection System Receiver will be turned on during possible DCP contracts by command. Although, more than one platform's information may be transmitted at a time, frequency separation within the 100 kHz IF output of the DCS receivers will likely occur because of slight variations in uplink frequency, doppler shift, etc. The signal-to-noise ratio is expected to be quite low, and special ground equipment will be used to extract the individual platform information by preprocessing equipment at the Alaska NTTF and Corpus remote sites, and at the GDHS.

At Alaska, the preprocessed data will be recorded on a standard tape recorder for post pass playback. The tape recorder will interface with the Alaska X144 data terminal line, mode 1. Preprocessed DCS data will be transferred to the GDHS.

The DCS data received atCorpus Christi will feed the unique DCS preprocessor (as at Alaska) and will interface a Mincom 22 tape recorder. Recorded, preprocessed data will be played back to the GDHS via the 642B computer and MODEMS.

The DCS data received at the NTTF will be relayed to the GDHS bypassing the 494 computer. The NTTF data will arrive at the GDHS via a hardline interface. NTTF-DCS data will be recorded on the GDHS recorder for subsequent processing in GDHS.

4.3.2.3 Telemetry Data

All MSFN/STADAN sites supporting ERTS will have the capability of relaying ERTS RT PCM data in real time. All remote sites except for the NTTF will send the RT data over NASCOM circuits interfacing with the GSFC 494. Alaska and NTTF will be capable of sending the 24 kbps dump in real time to the GDHS for processing.

Backup MSFN/STADAN sites will transfer dumped data to the GDHS postpass by playing back the recorded data at a slower rate compatible with the NASCOM 4.8 kbps interface. All sites, with the exception of the backup STADAN sites, are capable of receiving and displaying the Versatile Information Processor (VIP) used for Nimbus. The VIP will be programmed for the ERTS needs and tentatively will contain 20 columns and 80 rows of 10-bit words downlinked at 1 kbps. The first two columns will contain a unique sync pattern for each row and a third column will contain the incrementing minor frame ID (1 to 80). A major frame period is 16 seconds while the minor frame cycle is 5 minor frames per second for RT PCM. The dumped PCM is downlinked in reverse, i.e., newest recorded data is dumped first by running the tape backwards.

Real time PCM can be received on both the VHF and USB downlinks at Alaska. The non-coherent USB downlink will contain both the real time and dump PCM. This 1 kbps split-phase RT PCM signal will go to the DTS for transmission to the GDHS via the NASCOM 494 communication processor.

Corpus Christi will receive the RT PCM on the USB downlink. The 1 kbps PCM is fed to one of the three PCM ground stations through the data switching and distribution unit (DSDU). The ground station will decommutate the RT PCM and will provide local display. The PCM Decom will also feed the 642B TLM computer with RT PCM data, sync, and frame information, which will format the 1 kbps PCM data into a NASCOM format. The 642B computer will output two 600-bit blocks of data per second to a 4.8 kbps MODEM.

The two 600-bit blocks will be transmitted to the GDHS via 4.8 kbps MODEMS. The 4.8 kbps RB PCM data will arrive at GDHS through a compatible MODEM which feeds the GDHS 494 CP through a communication line terminal (CLT) and multiplexer. The 494 CP will buffer the incoming 600 bits and will transfer this data to a 303 type of MODEM at 50 kbps rate. The output from the GSFC 303 MODEM will feed a GDHS 303 compatible (Duplex) MODEM.

Dumped PCM is not expected to occur frequently at the Corpus Christi site since Alaska and the NTTF will normally receive all Narrowband Tape Recorder dumps. However, the 642B TLM computer is capable of formatting dumped parameters for post pass transmission to the GDHS.. The recorded dumped PCM data is played back at a reduced rate to the GDHS NASCOM circuits. The routing would be the same as the RT PCM.

The USB downlink containing the RT dump PCM, as previously discussed, would be received at the NTTF USB Receiving System. The RT and dump data would be demodulated and discriminated at the NTTF. This RT and dump raw PCM would be fed to the hardline interface patch panel at the NTTF.

Since RT and dump PCM is downlinked via the USB, and that the backup MSFN sites are configured similarly to Corpus Christi, the method of recording, displaying, and transferring RT PCM data is accomplished in exactly the same manner for all MSFN sites. The backup MSFN sites will have the 642B TLM computer software available. The backup MSFN sites will have the capability of relaying RT-dump DCM over 4.8 kbps interfaces to the GSFC and to the GDHS.

The selected backup STADAN sites will receive only that RT PCM which will be fed directly to the DTS. The DTS will format the 1 kbps RT PCM in a similar manner as the 642B computer for the MSFN sites. The output of the DTS will be two 600-bit blocks per second each containing NASCOM headers, PCM data, and command status bits. These two blocks will be transmitted to the GSFC 494 via 203 type MODEMS at 4.8 kbps.

Dumped PCM data will not normally be received at backup STADAN sites since the data is transmitted on the USB downlink. However, the VHF transmitter is capable of transmitting dumped data by increasing the VHF transmitter power to accommodate the 24 kbps PCM dumped data. If this emergency method were employed, the STADAN sites would record the dumped data and would play back the dumped data to GDHS over the 4.8 kbps interface reducing the playback output ratio to a data rate compatible with the interface. This slowed dump data would interface with the DTS which would necessitate routing through the GSFC 494.

4.3.2.4 Command Data

The GDHS shall originate and generate all commands for either MSFN or STADAN sites via NASCOM facilities. Outputs will be formatted in 600-bit blocks (serial bit transfer).

Upon receipt of the data, the NASCOM 494 computer, in conjunction with the polynomial buffer terminal (PBT), will check the error protection to see if any bits have changed. Correct command data will be routed to the selected Remote Site (MSFN or STADAN) by way of 4.8 kilobit MODEMS.

At the MSFN remote sites, the actual command bits containing sync, vehicle address key, mode, command, and other bits are sub-bit encoded by the 642B computer for transmission to the update buffer. The command is then routed through the remaining command equipment for transmission on the USB Uplink. Sub-bit encoded (five sub-bits per data bit) command is transmitted to the ERTS on the 70 kHz subcarrier oscillator (SCO) at a sub-bit rate of k kbps.

The selected STADAN site receives the command data in much the same fashion as the MSFN site. The 600-bit block arriving at the 4.8 kbps MODEM is routed to the Data Transmission System (DTS). The DTS acts as a bit stripper, removes the header information and polynomial bits, as well as the filler bits, and sends the command bits to the "new" STADAN encoder. The output of the STADAN encoder is sent to the VHF command equipment for data transmission at 128 bits per second.

Both the MSFN and STADAN will have echo check capability, thereby, comparing bit-for-bit the command as it is being transmitted. If an error is detected, the command is stopped and retransmission of the command must be accomplished from the GDHS by retransmitting the command(s).

Command verification of real time commands is accomplished at the GDHS by monitoring the appropriate TLM parameter associated with the command. Stored commands are normally verified by employing the COMSTOR verify function. The contents of COMSTOR are compared with the uplink and, if a correct load has been received, the selected COMSTOR is activated permitting the stored commands to be executed at the appropriate time. The actual execution of stored commands is verified by the playback of the narrowband tape recorder which has recorded these executions.

In summary, all command data is originated, stored, and transmitted from the GDHS. The remote sites relay, in real time, all types of commands received from the GDHS through the NASCOM interfaces. All command verification is accomplished at the GDHS. Echo checks are performed at the remote stations and a fault ceases transmission of commands.

4.3.2.5 Tracking Data

The MSFN, primarily Corpus Christi, will provide most of the ERTS tracking data to NASA Orbit Determination Group. The GDHS requires three ephemeris-related sets of data:

1. Satellite ground track

2. Sun elevation angle along the ground track

3. Ground station contact profiles (AOS, LOS).

T&DS will supply ERTS with machine-readable WMSAD data tapes which will contain all of the information required for one minute time intervals along the orbit track. This data is routinely produced by T&DS for all operational spacecraft. A validity check will also be performed on the WMSAD data.

The GDHS will accept ephemeris related data in the form of machine-readable WMSAD reports, e.g., ground track and sun elevation angle; and ground station contact data will be provided at one minute time intervals.

The requirement to maintain equivalent ground traces on successive coverage cycle to within ± 10 nm of each other requires the periodic adjustment of the ERTS orbit.

The ERTS OCC will be supported by the NASA Tracking and Data System (T&DS) organization to provide orbit determination and prediction functions. Because of the existing capabilities of T&DS, they will also provide the generation of the detailed orbit adjust subsystem parameters. Orbit adjust subsystem parameters will be provided by ERTS to T&DS to facilitate the required computations.

4.3.2.6 Weather Data

The Space Flight Meteorology Group, an ESSA organization, currently has the responsibility of providing direct support to manned space flight activities, and will provide support to an ERTS System.

A weather forecast facility responsible for providing System Scheduling support will require current data, to schedule their activities, as follows:

1. Nominal and updated ephemeris

2. Schedule of command loading to determine what revolution or portions thereof would be loaded at a specific time

3. Candidate areas of payload operation for each scheduled command loading

4. Deadline for receipt of each weather forecast at the mission planning facility.

The ephemeris information will be provided by an 18-day cycle ground grace, with periodic updates dictated primarily by orbit adjust maneuvers.

Since sensor operations will primarily be scheduled over land mass areas, under conditions of acceptable illumination, only a portion of any given orbit will satisfy these conditions. Therefore, this information will be supplied to ESSA in order to minimize the area for which forecasts must be made. This information will be communicated on a basis of latitude bands per orbit.

The schedule by which forecasts must be generated is dictated by the planned schedule of vehicle commanding. Thus, forecasts will nominally be provided on a rev-by-rev basis.

Weather forecasts will be in a form that can be quickly transmitted to the System Scheduling facility by telephone, teletype, or data link. It will consist of the following:

1. Revolution number for which forecast is provided

2. Latitude where the forecast begins (center part of ground swath)

3. Forecast in terms of (1) percent cloud-free skies within the latitude boundaries or the probability of some scene being cloud-free, and (2) the probability of significant haze or atmospheric pollution

4. Latitude at which the forecast changes or ends (center point of ground swath).

4.3.2.7 User Data

Data sent to the users will be in the form of 70 mm and 9-inch rolls of film stock, stocks of 9 x 9 inch prints, computer tapes, and miscellaneous other products. Maximum loading will be distributed to 10 major agency users. Specially requested data for the major agency users will be forwarded along with the bulk shipments. Specially requested data for other scientists will be at the rate of 20 to 40 small packages per week and will have no impact on the system.

Table 4.3-2 displays the daily packaging required for each of the 10 major user agencies. Special sized cartons will be ordered that will hold the following:

1. Two 250-foot rolls of 9-1/2 inch stock

2. 9-1/2 x 9-1/2 inch prints in stacks of 50, 150, 300 and 600

3. Five 100-foot rolls of 70 mm film

Computer tapes will be shipped in their original cartons.

Table 4.3-2. ERTS Daily Shipment for Each User Agency

Data Product	Form	Number	Cartons
Black and White Bulk Positives	9-1/2 in. rolls	8	4
Black and White Bulk Prints	9 x 9 in.	1,800	3
Black and White Bulk Negatives	70 mm rolls	5	1
Color Bulk	9 x 9	158	1
Black and White Precision	9-1/2 in. rolls and 9 x 9	276	2
Color Precision	9 x 9 in.	39	-
TOTAL CARTONS SHIPPED TO EACH USER EACH DAY			11

Based upon these figures, the total number of packages prepared and shipped during a week will be approximately 800 for photographic images and 30 for magnetic tapes.

4.3.3 GDHS PERFORMANCE ALLOCATION

Operational Control and Data Processing will be considered an integral part of the ERTS mission system requirements, as specified in Section 4.3.1, and the Ground Data Handling System will satisfy these requirements. The GDHS will consist of a central facility comprised of a colocated Operations Control Center (OCC) and a NASA Data Processing Facility (NDPF). The GDHS design will be based on a total systems design philosophy including the required hardware, software, manpower, and appropriate interfaces. The OCC and NDPF will be functionally non-duplicative but may depend upon each other for data or information such as "quick look" images involved in operations control and "quick look" spacecraft houskeeping or operations data for selective processing control. In addition, the NDPF will provide backup support for the OCC in the event of OCC computer failure.

4.3.3.1 Operations Control Center (OCC)

The Operations Control Center will be the operational focal point for the ERTS spacecraft, user operation requests, the interface with the STADAN/MSFN Networks, and the real time source of data for the Data Processing Area which provides users with processed data. Support to the control center to aid in the accomplishment of its mission will come from the NASCOM, NETCON, MSFNOC, OPSCON, and Orbit Determination and Support Computing Areas within Goddard. Environmental information such as cloud cover will be supplied by ESSA or other sources. Furthermore, it is expected that the functions to be performed by the OCC in the ERTS program are generally similar to those for other satellite systems. The OCC will provide for the following:

1. Serve as the focal point for project unique mission operations

2. Originate the spacecraft activity plane and coordinate schedules with STADAN/ MSFN and other supporting facilities

3. Direct and/or monitor all ERTS operations support

4. Operate the spacecraft

5. Operate the sensors

6. Analyze and evaluate data to determine spacecraft configuration, health and performance at a system and subsystem level

7. Analyze and evaluate data to determine sensor configuration, health and performance

8. Compile and maintain Operational records and data.

Based on user requests, the Operations Control Center shall generate plans for the scheduling and the interrogation of the ERTS. Various STADAN/MSFN stations will transmit commands to the satellite(s), track the satellite(s), and receive PCM and video data. Displays will be available for performance evaluation at some STADAN/MSFN stations and a real-time link will also be available to the OCC to permit direct voice and real-time telemetry and command data communication. The OCC shall, thus, perform its own evaluation and make operational decisions. Both video and PCM data are recorded on magnetic tape at the remote stations. The PCM dump telemetry and DCS data will be transmitted in real-time to the OCC during the past pass period. Video data will be transmitted in real-time to OCC from only the NTTF Station. These data, then, along with necessary auxiliary information will define the data base that must be used in the operational control of the ERTS. The OCC shall be capable of performing the following tasks in satisfaction of the requirements specified above and in Sections 4. 3. 1.

1. Generate, display and verify spacecraft commands for the following:

    a. Spacecraft status (configurations and performance)

    b. Orbit corrections

    c. Sensor operation

2. Receive, process, display, distribute, and store spacecraft data

3. Analyze and evaluate data to determine spacecraft status and performance for both real-time and historical trend analysis

4. Generate schedules for picture taking and platform data acquisition based on needs and requests of user agencies

5. Provide facilities for sensor and spacecraft displays and controls that may be required

6. Provide realistic spacecraft simulation capability for both command and data acquisition functions

4.3.3.2 NASA Data Processing Facility (NDPF)
The NASA Data Processing Facility will convert acquired mission data to user oriented and annotated media, organize the accumulation of data, and disseminate the data to the user community. The NDPF will receive both mission data and spacecraft performance data from the OCC as well as advance notice of predicted data loads. The user community will interface directly with the NDPF in ascertaining the availability of data and requesting direction for the special processing of data. The NDPF shall satisfy the mission requirements of Section 4.3.1 and will provide for the following:

1. Video-to-Film conversion of all RBV and MSS data

2. PCM data processing to derive image location and annotation information

3. DCS data processing to produce user DCS data products

4. Precision and Special processing and digitization of selected video data

5. Working and Archive storage of all data products

6. Production of an distribution of data products, including black and white and color imagery and magnetic tapes

7. Dissemination of the availability of data and NDPF services and capabilities to the user community.

The ERTS Data Processing Facility will perform two broad functions: (1) Image Data Processing, where the bulk of all data are transformed into user oriented media; and (2) Data Production and Services, where all data are produced, distributed, and stored in retrievable and reproducible form.

Image Data Processing will process all mission data received from data acquisition sites and spacecraft performance data from the OCC. These data are recorded on video magnetic tape for RBV and MSS data. All DCS platform and spacecraft performance data will be recorded on GSFC standard 7 track 1/2 inch instrumentation tape. Up to five (5) percent of the image data will require precision processing to produce high quality pictures. Selected images or portions of images of interest will be submitted for special processing. In satisfaction of the requirements specified above and in Section 4.3.1, the NDPF shall perform the following tasks:

1. The NDPF system will accept PCM data from instrumentation tape and produce computer listings or digital tapes containing platform data and correlative data for platform data users, and produce spacecraft performance master digital data tapes and image annotation data

2. All video data (RBV and MSS) will be converted from tape to annotated film with little or no geometric correction

3. RBV and MSS data will be precision processed in the best possible manner to achieve the best radiometric and geometric accuracies. Geometric accuracies achieved will be limited to that possible by using the outputs of the spacecraft attitude control system and the use of ground control points

4. RBV and MSS data will be specially processed to produce digitized image data in computer readable format.

The Data Production and Services function will perform data production and distribution and will perform the data management, handling, and control required to effect efficient operation of the NDPF. To perform these functions in satisfaction of the requirements specified above and in Section 4.3.1, the following tasks will be performed:

1. High quality reproductions will be made of all imagery

2. All data processing and production will be organized and scheduled

3. Imagery and DCS data will be abstracted and classified for purposes of developing an abstract file from which a Data Catalog is developed and supplied to user agencies. Typical classification of imagery will include image location, cloud cover, image quality, etc. Typical classification of DCS data will include such items as platform location, time of data acquisition, platform function (i.e., hydrology, etc.) and agency.

4. A montage catalog will be produced showing imagery organized on a coverage map from which user agencies can get an overall impression of image quality, quantity and information content

5. Requests will be received from users to perform precision and special processing. Upon receipt of such a request, the appropriate data will be retrieved from storage, processed, and shipped to the user

6. Working and archive data storage and a data storage and retrieval systems, will be provided to satisfy the mission data requirements

7. All data and data availability will be distributed and disseminated to the user community.

4.4 GDHS SPECIFICATIONS

Preliminary specifications have been prepared for all GDHS hardware and software and are provided in GDHS Specification volumes accompanying this Study Report. These specifications have generally been prepared to a level of detail equivalent to NPC 500 Part I specifications. As a result, the hardware specifications have been utilized, where appropriate, to obtain procurement quotes for vendor supplied equipment, and the software specifications were utilized in the preparation of ADP equipment specifications. In addition, software specifications are, in most cases, complete to the detail required to:

A. Provide a software implementation plan including all modules required.

B. Specify the software organization, control and processing sequence.

C. Specify inputs, outputs and tables required.

D. Define the mathematical methods and logic used.

E. Provide detailed flow diagrams describing detailed processing steps and decisions.

In general, then, the specifications have been prepared in sufficient detail to initiate procurement and begin detailed design at the start of Phase D.

Although NASA requirements called for the development of only preliminary specifications, detailed specifications have been prepared in many cases including those itemized below.

4.4.1 OCC DETAILED SPECIFICATIONS

A. OCC PCM Processing Software Subsystem

1. Decommutation Software

2. On-Line Evaluation Software

3. Off-Line Evaluation Software

B. Other OCC Software Subsystems

1. System Scheduling Software

C. OCC Command Generation Subsystem

1. Command Management Software

D. OCC Status Data Control and Display Subsystem

1. Display Generation Software

E. OCC Computer Services Subsystems

4.4.2 NDPF DETAILED SPECIFICATIONS

A. All vendor procured equipments including:

1. NDPF Computer Services Subsystem

2. High Density Digital Tape Recorders

3. High Resolution Film Recorders (FBR's)

4. Photographic Processing Equipment

The Specification Tree, shown in Figure 4.4-1 illustrates the specification structure, which conforms closely to the Summary Work Breakdown Structure and prescribes six levels of breakdown as:

0 - ERTS Program

1 - GDHS System

2 - Segment (OCC, NDPF)

3 - Subsystem (e.g., Image Processing, Photo Processing, etc.)

4 - Subsystem Element (Bulk Processing, Precision Processing, etc.)

5 - Component

It should be noted that in the GDHS Specification volumes accompanying this report, inasmuch as these are preliminary specifications, separate documents are provided only for Levels 1, 2, and 3 (GDHS System, GDHS Segments and GDHS Subsystem). However, within each subsystem specification, the subsystem is further divided into subsystem elements and these are in turn divided into components which correspond to equivalent hardware and software black boxes. Each of the components within the subsystems are thus specified as an entity. One exception of this procedure occurs within the NDPF Image Processing Subsystem where, because of the complexity of this particular subsystem, a separate document is provided for each subsystem element (Bulk Processing, Precision Processing and Special Processing). Conversely, several subsystems are less complex, and for these, the subsystem is directly divided into components. It should be further noted that, because of their large number, components are not shown on the specification tree, but are itemized in Tables 4.4-1 and 4.4-2.

In the interests of reducing duplication, the Requirements Specifications following under the categories of Operability and Design and Construction are provided in full only in the first level GDHS System Specification where it is stated that all GDHS equipment shall comply with these requirements unless specifically excepted in subsequent or lower level specifications. The principle equipments which are recognized exceptions are those which are manufactured to a manufacturer's design, have a model number or are characterized as off-the-shelf equipment. These equipments shall comply with GSFCS-323-P-5A, 15 March 1967, Quality Assurance Requirements for Standard Industrial Equipment.

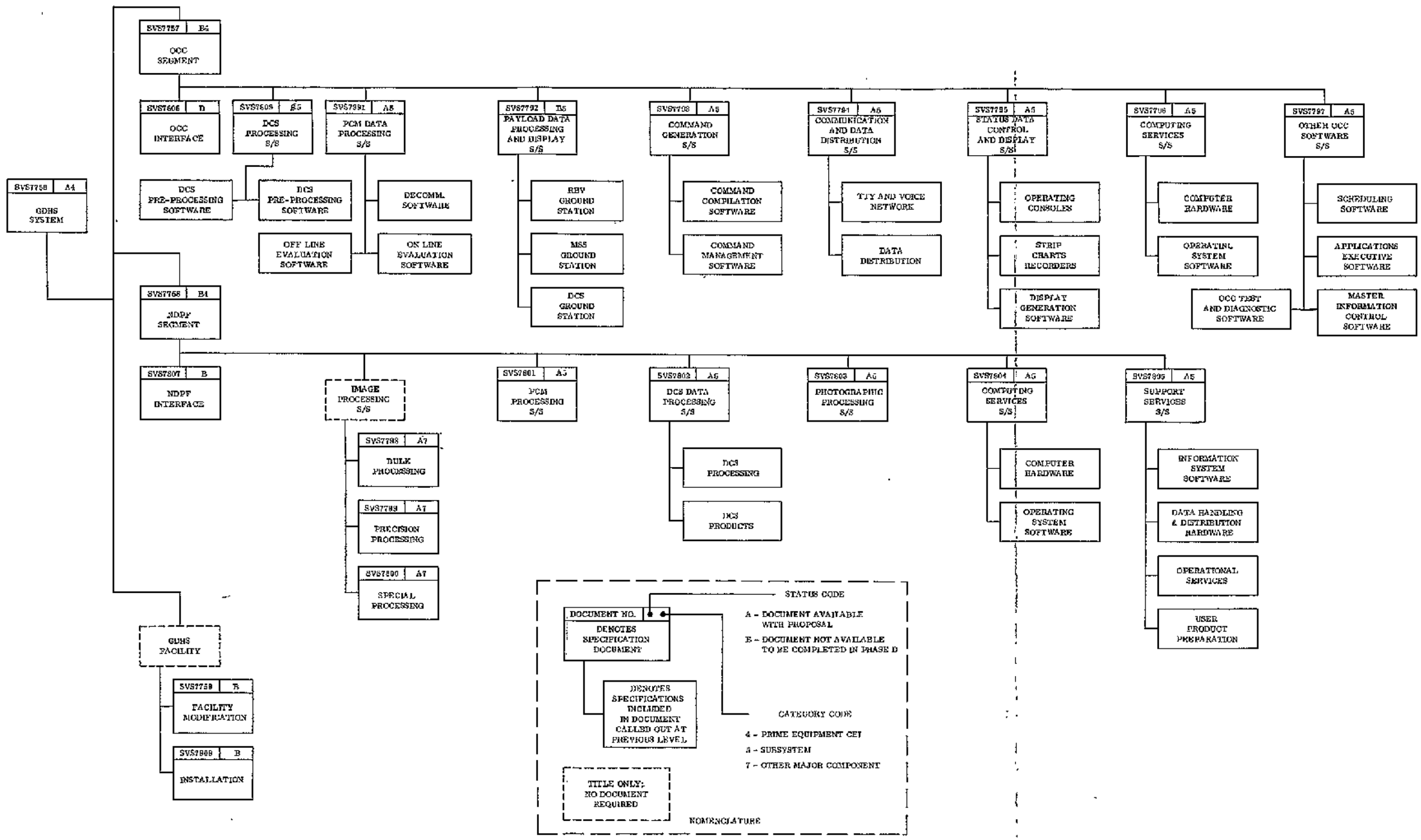


Figure 4.4-1. GDHS Specification Tree

FOLDOUT FRAME 1

FOLDOUT FRAME

FOLDOUT FRAME 2

Table 4.4-1. OCC Component Specifications (Baseline System)

Subsystem Spec No	Subsystem Name	Element Name	Component Name
SVS 7791	PCM Data Processing Subsystem	DCS Preprocessing Software	
		Decommutation Software	
		On-line Processing Evaluation Software	PCM Acquisition Spvr Normal TLM Process Pkg (TPP-1) Sensory Data Extractor (TPP-2) Memory Verifier (TPP-3) Matrix Verifier (TPP-4) GMV, Alarm, List (TPP-5)
		Off-line Processing Evaluation Software	Off-line Supervisor Generalized Statistics Power Analysis Thermal Analysis Controls Analysis Payload Analysis
SVS 7792	Image Data Processing Subsystem	RBV Video Recorder/ Processor and Display (GFE)	
		MSS Video Recorder/ Processor and Display (GFE)	
		DCS Ground Station	
SVS 7793	Command Generation Subsystem	Command Compilation Software	
		Command Management Software	
SVS 7794	Communications and Data Distribution Subsystem	Data Distribution	Signal Conditioning and Switching - I/O Patch and Switch - Bit Synchronizers - PCM Simulator and Tape Formatter Time Translator Maintenance and Operations Console Magnetic Tape Recorders
		TTY and Voice Terminals	TTY Terminals Communications Panels and Speakers
SVS 7795	Status Data Control and Display Subsystem	Operating Consoles	Spacecraft Evaluation Consoles Operations Supervisor Console Command Console
		Strip Chart Recorders	Analog and Event Strip Chart Recorders (including D/A converters) Portable Strip Chart Console Recorders
		Display Generation Software	Report Data Supervisor Report Generator Spvt Report Generator Pkg Plot Data Formatter Versatile Data Display
SVS 7796	Computing Services Subsystem	Computer Hardware (ADP) - Comm Processor - Computer Main Frame - Computer Console - Printer - Disk Memory - Card Reader - Card Punch - Tape Drives - Plotter	
		Operating System Software (ADP)	
SVS 7797	Other OCC Software Subsystems	Applications Executive	Operatings System Interface System Interface Control Systems Request Executive
		System Scheduling Software	Systems Scheduling Supervisor Data Processing Activity Scheduling
		Master Information Control	Master Info File Generator Master Info Table Generator Print Master Info. File
		OCC Test and Diagnostic	
SVS 7809	DCS Processing S/S	DCS Preprocessing Software	
		DCS Preprocessing Hardware	

Table 4.4-2. NDPF Component Specifications (Baseline System)

SVS 7794	Image Processing S/S	Bulk Processing	MSS Video Tape Recorder (GFE) MSS VTR Control RBV Video Tape Recorder (GFE) RBV VTR Control High Resolution Film Recorder HRFR Control Annotation Generator High Density Digital Tape Recorder HDDTR Control HRFR Image Correction Control Computer Interface Bulk Processing Element Interface Bulk Processing Application Software Bulk Processing Process Control Computer
SVS 7799	Image Processing S/S	Precision Processing	Viewer Scanner Video Printer Video Digitizer Control Point Station System Control and Interface Console Precision Process Application Software Precision Processing Process Control Computer (ADP)
SVS 7800	Image Processing S/S	Special Processing	High Density Digital Tape Recorder HDDTR Control Special Processing Element Cabling Special Processing Software Set No. 1
SVS 7801	PCM Processing S/S		
SVS 7802	DCS Processing S/S	DCS Processing Software	
		DCS Product Preparation Software	
SVS 7803	Photographic Processing S/S		Black and White Strip Printer Black and White Contact Printer Black and White Film Processors Black and White Film Processor Black and White Paper Processors Color Composite Printer Color Film Processor Color Contact Printer Color Paper Processor and Drier Automatic Paper Print Cutter Photographic Enlarger Utility Photographic Dark Room Equipment Mixing and Handling Equipment Film Inspection Equipment Film Inspection Equipment
SVS 7804	Computing Services S/S	Computer Hardware (ADP) - Computer Main Frame - Computer Console - Printer - Disk Memory - Card Reader - Card Punch - Tape Drivers - TTY Terminals	
		Operating System Software (ADP)	
SVS 7805	Support Services S/S	User Product Preparation Software	
		Data Handling, Storage and Distribution Hardware	Image Assessment and File Maintenance Equipment Bulk Storage Equipment Shipping and Receiving Equipment
		Information System Software	Information Retrieval Executive Software Information Retrieval Application Software

4.5.1.2 Spacecraft

4.5.1.2.1 Downlinks

The ERTS Spacecraft downlinks consist of VHF and S-band frequencies capable of being received by various STADAN/MSFN remote stations. The VHF downlink will normally contain real time (RT) 1 kbps PCM which will be received by all assigned STADAN sites. This downlink also serves as a minitrack beacon for interferometer tracking at the STADAN minitrack sites. The VHF downlink is also capable of containing narrow band tape recorded dump data transmitted at a recorded playback ratio of 24:1. Downlinking 24 kbps dumped data over the VHF link is considered to be used only during emergency conditions where only a STADAN site (other than Alaska) is available to receive the dumped data. The frequency assigned is 137.86 MHz.

There are three frequencies assigned to the S-band spectrum to downlink data from the ERTS Spacecraft. They are 2287.5 MHz for the unified S-band system, and 2229.5 MHz and 2265.5 MHz for the MSS and RBV payload data. The unified S-band downlink contains several types of data transmitted simultaneously over the 2287.5 MHz carrier. Pseudo-random noise (PRN) generated by the MSFN site uplink is relayed (in a coherent fashion) to the sending MSFN site on the USB downlink baseband. The narrow-band tape recorder (NBTR) dump at a 24-kbps rate is downlinked on a 576-kHz subcarrier oscillator (SCO). The DCS data is included in the USB downlink at a center frequency of 1.024 MHz. Finally, three inter-range instrumentation group (IRIG) channels are combined on the 1.250 SCO. These three IRIG's contain RT PCM at 1 kbps and two 100-pps time code clock signals transmitted in real time or from the auxillary track of each of two wideband video tape recorders (WBVTR). The time code information is used for time correlation with stored payload data. The remaining two S-band frequencies are used for the RBV and MSS data downlinked simultaneously.

4.5.1.2.2 Uplinks

The uplinks capable of being received by the ERTS Spacecraft are VHF command, S-band ranging and command, and UHF data collection platform (DCP) transmissions. The VHF uplink is generated by STADAN sites only. The uplink frequency is 154.20 MHz which contains the frequency shift keyed (FSK) command information to be received by the ERTS VHF command receivers at 128 bits per second. The S-band uplink consists of either pseudo-random noise or clock data (512 kHz) and command information on a 70-kHz subcarrier.

The USB uplink command information consists of sub-bit encoded command data phase shift keyed at a sub-bit rate of 1000 bits per second. Since 5 bit sub-bit encoding is used, the data uplink rate is 200 data bits per second. Both command systems are redundant and mutual interference is handled on the spacecraft by the command integrator unit.

The remaining uplink is the data collection platform uplink on a 401.9 MHz UHF frequency. This data is then converted to an intermediate frequency (100 kHz) and relayed to the ground around a center frequency of 1.024 MHz contained in the USB downlink.

4.5.1.2.3 Spacecraft Summary
In general, the spacecraft is capable of simultaneous downlink transmission of RT PCM, dump PCM, DCS data, ranging data, time code data, and MSS and RBV payload data. The specific links used depend on the particular interfacing MSFN/STADAN site as well as the phase of the mission. Commanding may be accomplished from either MSFN or STADAN sites individually but not simultaneously, and uplink ranging only from the former. DCS uplink signals are limited by the distribution of the remote DCP's and thus only occur over the continental United States.

4.5.1.3 <u>Remote Stations</u>

4.5.1.3.1 Alaska
Of the remote stations selected to participate in the ERTS mission, Alaska can be considered the "care and feeding" station because of its geographical location related to the ERTS sun-synchronous orbit. An average of 10 out of the 14 revolutions a day will be supported by the Alaska remote facility. This site will receive and record all downlinked data. Although Alaska cannot presently receive USB and the payload S-band downlinks, modifications are planned to accommodate the ERTS requirements. New wideband receiving equipment is planned for this facility along with ERTS unique recording and quick-look display equipment for the payload data. Other modifications and augmentation of the Alaska facility will permit DCS preprocessing and USB data demodulation required to support ERTS. Real-time transfer of RT PCM and dump PCM to GSFC will be accomplished using the X144 data transmission terminal and the data transmission system (DTS). Preprocessed DCS data will be relayed to GSFC via the X144 data terminal post-pass. In summary, Alaska will be capable of all remote site functions except for USB tracking.

4.5.1.3.2 Corpus Christi
Corpus Christi will also play a vital role in supporting the ERTS mission. Its geographical location is very favorable since the cone of coverage seen from Corpus includes practically all of the continental United States. Addition of ERTS unique equipment for the receipt, recording, and display of payload data will be necessary. Telemetry data handling, command, tracking, and recording will remain basically the same as used for the main line Apollo Project with some software changes anticipated. DCS preprocessing equipment will also be required at this MSFN site. Near RT transfer of DCS data to GSFC will be routed via NASCOM. Commanding will be accomplished on the USB uplink using the 642B command computer and associated command equipment. Local display of telemetry will be available and engineering unit conversion of PCM parameters will be displayed on the Maintenance and Operations (M&O) high-speed printer (HSP) as requested. Data transfer to and from Corpus is accomplished, for the most part, via the NASCOM 4.8-kbps lines interfacing with GSFC.

4.5.1.3.3 NTTF
The Network Test and Training Facility (NTTF) located in Building 25 at GSFC will be utilized as a "receive only" MSFN. USB and payload downlinks will be received and relayed to the OCC using dedicated hardline interfaces. RT PCM, dump PCM, DCS data and payload data (MSS-RBV) will arrive at the OCC all in the same time frame. The NTTF data will be routed to recording and quick-look display equipment in the OCC. USB data will be recorded at the NTTF on a MINCOM 22 tape recorder as a backup to the OCC.

4.5.1.3.4 Rosman

Working in conjunction with the NTTF, Rosman will perform the command function during mutual station contact. The VHF uplink function performed at Rosman is expected to be the only major support performed by this remote facility. Although several other capabilities exist, such as PCM data relay and local display, recording, and minitrack tracking, Rosman's primary support to the ERTS mission is uplinking commands.

4.5.1.3.5 Backup MSFN

Other MSFN sites are expected to be available to perform certain functions during the ERTS mission. Basically, these sites will be unmodified and will function in a similar manner to that of main line Apollo support. No hardware modifications or project-unique equipment is anticipated. The software developed for Corpus Christi is assumed available at these sites for the 642B TLM and command computers. Thus, any MSFN site will be capable of tracking, commanding, receiving, and recording the USB downlink and relaying RT PCM and dump PCM to GSFC via the existing remote site and NASCOM facilities. Payload data, VHF, and DCS preprocessed data is not assumed available at the backup MSFN sites. Only limited or emergency support is expected for the ERTS mission.

4.5.1.3.6 Backup STADAN

Those sites selected as backup STADAN sites will be capable of commanding, receiving, and recording the VHF downlink and locally displaying RT PCM parameters. The relaying of RT PCM data to the OCC will be accomplished using the data transmission system (DTS) interfacing with the NASCOM. During emergency situations when NBTR dump is accomplished on the VHF link, the backup STADAN sites will be capable of recording this data and subsequently playing back the data at a reduced rate compatible with the NASCOM interfaces for transfer to the OCC.

Minitrack data will also be available for transfer to NASA orbit determination at GSFC if required. However, minitrack data is expected to be used only as a backup to the MSFN USB tracking. Payload data, DCS data, and normally dumped PCM data will not be available from these sites.

4.5.1.3.7 NASCOM

The NASA Communications Network (NASCOM) is expected to handle most of the ERTS narrow band PCM data, DCS preprocessed data, and all command data transfer between the selected remote sites and GSFC, ERTS, and OCC. All remote sites will have at least one 4.8-kbps MODEM interface with GSFC. These duplex circuits will be capable of handling command and RT PCM transfers simultaneously. All data containing NASCOM headers originating at the STADAN data transmission systems (DTS's), the MSFN 642B computers, or the OCC located at GSFC will be routed through the GSFC 494 communications processor (CP). All incoming data from the MSFN/STADAN sites which interface with MODEMS will arrive at 4.8 kbps. This data will be transferred to the OCC area at a 50-kbps rate. The data will be formatted in 600-bit blocks. Command data originating at the OCC computer will be transferred to the GSFC 494 computer in 600-bit blocks over the duplex 50-kbps 494-OCC interface using 303-type MODEMS. Once the command data is checked for proper format, the 494 CP will transfer the command data to the selected site over 4.8-kbps MODEMS. The remote sites will act as a "command pipe" and will transmit all commands in real time.

Teletype messages will also be routed as a function of the GSFC 494 CP. Data which will not be routed by the GSFC 494 CP are: all NTTF data, Alaska X144 dump PCM, preprocessed DCS data, and voice. Voice data will be handled in the normal manner using SCAMA and other voice handling equipment.

4.5.1.3.8 OCC-NDPF

The Operations Control Center (OCC) and the NASA Data Processing Facility (NDPF) make up the ERTS Ground Data Handling System (GDHS). The OCC provides all real-time processing of data, spacecraft control, command generation functions, and implementation of all operational decisions. The NDPF performs the payload production, certain off line NB telemetry processing, and distributes the finished products to the users and other agencies.

In the following sections, the flow of individual types of data through the ERTS system is discussed.

4.5.1.4 Payload (MSS/RBV) Data Flow

Figure 4.5-2 describes the flow of the wideband payload data. Payload data is capable of being received at three remote facilities: Alaska, Corpus Christi, and NTTF. The payload data transfer from Alaska and Corpus Christi will be via hard data transfer (i.e., mailed tapes, hand carried, etc.). The NTTF will relay MSS and RBV data in real time to the OCC. The real-time soft data transfer from the NTTF is possible because of the planned hardware interface between the two buildings (Bldg. 25, NTTF, and Bldg. 23, OCC).

4.5.1.4.1 Spacecraft

The wideband imaging sensors for ERTS consist of three return beam vidicon cameras and a 4-channel (5 for ERTS B) multispectral scanner. Two tape recorders, each capable of recording either MSS or RBV data, are included in the payload. A switching and filtering network, signal conditioning equipment, modulators, power amplifiers, and antennas provide two parallel S-band communication links. Any two types of data from the combinations of real time, playback, MSS, or RBV data may be transmitted over these two links simultaneously. The wideband communications and data handling subsystem is cross strapped so that a single failure does not inhibit individual downlink of MSS or RBV data. The nominal configuration of downlinked payload data will be RT MSS/RBV data or WBVTR playback MSS/RBV data over the two assigned S-band frequencies. Data is recorded on the auxiliary tracks of the WBVTR's and downlinked in real time for time correlation purposes. These are 100-pps ERTS clock signals consisting of 40 bits in ten 4-bit BCD formats. This clock data is downlinked in real time and during WBVTR dump over IRIG channels 11 and 12 (for WBVTR auxiliary 1 and 2 tracks, respectively). IRIG channels 11 and 12 are then combined on the USB downlink via the 1250-MHz SCO. The RBV or MSS data may be downlinked interchangeably on either 2229.5 MHz or 2265.5 MHz. MSS data is in the form of PCM data downlinked at a 16-mbps rate, while the RBV data is in the form of FM video data. Both downlinks will employ a 20-MHz RF bandwidth to accommodate the sensor data.

4.5.1.4.2 Remote Stations Data Handling

A. Alaska. The Alaska site, as it exists today, could not receive the payload S-band downlink. Modifications are being engineered for existing equipment as well as adding new equipment at Alaska in order to meet the ERTS payload requirements. The payload downlinks will be received by the 85-foot dish and the S-band frequencies will be downconverted prior to leaving the antenna feed assembly. An intermediate frequency will be generated in the neighborhood of 400 to 500 MHz and, through multicouplers, will be fed to the appropriate receivers. The output video from these redundant payload receivers will feed a video patch panel. Selected patching configurations will route the MSS and RBV data to the ground wideband video tape recorders and to MSS and RBV displays. RBV data will be displayed on a cathode ray tube, while the MSS data will likely be viewed on an "A" scope. A hard copy of the displays will be provided for quick-look local data analysis. The 100-pps clock data which was downlinked over the USB system will be recorded concurrently on the auxiliary track of the ground WBVTR's. Thus, the MSS or RBV recorded data on the ground WBVTR will contain the video of each sensor on a main track(s) as well as the time code data on the auxiliary track, similar to the spaceborne WBVTR's.

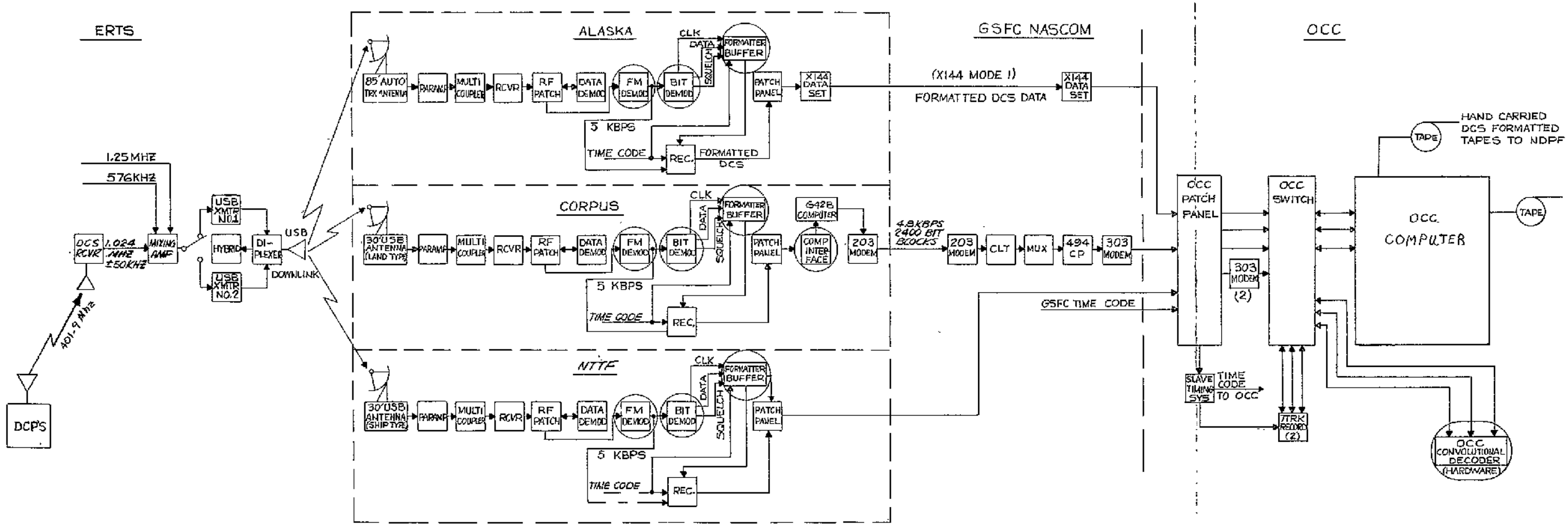
The recorded tapes would then be mailed or otherwise physically transferred to GSFC for processing at a future date. Other payload correlation data contained on the narrow band PCM downlink would be relayed to GSFC directly in real time. This data will be used for image annotation tape generation and other data required for final MSS-RBV processing.

4.5.1.4.3 Corpus Christi

The MSS and RBV payload data will be received and recorded at Corpus in the same manner as the Alaska station. The wideband video tape recorders will record the real-time or dumped MSS-RBV data along with the 100-pps ERTS clock. Displays of the incoming data will also be available as for Alaska. The payload tape will be transferred for future processing at the NDPF. The major difference between Corpus Christi and Alaska is the antenna size. Corpus employs a 30-foot USB X-Y antenna, while Alaska would normally use an 85-foot dish. Corpus will also have the RF modifications necessary to support the ERTS payload downlink.

4.5.1.4.4 NTTF

Part of the NTTF will be dedicated for support of the ERTS mission. The antenna used is a 30-foot size very similar to the Corpus Christi antenna. RF modifications will be made (similar to Corpus) allowing receipt of payload data. Figure 4.5-2 shows a concept where the payload video data is interfaced on a hard-line patch panel to the OCC. Also interfacing with this patch panel is the payload correlation data which has been demultiplexed and discriminated from the USB video and relayed to the OCC. At the OCC, the data may also be looked at in real time via payload displays. The NTTF-OCC combination is unique since downlinked payload data may be viewed in real time at the OCC unlike the other two payload receiving stations. No recording or display capability exists at the NTTF for wideband payload data.



NOTE:
○ INDICATES DCS UNIQUE EQUIPMENT

Figure 4.5-3. DCS Data Flow

FOLDOUT FRAME 1 FOLDOUT FRAME FOLDOUT FRAME 2

4.5.1.4.5 Alaska-Corpus Alternate Payload Data Transfer Concepts

A. Alaska Wideband Payload. The NASCOM capabilities are constantly undergoing change; during the ERTS time frame, there may be an updated X144 data system. If such a system were implemented, the transmission of "slowed" payload data may be possible from Alaska to the OCC in near real time.

B. Corpus Wideband Payload. An alternate method of speeding up the payload data transfer to the OCC (if such is desirable) may be possible during the ERTS time frame. The leasing of commercial lines (AT&T) from Corpus to the OCC could permit real-time or near real-time transfer of MSS and/or RBV data. Before such an approach is undertaken, trade studies must be performed to evaluate the cost, time, and other factors relating to the method.

4.5.1.5 Data Collection System (DCS)

The DCS data flow (see Figure 4.5-3) includes: the remote data collection platforms (DCP) where the data originates; the ERTS Spacecraft DCS receiver and the downlink on the USB System; the three remote sites (Alaska, Corpus, NTTF), NASCOM; and finally, GSFC and its unique DCS elements. The DCS platforms will be transmitting in a free running fashion (i.e., in an intentionally random manner, but with the average duration between the transmissions controlled). The spacecraft will be in mutual view of the DCP's and one or more remote sites during portions of two or three orbits every 12 hours. Near real-time processing of the DCS data will be accomplished in the NDPF and distributed to the appropriate agencies (users).

4.5.1.5.1 Data Collection Platforms (DCP's)

The DCP's will be located in remote locations throughout the continental United States. These platforms will uplink on an assigned UHF frequency of 401.9 MHz to the ERTS vehicle. Each DCP will transmit data to the ERTS vehicle asynchronously with data bursts of 37 milliseconds approximately every 90 or 180 seconds. Mutual interference from two or more DCP's transmitting is thus possible but unlikely, depending on the number of DCP's and the accuracy of their transmission frequency.

4.5.1.5.2 Spacecraft

The Data Collection System Receiver will generally be turned on during possible DCP contacts by real-time commands. The output from the DCS receiver will be a 100-kHz IF signal fed to the USB downlink. More than one platform's information may be transmitted at a time; however, frequency separation within the 100-kHz IF output of the DCS receivers will likely occur because of slight variations in uplink frequency doppler shift, etc. The signal-to-noise ratio is expected to be quite low and special ground equipment will be used to extract the individual platform information.

4.5.1.5.3 GDHS System Description

The downlinked DCS data will be received at the prime remote sites using unified S-band equipment. The USB video output from the receiver will be fed to a signal data demodulator where the output will be bandpass filtered and fed to the DCS preprocessing equipment. The preprocessor will extract the bursts of DCP data that fall within the 100-kHz bandwidth of the DCS receivers.

A. Remote Site Signal Processing and Recording. The 1.024-MHz signal is received by the FM subcarrier demodulator via the RF patch from the Data Demodulator. A video signal of 5.0-kbps is recovered by the FM subcarrier demodulator from the 1.024-MHz signal. The 5.0-kbps signal is simultaneously recorded and routed to the bit demodulator.

The bit demodulator determines signal presence and bit timing (5.0-kbps) from the video signal output of the FM subcarrier demodulator. A bit decision is made utilizing an integrate and dump process. The output of the integrate and dump operation is a 3-bit (8-level) representation of the "1" or "0" decision. The bit demodulator outputs to the formatter/buffer the bit timing, the parallel 3-bit representation, and the signal presence (squelch). The formatter/buffer receives the bit timing, the 3-bit parallel data word, and the squelch from the bit demodulator. Station time-of-day information is received from the timing subsystem. The formatter/buffer outputs 2400-bit blocks of NASCOM formatted data.

The 2400-bit blocks consist of the following:

1. Routing Header
   a. Synchronization Word - 24 bits
   b. Destination Code - 8 bits
   c. Source Code - 8 bits
   d. Data Format - 8 bits
2. Data Word (4 bits)
   a. 3-bit Data Word
   b. 1-bit Squelch Sample
3. Time of Day - 30 bits

These 2400-bit blocks are transmitted serially out to the recorder in bi-phase format. The recorder tape speed is 60 ips. The signal processing and recording at the three remote sites are identical with one exception. The output from the formatter/buffer at the NTTF is routed directly to the OCC patch panel.

4.5.1.5.4 System Considerations

A. Eight Level Quantization. The error-correcting capability of the sequential decoder utilized at the OCC (discussed in Section 6.2) is largely determined by the quantization level of the input bit decisions. Eight level quantization is recommended to provide the necessary error correction power and the equivalent improvement in S/N level at the OCC. Thus, the bit demodulator utilizes an integrate and dump process to determine the presence of a "1" or "0", and outputs a 3-bit (8-level) representation of the result, as indicated in Figure 4.5-4.

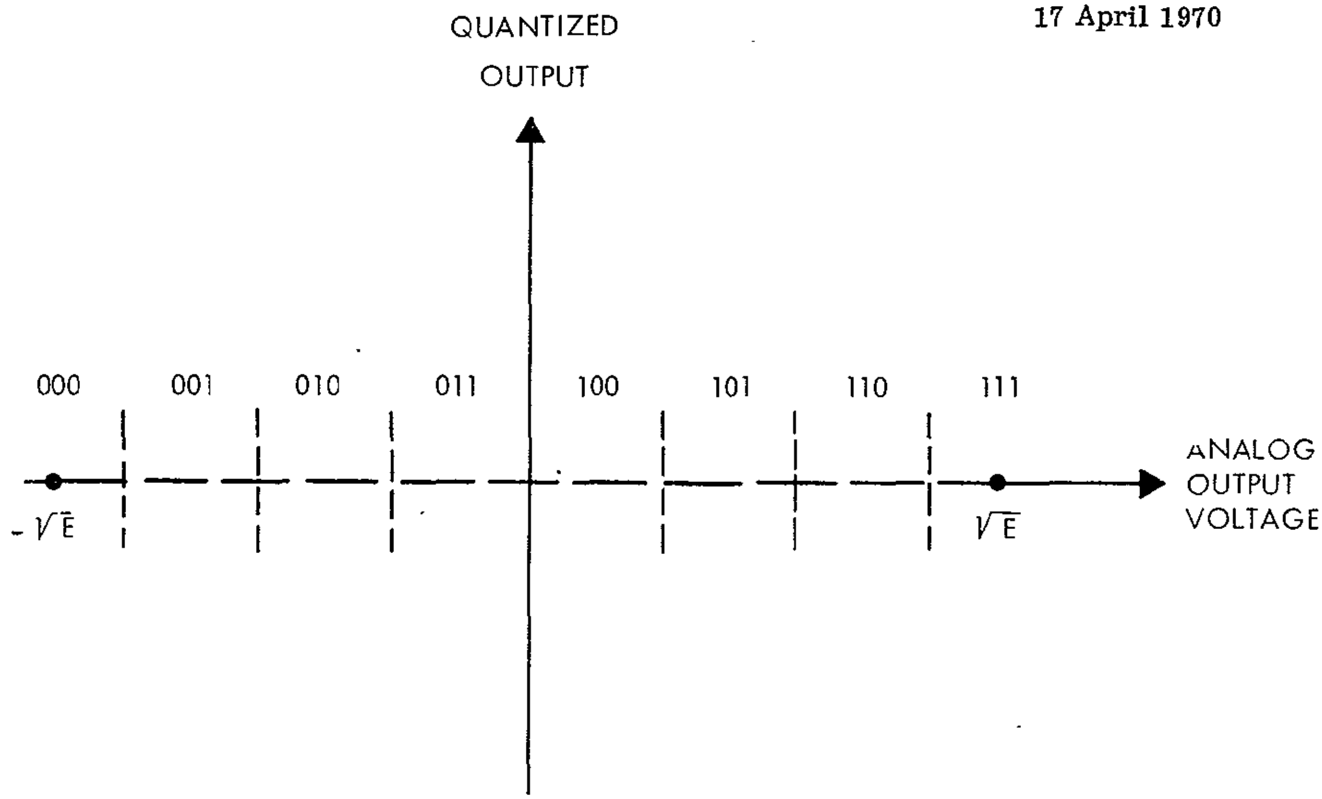


Figure 4.5-4. Integrate and Dump Analog Outputs Versus Quantized Outputs

B. Data Formatting. A 3-bit sample is generated by the bit demodulator for each message bit coming into the remote sites and is recorded on magnetic tape for later playback from the remote site to the OCC. In order for the data to be processed and decoded at the OCC, the 3-bit samples for each message bit must be identifiable. In arriving at the system design to achieve this, consideration was given to recording a clock track along with the serial data track and simultaneously transmitting the clock and data over the communications link on separate channels. Due to phase shift between the data and clock over the communications link, as well as skew between the recorded tracks, a timing scheme independent of these phase-shift problems was designed.

For the approach selected, the data from the bit demodulator is formatted in 2400-bit NASCOM format blocks prior to being recorded. A header is provided at the beginning of each block synchronization pattern. The first bit of each block following the header bits is the first bit of a 4-bit group containing squelch and a 3-bit sample word from the bit demodulator. When the recorded data is played back and received at the OCC via the communication link, blocks are identifiable by recognizing the NASCOM header, and each 3-bit word in a data block is identifiable by knowing that the first bit after the header is the first bit of the first group of bits. By counting from that point, each data sample can be extracted. Local time is sampled and formatted in the last bits of each data block.

By formatting the data prior to recording, advantages in addition to solving the phase-shift problems are realized. Since squelch and the 3-bit sample clock are contained in the formatting scheme, only one record track is required to record the output of the bit demod. Separate tracks for clock and squelch are not required.

C. Corpus 642B Computer Pre-processing/Formatting

1. 642B Computer. The purpose of the 642B computer is to compile and compress the DCS data into a relative functional grouping. Simultaneous to compiling the data, it must test it to determine whether this is valid data or just noise bursts on the input line. An input code will be supplied via the data input line to indicate the data validity. If a code is received to indicate invalid data, that portion of the input will be ignored and the system will await the next sequential code for a restart indication. This wait loop will be entered as often as necessary and for as long as necessary to obtain a full buffer of valid data for transmission.

The data will be received by the computer at a rate of $<$20 kbps via a patch panel. It will check, compress, delay, inhibit, and format the data on an as-received basis. It will transmit this data through the 203 MODEM in 2400-bit blocks with the appropriate NASCOM header information containing ID, sync, time, origin code, and destination code. The transmitted data will be sent to the OCC at a rate of 50 kbs in 2400-bit blocks on an as-acquired basis.

Figure 4.5-5 illustrates the final format of the data blocks to be transmitted.

D. Bi-Phase Recording. Data that is recorded at the remote sites is recorded in bi-phase format. Since magnetic tape recording systems act as a high-pass filter, problems in reproducing the low-frequency components are encountered if recording is done in NRZ formats. At 60 ips, the FR 1400 and MINCOM 22 recording systems can handle up to 750 kHz data. The formatted inputs to the recording subsystems is in the less than 20 kHz range for NRZ, or less than 40 kHz for bi-phase recording.

E. Backup Recording. Consideration was given to the overall reliability of the system in arriving at the system design. In addition to formatting and recording the output of the bit demod as messages are received, the output of the FM demodulator is also recorded on a separate tape track. In the case of a failure in the bit Demod during a transmission, the output of the FM demodulator track can be played back through the bit demodulation after the bit demodulator is repaired. The output of the bit demodulator is formatted and transferred to the OCC via the communication link. The resulting format and transmission is identical to playing back the recorded track of formatted data.

A redundant FM demodulator is provided as a backup spare to ensure system reliability in case of a malfunction in the on-line FM demodulator.

F. Remote Site Data Transfer

1. Alaska. The data recorded from the formatter/buffer is played back at 60 ips into a bi-phase to NRZ converter. The NRZ data stream is inputted to an existing X144 data set via the output patch panel. The X144 data set is operated in Mode I.

The remote site X144 data set transmits data over an existing wideband link. A NASCOM X144 data set receives the data and it is routed into the OCC via the OCC patch panel.

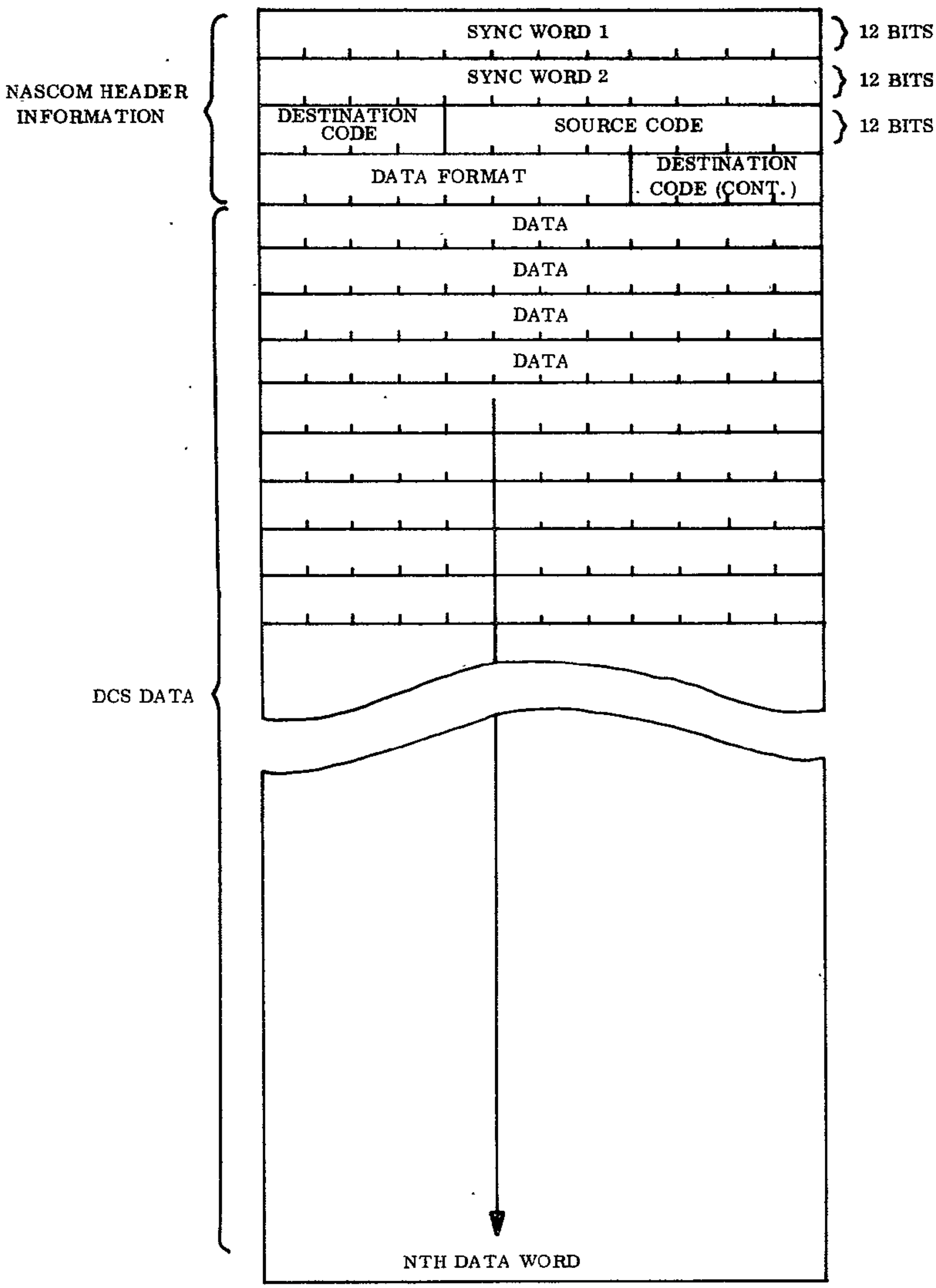


Figure 4.5-5. NASCOM MSP DCS Data Transmission Format

2. Corpus. The recorded DCS data is normally played back post-pass. The formatted bi-phase data is converted to NRZ-L and is routed to the Univac 642B via the patch panel for preprocessing prior to being transmitted to the OCC. The communications link from Corpus to OCC includes an existing land line band limited to 4.8-kHz. The formatted data rate exceeds the capacity of the 4.8-kHz link. Recorded data would have to be played at a reduced speed to reduce data at a rate compatible with the link. This would result in a playback time of approximately 40 minutes. In order to eliminate the operational disadvantage for this extended playback time, the 642B computer is utilized to perform data reduction and thus reduce the overall transmission time to the OCC.

The 642B computer receives the formatted data at the same rate as the data was recorded. Thus, 1000 platforms, each transmitting a message every 180 seconds, and each message requiring approximately 37 msec, results in 37 seconds of data during an 180-second interval. Ignoring header and time bits in the formatted 2400-bit block, this results in a possible data reduction of approximately 4 to 1. The 642B computer utilizes the squelch information in the formatted blocks to perform the data reduction and reconstructs a 2400-bit NASCOM block of data with intervals between messages eliminated.

The 642B computer outputs the reduced reformatted data blocks to the 203 MODEM at Corpus. The data is transferred to the GSFC 203 MODEM via the existing NASCOM 4.8-kHz interface. The output of the 203 receiver MODEM transfers data to the OCC via the communications line terminal, multiplexer, and the 494 Communications Processor. The 494 Communication Processor buffers data into the OCC at a 50-kHz burst rate. Up to two 2400 NASCOM blocks are transferred in this burst mode per second. The transfer is made via the high speed 303 MODEM.

3. NTTF. The output of the formatter/buffer is connected directly to the OCC patch panel via the NTTF patch panel and hardware interface. The NTTF transmits DCS data to the OCC in real time for recording on the OCC tape recorder. Preprocessing is performed at a later time when the OCC CP is available.

4.5.1.6 Telemetry Data Flow

Figure 4.5-6 shows the flow of real-time and playback narrowband PCM telemetry. All MSFN/STADAN sites supporting ERTS will have the capability of relaying ERTS RT PCM data in real time. All remote sites except for the NTTF will send the RT data over NASCOM circuits interfacing with the GSFC 494. Alaska and NTTF will be capable of sending the 24-kbps dump in real time to the OCC for processing. Backup MSFN/STADAN sites will transfer dumped data to the OCC post-pass by playing back the recorded data at a slower rate compatible with the NASCOM 4.8-kbps interfaces.

4.5.1.6.1 Spacecraft

Real-time and dumped PCM can be downlinked via the VHF transmitter and by the USB downlink. The VHF transmitter will normally downlink RT PCM split phase at 1 kbps. All assigned backup STADAN sites are capable of receiving this downlink. The VHF transmitter is also capable of transmitting the 24-kbps dumped PCM data during emergency situations. The VHF transmitter power is increased in order to maintain a reasonable S/N ratio for the increased bit rate. Little usage of this mode is expected since the normal method of dumping will be over the USB downlink. The normal configuration of the USB downlink, as pertains to PCM data, will be to place the RT PCM split phase on the channel 13 IRIG VCO which is mixed on the 1.250 SCO. The dumped 24-kbps data is placed on a 576-kHz SCO. These data are combined for simultaneous transmission over the USB 2287.5-MHz downlink carrier. The USB system is completely redundant and affords several modes of operation. All sites, with the exception of the backup STADAN sites, are capable of receiving and displaying the PCM data received in the USB downlink. The on-board PCM processor is the Versatile Information Processor (VIP) used for Nimbus. The VIP will be programmed for the ERTS needs and tentatively will contain 20 columns and 80 rows, 10-bit words downlinked at 1 kbps. The first two columns will contain a unique sync pattern for each row and a third column will contain the incrementing minor frame ID (1 to 80). A major frame period is 16 seconds, while the minor frame cycle is 5 minor frames per second for RT PCM. The dumped PCM is downlinked in reverse, i.e., newest recorded data is dumped first by running the tape backwards.

4.5.1.6.2 Remote Stations

A. Alaska RT - Dump PCM. Real-time PCM can be received on both the VHF and USB downlinks at Alaska. The noncoherent USB downlink will contain both the real-time and dump PCM. The RT PCM contained on the IRIG channel 13 and mixed on the 1.250-MHz SCO will be demodulated, discriminated, and filtered. This 1-kbps split-phase RT PCM signal will go to two interfaces: (1) to the DHE which will allow local display; and (2) to the DTS for transmission to the GSFC. The 1-kbps PCM will be routed to the GSFC 494 CP. (See STADAN RT PCM for further details.) RT PCM will then be routed to the OCC Comm Processor.

Dumped data normally received on the USB downlink at Alaska is transferred to the GSFC via the X144 data terminal. Once the 24-kbps data is extracted from the 576-kHz SCO, the dumped data is routed to the X144 data terminal for real-time transmission to the GSFC X144 terminal. The dump data is recorded on the OCC recorder for post-pass playback into the OCC communications processor.

The dumped data will be analyzed in near real time, which allows assessing of the previous orbit's data. Events which should have occurred while not over a receiving station are verified and decisions of a Go/No-Go nature are made for future events planned.

B. Corpus Real-Time PCM. Corpus will receive the RT PCM on the USB downlink. The 1-kbps PCM is extracted from the USB by demodulating the 1.250-MHz SCO and discriminating the data out of the IRIG channel 13. The output of this subcarrier discriminator is fed to one of the three PCM ground stations through the data switching and distribution unit (DSDU). The selected ground station (EMR or Dynatronics) will decommutate the RT PCM and will provide local display. These local displays are in the form of PCM count readout display on the Decom itself, as well as brush event recorder displays, meters, lights, etc., which are fed by the PCM ground station. The PCM Decom will also feed the 642B TLM computer with RT PCM data sync, and frame information. The 642B TLM computer will have the capability of outputting selected PCM parameters to the Maintenance and Operations (M&O) high speed printer. These TLM points may be displayed in percent full scale (PFS), PCM count, or in engineering units (EU). Special computations may be performed (if required) to display alarm conditions, reports by event, trend data, etc. The major function of the 642B TLM computer, however, is to format the 1-kbps PCM data into a NASCOM format. It is presently envisioned that the 642B computer will output two 2400-bit blocks of data per second to a 4.8-kbps MODEM. The first of the two 2400-bit blocks will contain 1000 bits of RT PCM data, (representing 1 second's worth of RT PCM data) preceded by the appropriate NASCOM header and sync information. Once the 1000 bits have been transferred, the remaining bits of the first 2400-bit block will be filler bits inserted by the 642B computer. The second 2400-bit block will contain the standard NASCOM header with the remaining bits being filler bits. The two 2400-bit blocks will be transmitted to the GSFC via 4.8-kbps MODEMS (probably 203 MODEMS). The 4.8-kbps RT PCM data will arrive at GSFC through a compatible MODEM which feeds the GSFC 494 CP through a communication line terminal (CLT) and multiplexer. The 494 CP will buffer the incoming 4800 bits and, if the data is correct, will transfer this data to a 303 type of MODEM at 50 kbps. The output from the GSFC 303 MODEM will feed an OCC 303 compatible (Duplex) MODEM. The 50-kbps output of the OCC MODEM feeds the OCC Comm Processor via the OCC patch panel and OCC switch.

The 50-kbps data containing NASCOM header information, RT PCM data, filler bits, etc., is received by the OCC Comm Processor. The Comm Processor acts as the interface between the 494 and the OCC computer. The serialized input is then decommutated for display on brush and event recorders. The Comm Processor also provides the OCC computer with the necessary data to perform further computations on the real-time PCM data. OCC driven displays, such as cathode ray tubes and high speed printers, provide evaluation personnel with the data required. Several advantages of interfacing the 494 CP with the OCC CP exist. An operational advantage is that certain data may be displayed on brush event recorders driven by this unit, even if the OCC computer is not functioning. Another advantage is that the OCC computer is not required to decommutate incoming data, thereby better utilizing core space (or permitting the use of a smaller OCC computer). Also, the OCC computer sees the same type of RT PCM data whether the data arrives over NASCOM interfaces, hardline outputs, or data terminal outputs. This simplifies RT data processing in the OCC computer.

C. Corpus Dump PCM. Dumped PCM is not expected to occur frequently at the CORPUS site since Alaska and the NTTF will be normally receiving all Narrowband Tape Recorder dumps. However, the 642B TLM computer is capable of formatting dumped parameters for post-pass transmission to the OCC. The recorded dumped PCM data is played back at a reduced rate to the OCC NASCOM circuits. The routing would be the same as the RT PCM.

D. NTTF RT-Dump PCM. The USB downlink containing the RT dump PCM, as previously discussed, would be received at the NTTF USB Receiving System. The RT and dump data would be demodulated and discriminated at the NTTF. This RT-dump raw PCM would be fed to the hardline interface patch panel at the NTTF. The OCC hardline patch panel would route the RT PCM data to the OCC Comm Processor preceding the OCC computer. The outputs of the processor would feed hardware display devices and would also feed the OCC computer for extended processing and display. NTTF then acts as the "front end" to the OCC, and provides backup USB recording of the data.

E. Backup MSFN RT-Dump. Since RT dump PCM is downlinked via the MSFN, compatible USB and the backup MSFN sites are configured similarly to Corpus; the method of recording, displaying, and transferring RT PCM data is accomplished in exactly the same manner for all MSFN sites. It is assumed that the backup MSFN sites will have available the 642B TLM computer software. No modifications are required or assumed for these backup MSFN sites. Therefore, like Corpus, the backup MSFN sites will have the capability of relaying RT-dump DCM over 4.8-kbps interfaces to the GSFC and to the OCC.

F. Backup STADAN RT PCM. The selected backup STADAN sites will receive RT PCM only on the VHF downlink. The VHF receiver output will be 1-kbps RT PCM filtered in a split-phase PCM format. This RT data will be fed to data handling equipment for local display. Also, RT PCM will be fed directly to the DTS. The DTS will format the 1-kbps RT PCM in a similar manner as the 642B computer for the MSFN sites. The output of the DTS will be two 2400-bit blocks, each containing NASCOM headers, PCM data (1000 bits), and filler bits. These two blocks will be transmitted to the GSFC 494 via 203 type MODEMS at 4.8 kbps. The same functions will be performed by the 494, 303 MODEMS, OCC Comm Processor, display and OCC computer as were performed for the incoming MSFN RT PCM data.

G. Backup STADAN Dump (Emergency). Dumped PCM data will not normally be received at backup STADAN sites since the data is transmitted on the USB downlink. However, the VHF transmitter is capable of transmitting dumped data by increasing the VHF transmitter power to accommodate the 24-kbps PCM dumped data. If this emergency method were employed, the STADAN sites would record the dumped data and would play back the dumped data to GSFC over the 4.8-kbps interface by reducing the playback ratio to output a data rate compatible with the interface. This "slowed" dump data would interface with the DTS which would necessitate routing through the GSFC 494.

4.5.1.7 Command Data Flow

The flow of command data through the ERTS system is shown in Figure 4.5-7.

4.5.1.7.1 Spacecraft

The command/clock system selected for the ERTS is that used on the Nimbus D vehicle. The on-board STADAN VHF command receiver is redundant and conforms to STADAN standards. The 128-bps Frequency Shift Keyed (FSK) uplink consisting of 50 bits per command is fed to the command integrator unit. This unit serves as an isolation device for the MSFN/STADAN commands and feeds the ERTS command clock. The MSFN will command on the USB uplink by sub-bit encoding data on a 70-kHz SCO. These sub-bits are in the form of 1 and 2 kHz phase-shift keyed (PSK) audio signals. The uplink sub-bit rate is 1000 bps and, since five sub-bits per data bit encoding is chosen, the uplink data rate from MSFN is 200 bits/second. Both VHF and MSFN redundant systems can operate with only one prime system activated. In the event of a prime command system failure, the operating command system can select the redundant command system.

4.5.1.7.2 OCC Command Generation
The OCC computer will originate and generate all commands for either MSFN or STADAN sites. Output buffers will be formatted in 600-bit blocks. Each block will contain NASCOM header information, such as type of command, word length, selected site ID, polynominal protection (nominally 33 bits), command bits, filler bits, etc. Upon activation by an OCC generated command request, command data is transferred to the 494 CP via the OCC Comm Processor and 303 MODEM. This transfer takes place at 50 kbps in 600-bit blocks (serial bit transfer).

4.5.1.7.3 494 - NASCOM Transfer
Upon receipt of the data, the 494, in conjunction with the polynominal buffer terminal (PBT), will check the error protection to see if any bits changed. Correct command data will be routed to the selected remote site (MSFN or STADAN) by way of 4.8-kilobit MODEMS.

4.5.1.7.4 Receipt of Command Data at MSFN/STADAN Sites

A. MSFN Command. The MSFN sites will receive the command data at the compatible MODEM and will route the data to the data transmission unit (DTU) which interfaces with the 1299 switchboard. Upon receipt of command data at the 642B computer, certain checks are made for address, format, polynominal bits, etc. If the command data is correct, the 642B will strip off the site address, polynominal bits, and the filler bits which were inserted at the OCC to make up a 600-word block.

The actual command bits containing sync, vehicle address key, mode, command, and other bits are sub-bit encoded by the 642B computer for transmission to the updata buffer. The command is then routed through the remaining command equipment for transmission on the USB uplink. Sub-bit encoded (five sub-bits per data bit) command is transmitted to the ERTS on the 70-kHz subcarrier oscillator (SCO) at a sub-bit rate of 1 kbps.

B. STADAN Command. The selected STADAN site receives the command data in much the same fashion as the MSFN site. The 600-bit block arriving at the 4.8-kbps MODEM is routed to the Data Transmission System (DTS). The DTS acts as a bit stripper, removes the header information and polynomial bits, as well as the filler bits, and sends the command bits to the "new"* STADAN encoder.

The output of the STADAN encoder is sent to the VHF command equipment for data transmission at 128 bits per second.

C. Command Verification Echo Check. Both the MSFN and STADAN will have "echo" check capability, thereby comparing bit for bit the command as it is being transmitted. If an error is detected, the command is stopped and retransmission of the command must be accomplished from the OCC by retransmitting the command.

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*It is assumed that this encoder will be available during the ERTS time frame.

Command verification of real-time commands is accomplished at the OCC by monitoring the appropriate TLM parameter associated with the command. Stored commands are normally verified by employing the COMSTOR verify function. The contents of COMSTOR are compared with the uplink and, if a correct load has been received, the selected COMSTOR is activated permitting the stored commands to be executed at the appropriate time. The actual execution of stored commands is verified by the playback of the narrowband tape recorder which has recorded these executions.

In summary, all command data is originated, stored, and transmitted from the OCC. The remote sites "relay" in real time all types of commands received from the OCC through the NASCOM interfaces. All command verification is accomplished at the OCC except echo checks which are performed at the remote stations and a fault ceases transmission of commands.

4.5.1.8 Tracking Data Flow

Both the prime USB ranging and minitrack interferometer tracking systems used for ERTS are shown in Figure 4.5-8.

4.5.1.8.1 Spacecraft

The primary tracking equipment on-board the spacecraft is the phase lock coherent USB transponder, similar to that used on main line Apollo. The on-board receivers will receive 2106.4 MHz containing Pseudo Random Noise (PRN) on the baseband from an uplinking MSFN site. The on-board system will multiply this incoming frequency by 240/221 and will transmit a downlink at a frequency of 2287.5 MHz containing the PRN. The on-board system, like most other subsystems, is completely redundant. The secondary tracking information is derived from the VHF transmitter.

4.5.1.8.2 MSFN Tracking

The MSFN, primarily Corpus Christi, will provide most of the ERTS tracking data to GSFC. There exists two methods of transferring MSFN data to GSFC:

1. High speed data (HSD) trandfer at 4.8 kbps
2. TTY at 100 wpm in real time or near real time

The primary method used for ERTS will be teletype.

The MSFN USB tracking method is to transmit on 2106.4 MHz a PRN originated in the tracking data processor. The uplink is received by the phase-locked receiver multiplied by a 240/221 ratio, and then transmitted to the MSFN site for comparison. The baseband USB downlink is fed to the Mark 1 ranging system and also fed to the tracking data processor. This tracking system employs the double-doppler tracking method, from which spacecraft velocity, acceleration, and range can be determined. Information from the tracking data processor is transferred to the GSFC orbit determination group, via TTY circuit. The OCC computer would receive orbit data from the GSFC orbit determination group as required on magnetic tape and computer listings.

4.5.1.8.3 STADAN Minitrack

STADAN minitrack data, extracted from the ERTS VHF transmitter, is expected to be used only as a backup to the MSFN tracking data. The MSFN tracking will be received by the GSFC orbit determination function and will provide orbit data to the OCC mission planning element as required.

4.5.1.9 Summary Information Flow

Figure 4.5-9 illustrates the major data transfer functions for the MSFN/STADAN sites. Hard data transfer is shown by the dashed line going from the network sites to the GSFC. All data containing NASCOM headers will be routed through the GSFC Univac 494 communications processor (CP). This includes all uplink data generated by the OCC, STADAN RT PCM data, MSFN RT PCM, and MSFN processed PCM dumped data transmitted in near real time. Alaska dump data and all data from the NTTF will bypass the 494 CP. Wideband payload data (MSS and RBV) will arrive at the OCC as hard data from both Corpus Christi, Texas, and Alaska. Hardlines will be used for NTTF. Voice circuits will be terminated using the SCAMA conferencing equipment, and other voice handling equipment. MSFN tracking and STADAN minitrack data will be sent to GSFC via TTY circuits. DCS data will be preprocessed at Alaska and Corpus and transmitted to GSFC in near real time.

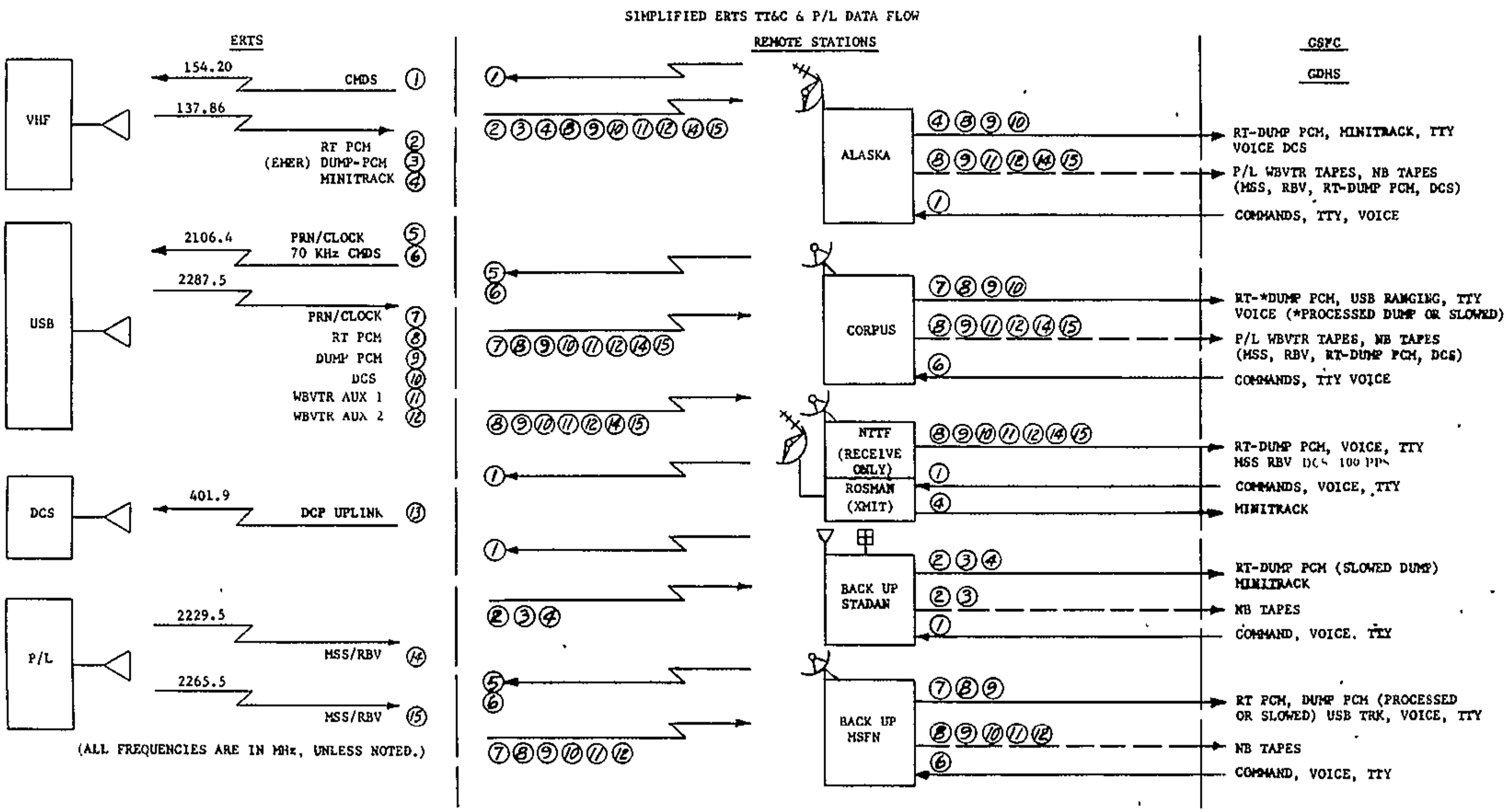


Figure 4.5-9. Major Data Transfer Functions

4.5.2 SYSTEM THROUGHPUT ANALYSIS

The amount and kinds of data produced in and by the GDHS must be known to assess design feasibility and the amount of equipment and labor needed to implement a design. For this end and to provide other data necessary for spacecraft design (i.e., thermal analysis), a mission simulation was performed.

The basic problem simulated was the on-orbit operation of the sensor payloads, the management of the onboard recorder resource, and the management of the acquisition of data by the ground sites. Of primary importance in the design of the simulation was to incorporate both the operational capabilities of the system and the constraints and limitations of both the system and the mission. Since much of the overall operational philosophy was not solidified at the time of this simulation design, a need for flexibility in specifying the parameters and conditions of the simulation cases was mandatory. The resulting simulation capabilitiy provided a versatile tool that enabled not only a baseline profile to be generated but also provided the capability to investigate the significance of variation in the basic parameters and conditions of the mission/system.

4.5.2.1 Simulation Model

The simulation capability is a computer aided process. The basic model is designed around four basic types of mission/system descriptors:

1. Prioritized world coverage map
2. Orbital ground trace
3. Data acquisition site coverage
4. Spacecraft and sensor capabilities and constraints

4.5.2.1.1 Prioritized Coverage Map

To simulate the anticipated preferences for specific geographical coverage by ERTS, the capability was provided to partition the world map into homogeneous regions. The boundary of each region is a variable and each region is assigned to one of eight different categories. Since it is expected that the desire to image certain areas will be greater than for others, the categories were assigned to relative priority structure. Figure 4.5.10 presents the prioritized map used for this simulation. The finest granularity of region segmenting was at a country level. Although it is expected that finer coverage region definition will be employed operationally, it is felt that the map used here does present a realistic coverage requirement distribution on which to develop design profiles.

4.5.2.1.2 Orbital Ground Trace

Although the simulation model can handle any specified orbit, the unique features of the ERTS orbit (i.e., 18-day repeat cycle, sun synchronous) allows for some simplifications to be made in the simulation. With this orbit it is necessary to only examine the operations for a single 18-day cycle. The sun synchronous condition simplifies the accounting for variations resulting from effects of time of year. Effectively, different times of year result in a translation of the region of acceptable sun angle within an orbit and can be assumed to be essentially

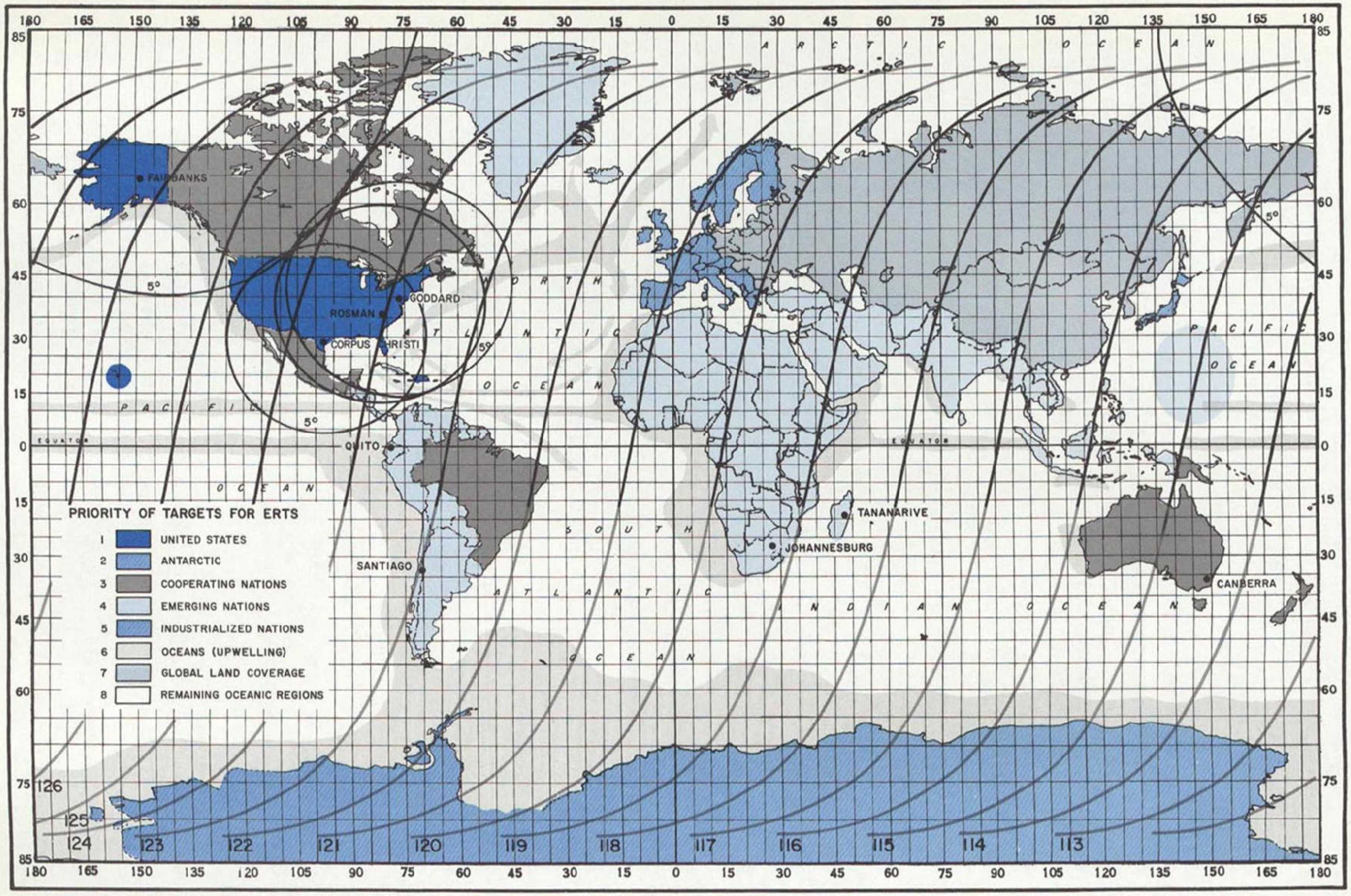


Figure 4.5-10. World Coverage Map

a fixed translation for all orbits within an 18-day cycle. On Figure 4.5-10, the descending ground traces for a typical day in an 18-day cycle are shown. The particular case shown is for "day 9" of the cycle. For each successive day in a cycle, the ground trace overlay would shift approximately 1.5 degrees west at the equator, and on the 19th day the ground trace pattern will essentially be the same as day 1.

4.5.2.1.3 Data Acquisition Site Coverage

Three data acquisition sites capable of receiving the wideband sensor video data were used (Alaska, Corpus Christi, and NTTF). It was assumed that data could be transmitted to the ground sites during any pass over the site (day or night). Although the simulation model can handle any station cone angle, it was assumed for these cases that wideband data could be received any time the spacecraft was at an elevation of more than 5 degrees from the site. Figure 4.5.10 shows the ground station cones for 5 degrees elevation angles. In addition to the three wideband acquisition sites, Rosman is also shown.

Where two or more sites can see the spacecraft at the same time, it was assumed that both sites could receive the video data simultaneously.

4.5.2.1.4 Spacecraft/Sensor Considerations

The operations of the sensors must be scheduled in a manner that will return imagery over the land areas of interest. The ERTS system has been designed to provide the capability to image the ground during the appropriate daylight portion of the orbit and to store this data for future transmission to earth during those times when not in contact with a ground station. During a contact with a data acquisition station, either data from real time operations of the sensors or the dumping of previously recorded data can be scheduled.

The simulation problem is to generate the schedules for the operations of sensors, onboard recorders, data transmission cycles, and spacecraft subsystem support requirements in a manner that best satisfies the coverage requirement. The resultant schedules from the simulation must be feasible for the ERTS system to perform. This requires that the simulation process consider the capabilities of the spacecraft/sensor system and any limitations or constraints imposed on its operations either by the spaceborne system itself, the ground support constraints, or because of operational ground rules. The simulation is capable of handling spacecraft and sensor parameters such as:

1. Onboard wideband tape recorder capacity
2. Maximum allowable operation time per orbit
3. Sensor operating sequences
4. Sun angle limits for sensor operations
5. Real time or recorded operations
6. Selective inhibiting of specific operations or groups of operations.

Figure 4.5-11 depicts the simulation tool from a logic flow point of view.

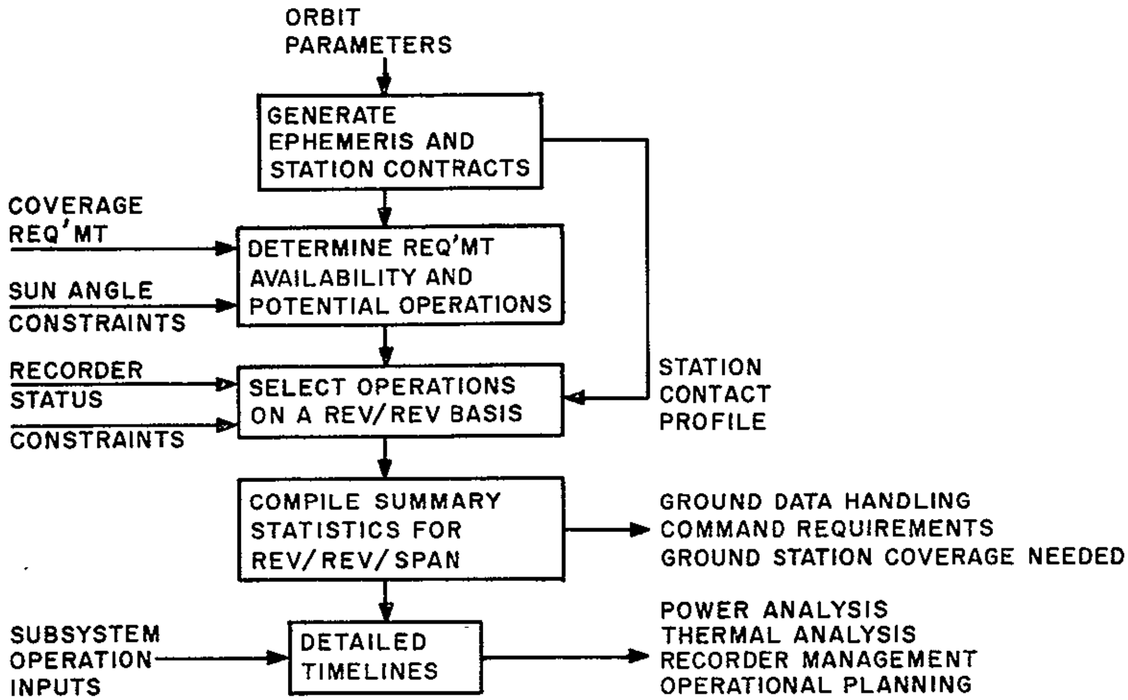


Figure 4.5-11. Simulation Logic Flow

4.5.2.2 Simulation Cases

4.5.2.2.1 Purpose

Simulation mission operations were used to support the spacecraft design and are continuing to establish the ground support requirements. The specific results obtained for use in the spacecraft design include:

1. Maximum daily payload operations

2. Maximum number of stored commands for payload operations between ground station acquisitions

3. Recorder usage

Specific results being obtained for ground data handling system design include:

1. Maximum daily payload operations

2. Command requirements

3. Ground station coverage planned

4.5.2.2.2 Inputs

The simulated mission operations that were conducted to establish worst case requirements for the spacecraft design used the following parameters and operational ground rules:

1. Orbital parameters (ground traces shown in Figure 4.5-10)

inclination	99.088°
altitude	492.35 nm
period	6196.0 sec
descending node time	0930

2. Land mass coverage

   Complete global coverage over an 18-day cycle

   Consider no cloud restrictions

   Land priority structure used if required (priority structure is shown in Figure 4.5-10)

   Schedule coverage above 60°N latitude on alternate revs only*

   Sensors continue to operate between land masses whenever their off period would be less than 2 minutes.

3. Payload Operation

   Simultaneous MSS and RBV operation are scheduled whenever the following three conditions are met:

   a. Sensor operation allowable for sun angle ≥ 35° (summer solstice case shown in Figure 4.5-10 by darker portion of orbit traces)

   b. A real time link or WBVTR available

   c. The subsatellite point is over land, coastal waters, or major island groups

*Above 60°N latitude, alternate contiguous subsatellite swaths provide the required coverage including overlap. Therefore, complete coverage can be obtained in 18 days by scheduling alternate rev operation. Elimination of this duplicate coverage permits more effective use of the Alaska ground station and in recovering data from other areas of the world.

4. Data Acquisition Stations

Alaska, Corpus and NTTF/Rosman

Unrestricted wideband link operations within 5° elevation cone

Minimum station contact of two minutes required in order to schedule WBVTR playback.

Unrestricted use of in-cone time (i.e., ground station support whenever required)

5. Spacecraft Recording Capability

2 WBVTRS

30 minute capacity each

No operating life restrictions

4.5.2.2.3 Mission Profiles

Simulated mission operations using the above ground rules have been performed for 18-day periods at summer solstice, vernal equinox, and winter solstice. The autumnal equinox is nearly identical to the vernal equinox, therefore, changes in payload operation can be projected for a full year of operation.

Mission operations data has been summarized in three tables. Table 4.5-1 contains the information for summer solstice, Table 4.5-2 for fall and spring, and Table 4.5-3 for winter operations.

These tables show: (I), the total land mass covered for a sun angle ≥ 35°; (II), the total land mass covered for a sun angle ≥ 35° less the duplicate coverage that exists in 18 days at latitudes greater than 60°; (III), scheduled mission operations. Each of these three major columns further shows the breakdown of this coverage by real time, remote coverage and their totals. A fourth major column, (IV), shows the total land mass missed because of combined recorder/ground station limitations.

Examination of the maximum case of payload operations is required as a worst case input to power analysis, thermal analysis, and ground operations. As expected, the maximum payload operations occur during summer solstice. Average daily operations during this season are approximately 135 minutes. Average daily operations for Spring/Fall and Winter seasons are 108 and 64 minutes, respectively. Note that summer operations are double those for winter and 25 percent higher than the equinox case. Within summer solstice, day 9 operations (147 minutes), represents the absolute worst case.

Table 4.5-1. Operations Summary 18-Day, Summer Solstice

	I Available Land Mass Sun Angle 35°			II Available Land Mass Sun Angle 35° Duplicate Coverage Removed -> 60°			III Actual Scheduled Mission Operations			IV Available Land Mass Missed
Day	Total	Total Real Time	Total Remote	Total	Total Real Time	Total Remote	Total	Total Real Time	Total Recorded	Total
1	182.4	42.9	139.5	156.9	30.5	126.4	139.3	30.5	108.8	18.6
2	183.3	45.5	139.8	159.4	37.5	121.9	143.4	37.5	105.9	16.0
3	177.6	41.8	135.8	151.7	30.4	121.3	136.9	30.4	106.5	14.7
4	180.4	42.2	138.2	152.1	34.4	117.7	137.1	34.4	102.7	15.0
5	183.0	44.5	138.5	156.2	33.1	123.1	137.1	33.1	104.0	19.1
6	186.5	43.0	143.5	156.3	33.4	123.3	135.2	33.4	101.8	21.5
7	192.0	43.4	148.6	164.9	34.2	130.7	139.3	34.2	105.1	25.6
8	187.9	39.3	148.6	159.1	30.1	129.1	137.0	30.1	106.9	22.2
9	193.6	46.3	147.3	170.7	37.9	132.8	147.1	40.7	106.4	24.5
10	187.9	40.2	147.7	160.8	33.1	127.7	141.2	33.1	108.1	19.6
11	184.7	40.1	144.6	161.4	33.3	128.1	135.2	33.3	101.9	26.2
12	181.3	40.0	141.3	153.6	29.4	124.2	133.3	29.4	103.9	20.3
13	174.8	40.8	134.0	150.2	33.8	116.4	126.9	33.8	93.1	23.3
14	171.9	41.0	130.9	145.6	30.4	115.2	128.0	30.4	97.6	17.6
15	171.7	41.6	130.1	147.2	34.3	113.9	128.8	34.3	94.5	19.4
16	164.9	38.5	126.4	141.3	29.3	112.0	127.0	29.3	97.7	14.3
17	170.0	40.7	129.3	145.1	33.2	111.9	131.8	33.2	98.6	13.3
18	166.9	40.2	126.7	144.1	31.6	112.5	134.4	31.6	102.8	9.7

(TIMES IN MINUTES)

Table 4.5-2. Operations Summary 18-Day, Vernal/Autumnal Equinox

Day	I Available Land Mass Sun Angle 35°			II Available Land Mass Sun Angle 35° & Duplicate Coverage Removed - > 60°			III Actual Scheduled Mission Operations			IV Available Land Mass Missed
	Total	Total Real Time	Total Remote	Total	Total Real Time	Total Remote	Total	Total Real Time	Total Recorded	Total
1	123.6	11.9	111.7	Same as Column I			115.8	11.9	103.9	7.8
2	131.3	17.2	114.1				122.9	17.2	105.7	8.4
3	125.6	15.7	110.0				117.3	15.7	101.6	8.3
4	123.9	15.6	108.3				114.9	15.6	99.3	9.0
5	121.8	16.5	105.3				112.3	16.5	95.8	9.5
6	122.7	15.8	107.0				112.8	15.8	97.0	10.0
7	121.0	14.3	106.7				111.7	14.3	97.4	9.3
8	120.5	13.6	106.9				110.2	13.6	96.6	10.3
9	127.6	20.6	107.0				112.9	20.6	92.3	14.7
10	121.1	16.0	105.1				106.1	16.0	90.1	15.0
11	119.5	14.8	104.7				105.6	14.8	90.8	13.9
12	116.8	14.5	102.3				102.5	14.5	88.0	14.3
13	114.0	16.0	98.0				100.3	16.0	84.3	13.7
14	110.0	14.7	95.3				96.9	14.7	82.2	13.1
15	113.9	15.7	98.2				100.0	15.7	84.3	13.9
16	110.0	13.6	96.4				98.8	13.6	85.2	11.2
17	113.9	14.0	99.9				103.6	14.0	89.6	10.3
18	113.4	14.0	99.4				98.7	14.0	84.7	14.7

(TIMES IN MINUTES)

Table 4.5-3. Operations Summary 18-Day Winter Solstice

	I			II			III			IV
	Available Land Mass Sun Angle 35°			Available Land Mass Sun Angle 35° Duplicate Coverage Removed - >60°			Actual Scheduled Mission Operations			Available Land Mass Missed
Day	Total	Total Real Time	Total Remote	Total	Total Real Time	Total Remote	Total	Total Real Time	Total Recorded	Total
1	67.9	1.2	66.7	Same as Column I			67.9	1.2	66.7	0
2	77.4	2.6	74.8				77.4	2.6	74.8	0
3	75.1	1.7	73.4				75.1	1.7	73.4	0
4	72.3	2.5	69.8				72.3	2.5	69.8	0
5	70.3	3.1	67.2				70.3	3.1	67.2	0
6	71.2	2.2	69.0				71.2	2.2	69.0	0
7	68.9	1.9	67.0				68.9	1.9	67.0	0
8	66.3	0.5	65.8				66.3	0.5	65.8	0
9	71.1	3.9	67.2				71.1	3.9	67.2	0
10	64.5	0.5	64.0				64.5	0.5	64.0	0
11	57.9	0.9	57.0				57.9	0.9	57.0	0
12	55.4	0.9	54.5				55.4	0.9	54.5	0
13	54.7	2.4	52.3				54.7	2.4	52.3	0
14	51.1	0.9	50.2				51.1	0.9	50.2	0
15	55.6	2.1	53.5				55.6	2.1	53.5	0
16	56.7	0.5	56.1				56.6	0.5	56.1	0
17	61.8	0.9	60.9				61.8	0.9	60.9	0
18	60.5	1.5	59.0				60.5	1.5	59.0	0

NOTE:

Lower latitude limit for a sun elevation angle ≥ 35° is -65.7°. All of Antarctica is below this latitude. Sensor operations should be possible for lower sun angles over this region because of the increased reflectivity of the area. These operations are not shown on this table because of the ground rule of sun angle ≥ 35° Alternate rev operation would be scheduled for mission operations over Antarctica.

(TIMES IN MINUTES)

4.5.2.2.4 Summary

The system is capable of gathering data for more than 78 minutes/day except during winter months. "Case B" coverage is defined as one hour of operation outside the U.S. plus real time coverage of the U.S. (which averages 18 min/day at summer solstice) for a total of 78 minutes/day operation. As the spacecraft is capable of more operation as shown by the simulation, and cloud cover data can be used in mission planning, 78 minutes/day will be taken as the design load. "Case A" (U.S. coverage only) is then 18 minutes/day or a factor of 0.231 of Case B, while operation based on all real time plus remote operations limited only by the 30 minute capacity of the recorder yields 135 minutes/day (average, summer solstice) which is a factor of 1.73 times the Case B load.

Measuring one scene per 25 second operation and counting 7 images per scene (8 for ERTS-B) yields:

$$78\,\frac{\text{min.}}{\text{day}} \cdot 60\,\frac{\text{sec}}{\text{min}} \cdot \frac{1\text{ scene}}{25\text{ sec}} \cdot 7\,\frac{\text{images}}{\text{scene}} = 1310.4\,\frac{\text{images}}{\text{day}}$$

This number has been rounded up to 1316 images/day to allow counting 188 operations/day x 7 images/operation. Other operational modes yield loading data as follows:

Operations Mode	Minutes Per Day	Images Per Day	Images Per Week
1. Real time, U.S. (incl Alaska)	18	315	2,205
2. Real time, all Land with coverage cones	44	740	5,180
3. Real time, U.S. plus one hour	78	1,316	9.212
4. 30 minute recorder limited, attempt global land coverage	135	2,268	15,876
5. Three ground station contact limit, no recorder limit, attempt global land coverage	208	3,495	24,465
6. Average 20 min/rev operation	280	4,704	32,928

4.5.2.3 OCC Loading

The orbit analyses indicate that of the 14 revs/day, usually 12 involve ground station contact and 2 are "dead" revs having no ground station contact. There are instances where the breakdown is 13 live and one "dead". To achieve best control, the OCC must be prepared to operate for each ground station contact. The timelines resulting from this schedule are presented in Section 8.2.

4.5.2.4 Photographic Material Loading

Table 4.5-4 shows the requirements for production of photographic materials in the NDPF. Numbers are based on Case B loading and, where not specified, numbers are weekly (7 days) figures.

These requirements and throughput levels are summarized in Table 4.5-5 for Case A, Case B, and Recorder Limit loading cases. This data totals as follows, per week for Case B

9,672	Black and white masters
96,720	Each of black and white negatives, positive transparencies and positive prints
986.4	Color composite negatives
9,864	Color prints

4.5.2.5 Magnetic Tape Loading

4.5.2.5.1 Computer Tape Loading

Estimates of computer tape loading throughput the system is reported in Section 11.7 as to numbers, use, and disposition. The largest requirement is for the tapes required for digitized image data. Table 4.5-4 lists the tapes per week to be sent to users to total approximately 2300 tapes/week.

4.5.2.5.2 Wideband Video Tapes

Information was generated to estimate the number of wideband data tapes produced daily as a preliminary basis for sizing GDHS design. The estimates are worst case and are based on the "day 9" summer solstice operating profile. The following assumptions were made in computing the estimates:

1. A 30-minute record capacity exists on the ground WBVTR's at the acquisition sites.

2. Data received on different passes will be recorded on a single tape if space exists.

3. Data will be received at Alaska, Corpus Christi, and the NTTF.

4. All acquisition passes (both day and night) were considered available for data receipt.

5. The basic profile considered sensor operations compatible with the capabilities of the spacecraft system, therefore, the total amount of data gathered exceeds the Case B coverage requirement as stated in the spec.

Table 4.5-6 shows the breakdown of data receiving passes at each of the three acquisition sites as a function of rev. All numbers relating to the amount of data is shown in minutes; for each pass, whether data is real time or dumped recorder is indicated. The status of the WBVTR's at the sites after each pass is also shown.

Table 4.5-4. NDPF Production Requirements

B-W	Black and White
C	Color
+	Positive transparency
-	Negative transparency
+ Prints	Positive paper prints
C Prints	Color Positive Paper prints

Input	Product	Scenes Per Week	For Each Scene	Items Per Week
RBV Input: 188 Scenes/Day, 564 Images/Day; 1316 Scenes/Week, 3948 Images/Week	100% Bulk	1316	3 B-W masters	3,948
			30 +	39,480
			30 -	39,480
			30 + prints	39,480
	20% Bulk Color	263	1 C-	263
			10 C prints	2,360
	5% Precision	66	3 B-W masters	198
			30 -	1,980
			30 +	1,980
			30 + prints	1,980
			1 C-	66
			10 C prints	660
			Computer Readable	≈ 238 Tapes
	1% Digitized	13.2	3 copies Computer readable	≈ 158 tapes
MSS Input: 188 Scenes/day, 752 images/day; 1316 Scenes/week, 5264 Images/week	100% Bulk	1316	4 B-W masters	5,264
			40 +	52,640
			40 -	52,640
			40 + prints	52,640
	20% Bulk Color	263	2 C-	526
			20 C prints	5,260
	5% Precision	66	4 B-W masters	264
			40+	2,640
			40 -	2,640
			40 + prints	2,640
			2 C-	132
			20 C prints	1,320
			Computer Readable	≈ 238 Tapes
	5% Comp Readable	66	3 copies Computer Readable	≈ 713 tapes

Table 4.5-5. Case A, Case B, and Recorder Limit Cases.

	Case A	Case B	Recorder Limit
1. Images/day (4/7 MSS + 3/7 RBV)	315	1,316	2,268
2. Images/week (4/7 MSS + 3/7 RBV)	2,205	9,212	15,876
3. Color neg, RBV/week (20% of line 2 ÷ 3 x 3/7)	63	263	453
4. Color neg, MSS/week (line 3 x 2)	126	526	906
5. Total, line 3 + line 4	189	789	1,359
6. Precision B&W neg/week (5% of line 2)	110.3	460.6	793.8
7. Precision color neg/week (3/7 of line 6)	47.4	197.4	340.2
Bulk B&W images/hr - 40 hr week	55.1	230.3	396.9
- 80 hr week	27.6	115.2	198.5
- 160 hr week	13.4	56.1	96.8
<u>Production Processing</u>			
8. B&W bulk/week (10 x line 2)	22,050	92,120	158,760
9. Color bulk/week (10 x line 5)	1,890	7,890	13,590
10. Precision B&W/week (10 x line 6)	1,103	4,606	7,938
11. Precision color/week (10 x line 7)	473	1,974	3,402

Table 4.5-6. Sensor Data Recorded by Ground Stations

	Alaska Pass			Corpus Pass			NTTF Pass		
REV	RT	Dump	WBVTR Status	RT	Dump	WBVTR Status	RT	Dump	WBVTR Status
1	5.7	5.0	10.7	-	-	-	-	-	-
2	-	12.4	23.1	-	-	-	-	-	-
3	3.3	-	26.4	-	-	-	-	-	-
4	-	-	-	-	-	-	-	6.9	6.9
5	-	2.0	28.4*	-	10.7	10.7	-	13.5	20.4
6	-	5.1	5.1	-	12.9	23.6*	-	-	-
7	-	12.1	17.2	-	-	-	-	-	-
8	-	12.3	29.5*	-	-	-	-	-	-
9	-	5.6	5.6	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	-	-	-	9.2	29.6*
12	-	-	-	10.0	-	10.0	13.8	-	13.8
13	4.5	-	10.1	8.8	4.0	22.8*	8.5	-	22.3*
14	3.3	8.0	21.4*	-	-	-	-	-	-

*Indicates that tape cannot accommodate all data from next pass and thus is demounted and ready for shipment to NDPF.

Table 4.5-7 summarizes the wideband recorded per day as a function of site, tape ID No., amount of data on tape, and the passes (rev) from which data was recorded.

Table 4.5-7. Summary of Ground Recorded Tapes

Site (Tape ID No.)	Amount of Data Min	Passes Recorded (Rev)
Alaska (1)	28.4	1, 2, 3, 5
Alaska (2)	29.5	6, 7, 8
Alaska (3)	21.4	9, 13, 14
Corpus (1)	23.6	5, 6
Corpus (2)	22.8	12, 13
NTTF (1)	29.6	4, 5, 11
NTTF (2)	23.3	12, 13

Based on the above data, a maximum of 14 wideband tapes (7 RBV, 7 MSS) would be required per day. For Case B coverage (a total of approximately 78 min/day as opposed to the approximate 147 min/day as shown), a maximum of 12 tapes would be required per day. This would reduce to a total of 8 tapes per day (4 from Alaska, 2 from Corpus, and 2 from NTTF), if a carryover of more than a day is permitted for the Corpus and NTTF stations.

The absolute minimum number of tapes based on data volumes and tape capacity would be 6 per day. This assumes a total of 78 minutes of operations per day and would allow approximately 12 minutes for redundant recording by two sites simultaneously. This is not considered practical because of the tape packing density and does not allow adequate room for data segmenting information, headers, etc.

Table 4.5-8 summarized the various cases versus the tape requirements.

As can be seen from Table 4.5-8, the number of tapes required per day vary significantly depending on assumptions. It appears that (if tape packing is employed) Cases 3, 4 and 5 would most likely occur with Case 3 and 4 being the most probable. Therefore, for design purposes, the Ground Data Handling System should expect approximately 10-12 wideband video tapes per day from acquisition sites.

Table 4.5-8. Mission Operating Cases Versus Tape Requirements

Case	Alaska	Corpus	NTTF	Total
1. Data dumped every pass (20 passes/day) (new tape each pass*)	22	8	10	40
2. Worst case mission profile (new tape each pass)	20	8	10	38
3. Worst case mission profile (tape packing)	6	4	4	14
4. Case B profile (tape packing, contiguous pass)	4	4	4	12
5. Case B profile (tape packing; day and night passes NTTF and Corpus packed)	4	2	2	8
6. Absolute minimum number tapes (data volume)	2	2	2	6

*A total of 20 passes over the acquisition sites occurred on the day considered. Case 1 assumed that data would be received at each of these passes and a new tape would be used each time.

4.5.3 OCC AND NDPF LOCATION

4.5.3.1 Study Definition

The baseline design for the GDHS provides for co-location of the OCC and NDPF on the third floor of Building 23 at GSFC per Specification (paragraph 7.14.1.1). In response to paragraph 7.14.1 of the Specification, separation of the facilities was considered.

It is assumed that "separation" means physical distances large enough to prevent, without additional equipment, the control of a device at one location by a computer at another. If not, the design presented here would change only in facility design, voice communication requirements, and interconnecting cable lengths.

4.5.3.2 Study Results

Separation of the facilities will have some small effect on every aspect of the design, but in the design presented herein, the only significant effects are:

1. Loss of OCC computer backup by NDPF central computer. The OCC backup is provided at other levels by redundant hardware, standalone preprocessors and voice control.

2. Need for some additional communication capability between the OCC and NDPF. This capability can easily be provided by commercial lines for teletype and DCS data transmission.

Of course, the facilities design provided in this study would require modification as power, air conditioning, sewage and other facility design items have been specified with co-location in mind. Separation with regards to facility design is covered in Section 4.5.5.

4.5.3.3 Study Analyses

4.5.3.3.1 Data Interfaces

The first items to be considered in OCC/NDPF separation are the data interfaces. Inasmuch as the OCC is designed as a spacecraft oriented, 4 shift, 7 day/week operation while the NDPF is designed as a data throughput oriented 1 to 3 shifts, 5 day/week operation, the interfaces were designed to be physical items (such as tapes, paper, etc.) so the facilities could operate independently.

The data interfaces between the OCC and NDPF are the following:

1. OCC to NDPF:

   a. DCS tapes

   b. Video tapes received via NTTF

   c. Spacecraft Performance Data Tapes

   d. Estimated Workload

2. NDPF to OCC:

   a. Coverage Requirements

   b. Sample Products

These type items do not require real-time transmission and, therefore, do not require tight coordination of operating schedules between the OCC and NDPF. That is; the NDPF schedule is not dictated by the ground station contact schedule of the spacecraft. Instead, data is transferred by tape or hard copy and then can easily fit into existing schedules.

4.5.3.3.2 DCS Data Tapes
In the case of DCS data, the NDPF will process the data as soon as possible, but does not have to interrupt or postpone other processes being done at the moment of DCS data receipt. No penalty or backup is required if the NDPF computer cannot receive and process the data at the moment of receipt.

If the NDPF and OCC are separated, some delay would be expected in physical transmission of DCS tapes between the OCC and NDPF which may be undesirable due to data perishability. These could easily be transmitted over commercial data lines between the OCC and NDPF central computers with a small amount of additional equipment.

4.5.3.3.3 Video Data Tapes
Video data received at the NTTF is also transferred on video tape to be entered into the film production queue, the same as remote received video data. To perform the production of final film imagery in near real-time for quick turn-around evaluation, the NDPF schedule will have to be coordinated with that of the OCC to have the equipment in the NDPF waiting, available for use. This can be done, on prior request, in a co-located facility, but not in a separate configuration. Therefore, unless a wideband link were provided or time allowed for physical transfer of the data, quick (one-orbit) response could not be performed by separate facilities.

4.5.3.3.4 Other Data Interface Items
All the other interface data (coverage data, workloads and sample products) can be transmitted by teletype or be physically transferred without causing undue scheduling or throughput delay problems.

A. Functional Interfaces - The second consideration in the OCC/NDPF separation study involves the functional interfaces. These are:

1. OCC computer backup by NDPF central computer

2. Facilities design

3. Staffing

4. Logistics

4.5.3.3.5 OCC Computer Backup

The concept of using the NDPF central computer to backup the OCC computer for commanding and minimal telemetry processing is one of the levels of OCC redundancy and depends on physical closeness to facilitate the required switching of computer interface units and peripherals. Backup could be achieved even with separated facilities with the addition of computer communication links and devices to provide transmission of telemetry data and console display information. This is not considered cost-effective in light of the other OCC backup modes. That is, the co-location of the NDPF and OCC permits the computer backup configuration, and, if separate facilities are used, the backup of the OCC computer by the NDPF central computer is not recommended.

4.5.3.3.6 Facilities Design

The changes in Building 23 facility design are covered in Section 4.5.3 and reflect the fact that almost all modifications necessary to adapt Building 23 to the GDHS are due to the requirements imposed by the NDPF. That is, removal of the OCC from the third floor of Building 23 will not change the necessary modifications while removal of the NDPF from the building will remove almost all requirements for facility modifications. Most likely, similar facility modifications (light-tight areas, sewage, water and venting requirements) would have to be made whereever the NDPF would be located.

4.5.3.3.7 Staffing

Staffing requirements would not change because the NDPF and OCC are independently operated and therefore separately staffed.

4.5.3.3.8 Logistics

Logistic changes are limited to maintenance of separate inventories for some computer-related expandables. That is, a common computer working tape pool could not be used and an inventory of tapes and paper would have to be maintained in two locations. This is not considered to be a significant consideration.

4.5.4 APPLICABLE EQUIPMENT

4.5.4.1 GFE Equipment

The purpose of this section is to present the contractor's understanding of the Government Furnished Equipment (GFE) to be provided for the GDHS. The equipment is as follows:

1. OCC Equipment

    a. 303 MODEM

    b. X144 Data Terminal

    c. NTTF Patch Panel

    d. WBVTR's

e. Video Displays

f. Video Hardcopier

g. Scama Circuits

h. PBX Circuits

i. CCL Circuits

j. GFSC Master Timing Unit

2. NDPF

a. PBX Circuits

b. CCL Circuits

4.5.4.2 MSFN/STADAN Site Equipment

Summary

ERTS unique equipments will be required at all prime stations supporting ERTS. The RBV and MSS downlinks will be new to Corpus, Alaska and the NTTF. Modifications and augmentation of equipment will be required to provide the necessary support. Alaska, though not a USB Site, will be modified to support the ERTS USB downlink. As a rule, assigned STADAN and all MSFN Sites will be capable of tracking, commanding, and telemetry relay. However, recent MSFN hardware implementation plans concerning the ground 576 kHz subcarrier demodulator (SCD) indicate that this demodulator will be installed at the DSIF Sites for the Apollo Lunar Experiment Module (ALEM) support. The implementation of this SCD will be required at all MSFN Sites if they are to support ERTS dumped PCM data on this SCD. Table 4.5-9 lists GE's understanding of the existing and modifications required to support ERTS for the MSFN and STADAN Sites.

4.5.5 FACILITY DESIGN

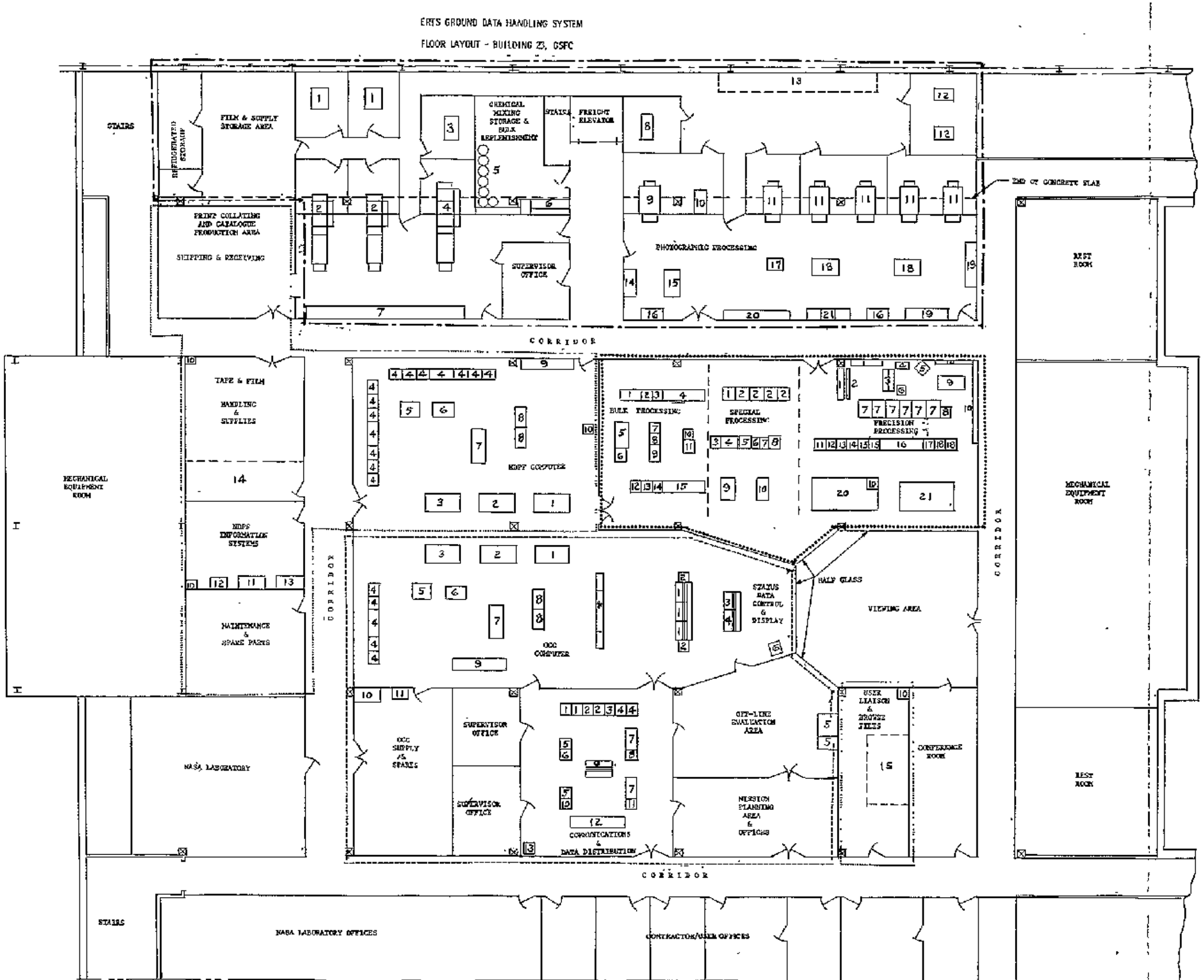
4.5.5.1 Layout

4.5.5.1.1 Analysis

The facility design aspects of the second floor of Building 23 at GSFC were examined for the purpose of arranging the GDHS in the most efficient and economical manner, while providing ready visibility of key operations in order to facilitate orientation of ERTS system users and vistors with minimum disruption of day-to-day operations. Figure 4.5-12 depicts the proposed layout.

Table 4.5-9. Modifications - Prime Sites

	Alaska
System	Equipment/Mods
1. Antenna	Feed Mods
2. Receiver/FM Demod (P/L)	Capable of handling ERTS USB, MSS, RBV Downlinks
3. Recorders	MSS/RBV Compatible
4. Preprocessing Equipment	Unique DCS Proprocessing Equipment
5. Displays	Quick-look Displays for RBV and MSS Status
6. Demodulators/Subcarrier Discriminators	USB (MSFN/Type Demods) (1.024, 1.250 MHz) 576 SCD IRIG - SCD's for Channels 11, 12, 13
	Corpus
System	Equipment/Mods
1. Antenna RF	Feed modifications Waveguide filter Cooled paramp Preselector filter
2. Receiver/demod	Two wideband receivers (20 MHz RF bandwidth; 110 MHz IF C Frequency) Demod/demultiplexer for MSPS data with 28 channel recorder and status monitor
3. Recorders	Back-up 28 channel recorder for MSS data Two rotary head TV recorders for RBV data
4. Displays	Quick-look displays for RBV data (including peripheral equipment)
5. Demod	576 kHz for ERTS dump data
6. Preprocessing Equipment	Unique DCS Preprocessing Equipment
	NTTF
System	Equipment/Mods
1. Antenna	New installation (ship surplus) Feed modifications Waveguide filter Cooled Paramp Preselector Filter
2. Receiver/Demod	Two wideband receivers (20 MHz RF bandwidth; 110 MHz IF frequency)
3. Recorders	Backup 28 channel recorder for MSS data Two rotary head TV recorders to RBV data
4. Demod's	576 kHz for ERTS Dump Data
5. Preprocessing Equipment	Unique DCS Preprocessing Equipment



NASA DATA PROCESSING FACILITY

IMAGE PROCESSING SUBSYSTEM

BULK IMAGE PROCESSING ELEMENT

1. RBV VIDEO TAPE RECORDER
2. RBV VTR CONTROL
3. HRFR CONTROL/EBR IMAGE CORRECTOR
4. HIGH RESOLUTION FILM RECORDER
5. COMPUTER TAPE UNITS (HIGH PERFORMANCE)
6. MAGNETIC TAPE UNIT CONTROL
7. BULK PROCESSING CONTROL COMPUTER
8. CONTROL COMPUTER INTERFACE
9. TELETYPE KEYBOARD PRINTER
10. HIGH DENSITY DIGITAL TAPE RECORDER
11. HDDTR CONTROL & ANNOTATION GENERATOR
12. MSS VIDEO TAPE RECORDER
13. MSS VTR CONTROL
14. HRFR CONTROL/EBR IMAGE CORRECTOR (OPTION)
15. HIGH RESOLUTION FILM RECORDER (OPTION)

SPECIAL IMAGE PROCESSING ELEMENT

1. MAGNETIC TAPE UNIT/TAPE CONTROL
2. HIGH PERFORMANCE MAGNETIC TAPE UNITS/CONTROLLER
3. SPECIAL PROCESSING CONTROL COMPUTER
4. KEYBOARD PRINTER WITH PAPER TAPE I/O
5. HDDTR CONTROL
6. HIGH DENSITY DIGITAL TAPE RECORDER
7. HIGH DENSITY DIGITAL TAPE RECORDER (OPTION)
8. HDDTR CONTROL (OPTION)
9. CRT DISPLAY, INTERFACE & CONTROL CONSOLES (OPTION)
10. THEMATIC PROCESSOR (OPTION)

PRECISION IMAGE PROCESSING ELEMENT

1. FILM FILES
2. PROJECTOR SCREEN
3. LIGHT TABLE AND OVERHEAD PROJECTOR
4. TELEPRINTER AND PAPER TAPE I/O
5. X-Y DIGITIZER
6. GRIP PLATE STATUS CHART TABLE
7. MAP FILES
8. GRIP PLATE FILE
9. WORK TABLE
10. STATUS MAP DISPLAY BOARD
11. MAGNETIC TAPE READER
12. MAGNETIC TAPE RECORDER
13. COMPUTER STANDARD PERIPHERAL INTERFACE
14. BULK STORAGE
15. PRECISION PROCESSING CONTROL COMPUTER
16. SYSTEM CONTROL & INTERFACE CONSOLE
17. VIDEO DIGITIZER HIGH SPEED RECORDER
18. VIDEO DIGITIZER CONVERTER/BUFFERS
19. TELEPRINTER WITH PAPER TAPE OUTPUT
20. VIEWER-SCANNER ASSEMBLY
21. VIDEO PRINTER ASSEMBLY

PHOTOGRAPHIC PROCESSING SUBSYSTEM

1. BLACK & WHITE CONTACT PRINTER
2. BLACK & WHITE PRINT PROCESSOR/DRYER
3. COLOR CONTACT PRINTER
4. COLOR PAPER PRINT PROCESSOR/DRYER
5. CHEMICAL MIXING AND STORAGE
6. SINK
7. WORK BENCHES & PAPER CUTTERS
8. PHOTOGRAPHIC ENLARGER
9. COLOR FILM PROCESSOR
10. COLOR COMPOSITE PRINTER
11. BLACK & WHITE FILM PROCESSOR
12. BLACK & WHITE CONTINUOUS STRIP PRINTER
13. UTILITY DARKROOM EQUIPMENT
14. PLOTTING TABLE
15. WORK TABLE
16. FILM INSPECTION EQUIPMENT
17. HOLE PUNCH
18. LIGHT TABLE
19. WORK BENCHES
20. TAPE, FILM & CARD BULK STORAGE
21. MICROFILM PROCESSING & REPRODUCTION (OPTION)
    COLOR CONTACT PRINTER (OPTION - NOT SHOWN)
    COLOR FILM PROCESSOR-AUTOMATIC (OPTION - NOT SHOWN)

NDPF COMPUTATION & SUPPORT SERVICES SUBSYSTEM

1. CENTRAL PROCESSING UNIT
2. CORE MEMORY
3. I/O CONTROL
4. TAPE DRIVE UNIT & CONTROLLERS
5. COMPUTER CONSOLE
6. CARD READER
7. PRINTER
8. DISK MEMORY/ELECTRONICS
9. TAPE STORAGE RACK
10. TELETYPE TERMINALS
11. CARD PUNCH
12. KEY PUNCH VERIFIER
13. KEYPUNCH
14. MICROFILM PROCESSING & REPRODUCTION (OPTION)
15. BROWSE FILE EQUIPMENT (OPTION)

OPERATIONS CONTROL CENTER

COMPUTING SERVICES SUBSYSTEM

1. CENTRAL PROCESSING UNIT
2. CORE MEMORY
3. I/O CONTROL
4. TAPE DRIVE UNITS & CONTROLLERS
5. COMPUTER CONSOLE
6. CARD READER
7. PRINTER
8. DISK MEMORY
9. COMMUNICATION PROCESSOR
10. CARD PUNCH
11. KEY PUNCH VERIFIER

COMMUNICATIONS & DATA DISTRIBUTION
IMAGE DATA PROCESSING & DISPLAY SUBSYSTEMS

1. MAGNETIC TAPE RECORDERS
2. SIGNAL CONDITIONING & OCC/NDPF COMPUTER SWITCHING
3. PCM SIMULATOR/FORMATTER/TRANSLATOR
4. STRIP CHART ANALOG/EVENT RECORDERS
5. MSS VIDEO TAPE RECORDER
6. MSS PROCESSOR/DISPLAY
7. RBV VIDEO RECORDERS
8. RBV PROCESSOR/DISPLAY
9. MAINTENANCE & OPERATIONS CONSOLE
10. INPUT/OUTPUT PATCH & SWITCH
11. DCS CONVOLUTION DECODER
12. MODEMS & INCOMING DISTRIBUTION
13. TELETYPE TERMINALS

STATUS DATA CONTROL & DISPLAY

1. SPACECRAFT EVALUATION CONSOLES
2. PORTABLE STRIP CHART RECORDERS
3. COMMAND CONSOLE
4. OPERATIONS SUPERVISOR CONSOLE
5. TELETYPE TERMINAL
6. PLOTTER
   *STATUS SUMMARY DISPLAY (TBD)

Figure 4.5-12. Proposed ERTS Ground Data Handling System Layout

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

A. Photographic Processing - Of particular concern was the color and black and white photoprocesses which use corrosive liquids and generate toxic fumes, both of which require positive isolation from the electronic equipment.

The concrete floor area was chosen for this photo processing to prevent leakage into the air plenum beneath the false floor. Another factor in the selection of the area is the ease with which it can be sealed off and converted to dark room operations without seriously affecting the existing air conditioning system. Of the two concrete floor areas, the east side was selected because of its proximity to the existing water and drain lines and the location of the freight elevator. The latter will be used primarily for transporting the incoming photo processing chemicals, film, printing paper and the outgoing prints. Film, paper and chemical storage areas are located conveniently close the the elevator, thereby eliminating this traffic flow from the operating areas. The chemicals are stored on the concrete floor area to prevent contamination of the air plenum under the false floor should spillage occur.

Other features of the photo processing layout include a lineup of processors such that the stainless steel discharge lines forming a manifold immediately drop down below the false floor to provide gradient for the drain lines until they reach the existing facility down-comer.

The color processors are located close to the color image generation area for efficiency in transferring the exposed images.

B. Office - The concrete floor area on the west side now being used for offices will remain as offices and would be used for NASA/GSFC ERTS program management personnel, and contractor management personnel. Conference rooms are also available in this area. This effects a separation of management and equipment operations, while maintaining the required proximity to those areas of concern.

C. Computer Complex - The computer complex will be located on the available false floor in the central area. Other allied functions such as operation control and digital image processing, using dry equipment will share the raised floor. These are naturally grouped around a glassed-in central viewing room which is convenient to the passenger elevator and rest rooms.

D. OCC - Directly ahead of the viewing room is the Operations Status and Control Room (OS&CR) with its control consoles and display panels. On the left is the OCC Mission Planning and the off-line evaluation areas, which are adjacent to the OS&CR. On the right is the Image Processing area with the precision processing viewer-scanner and the special processing display and control console easily visible from the viewing room.

E. NDPF - Behind and around the OCC (Operations Control Center) is the NDPF ADP equipment, closely linked electrically, but separated physically from the OCC ADP equipment. Tape handling and maintenance areas are across the corridor from these equipments and convenient both ot offices and the data processing equipment.

This mutually adjacent location of the OCC and NDPF main computer offers a logical grouping of similar functions and also facilitates the use of the NDPF computer to back-up the OCC computer. A similar approach is being considered for the process control computers in the Image Processing area. This decision depends on the final outcome of the ADPE feasibility study. Assuming compatibility of the Bulk, Special and Photogrammetric process control computers such a central location would facilitate switchover for back-up purposes. This will be determined in Phase D. It will not impact the overall area equipments or location for the Image Processing function.

4.5.5.1.2 Growth Potential
Space is available in both the OCC and NDPF for additional equipment. Increased data flow, or increased user requirements should not have a serious impact on those areas.

The photo processing area, however, is affected by either increased data flow or increased user requirements. It is technically feasible to double the number of equipments in the space available. Enlarged facility water supply and drain lines would be required for this growth; and although tight, sufficient storage space remains for tapes, paper, film and chemicals.

4.5.5.2 Facility Modification

4.5.5.2.1 Electrical
There are two existing power panels which are connected to the "technical" main. The available capacity is sufficient for the OCC and NDPF areas which house the computing and image processing areas. Circuit breaker boxes would be located at several columns convenient to the equipment to be connected. The available capacity on the existing "utility" power panel is not believed to be sufficient to handle the photo processing equipment. Therefore, it is proposed that a feeder line be run from the utility main power frame in the basement to a new utility power panel to be located in the southeastern part of the second floor. Two 200 ampere circuits will feed the film processors and one 200 ampere circuit will feed the print processors. An additional 100 ampere circuit will handle paper cutters and other equipment in the print collating area. The individual equipment power requirements are contained in Tables 4.5-10 through 4.5-16.

Other proposed modifications include the relocation of light fixtures and switches, the addition of duplex outlets in all rooms, and the addition of light dimmers at the consoles in the OCC Control Room and NDPF Image Processing Area.

4.5.5.2.2 Mechanical
The existing 1/2-inch cold water lines which are capped off in the floor will not handle the 70 gpm estimated flow rate required by the photoprocessors. A water supply riser to the second floor with a horizontal run of 2-inch diameter pipe and 1/2-inch tees for each machine are proposed. The capacity of the existing hot water line is estimated to be sufficient to feed the photo processing units, but needs to be extended to those units. Because of the high water use, the possibility of reprocessing was investigated. The most likely candidate, a reverse osmosis unit, cannot remove the dissolved chemicals to the degree necessary. In addition, the units are large and expensive.

Because the corrosiveness of the liquids from the photo processors and a need for a 4-inch diameter drain, it is proposed that the existing 3-inch diameter iron drain pipe not be used. To be conservative, it is proposed that a 4-inch diameter type 316 stainless steel be installed to make a horizontal run of approximately 60 feet from the photo processors to an existing facility down-comer. Heliarc welded joints would preclude leakage; but polyvinyl chloride (pvc) piping may be considered as an acceptable alternative. In Section 4.5.5.2.6, the results of a study on drainage line deterioration due to photographic chemicals discuss this subject in more detail. Compressed air capacity is believed to be sufficient; the pipe needs to be extended to the printer platens in the photo processing area.

The conservatively estimated heat load is equivalent to 75 tons of air conditioning. The additional loads from lighting and the operating personnel should not exceed half the estimated installed capacity. However, the return air ducting must be removed, relocated, and some sections rebuilt. The personnel air conditioning duct must be extended. The individual equipment heat dissipation requirements are contained in Tables 4.5-10 through 4.5-16.

Each photo processing machine must be vented by means of a polyvinyl chloride (pvc) hood equipped with a blower to exhaust toxic fumes. It is proposed that a 2-inch pvc pipe from each machine be manifolded into a 4-inch pvc pipe which would be vented through the ceiling to the atmosphere.

4.5.5.2.3 Architectural

The existing vinyl asbestos tiles on the concrete floor of the photo processing and chemical storage and mixing areas should be replaced with a chemically resistant material such as fiberglass, sealed to prevent leaks, and extending up the walls in the chemical mixing area. Other floor areas do not need special treatment.

The northeast corridor would be moved away from the outside wall to accommodate the photo production requirements. The corridor will terminate at the north end in front of the telephone closet. The corridor will continue to the stairs. It will also branch off to the freight elevator. This completes a network of corridors and exits which ensure rapid, safe emergency egress from the facility. The existing storage area behind the freight elevator would be converted to an aisle for a controlled light access between the photo processing areas.

Existing partitions on the second floor would be relocated and reused. The existing linear feet (1,800 feet) is greater than that required by the facility layout (1,300 feet). Only glass for the viewing room needs to be purchased. Walls in the photo processing area must be sealed off to prevent light leakage. Existing doors would also be relocated where possible.

Some repainting probably would be desirable, particularly in the dark room side of the photo processing area.

4.5.5.2.4 Structural

The NASA/GSFC Structural Dynamics Branch conducted a Building 23 vibration survey dated February 3, 1970 which was very helpful to the designers of the image processing equipment. The results indicate that building vibration does not pose a problem; and the vibration frequency and amplitude measurements provide a basis for the design of the iso-mode vibration isolation pads.

There is, however, a potential structural problem due to the weight of the Viewer Scanner and the Video Printer assemblies. The estimated total installed weight of the former is 11,800 pounds and the latter is 7,480 pounds. The former sits astride a 16 WF50 beam while the latter is astride a 14 WF30 beam. Each unit is supported from the floor by four air bags covering about 6 square feet of surface area. Considering the concrete slap reinforcement and its tie-in to the beams, the floor loading may be marginal. If it turns out to be a problem it may be overcome in several ways. From a building modification standpoint, the simplest is probably to weld cap strips to the beams. From the equipment standpoint, the area of the feet may be increased. It may also be feasible to reduce the weight by decreasing the thickness of the slabs used for the optical benches.

4.5.5.2.5 Facility Modification Cost
An estimate of the cost to modify the second floor of Building 23 at NASA/GSFC to accommodate the GDHS has been made and is summarized in the table below:

Area	Labor	Materials	Total
OCC	$ 13,794	$ 2,998	$ 16,792
NDPF	68,665	27,875	96,540
Totals	$ 82,459	$ 30,873	$ 113,332

Labor rates published by the Department of Labor for the Greenbelt area and dated April 1969 were used in the above cost estimate.

4.5.5.2.6 Study of Drainage Line Deterioration Due to Photographic Chemical Instruction
The possibility of drain line deterioration due to the introduction of photographic chemicals into the ERTS/DSL Goddard Drain System does not appear to be of sufficient impact to warrant the additional expense which would be required for the construction of a drainage holding tank or device.

All drain systems constructed in ERTS/Photo Processing facility will be of stainless steel or polyvinyl chloride composition. Both materials are chemically inert, and therefore, will not react to chemical agents introduced into drain lines.

Drain lines will be functional in only two possible operational cycles, as follows:

1. Process Cycle. In this cycle, the processing units will be operating under normal drainage conditions. In this mode, 98 percent of all liquids entering system will be water. The additional 2 percent will be chemical residue which will be more than sufficiently diluted so as to present no line deterioration or residue formation problems.

2. Dumping or Purging of Processors. This action will be undertaken on a controlled or scheduled basis only. At no time will a series of processors be purged simultaneously.

   Subsequent to purging of processors there is to be a follow-up flushing action with fresh water to be introduced into system. This action will ensure the removal of all chemical residue from drain lines.

There is always a distinct possibility of drainage damage over an extended period of time but in consideration of the weighed factors of probability, cost, and inherent problems with solution holding, the exclusion of a holding tank or device is recommended at this time.

4.5.5.2.7 Study of Silver Recovery in CDHS Photographic Element
Due to the expected high throughput of silver content photographic materials in the GDHS function there appears to be sufficient reason to justify the installation of silver reclamation devices on all pertinent film and paper processor units.

By installing well-designed reclaiming units on processors approximately 80 percent of all inherent emulsion silver may be salvaged. This act could result in an effective material cost savings for the project.

An example of reclamation/return is given as follows for a single bulk process item which is required by project specifications.

1. Item: Black and white film transparencies (9 x 9)

2. Weekly production: 92,120 units

3. Recoverable silver content: 193 Troy ounces (approximate)

4. Savings/return: $ 257.05 at $ 1.85 per Troy ounce

In view of this possible savings on a single production item, a fairly accurate estimate of total photo facility savings return would appear to be in excess of $ 500.00 per week.

For the past several years Goddard Space Flight Center has utilized a regional General Services Administration Contractor for the installation and servicing of silver reclaiming devices. This has been a satisfactory arrangement in the case of the National Space Science Data Center, with no operational interference on production down time attributable to the GSA Reclamation Contractor.

In conclusion, it should be noted that all of the film and paper processor units recommended for Photographic Processing use may be easily interfaced with reclamation devices. The manufacturers of the recommended processor units have designed such reclamation devices for interface with their machines.

Table 4.5-10. OCC Computer Equipment Utility Requirements*

Item	No. of Units	Power Requirements	Heat Load Watts Dissipated
CPU	1	120/208, 3 phase 13 amps	2200
Core Memory	1	120/208, 3 phase 18 amps	3600
Input - Output	1	120/208, 3 phase 18 amps	3600
Console	1	120/208, 3 phase 3 amps	500
Printer	1	120/208, 3 phase 26 amps	3200
Card Reader	1	120/208, 3 phase 20 amps	3500
Card Punch	1	120/208, 3 phase 10 amps	1300
Magnetic Tape Units	6	120/208, 3 phase 80 amps	4500
Tape Controller	1	120/208, 3 phase 10 amps	1700
Card Interpreter	1	120/208, 3 phase 10 amps	1300
Disc Storage Units	1	120/208, 3 phase 29 amps	1200
Disc Storage Electronics	1	120/208, 3 phase 3 amps	500
Data Net	1	120/208, 3 phase 44 amps	1000
Key Punch	1	120/208, 3 phase 10 amps	1000

*Estimated pending ADP vendor selection

Table 4.5-11. NDPF Computer Equipment Utility Requirements*

Item	No. of Units	Power Requirements	Heat Load Watts Dissipated
CPU	1	120/208, 3 phase 13 amps	2200
Core Memory	1	120/208, 3 phase 18 amps	3600
Input - Output	1	120/208, 3 phase 18 amps	3600
Console	1	120/208, 3 phase 3 amps	500
Printer	1	120/208, 3 phase 26 amps	3200
Card Reader	1	120/208, 3 phase 20 amps	3500
Card Punch	1	120/208, 3 phase 10 amps	1300
Magnetic Tape Units	14	120/208, 3 phase 80 amps	4500
Tape Controller	1	120/208, 3 phase 10 amps	1700
Card Interpreter	1	120/208, 3 phase 10 amps	1300
Disc Storage Units	1	120/208, 3 phase 29 amps	1200
Disc Storage Electronics	1	120/208, 3 phase 3 amps	500
Data Net	1	120/208, 3 phase 44 amps	1000

*Estimated pending ADP vendor selection

Table 4.5-12. OCC Equipment Utility Requirements

Item	Quantity	Power	Heat Load Watts Dissipated
Stripchart and Decoder	2	120v - 9 amps 120v - 11.3 amps	2200
Signal and Switching Unit	1	120v - 9.1 amps 120v - 5.75 amps	1640
Timing Unit	1	120v - 5.5 amps	700
Magnetic Tape Recorder	2	120v - 33.3 amps	4000
Operations Supervisor Console	1	120v - 15 amps	1805
Command Operators Console	1	120v - 15 amps	1805
M&O Supervisor Console		120v - 10.8 amps	1295
S/C Evaluator Consoles	3	120v - 15 amps 120v - 15 amps 120v - 15 amps	5335
Portable Strip Chart Recorder	2	120v - 5.3 amps 120v - 5.3 amps	1500
Status and Display	1	120v - 20 amps	2400
Plotter/Console	1	120v - 15 amps 230v - 8 amps	3595

Table 4.5-13. Photographic Processing Equipment Utility Requirements

Item	No of Units	Power Requirements	Heat Load		Water Supply Requirements	Drains	Venting - Filtering	Comments
			Watts	Btu/hr				
Logetronics Mark II R5A Black and White Contact Printer	2	117 vac 50-60 Hz Regulation req'd 105/130 vac	4000		None	None	Dust	
Logetronics Mark III Color Contact Printer	1	117 vac, 50-60 Hz Regulation req'd 105/130 vac	2000		None	None	Dust	
Logetronics SP 10/70C Continuous Strip Printer	2	105/130 vac 60 cps - 8 amps Regulation req'd	1600		None	None	Dust	
Pakorol-G Film Processor Model 24-1 5	5	120/240 v, 60 Hz 1 Phase, 3 wire 49 2 amps No regulation	46590		Chilled req'd filtered Tap required, filtered 4 gpm Hot required Hot required, filtered	PVC drain lines req'd	Drain lines must be tapped and vented to meet GSFC specs	Equipment leveling required if floor 1/2 in out of level
Pakopak, B&W Paper Processor Model 2	2	115 vac, 60 cycle 5 amps	20900		Tap, filtered, 4 gpm	PVC drains required	Drain lines must be tapped and vented	Floor tie down recommended
Pakopak Dryer for B&W Model 2	2	115 vac 60 cycle 5 amps 3-600 watts/230 volts 10 1 kilowatts			None	None	N/A	
Pakopak Color Paper Processor Model 4	1	115 vac 60 cycle 5 amps, 350 watts	9650		Tap filtered 14 gpm	PVC drain lines req'd	Drain lines must be tapped and vented	Alignment with dryer and floor tie down required
Pakopak Dryer for Color Paper Processor	1	115 vac 60 cycle 5 amps 230 v, 3 phase, 4 wire 25 amps, 9300 watts			None	None	N/A	
Color Film Processor	1	208/220 vac 60 Hz 3 phase, 4 wire 25 amps	9300		8 gpm	PVC drain lines req'd	Drain lines must be tapped and vented	
Color Composite Printer and Alignment Jig	1	115 vac 1 phase 60 Hz, 10 amps	1200	4100				Compressed air 30 psi/min 10 cfm vacuum
Alignment Hole Punch	1	115 vac 1 phase	350	1000				
Photo Enlarger Copier	1	115 vac 1 phase 15 amps	1800	5200				
Pako Paper Cutter Auto 2 12	2	115 vac No regulation req'd			None	None	N/A	
Contact Printer - Utility	1	115 vac No regulation req'd			None	None	N/A	
4 x 5 Utility Enlarger	1	115 vac No regulation req'd			None	None	N/A	
10 x 10 Utility Enlarger	1	115 vac Regulation req'd			None	None	N/A	
Sink Processing Utility	1	115 vac outlets in area			Not - tap - chilled filtered with mixing valve 2 gpm	Required	N/A	
Color Print Processor Utility	1	115 vac No regulation req'd			Hot - tap chilled filtered with mixing valve 2 gpm	Required	N/A	
Print Dryer Pako 26W Utility	1	115 vac, 60 cycle 5 amps, 230 v. 3 phase, 23 2 amps			None	None	N/A	
McBeth Reflection Densitometer Model RD-400	2	120 vac Internal regulation req'd			None	None		
McBeth Transmission Densitometer Model TD-402	3	120 vac Voltage regluation req'd	1200		None	None		
McBeth Color Transmission Densitometer Model TD-403	1	120 vac Voltage regulation req'd			None	None		
EG&G Sensitometer Mark VII	1	115 vac, 60 cycle Internal regulation			None	None		
Microfilm Processor	1	110-120 vac 60 cycles single phase 18 amps			Standard hot and cold with mixing valve	Required		
Microfilm Optical Printer	1	220 v, single phase 110 v 50 or 60 cycle ac			None	None		
Microfilm Roll Contact Printer	1	118 v, 60 Hz 10 amps			None	None		
Chemical Mixers Mixing and Storage-Utility	5	115 vac			Hot filtered Tap filtered			Drop hose to drain
Light Tables Rewinders	5	115 vac	4800		None	None	N/A	
Copy Camera - Utility	1	115 vac			None	None	N/A	

Table 4.5-14. Image Processing Equipment Utility Requirements

Item	No. of Units	Power Requirements	Heat Load	
			Watts Diss.	Btu/hr
MSS Video Tape Recorder	1	120 vac, 1 phase	2000	6830
RBV Video Tape Recorder	1	120 vac, 1 phase	2000	6830
MSS Video Tape Recorder Interface	1	120 vac, 1 phase	500	1707
MSS High Resolution Film Recorder Interface	1	120 vac, 1 phase		
RBV Video Tape Recorder Interface	1	120 vac, 1 phase		
RBV High Resolution Tape Recorder Interface	1	120 vac, 1 phase		
MSS High Resolution Film Recorder	1	120 vac, 1 phase 208 vac, 3 phase	4000	13660
RBV High Resolution Film Recorder	1	120 vac, 1 phase 208 vac, 3 phase	4000	13660
Control Computer Interface	1	115 vac, 1 phase	350	1200
High Density Digital Tape Interface	1	120 vac, 1 phase	250	855
High Density Digital Tape Recorder	1	120 vac, 1 phase 600 v-a (with 1600 v-a surge)		2050
Annotation Generator	1	115 vac ± 10%, 1 phase	100	340
Annotation Magnetic Tape Reader	1	115/230 vac, 1 phase 60 Hz, 3 wire + grnd 2050 v-a forward 3350 v-a rewind		7200
Software Magnetic Tape Reader	1	115/230 vac, 1 phase 60 Hz, 3 wire + grnd 2050 v-a forward 3350 v-a rewind		7200
Control Computer	1	115 vac, 1 phase 230 vac	1600	5460
Keyboard Printer	1	115 vac, 1 phase 60 Hz	350	1200
Tape Controller	1	115 vac	1600	5460

Table 4.5-15. Special Processing Equipment Utility Requirements

Item	No. of Units	Power Requirements	Heat Load Watts Diss.	Heat Load Btu/hr
High Density Digital Tape Recorder	1	120 vac, 1 phase 60 Hz	2000	6830
High Density Digital Tape Interface	1	120 vac, 1 phase 60 Hz	500	1707
CRT Display, Interface and Control	1	120 vac, 1 phase 60 Hz	2500	8550
Thematic Processor	1	120 vac, 1 phase 60 v	3000	10200
Annotation Tape Reader	1	115/230 vac, 1 phase 60 Hz, 3 wire + grnd 2050 v-a forward 3350 v-a rewind		7200
Annotation Tape Controller	1	115 vac	1600	5460
System Disc Memory	1	115/230 vac, 1 phase 3 wire + grnd 1560 v-a		7900
Disc Memory Interface	1	115 vac, 1 phase 60 Hz	1600	5460
Control Computer	1	115 vac, 1 phase 60 Hz	3200	10920
Keyboard Printer	1	115 vac, 1 phase 60 Hz	350	1200
Output Tape Controller	1	115 vac, 1 phase 60 Hz	6400	21840
Tape Drives	4	115 vac, 1 phase + ground 8200 v-a forward 9500 v-a, 3 F/1 R 13400 v-a, 4 rewind		27300

Table 4.5-16. Precision Processing Equipment Utility Requirements

Item	No. of Units	Power Requirements	Heat Load Watts	Heat Load Btu/hr	Comments
System Control and Interface Console	1	110 v, 1 phase 220 v, 3 phase 1% reg, 18 kva	18000	61000	75°F ± 5°F A/C 40% - 60% RH
Control Computer Assembly	1	110 v, 220 v, 60 Hz, 1% reg 7 kva	7000	24000	75°F ± 10°F A/C 40% - 60% RH
Viewer/Scanner Assembly	1	Included in system control and interface console	Included in systems control and interface console		± 2°F A/C from calibration temp. Floor load ≈ 1500 lb/ft²
Video Printer Assembly	1	Included in system control and interface console	Included in system control and interface console		1500 lb/ft² floor load, ± 5°F from cal. temp.
Video Digitizer Assembly	1	Included in system control and interface console	Included in system control and interface console		75°F ± 10°F A/C 40% to 60% RH
Control Point Station Console	1	110 v, 10 a, 60 cps	1 kw max		75°F ± 5°F 40% to 60% RH

4.5.6 ACTIVATION

In developing this activation plan and schedule, particular consideration has been given to the potential NASA addition of a new top-floor to building 23. The information presently available indicates that this activity will be completely finished by January 1972, with the major construction work being completed by about July 1971. This overlaps three months of the GDHS installation, integration and test activities, which begins in April. Further, the finishing process of the new addition continues up to the end of the GDHS integration and test period.

It is felt that with thorough advance planning and clearly established procedures for resolving potential conflicts, these two major facility tasks can proceed successfully in parallel. The need for close coordination from the start of Phase D, however, is critical. To facilitate achieving this coordination, the contractor proposed GDHS activation organization and procedures are defined in detail below.

4.5.6.1 <u>Installation and Checkout Organization</u>

The organization structure which is arranged to perform the activation functions is as follows:

1. Project Control
2. Property Control
3. Work Control
4. Installation and Integration Engineer
5. Quality Control Engineer and Specialist
6. Financial Advisor
7. Contract Administrator

The organization structure to implement these functions is outlined in Figure 4.5-13.

4.5.6.1.1 Project Control

Project Control schedules the project activities in both the OCC and NDPF in Mark III format; displays the program schedules; monitors and maintains daily status of all program, contractor, and field activities. It forecasts problems and trends; resolves problem areas with recommended workarounds; coordinates with the customer on all program interfaces; participates in customer briefings; prepares and maintains "War Room" wall charts in installation, integration and test scheduling displays, discrepancy cleanup schedules, training schedules and program and contract schedules. It monitors and maintains daily status of procurement installation, checkout and subcontractor field activities; participates in subcontractor status briefings and Red Flag installation and checkout problems; maintains and displays manhours expended and actual cost versus planned cost of subcontractor installation activities.

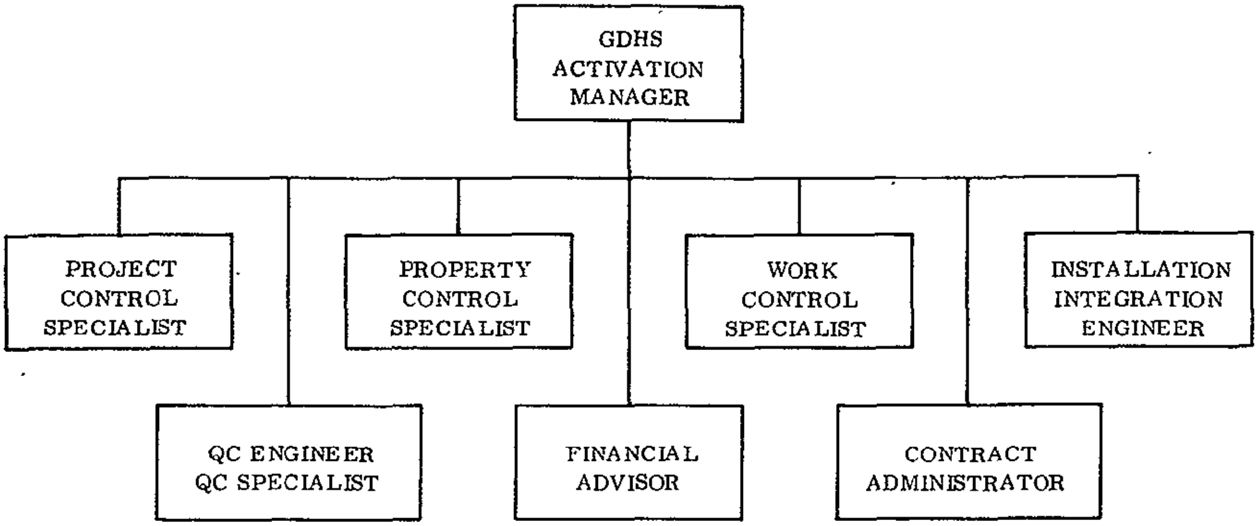


Figure 4.5-13. Installation and Checkout Organization

4.5.6.1.2 Work Control

Work Control is primarily responsible for the successful turnover of both OCC and NDPF installed technical systems to the customer. To successfully accomplish this mission, continuous monitoring and control of the field activities is performed in the following areas:

1. JOD Requests. Log, review, obtain General Electric signatures and forward to NASA.

2. Installation Task Packages. Log, obtain Mark III Control Numbers, obtain General Electric signatures, issue packages, revise packages, arrange for required access, conduct task package closing reviews, accumulate all documentation pertaining to package, identify all discrepancies, start discrepancy cleanup action, close task package.

3. Change Control. Log and obtain customer approval of ECR's and log FAN's and drawing revisions caused by ECR's and FAN's. Modifications not peculiar to the installation drawings will be documented by an ECR and require customer technical concurrence prior to implementation.

4. Test. Log Intent to Test form and distribute; generate Test Orders; arrange for support personnel and activities; arrange access and accumulate documentation.

5. Turnover. Accumulate documentation required for turnover; prepare turnover package; prepare DD250; accumulate warranty information; accumulate and/or identify vendor data information; and coordinate with customer.

6. Operating Procedures. Identify and generate procedures required for overall program needs, activation, turnover, logistics, modifications, and preparation of reports.

7. Central Files. Maintain a central file for GDHS; reproduce and distribute documentation and drawings; establish and maintain a microfilm file; issue and distribute computer tab runs.

8. Test Planning. Responsible for the scheduling of testing activities of the GDHS Technical Systems, and identifying the prerequisites necessary to conduct those tests. These prerequisites include the identification of Task Packages used in installing a system to be tested.

4.5.6.1.3 Property Control

Property Control is responsible for the accountability and flow of material. To fulfill its objectives, in both the OCC and NDPF, it is responsible for: receiving of material; staging of the material in accordance with material requests generated in response to Task Packages; control of material, material inventories and arranging for the loading of materials for shipment to the site. It is also responsible for control of GFE and CFE property, subcontractor surplus disposal, salvage, identification and generation of procedures for material flow, property management, material disposition, accountability transfer, and plant closing.

4.5.6.1.4 Installation and Integration

Installation and Integration is primarily responsible for interfacing with and managing the work of the installation subcontractor. It coordinates its activities with Program Control and Work Control. It directs the installation and checkout of all OCC and NDPF equipment as required. It directs the interconnection of OCC equipment items and sequentially integrates components and subsystems as necessary to verify proper functioning. It directs the acceptance tests of both OCC and NDPF hardware and software in accordance with the GDHS Systems Test Requirements Document. This activity will be performed by six groups:

1. OCC

2. NDPF Computation and Support

3. Bulk Image Processing

4. Precision Image Processing

5. Special Processing

6. Photographic Processing

Each team will be comprised of personnel from:

1. Equipment Supplier (e.g., Wolf, Bendix, General Electric)

2. GDHS Engineering

3. Installation and Integration Engineering

4. Quality Assurance

5. NASA/GSFC

6. Operations

The activities of each team will be supervised by the Installation and Integration Engineer on that team. Some personnel will be common to two or more groups depending on the similarity of equipment and time schedule.

4.5.6.1.5 Staff

These functions report administratively to the Activation Manager for assignment but are responsible to their own organization for the quality of their work.

A. Finance. Finance functions are summarized below:

1. Maintain cumulative contractor and subcontractor project manhours and costs.

2. Maintain up-to-date cumulative installation subcontractor project manhours and cost.

3. Cost the estimated and actual labor and materials charged to each Task Package.

4. Provide weekly and monthly status reports of manpower and material costs.

B. Contracts. Contracts personnel represent the contractor and are authorized to commit the contractor contractually with NASA and with vendors. They provide the following services:

1. Provide interface with the NASA/GSFC contracting officer on contractual matters dealing with installation and checkout.

2. Provide interface with the installation contractor on all contractual matters.

3. Obtain bids and process purchase orders for long lead items or other materials as may be required by the contractor or as directed by NASA.

4. Negotiate and execute contracts on behalf of the contractor with vendors or with NASA.

C. Quality Control. Quality Control functions are summarized below:

1. Inspect all incoming equipment for identification and visual damage at the Goddard receiving point.

2. Inspect all equipment before and after being moved to its new location by the installation subcontractor.

3. Inspect all installation work in progress and make a final inspection and report on completion of each Task Package.

4. Review change notices and their effect on interfacing equipment.

5. Report data relative to the progress of the work.

6. Make a final inspection of assemblies and subsystems prior to the testing phase.

7. Inspect each test setup in accordance with requirements, including calibration of test instrumentation.

8. Participate in each test and inspect results relative to test specifications.

9. Provide documentation and records of inspection such as: In-Process Inspection Record, Reject Tag, Squawk Sheet, Withheld Materials Report, Field Inspection Log, Modification Log, Certificate of Compliance, Tool and Equipment Log and Field Advance Drawing Change Notice.

10. Provide action in the following manner:

    a. Acceptance - When the inspector determines that all characteristics, dimensions, and workmanship have been satisfied, he will so indicate by stamp, date, and initial in the appropriate column of the inspection record.

    b. Rejection - Should a nonconformance exist, the inspector will note the discrepancy on the Squawk Sheet and immediately inform the activation supervisor. He will allow a reasonable period of time for corrective action before reinspecting. If the nature of the rejection requires additional time or disposition by Engineering, a Reject Tag or a Withheld Material Report, whichever is applicable, will be initiated by the inspector. The form will be attached to the rejected item. It will be the inspector's responsibility to follow through until final disposition. The Reject Tag may be removed by the inspector. The Withheld Material Report may be removed by the inspection supervisor. This can be done only when engineering has held a Material Review and proper signatures have been affixed.

    c. Material Review - Unless otherwise directed by NASA, the Material Review will be at the preliminary level, thus allowing expedient processing and disposition of discrepancies.

4.5.6.2 Activation Control

The Activation Control Plan must provide the tools for managing the activation phase of a project so that it can be accomplished in minimum time at minimum cost. It provides visibility and measurement of the progress of the complete project and all its components against the program plan, for contractor and NASA monitor.

4.5.6.2.1 Activation Control Plan Implementation

Accomplishment of the Activation Control Plan requires the following prerequisites:

1. Approved installation drawings and specifications
2. Approved equipment delivery schedule
3. Approved activation schedule
4. Joint Occupancy Date (JOD) or Beneficial Occupancy Date (BOD) established by NASA/GSFC
5. An Activation Team Organization (located at NASA/GSFC - Figure 4.5-13)
6. Office space for the Activation Team and the Activation Control Room
7. A staging area or warehousing space.

4.5.6.2.2 Activation Control Plan Elements

The elements of the Activation Control Plan are described in the following paragraphs.

A. PERT Plan. PERT networks for the installation and checkout phase are generated for each subsystem (NDPF and OCC) as well as fragnets for each of the components of the subsystem. Computer runs can be made if the networks are sufficiently complex; however, this is probably not necessary for the GDHS.

B. PERT Event Count. The PERT event count chart is a management summary which shows the cumulative number of PERT events accomplished versus time, compared to the number of events scheduled to be completed at that time.

C. Cost Control. A series of financial charts give another measure of the progress of the program. These include:

1. Total actual expenditure (labor materials, subcontract, T&L, etc.) versus planned
2. Number of people on the project versus planned
3. Cumulative actual manhours versus planned
4. Installation subcontracts people versus planned
5. Subcontracts cumulative number versus planned.

D. Activation Control Room. All charts of plans and progress are displayed in this office and all meetings are conducted in the room to aid in discussing progress.

E. Activation Meetings - Weekly. The program status is reviewed by the Activation Manager and NASA. Action items are documented and responsibility assigned for resolution. All project leaders attend. The Activation Manager conducts the meeting.

F. Activation Meeting - Daily. At the beginning of each day, the Activation Manager holds a brief planning meeting to discuss the day's schedule and the corrective action required by the problems of the previous day.

G. Facilities Control. All requirements for facilities by the installation contractor are processed through the Activation Team for approval and procurement. This includes space, power, water, access to staging area, telephones, etc.

H. Installation Contractor Plan Approval. The installation contractor submits a plan for approval that describes how he plans to proceed with the work, including his manpower loading plan, material pick-off and work sequence.

I. Task Package Preparation. Each manageable unit of installation work is defined and controlled by the contractor by means of a task package. The technical requirements of the task are prepared by the Activation Team. The work will then be keyed to specific events or groups of events in the detailed PERT network. The task packages are used by the Installation Contractor as a basis for materials pick-off and manhour estimates. An instruction sheet is issued to the Installation Contractor to authorize the task to proceed. All replans, discrepancies in work and buy-offs are to the task package.

J. Daily Installation Contractor Reports to General Electric. The Installation Contractor will report to General Electric at the end of each day on each task in process. This report covers, depending on size of contract:

1. Actual work accomplished per task
2. Number of people working per task
3. Manhours lost and reason
4. Critical problems and action required
5. Tasks completed.

K. Task Scheduling. Each task package is scheduled according to PERT network need dates and is displayed in bar format on Task Schedules. These schedules are directly correlated with the two-week work schedule.

L. Two-Week Work Schedule. The two-week work schedule is issued weekly by the Activation Team. It describes the tasks to be worked this week and the forecasted tasks for next week.

M. Materials Release to Installation Contractor. Materials releases are controlled by task. The Installation Contractor provides his materials requirements for each task as defined and documented by the Activation Team. The Installation Contractor signs the Stores Transfer Form, at time of pick-up as a record of all equipment being transferred.

N. Control of Equipment in Installation Contractor Possession. A Quality Control Inspector is present at all times during equipment installation. He witnesses the installation contractor delivery of equipment to the site, unloading and installation of equipment. If any discrepancy arises an Inspection Report (IR) is prepared. The Activation Team then arranges for corrective action. The Activation Team logs and follows-up all IR's as part of the task package status.

O. Verification of Task Completion. The Installation Contractor notifies the Activation Team when a task is completed. The Activation Team then calls a review (task requirement, I. R. 's modification, drawing changes, material usage) by a review board consisting of the Activation Team, and NASA. If all items are satisfactory, a Certificate of Verification is issued, signifying task completion and an Installation Buy-off tag is affixed to the equipment. A snap-out copy of the tag is filed with the task package by the Activation Team.

4.5.6.3 Installation Plan

The physical installation of the GDHS equipment is covered by the Davis-Bacon Act which requires that this type of work be performed by construction workers. To prepare for this phase of the effort, the following must be accomplished:

1. A complete set of installation drawings and specifications must be prepared.

2. A detailed cost estimate of the installation must be generated.

3. A common delivery point must be designated for all equipment and materials vendors so the installation contractor will be able to estimate his handling cost.

4. The delivery schedule for all equipment and installation materials must be generated.

5. Installation materials that cannot be purchased by the installation contractor in time to meet installation schedule must be purchased in advance. (Electrical cable is probably in this category.)

6. An RFP (described below) must be written for the installation, with engineering supplying the work statement and installation drawings and specifications, while Contracts provides the remainder.

7. NASA must approve the bidder's list.

8. A Bid Evaluation team comprised of Engineering, Facilities, Contracts, Finance, and Program Management personnel must be designated. A bid evaluation form suitable for this particular procurement must be generated for use by the evaluation team.

9. The Bid Evaluation Team must score each competitor according to his analysis of the bid together with the results of an oral presentation (if given).

10. The selected competitor must be recommended to NASA for approval.

11. The estimated time schedule required for the above is shown in Figure 4.5-14.

The RFP for installation requires a detailed listing of requirements so that not only will the best qualified company be evident from the response, but the basis will be established for firm installation management control. The following constitutes an outline of such an RFP:

1. Letter Requesting Proposal
   a. Invitation to submit bid
   b. Type of contract
   c. Services in accordance with terms and conditions of the proposed contract
   d. Reference to installation work statement and specifications
   e. Schedule of work
   f. Response to RFP
   g. Contents of RFP
   h. Contracting officer
   i. Proposal due date
2. Proposal Instruction
   a. General
   b. Technical evaluation criteria
   c. Business management evaluation criteria
   d. Procedure for submittal of proposal
3. Proposal Format
   a. Technical section
   b. Experience of the company
   c. Source of personnel
   d. Resumes
   e. Subcontract
   f. Exceptions
4. Cost
   a. Cost and Fee
   b. Accounting System
   c. Balance Sheet
   d. Certification
   e. Cost Breakdown
   f. Manpower Profile

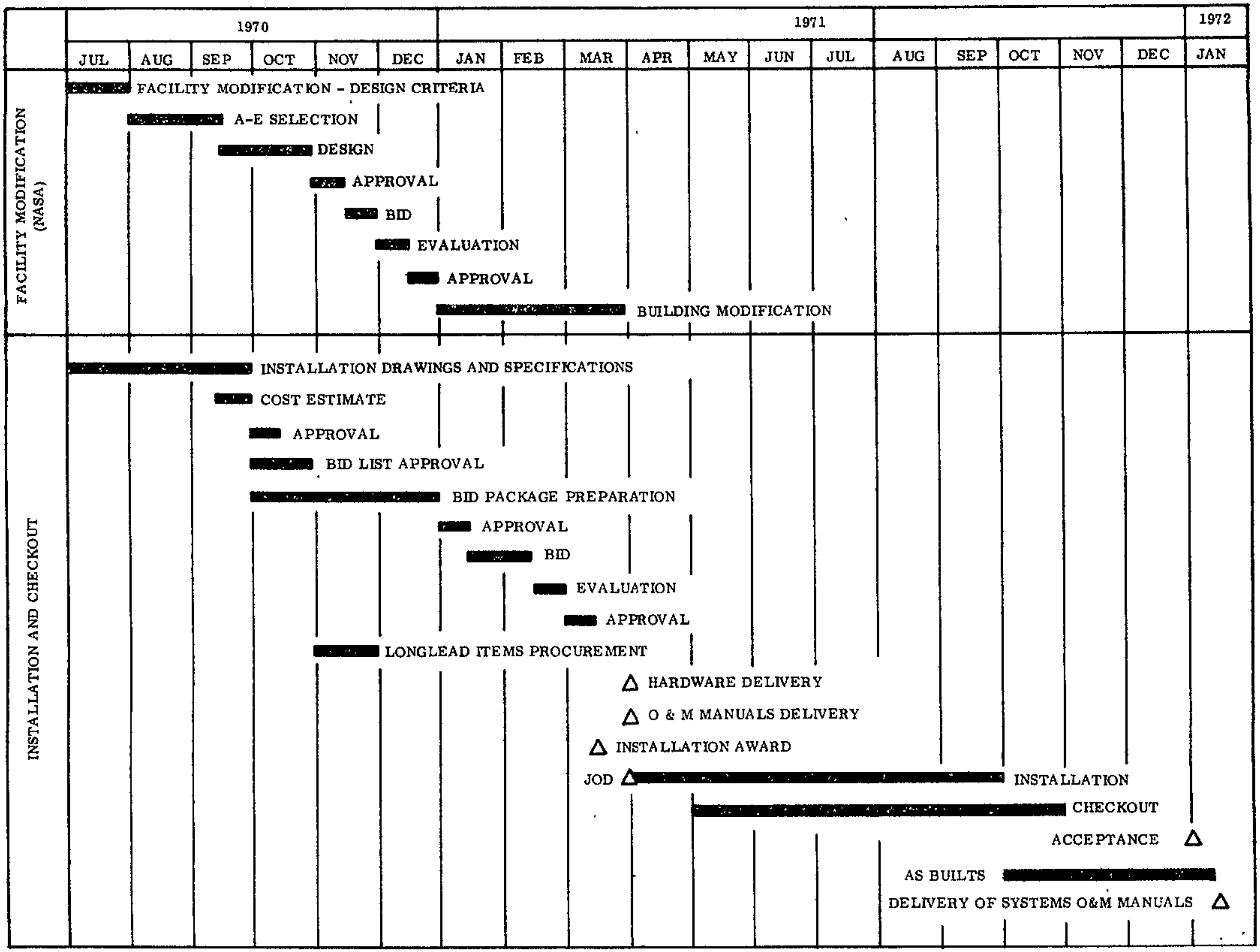


Figure 4.5-14. GDHS Installation and Checkout Schedule

5. Proposed Contract
    a. General Provisions
    b. Special Provisions
6. Statement of Work
    a. Scope
    b. Applicable Documents
    c. Procedures
    d. JOD's and BOD's
    e. Equipment, services, materials required
    f. Reporting
    g. Quality Assurance requirements
    h. Installation contractor responsibility
7. Specifications
    a. General
    b. Technical
        (1) Equipment installation
        (2) Wiring and electrical
        (3) Tubing and piping
        (4) Metal work
        (5) Painting
8. Appendix
    a. Equipment data sheets
    b. Furnished equipment
    c. Installation drawing list
    d. Brick and Mortar drawing list.

4.5.6.4 Turnover Procedures

At the time of successful completion of each subsystem test, the subsystem is ready to be turned over to the customer. The turnover consists not only of the turnover of hardware equipment but also the delivery of documentation that clearly describes the hardware, its installation, and testing. Objective evidence of successful completion of all phases of the activation of a system is given in the form of an Acceptance and Turnover Document.

The Acceptance and Turnover Document consists of the following:

1. Receiving and Shipping Documents
2. Warranty/Guaranty
3. Installation Verification Certificate
4. Modification Historical Records
5. In-Line Equipment Inventory
6. Certification of Calibration
7. Intent to Test
8. Test Order
9. Test Readiness Certificate
10. Test Procedure (as run)
11. Test Data Evaluation Report

12. Exceptions
13. Waivers
14. Certificate of Acceptance for Test
15. DD-250.

4.5.7 GDHS OPERATION AND MAINTENANCE AND LOGISTICS

4.5.7.1 Operation and Maintenance

The operation and maintenance of all components, subsystems, and systems will be described completely in the Operation and Maintenance (O & M) Manuals provided by the equipment manufacturers and the subcontractors. In accordance with the ERTS program, NASA/GSFC will provide operations and maintenance personnel during the testing phase. The O&M Manuals will be the primary source of material to be presented to these personnel in the training sessions. On-the-job training will be conducted concurrently. As the O&M personnel are trained they will be phased into the operation and maintenance activity such that within 90 days after the first launch they will be able to perform all operations under the supervision of NASA/GSFC.

4.5.7.2 Operation and Maintenance Manuals

These manuals describe the equipment, its function and operating characteristics, as well as preventive and unscheduled maintenance procedures.

Two categories of Operations and Maintenance Manuals will be provided, component and subsystem.

Each equipment vendor will submit O&M Manuals covering each model of equipment which will be located in the Ground Data Handling System.

A review of the proposed GDHS equipments indicates that commercial O&M Manuals will be acceptable for off-the-shelf production type equipment; however, they must substantially meet the requirements for Type I Manuals described in NASA/GSFC STD 256-4, Preparation of Operation and Maintenance Manuals, dated July 1966. In all other cases the O&M Manual writers must follow this standard for detailed information on preparing Type I Manuals. Six copies and a reproducible are required.

Delivery of these O&M Manuals will be at time of delivery of the equipment.

The manuals recommended for the GDHS are identified in Section 8.3 for the OCC and Section 13.4 for the NDPF.

4.5.7.3 Maintenance

Two methods of providing maintenance are applicable to the GDHS. Each has been examined primarily from the standpoint of cost.

For off-the-shelf equipment which exists in sufficient quantity in the area, lower cost and better quality service is usually obtained by writing a service contract with the equipment supplier. This minimizes the number of full time maintenance personnel required on the job and also minimizes the on-site spares inventory.

For specialized equipment, it is necessary to have properly trained and skilled O&M personnel available to perform the necessary operations. The conclusions regarding the type of maintenance recommended for the various equipments are contained in Section 8.4 for the OCC and Section 13.5 for the NDPF.

4.5.7.4 Logistics

A list of vendor recommended spare parts, with guaranteed prices, to cover one year of operation is included in Purchase inquiries for each piece of equipment. Experience has shown that the recommended spare parts lists are quite conservative. Therefore, it is planned to examine each purchase request to determine if General Electric has, from usage experience, a failure history which will indicate a more realistic spares requirements. In addition, the Goddard Logistics System will be checked to determine what spare parts are already available for the planned equipment. It is proposed that the vendor recommended spare parts be purchased where there has been little experience with the equipment. General Electric will purchase, with NASA/GSFC approval, spare parts for 90 days of operation and will provide NASA/GSFC with a list of spare parts needed for one year of operation. It is also recommended that the spare parts requirements be reviewed frequently in order to minimize the inventory cost.

Expendable material, such as film, printing paper, chemicals, tapes, and computer paper will be purchased by General Electric only for the checkout and test period. However, the specifications, quantities, and types of expendables for a 90 day period will be provided to NASA/GSFC.

4.5.8 GDHS ADPE

4.5.8.1 Functional Requirements

The GDHS functions relative to the ERTS mission have been translated into a hardware system configuration answering the functional requirements. This GDHS has been subdivided, because of distinct differences in function, into the OCC and NDPF, as indicated in Section 4. The baseline hardware implementation design is shown in Figure 4.5-15. The ADP subsystems are those groups of computer equipments, their I/O devices, peripherals, and displays associated with the OCC and NDPF.

The following subsections contain overviews of the ADPE in these two functional areas. Detailed descriptions are presented in Sections 5 and 10.

4.5.8.1.1 OCC Computer System

The OCC Computer System is designed to satisfy all of the processing and computation requirements that result from the OCC functional design depicted in Figure 4.5-15. The OCC is divided into the following four major areas of functional responsibility:

1. Mission Planning and Operations Scheduling
2. Command Generation
3. Spacecraft Evaluation and Management
4. Operations Control

Mission Planning and Operations Scheduling involves the development of time-sequenced activity plans for sensor, spacecraft, and ground system operations. Command Generation converts these activity plans into spacecraft-recognizable command messages that are compatible with the established command link transmission facilities. Spacecraft Evaluation and Management uses PCM telemetry data as its principal input in performing both on-line and off-line analysis of the spacecraft status, configuration, performance, and health. Operations Control provides overall direction and monitoring of the OCC itself, and of the supporting elements.

The processing and computational requirements of the OCC fall into several categories, many of which can be satisfied by the capabilities of a third-generation, general purpose computer system. Mission planning and operations scheduling are performed by applications software packages operating in a non-real-time batch or time-shared mode. The algorithmic operations to be performed include event prioritization, scheduling, expendables management, and some ephemeris computations.

Command generation requires both an interactive user mode and a semidedicated, real-time operations mode. The interactive mode permits the applications software to operate effectively through the iterative steps required to develop and display the time-sequenced spacecraft command list. These commands will then be processed and formatted for output to the spacecraft in real-time via the NASCOM uplink. This aspect of command generation requires specialized software and hardware interfaces within the OCC in order to utilize the existing NASCOM uplink facilities.

The Spacecraft Evaluation and Management function is perhaps the most demanding in terms of computer system requirements. This results from the fact that considerable specialized hardware is required, and the various applications programs must operate in real-time, batch, and time-shared modes. Furthermore, a flexible, efficient capability for the display of results must be provided.

The computer system concept, shown in Figure 4.5-16, provides the necessary operating environments required of the applications programs, with special emphasis on the use of CRT displays with input keyboards to satisfy the need for effective display in real-time and user interaction in the time-shared mode. A mass memory device: (1) provides an efficient mechanism for rapid storage and retrieval of large amounts of often-used information which composes a significant percentage of the integrated OCC data base and (2) affords (in conjunction with the operating system and applications programs) an effective means for inter-program transfers. Tapes provide media for mass memory purging, program storage, archiving of OCC data, NDPF interface, and plotter interface.

The transfer of command data from the OCC computer to the NASCOM 494 Communications Processor will be accomplished by means of specialized interface boxes designed for the purpose. Telemetry data handling from the various NASCOM sources is also accomplished by specialized interface and formatting units; this permits a single, standardized design to suffice for the PCM decommutation equipment.

4.5.8.1.2 NDPF Computer Systems

The ADPE in the NDPF consists of two types: general purpose and process control equipment.

The general purpose equipment is designed to implement the following functions:

1. Library functions of storage and retrieval

2. Computational functions of data location, platform processing, and OCC backup

3. Data handling functions of tape duplication and report generation

4. Interactive support for accounting, logistics, process management, and response to queries to the information base

To accomplish these functions, a third-generation, general purpose central computer system is recommended, with the standard peripherals, such as tape decks, input/display terminals, high-speed printers and card readers/punchers. Mass storage is required to maintain the large amount of data involved in the library functions. The system software required must control foreground/background processing, time-share capability for user interaction, and data classification, as well as batch processing for data location applications programs.

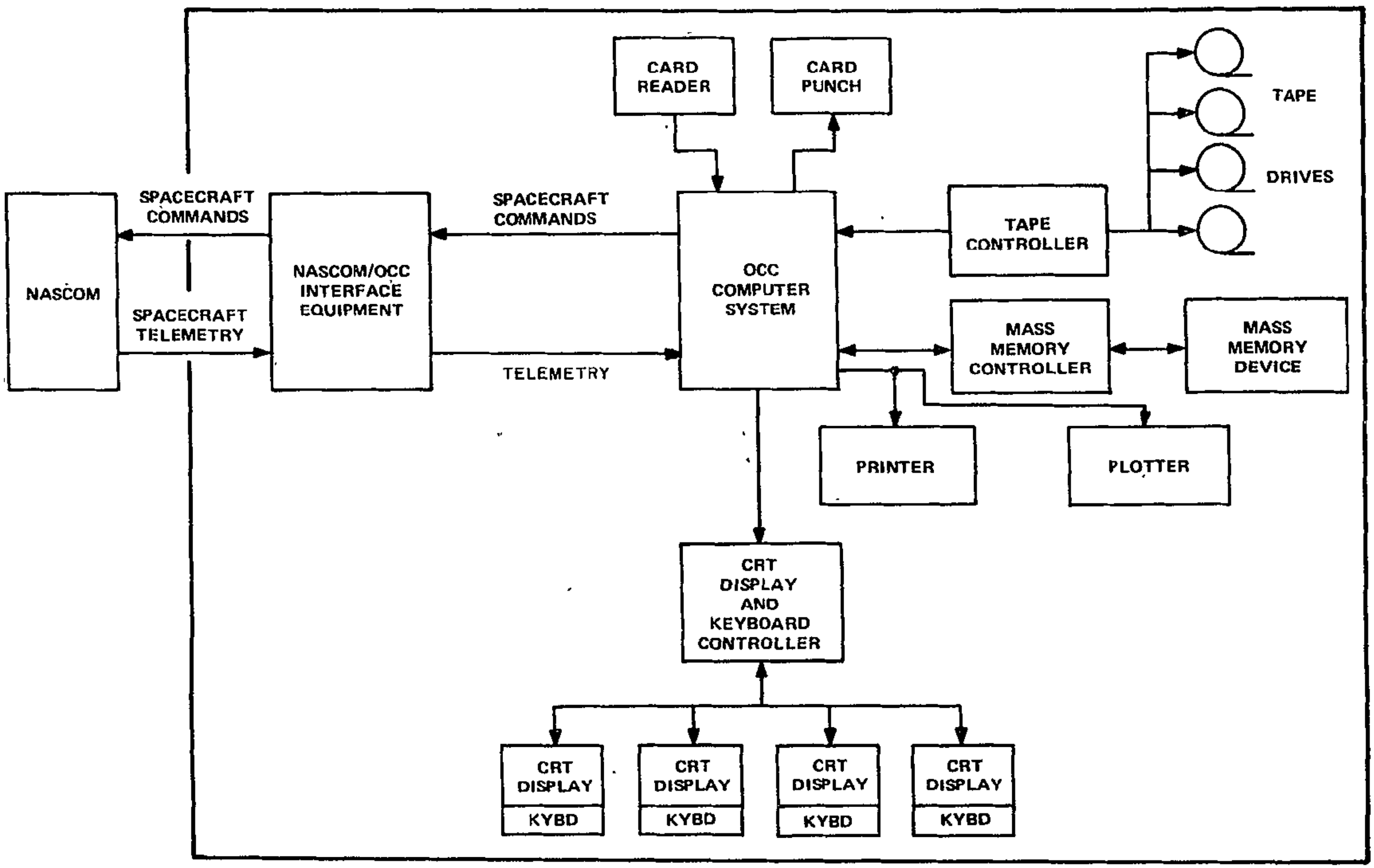


Figure 4.5-16. OCC Computer System Concept

The NDPF central computer system must also be capable of performing the critical OCC functions to provide redundancy for spacecraft support.

The NDPF central computer configuration is shown in Figure 4.5-17.

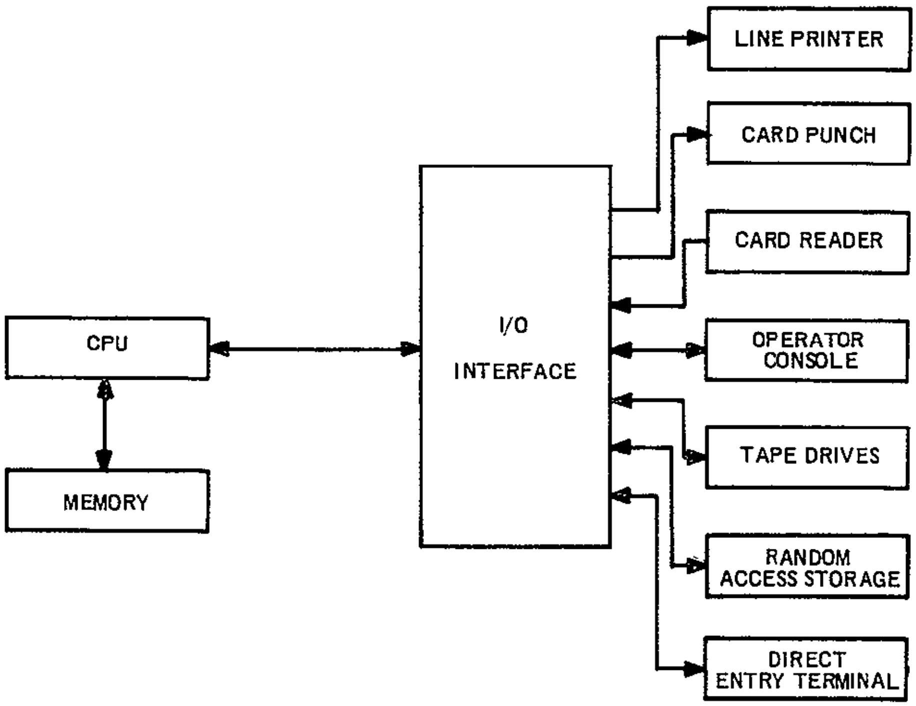


Figure 4.5-17. NDPF Central Computer System Configuration

Process control equipment is also required in the NDPF. In the three process control applications (Bulk Image Processing, Precision Processing and Special Processing, shown in Figures 4.5-18, 19, and 20) a digital process control device must be either dedicated to the controlled equipment or fully utilized in the processes. In both Bulk Image Processing and Precision Processing, the computers may be small devices connected to analog video processing devices through specialized interface hardware, but they cannot be interrupted from the real-time processing without risking loss of data. These pieces of ADPE control scanning beam patterns, video tape recorders/reproducers, high resolution film recorders, annotation generators, and control consoles.

The processor required in the Special Processing function is essentially a peripheral control device with the capability to alter data formats. None of the process control computers require sophisticated operating system software because most of the application software

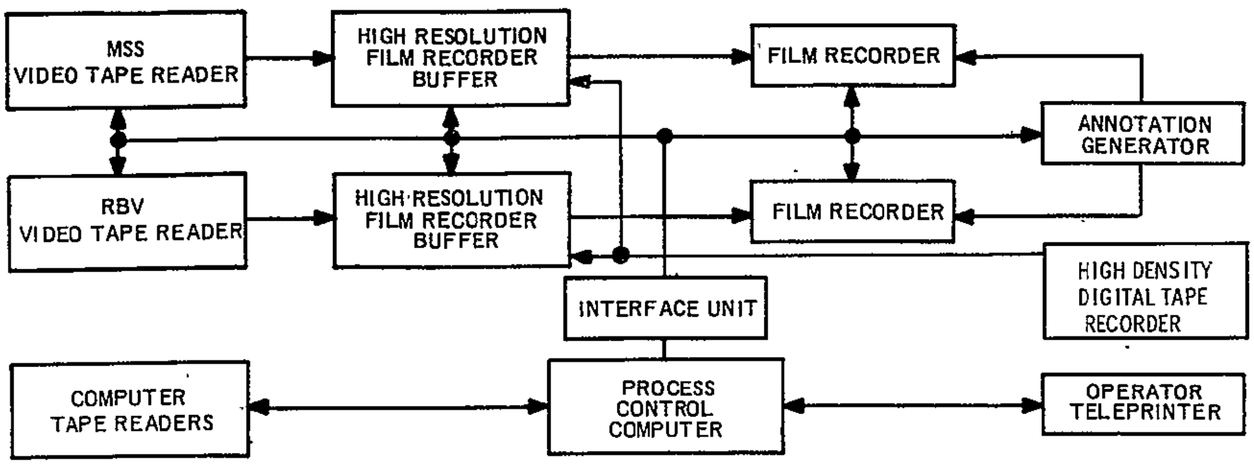


Figure 4.5-18. Bulk Image Processing

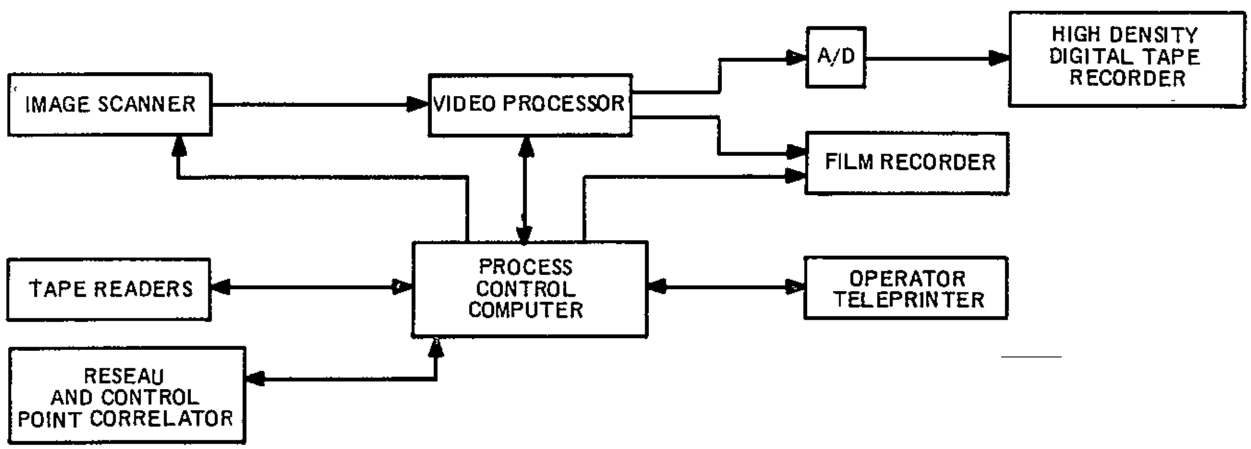


Figure 4.5-19. Precision Processing

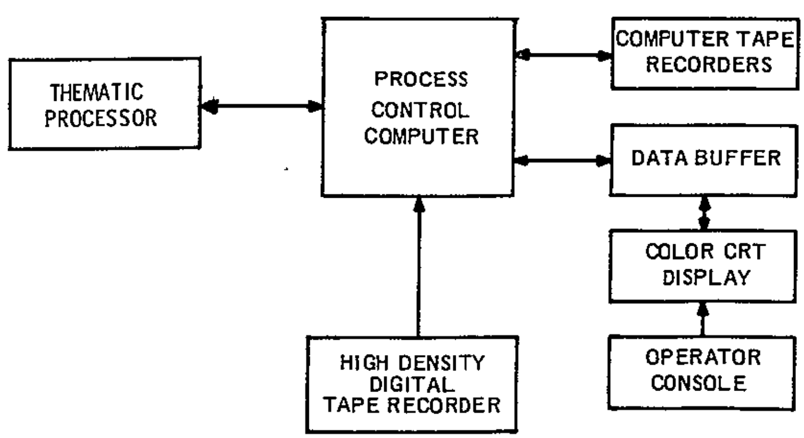


Figure 4.5-20. Special Processing

will be machine code and will perform such functions as I/O control and interrupt processing, which are usually done by operating system software. The standard peripherals required are tape drives for normal 9-track, 800 bpi-tape and teletypewriters.

Figures 4.5-18, 19, and 20 show how the process controllers fit with the controller devices for Bulk Image Processing, Precision Processing, and Special Processing, respectively.

4.5.8.2 Overall ADP Equipment Summary

The ADP equipment in the GDHS forms five groupings. (The OCC ADP system and the NDPF Central Computer system are "systems" in the usual sense of equipment organized at a central location (with perhaps remote peripherals) to provide a data handling/computation service. The ADP used for the Bulk Image Processing, Precision Processing, and Special Processing functions are used to control on-line processes and are only referred to as "systems" in the following sections to allow convenient presentation.

4.5.8.2.1 OCC

The OCC ADP system features real-time computation, display, and control to support the command and evaluation necessary to operate and maintain the spacecraft. It is also capable of providing the capability to perform in-depth system analysis, mission planning, and computation support, using the same peripherals and data used in the critical real-time spacecraft acquisition mode. The ADP to support these activities consists of the following:

1. Central processor
2. Memory
3. Mass storage device and controller
4. Tape handlers and controllers
5. CRT displays and controllers
6. Printer
7. Card punch/reader
8. PCM decommutator
9. 494/command formatter unit
10. 494/PCM formatter unit
11. X144/PCM interface unit
12. Plotter

13. Computer system software

14. Computer utility software

4.5.8.2.2 NDPF

The NDPF Central Computer system is a flexible system primarily oriented to: (1) perform the library functions of the GDHS and (2) provide interactive use with the data base to respond to user queries. The ADPE to support these activities consists of the following:

1. Central processor
2. Memory
3. I/O buffering devices
4. Operator console
5. Card reader/punch
6. High speed printer
7. Tape readers
8. Random access storage devices and controllers
9. Display and/or teletype terminal
10. Key punch

The process controllers required in the NDPF are separately adapted to the specific process of concern. In each case, it is expected that state-of-the-art, small scale, or special purpose computers used to perform these functions will be fully loaded and operating at capacity to support the other equipment involved in each function. The following groups of ADPE are used to process control tasks:

1. Bulk Image Processing
    a. Computer
    b. Magnetic tape controller(s)
    c. Tape deck drive(s)
    d. Keyboard/printer

2. Precision Processing

    a. Computer

    b. Magnetic tape controller(s)

    c. Tape deck drive(s)

    d. Disc drive and controller

    e. Keyboard/printer

    f. Paper tape reader/punch

    g. Teletype

3. Special Processing

    a. Computer

    b. Magnetic tape controller(s)

    c. Tape deck drive(s)

    d. Keyboard/printer

4.5.8.2.3 SITE

The ADP equipment in the SITE forms two subsystems: (1) the equipment to be installed at the contractor''s facility and (2) the equipment to be shipped to the Western Test Range to support field checkout of the spacecraft. The ADPE in these two subsystems consists of the following:

1. Contractor Facility

    a. Computer/memory

    b. Magnetic tape controller(s)

    c. Tape deck drive(s)

    d. Operator console/displays

    e. Card reader/punch

    f. Printer

4

g. CRT

h. External direct access memory

2. WTR Field Facility

a. Computer

b. Magnetic tape controller(s)

c. Operator console/displays

d. Card reader/punch

e. Printer

f. CRT

g. External direct access memory

4.5.8.3 RFQ Information

The General Electric Automatic Data Processing Equipment (ADPE) Request for Proposal (RFP) RTM-70-21 was sent to prospective bidders on February 20, 1970, with a proposal return due date of March 20, 1970. A synposis of the RFP also appeared in the publication Commerce Business Daily on February 27, 1970. A pre-proposal bidders meeting was held on February 27 to answer questions regarding the RFP. Transcripts of the proceedings of that meeting were sent to prospective bidders on March 4, 1970.

As of March 20, 1970, formal no-bid responses were obtained from the following companies:

1. IBM Corporation
2. Interdata
3. Bunker-Ramo Corporation
4. Technitrol Engineering
5. Kelly Scientific
6. Link Division-Singer
7. Lockheed Aircraft
8. Programming Sciences Corporation
9. Data Graphics Corporation

11. A. J. Associates, Inc.
12. Stein Associates
13. Comptek
14. Applied Systems Corporation
15. Gulton Inc.
16. NCS Computing Service
17. Nuclear Service
18. H. R. B. Singer, Inc.
19. Data Craft Corporation
20. ESL, Inc.
21. DBA Systems
22. Interstate Electric
23. Engineering Associates, Inc.
24. RCA Information Systems
25. Alton Associates
26. Opportunity Systems, Inc.
27. Datacom, Inc.
28. Goodyear Aerospace
29. Sperry Gyroscope
30. Radiation, Inc.
31. EAI
32. Magnamatrix
33. Wyle Labs
34. EDP Technology

35. Boeing

36. Scientific Control Corporation

37. Symbolic Control

The vendors who submitted proposals are identified in the matrix below; each vendor is associated with the configuration he bid:

	OCC	NDPF	SITE
Burroughs Corporation	X	X	X
Control Data Corporation	X.	X	X
Digital Equipment Corporation	X	X	X
EMR - Telemetry	-	-	X
Honeywell, Inc.	X	X	X
General Electric	X	X	-
Systems Engineering Laboratories	X	X	X
Sperry Rand - Univac Division	X	X	-
Xerox Data Systems	X	X	X

NOTE: X identifies system bid

4.5.8.4 Evaluation Criteria

The Technical Evaluation Plan as submitted to NASA Goddard Space Flight Center contains the following as major factors to be considered:

Major Evaluation Factors

	Factor	Relative Weight		
		OCC	NDPF	SITE
1.	Suitability of proposed hardware for system application	25	20	28
2.	Suitability of proposed software for system application	25	25	25
3.	Offeror's qualifications	15	15	15
4.	Expansion capabilities	10	15	7
5.	Equipment reliability	9	9	7
6.	Ability to meet environmental requirements	8	8	10
7.	Supporting services provided	8	8	8

Each of these major factors is then further broken down into a series of sub-factors:

Suitability of Proposed Hardware for System Application

Sub-Factor	Relative Weight OCC	NDPF	SITE
Central processor	30	35	35
Communications interface	15	--	25
Compatibility	15	20	10
Mass memory	14	20	15
CRT displays/keyboards	10	5	--
Magnetic tape drives	7	12	8
Other peripherals	6	8	7
Plotter	3	--	--

Suitability of Proposed Software for System Application

Sub-Factor	Relative Weight OCC	NDPF	SITE
Operating system	22	25	20
Data management	16	20	12
Communications control	15	--	15
Compatibility	15	15	10
Fallback and recovery	10	12	5
Programming languages	10	12	25
Documentation	5	7	5
Utility services	4	5	5
Diagnostics	3	4	3

17 April 1970

Offeror's Qualification

Sub-Factor	Relative Weight		
	OCC	NDPF	SITE
Status of proposed software	25	25	25
Customer feedback on equipment performance	25	25	25
Production facilities and staff	15	15	15
Ratings of qualified experts	15	15	15
Length of time equipment has been in production	10	10	10
Past delivery performance on comparable procurements	10	10	10

Expansion Capabilities

Sub-Factor	Relative Weight		
	OCC	NDPF	SITE
Increased CPU memory	30	25	30
Addition of mass memory	25	20	25
Increased processing speed	20	20	20
Increased I/O capability	15	20	15
Addition of peripherals	10	15	10

Equipment Reliability

Sub-Factor	Relative Weight		
	OCC	NDPF	SITE
Reported experience	40	40	40
Availability data	20	20	20
Is equipment part of standard line?	20	20	20
Failure rate data	10	10	10
Preventive maintenance requirements	10	10	10

Ability to Meet Environmental Requirements

Sub-Factor	Relative Weight		
	OCC	NDPF	SITE
Floor space	20	20	15
Lighting	15	15	10
Accessibility	10	10	10
Floor loading	10	10	10
Humidity	10	10	15
Noise level	10	10	10
Temperature	10	10	15
Overall protection	5	5	5
Power	5	5	5
Safety	5	5	5

Supporting Services Provided

Sub-Factor	Relative Weight		
	OCC	NDPF	SITE
Scope of responsibility	25	25	25
Systems engineers	20	20	20
Maintenance	15	15	15
Pre-installation test equipment	15	15	15
Documentation	10	10	10
Training	10	10	10
Backup	5	5	5

The scoring system used in the technical evaluation was based upon a 0 through 5 rating scale, with the following as criteria:

Numerical Score	Concept
5	Very substantially exceeds requirement
4	Demonstrably exceeds requirements
3	Meets requirement without need for arguing compensatory factors
2	(a) Does not directly meet requirements, but direct compensating factors clearly provide equivalent system performance or (b) Appears to meet requirement, but description is insufficient to remove all uncertainties.
1	Partially meets requirements
0	Item missing, or having no specified functional value to system

Through the appropriate combination of ratings and relative weights, a score has been derived for each proposal in contention. Of course cost data was also generated for each proposal and will be shown in association with the corresponding technical evaluation score at a later date.

The method of arriving at a total technical merit rating for a given proposal was as follows

$$\frac{\text{Sub-Factor Rating}}{5} \times \text{Sub-Factor Weight} = \text{Weighted Sub-Factor Rating}$$

The Sum of a Set of Weighted Sub-Factor Ratings = Factor Rating

$$\text{Factor Rating} \times \frac{\text{Factor Weight}}{100} = \text{Weighted Factor Rating}$$

The Sum of Weighted Factor Ratings = Total Merit Rating

The total merit rating possible was therefore in the range from 0 to 100. The minimum score for an acceptable technical rating is 60.

SECTION 5

OPERATIONS CONTROL CENTER DESIGN

The design of the Operations Control Center (OCC) has been predicated on the baseline requirements presented in the ERTS Design Study Specification (S-701-P-3). These requirements served as the basis for establishing the functional design concept which, in turn, permitted the deriviation of detailed design requirements at both the system and subsystem level, and afforded a mechanism by which various design configurations and design tradeoffs could be evaluated. The results of this effort have become the basis for the detailed design of the OCC.

5.1 OCC OVERVIEW

The OCC is the focal point for all ERTS unique mission operations and the command and control point for all spacecraft flight operations (see Figure 5.1-1). The OCC operates on a 24-hour day, 7-day week basis and is responsible for operational planning and scheduling, spacecraft commanding, spacecraft and payload evaluation, and flight operations control (Figure 5.1-2). Virtually all OCC activities are geared to the operations timeline dictated by the spacecraft orbit and network coverage capability. Using the three prime stations at Corpus Christi, Alaska, and the NTTF, the OCC will have real-time contact with the spacecraft on 12 or 13 of the 14 orbits each day.

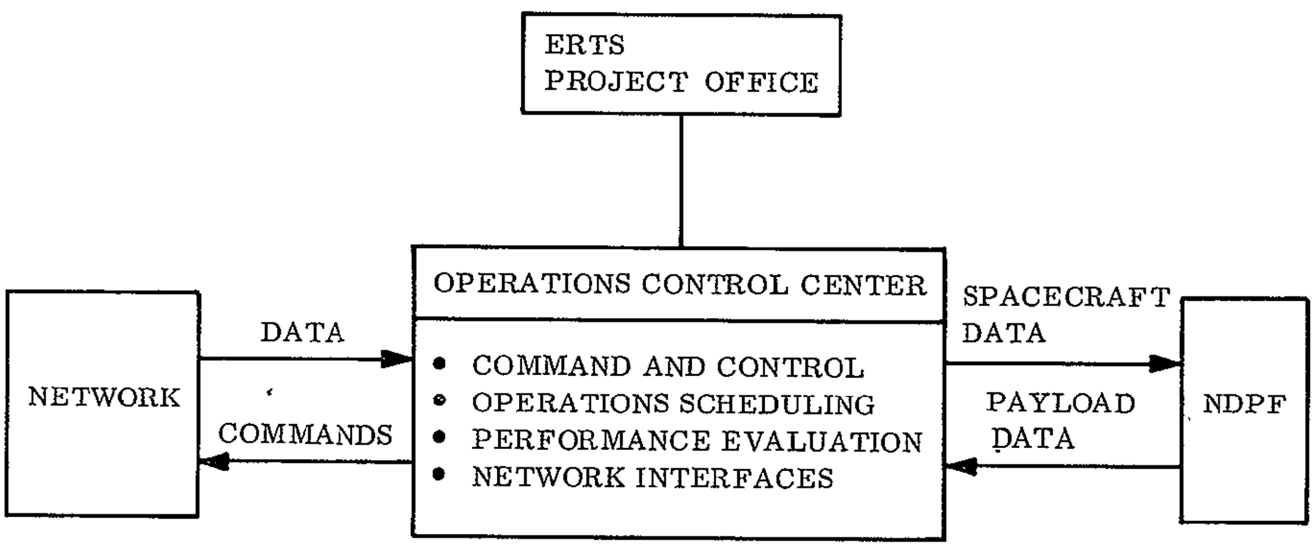


Figure 5.1-1. OCC Overview

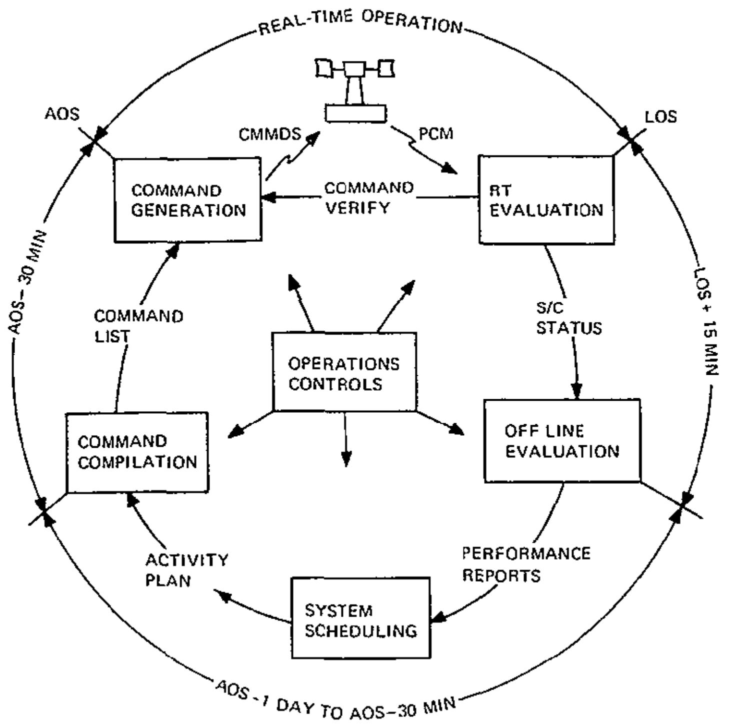


Figure 5.1-2. OCC Operational Flow

During the interorbit periods, the OCC performs the detailed evaluation of the spacecraft and payload subsystem performance, investigates any anomalies, and prepares for the next spacecraft contact.

5.2 OCC REQUIREMENTS

The baseline requirements for the OCC were presented in the Design Study Specification. These requirements define four major areas of responsibility for the OCC (Figure 5.2-1):

1. Planning and scheduling
2. Spacecraft command generation
3. Spacecraft and payload performance evaluation
4. Flight operations control

The following sections define the functional requirements of the OCC in each of these areas.

5.2.1 PLANNING AND SCHEDULING

The OCC is required to perform those planning and scheduling functions which define the spacecraft and ground activities necessary to effectively satisfy the mission and flight operation requirements. The plans and schedules must be based upon sensor coverage requirements (including DCS), spacecraft and payload configuration, network availability, and environmental constraints. The resultant activity plan is a time-ordered list of spacecraft, payload, and network events.

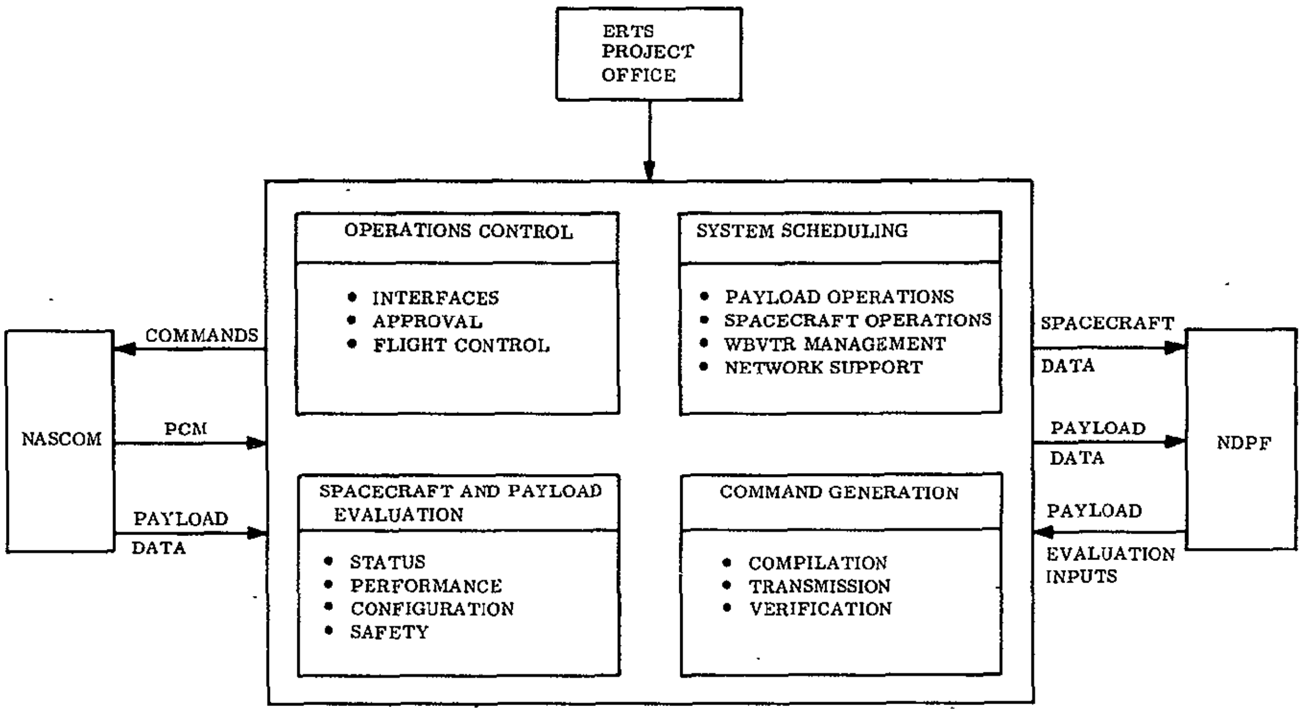


Figure 5.2-1. OCC Functional Requirements

5.2.1.1 Sensor Coverage Requirements

Sensor coverage requirements will include those areas to be covered while in contact with a ground station, as well as those outside the contact area. In the latter case, the OCC must schedule and manage the use of the on-board wideband tape recorder and insure that contact time is available for its readout. The useful life of this recorder is limited, and its operation is specified as an average of 1 hour per day. Further, precautions should be taken to avoid using the recorder to collect data over cloud covered areas.

5.2.1.2 Spacecraft and Payload Configuration

Spacecraft and payload configuration must be considered in the development of the activity plan in order to ensure that the current resources of the spacecraft system are effectively utilized. Changes in the status or operability of the spacecraft or payload must be identified and input to the activity planning function in order to prevent any compromise to their health and safety.

5.2.1.3 Network Availability

Network availability must be determined for routine contact operations as well as tracking. Tracking requirements will be input to the OCC by the NASA orbit determination group and will define requirements for both routine tracking and special tracking for orbit adjust maneuvers. Orbit adjust requirements will also be determined by this group and input to the OCC. The OCC must factor these requirements into the activity plan. The OCC must coordinate all network support requirements with STADAN and/or MSFN and be capable of iterating the activity plan as a result of network schedule conflicts.

5.2.1.4 Environmental Constraints

Environmental constraints include those factors which affect or restrict payload operations, namely sun angle and weather. Cloud cover was also mentioned earlier as an important limiting factor in wideband tape recorder operations.

The planning and scheduling responsibilities of the OCC, then, cover all elements of the operational mission system and must be designed to make most effective use of the resources of that system.

5.2.2 SPACECRAFT COMMAND GENERATION

The OCC is required to generate the commands necessary to operate the spacecraft and its payload. Command generation responsibility includes:

1. Compilation of commands which satisfy the activity plan and spacecraft system performance and configuration requirements

2. Display and verification of commands prior to transmission to ensure that the command list is correct and does not violate prescribed operational procedures

3. Blocking and formatting of commands and transmission via the appropriate support network

4. Verification of command execution in the spacecraft for both real-time and stored program commands

5.2.3 SPACECRAFT AND PAYLOAD PERFORMANCE EVALUATION

The OCC is responsible for the analysis and evaluation of spacecraft and payload data to determine their configuration, health, and performance at both a system and subsystem level. This responsibility includes both real-time and historical trend analysis. Real-time processing and analysis are required to permit on-line command and control over the spacecraft. Historical trend and related analyses provide the capability for in-depth, long-term performance evaluation and the investigation of anomalies. Implicit within these requirements is the fact that the OCC must be capable of receiving, processing, displaying, distributing, and storing the spacecraft data necessary to fulfill these responsibilities.

5.2.4 OPERATIONS CONTROL

The OCC is defined as the focal point and control point for all ERTS unique operations. The OCC operations control function therefore, must have the ability to direct all internal OCC activities in order to ensure effective and efficient flight operations and rapid response to contingencies. Externally, operations control must define the required network support activities to be performed and must be capable of determining the status and configuration of the support elements.

5.3 FUNCTIONAL ANALYSIS AND DESIGN

The requirements presented in Section 5.2 served as the basis for a detailed functional analysis of the OCC which resulted in the baseline functional design concept shown in Figure 5.3-1. The purpose of this analysis was to identify the functions to be performed within each area of OCC responsibility, the interfaces between these areas, the interfaces required with the rest of the mission system, and all of the data required in the OCC.

The resultant functional design baseline divides the OCC into four interrelated functional areas which parallel those defined in Section 5.2. The functional design defines these as:

1. System scheduling
2. Command generation
3. Spacecraft and payload evaluation
4. Operations control

5.3.1 SYSTEM SCHEDULING

System scheduling accepts the various coverage and scheduling requests and other data interfaces and proceeds through the development of the payload and orbit adjust activity plans. These are integrated, approved, and passed to command generation via the data base. The design makes use of available cloud cover mission planning models which can be readily integrated into the operational on-line planning sequence when sufficient confidence in them is gained.

5.3.2 COMMAND GENERATION

Command generation is initiated by the activity plan from the system scheduling area. The design provides a check and balance to ensure compliance with operational constraints and spacecraft system capability.

5.3.3 SPACECRAFT AND PAYLOAD EVALUATION

Spacecraft and payload evaluation accepts the spacecraft and payload data and performs those functions required to determine status, performance, and health. Real-time analysis results are relayed to operations control for rapid command and control response. The results of the in-depth analysis are used in the detailed evaluation and management of the spacecraft system.

5.3.4 OPERATIONS CONTROL

Operations control has the ability to direct all flight operation activities within the OCC and can, by virtue of prepass briefings and operational readiness testing, assure the readiness of the support elements.

5.4 OCC SYSTEM DESIGN

5.4.1 DESIGN DESCRIPTION

The OCC system design configuration is shown in Figure 5.4-1. The OCC computer satisfies the basic requirements for processing and computation within the OCC. This is a medium to large scale general purpose digital computer with the standard array of peripherals. (This computer was discussed extensively in the ERTS ADPE Feasibility Study and the subsequent ADPE Procurement Specification.)

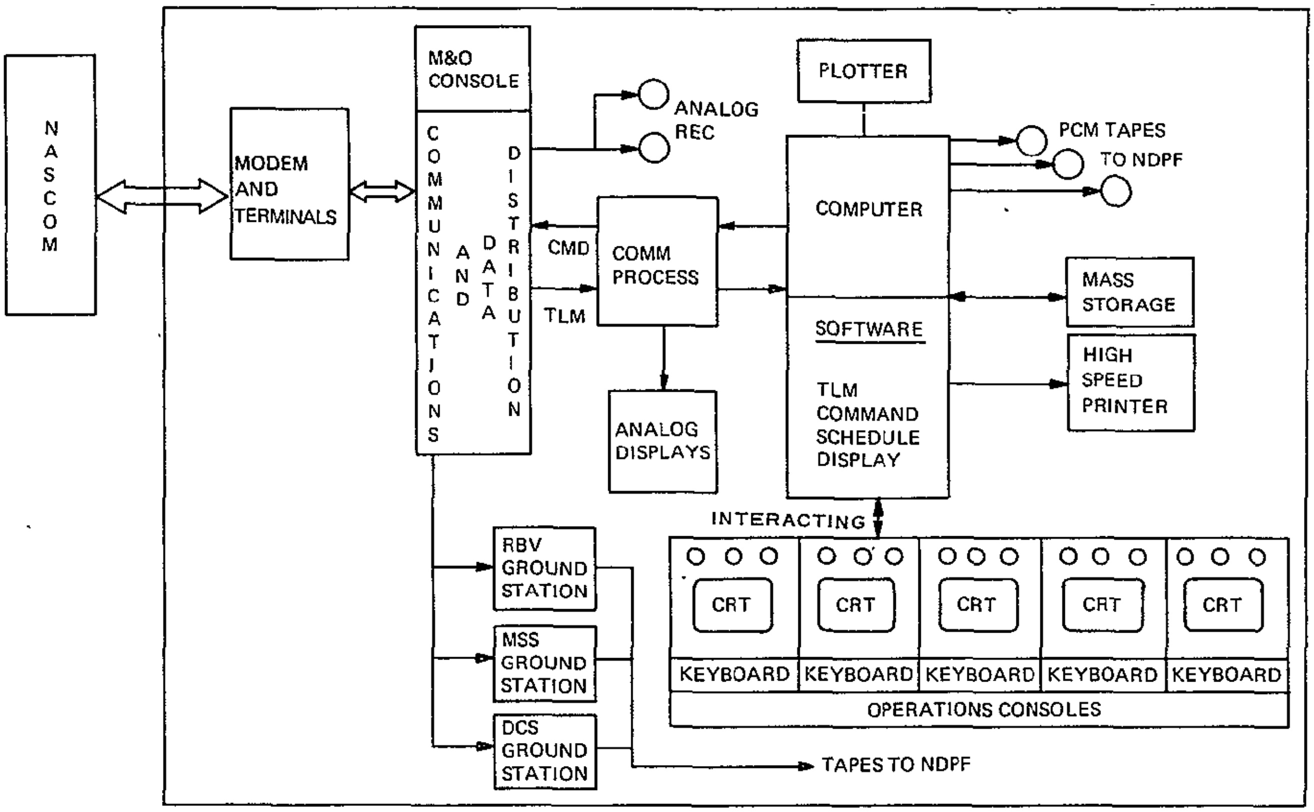


Figure 5.4-1. OCC System Design

Operating within the computer is the OCC applications software designed for telemetry processing, command generation, display processing, system scheduling, and other software functions. The applications software operates in conjunction with the computer's operating system which, in turn, provides the capability for real-time, batch, and extensive multiprocessing operations. Interacting with the computer and its software are the OCC operations consoles. These consoles are designed to provide the operations personnel with all of the information required to make rapid command and control decisions and an effective mechanism with which to implement them. Each console contains a CRT display, data entry keyboard, communications panel, clocks, and other status and alarm indicators. The CRT's are driven by the computer and the display software permits each operator immediate call-up of any display in the system display library by keyboard request.

The communications processor provides an effective and efficient interface between the OCC computer and the NASCOM interfaces. This processor is designed to accept the serial PCM input data from the various NASCOM modems and terminals, perform the stripping and decommutation processing, and output the data to the computer and strip chart and event recorders. The communications processor also accepts command transmission messages from the computer and outputs these to NASCOM at the required serial rate. This design approach relieves the computer of the time and processing overhead burden otherwise imposed and makes use of the communications processor as a backup command and PCM processor/display generator in the event of main computer failure.

The communications and data distribution equipment centralizes all external interface and communication terminals and provides complete capability for patching and switching data flow within the OCC. Also included are the equipment for signal conditioning, timing, and recording. This equipment operates under the control of the OCC M&O console, which remotely controls all input/output functions and provides the capability for overall OCC configuration management. The M&O console controls also allow OCC operations consoles to access the NDPF data base.

The RBV, MSS, and DCS ground stations provide the capability to record and process payload data acquired locally via NTTF. The RBV and MSS data are also displayed for quick-look evaluation of sensor performance. The DCS data is preprocessed in the OCC for subsequent user formatting in the NDPF.

5.4.2 OCC SYSTEM DESIGN CONCEPTS

The actual design of the OCC is the implementation of the functional design (described in Section 5.3.1) in terms of OCC system definition, subsystem definition, hardware, software, and interfaces. This implementation is predicted, further, on design concepts and an operational philosophy derived from experience and from an appreciation and understanding of the OCC role within the ERTS mission system. These have served as essential guidelines throughout the OCC system design study effort, emphasizing the following four factors in OCC design:

1. Spacecraft command and control capability

2. Operational reliability

3. Network compatibility

4. Software design concept

5.4.2.1 Spacecraft Command and Control

In terms of both design concept and operating philosophy, the OCC has complete responsibility for ERTS spacecraft operations, and for the health and safety of the spacecraft itself. To accomplish this, the OCC requires positive command and control over both the spacecraft and the payload. This implies two things:

1. The OCC must be capable of acquiring and analyzing the information required to make rapid command and control decisions.

2. The OCC must have available the means to implement these decisions in an effective and timely manner.

As a result of this, the OCC design provides complete capability for spacecraft data processing and display and for command generation and verification. This permits the OCC to be self-reliant so far as these basic and essential command and control functions are concerned, although network and other support is implied. The spacecraft data is processed in real-time and displayed for meaningful quick-look evaluation of status, health, and performance at both a system and subsystem level. Critical events and anomalies are flagged and displayed automatically. Commands are compiled, validated, transmitted, and verified by computer under direction of the command operator. The operator retains full control over all command activities at all times.

5.4.2.2 Operational Reliability

The OCC responsibility for spacecraft command and control carries with it the requirement for operational reliability within the OCC itself. The OCC must be capable of continued operation even in the event of equipment or other failures. The design provides for this in several ways:

1. Selected equipments which perform critical functions are duplicated within the OCC. In almost every case, the duplicate equipment has been integrated into the normal operational configuration and contributes to routine operations. In the event of failure, this equipment can be switched into the critical flow or can be configured to operate in a contingency mode. This approach provides several backup operating modes within the OCC itself, without the need for NDPF or other support.

2. In the event that the OCC should lose its computer facilities, the work can be shifted to the NDPF. Both of these computers are expected to possess a degree of commonality which will include OCC applications software operability on the NDPF computer. Reconfiguration will be simple and will require only peripheral switching for the most part.

3. An emergency backup mode is also available to the OCC for spacecraft command and control in the event of network failure or other major contingency. In this mode, the OCC will direct command activities by voice communication with the remote stations. This mode is initiated by the OCC itself and carried out under prescribed contingency procedures. The remote stations will command the spacecraft at OCC direction, and transmit individual commands or predefined contingency command sequences established by the OCC in advance.

5.4.2.3 Network Capability and Compatibility

One of the more basic design concepts for the OCC has been to make maximum use of existing and/or planned network capabilities and to formulate an interface concept which is compatible with both MSFN and STADAN. This has been effectively achieved by using the switching and routing capabilities of the NASCOM 494 communications processor to relay command messages from the OCC to the remote sites. This permits the use of a single command output interface between the OCC and NASCOM. All transmission utilize the prescribed NASCOM message format which is compatible with the command equipment at the remote sites. The 494 is also used to return PCM data to the OCC from two of the prime sites, Corpus Christi and Alaska, in real-time. Again, this utilizes the standard NASCOM message formats and, further, permits valuable command message data required by the OCC to be merged or interspersed with the PCM data. This command message data indicates whether or not commands sent to the station were polynomially decoded and also whether these commands passed the radiation echo check. When the 494 link is used for transmission of this data, it closes the commanding loop well before command verify data is available from the spacecraft telemetry system and permits rapid and automatic retransmission of commands if necessary.

5.4.2.4 OCC Software

The OCC software is a major element of the OCC design and, more important, is a critical portion of the mechanism by which the OCC satisfies its responsibilities. Many of the software techniques needed to fulfill the requirements of the OCC for ERTS scheduling, commanding, and telemetry data processing have already been developed on Nimbus and other programs. These techniques, many of which involve relatively sophisticated and complex logical decisions and causal relationships, have already been designed, implemented, and proven effective. Because of this, these techniques serve as the basis for much of the OCC software design.

5.4.3 OCC SUBSYSTEM DEFINITION

The OCC system (Figure 5.4-1) is divided into seven subsystems as shown in Figure 5.4-2:

1. PCM data processing
2. Image data processing and display
3. Command generation
4. Communication and data distribution
5. Status data control and display
6. Computing services
7. OCC software

Each of these subsystems is described briefly below, and is discussed in detail in Section 6.

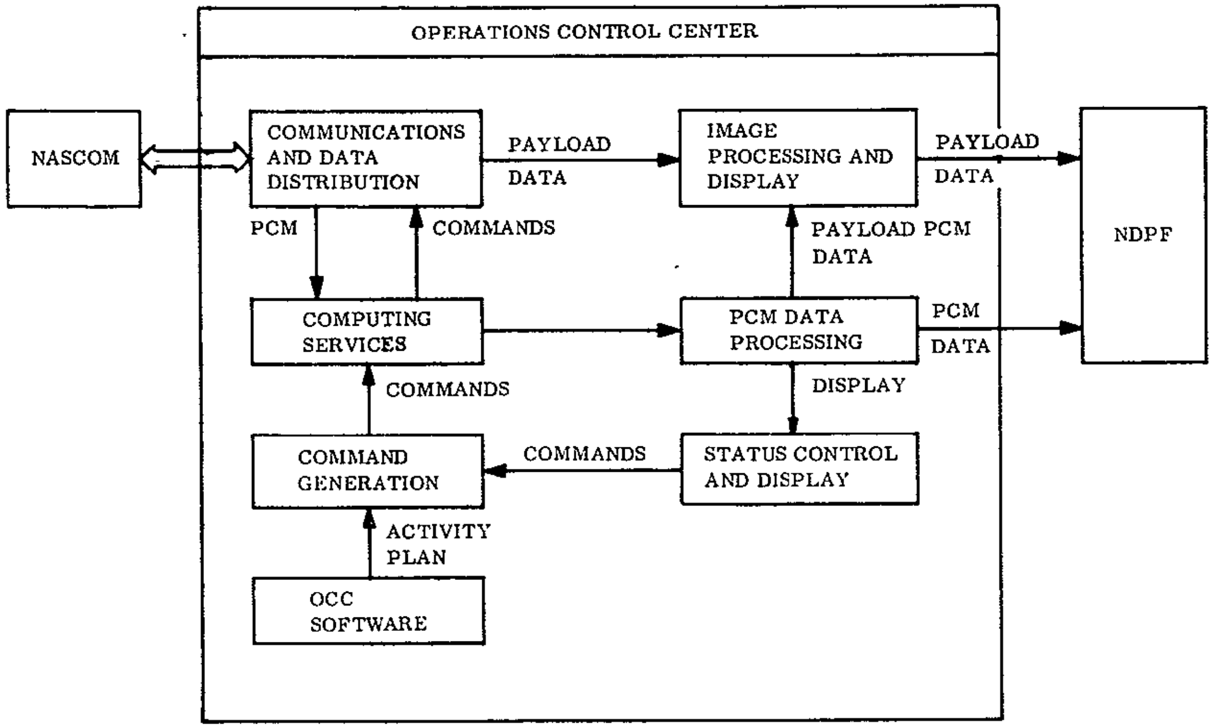


Figure 5.4-2. OCC Subsystems

5.4.3.1 PCM Data Processing

The PCM data processing subsystem performs the functions required by the OCC for the processing, analysis, and display of the spacecraft telemetry data. This subsystem consists primarily of telemetry processing applications software operating within the OCC computer. The PCM data processing subsystem operates on both real-time and playback telemetry data.

5.4.3.2 Image Data Processing and Display

The image data processing and display subsystem in the OCC provides the ability to monitor sensor operation during real time NTTF station contact. This capability will allow real-time evaluation of payload operation and response to command. Because of the unique nature of the equipment, it will be provided as GFE.

5.4.3.3 Command Generation

The command generation subsystem compiles the spacecraft command list based upon the activity plan generated by system scheduling software. It then blocks and formats these commands and outputs them to the NASCOM for transmission to the spacecraft. This subsystem consists of two applications software packages, the command compiler and command management programs, which operate in the OCC computer.

5.4.3.4 Communications and Data Distribution

The communication and data distribution subsystem provides the capability for monitoring and control of all OCC/NASCOM interfaces within the OCC. This subsystem contains the equipment required for switching, signal conditioning, time code translation, as well as analog recording. The M&O console contained within this subsystem provides control over internal OCC data flow and configuration.

5.4.3.5 Status Data Control and Display

The status data control and display subsystem consists of the hardware and software necessary to present, maintain, and update the mission system and spacecraft system status data essential to flight operations. The major components of the subsystem are:

1. OCC operations consoles (including the command console)

2. Analog and event display recorders

3. Display control and report generator software which operates in the OCC computer.

The primary status display medium within this subsystem is the CRT display mounted in each of the operations consoles. Each display is driven by the display control and report generation software operating in the OCC computer. This software is co-resident with both the telemetry processing and command generation software and has access to all reports generated by these programs. This software is also used to drive the analog displays and event recorders.

5.4.3.6 Computing Services

The computer services subsystem consists of the OCC general purpose computer and its peripherals. This subsystem also contains the computer operating system software and general utilities software. The computer services subsystem provides the computer capability for operation of the OCC applications software.

5.4.3.7 OCC Software

This subsystem contains the other software required within the OCC which was not discussed previously. This includes:

1. Applications executive software required for hardware and software interface control.

2. System scheduling software which generates the operational activity plans.

3. OCC test and diagnostic software required for OCC subsystem testing, system integration, and operational readiness testing.

SECTION 6

OCC SUBSYSTEMS

This section presents the design of each OCC subsystem resulting from the study effort. In addition, the analyses, tradeoffs, and other study results are described for each subsystem.

The subsystems covered in the following paragraphs are structured as shown below:

1. PCM Data Processing
2. Image Data Processing and Display
3. Command Generation
4. Communications and Data Distribution
5. Status Data Control and Display
6. System Scheduling
7. Computing Services
8. OCC Software.

For the purpose of this study report, System Scheduling is treated as a separate OCC subsystem. System Scheduling is a significant function within the OCC and a considerable number of design studies were performed in this specific area.

In the Phase D Proposal, System Scheduling will be treated as part of the OCC Software Subsystem, as prescribed by the NASA Phase D Proposal Instructions.

6.1 PCM DATA PROCESSING SUBSYSTEM

The PCM Data Processing Subsystem, performs the functions required by the OCC for the processing, analysis, and evaluation of the spacecraft telemetry data and for the preprocessing of DCS data. This subsystem consists primarily of telemetry processing applications software operating within the OCC computer. The PCM Data Processing Subsystem operates on both real-time and playback telemetry data and consists of four software elements (Figure 6.1-1):

1. Decommutation Software - Decommutates all spacecraft telemetry data input to the OCC and prepares it for analog display and further computer processing.

2. On-Line Processing and Analysis Software - Processes all decommutated spacecraft telemetry for real-time display and evaluation and prepares the data for off-line processing.

3. Off-Line Processing and Analysis Software - Processes playback spacecraft telemetry data for in-depth evaluation of system and subsystem performance.

4. DCS Preprocessing Software and Hardware - Prepares the DCS data for input to the convolution decoder and formats the decoder output for further processing by the NDPF.

The first three of these elements, together, satisfy all of the OCC requirements for spacecraft telemetry processing. Figure 6.1-2 shows the flow of data through these elements and the following paragraphs describe their operation and their interfaces. The DCS Preprocessing Software is designed for processing unique to the DCS data, and operates independent of the other elements. The operation of this software is also described in a later paragraph. Software design specifictions for each element (and component) of the subsystem are found in Books 4, 5 and 6.

Decommutation Software

The Decommutation Software operates in the OCC communications processor, which is part of the OCC Computing Services Subsystem described in Section 6.6. All spacecraft telemetry data received at the OCC is input to the communications processor and is operated on by the Decommutation Software as shown in Figure 6.1-3.

Only one of the signals shown in the figure is input at any one time, and the processing flow within the Decommutation Software differs somewhat for each input type.

The NTTF real time (1 kbps) and playbadk (24 kbps), and the Alaska playback data (24 kbps) are inputs to the Decommutation Software in bit synchronized, serial form. The software performs the processing necessary to establish frame, subframe, and word sync, and then transfers the data, one major frame at a time, to the On-Line Processor and Analysis Software operating in the OCC computer. The Decommutation Software also extracts selected words from the decommutated data and formats and outputs these for display at strip chart and event recorders. The selection of these words and their routing is controlled by distribution tables input by the operator or by the OCC computer.

Corpus Christi and Alaska real-time data are input to the OCC via the NASCOM 494 Communications Processor in the standard NASCOM 600-bit block format. Each block contains NASCOM header data and source and destination codes, followed by telemetry data and flag bits. Each 600 bit block of data is input to the Decommutation Software in 50 kbps bursts.

The software first verifies the NASCOM header data to insure that this block contains telemetry data intended for the OCC. (Inputs other than telemetry and other predefined data will be ignored by the Decommutation Software.) It then examines the 36 flag bits to determine whether any command status information is present. These bits are generated by the command equipment at the remote site and inserted into the telemetry data blocks. The command status information provides a near real-time indication of the status of commands transmitted from the OCC. The flag bits are encoded to identify the command number, to go/no go results of the polynomial decoding and RF echo check, and the time of transmission (minute and second) from the remote station.

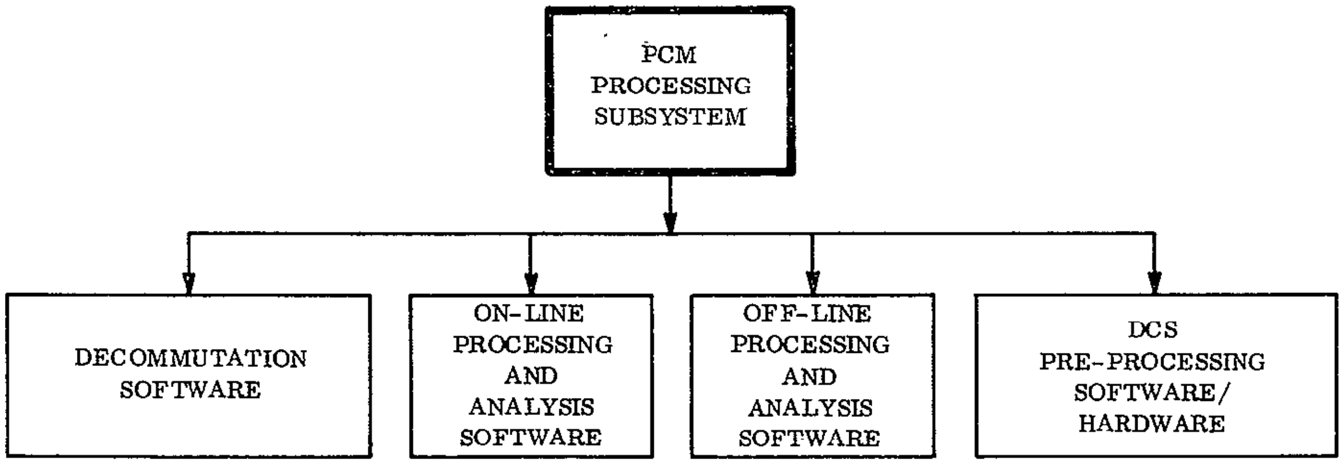


Figure 6.1-1. PCM Processing Subsystem Elements

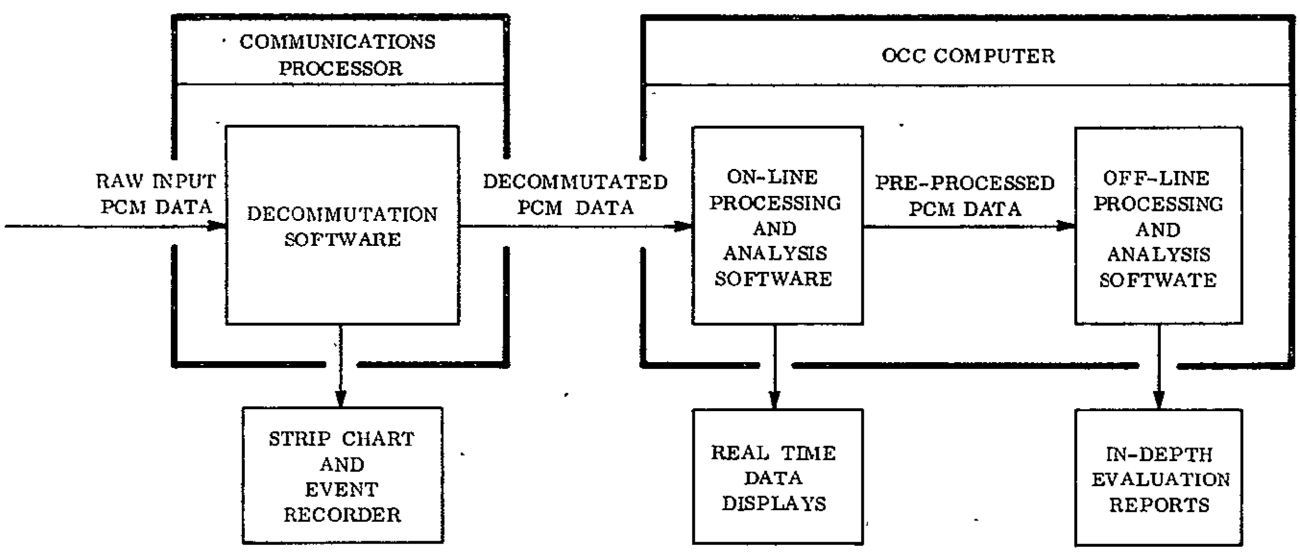


Figure 6.1-2. S/C Telemetry Processing Flow PCM Processing Subsystem

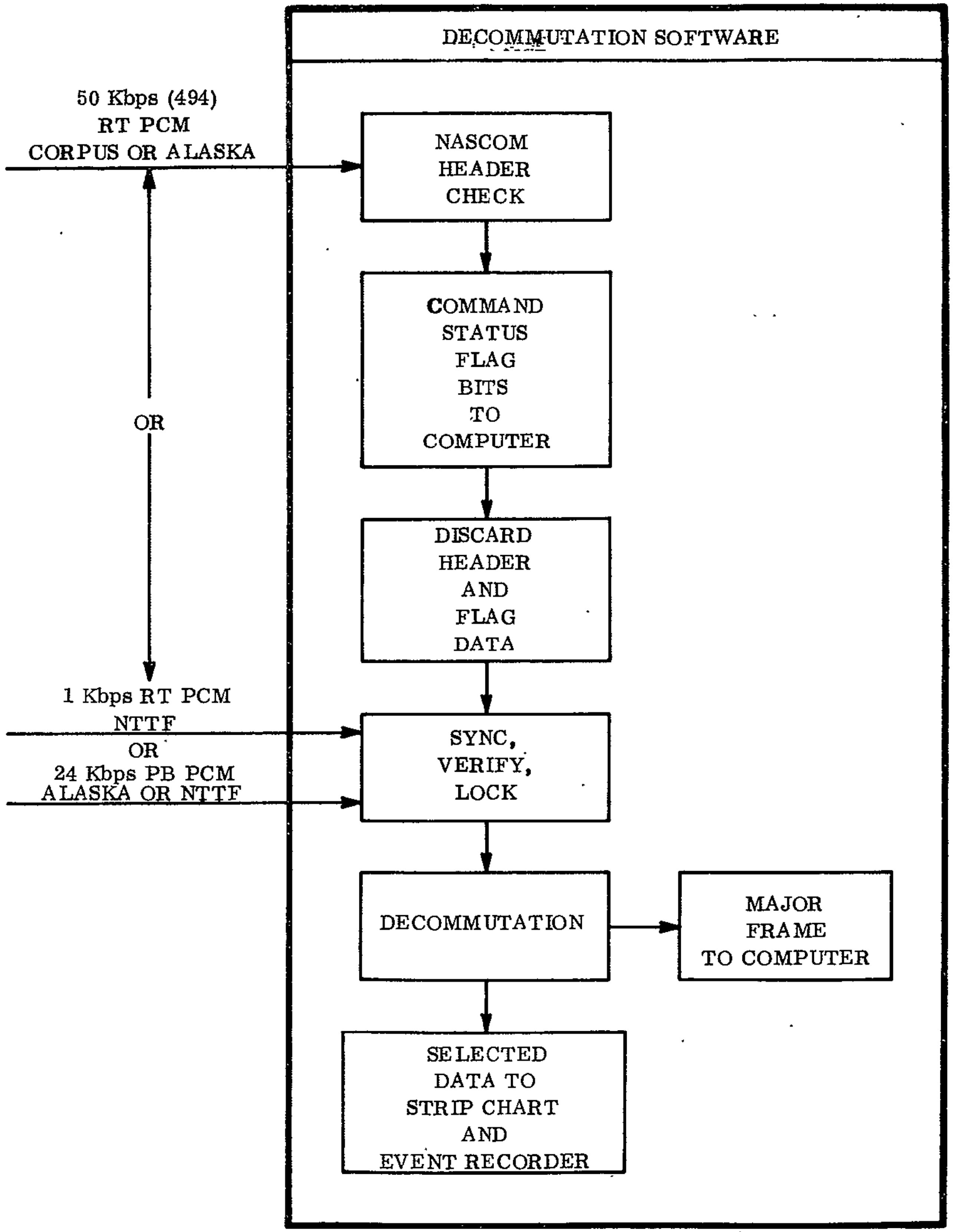


Figure 6.1-3. Decommutation Software Process Flow

This data provides almost immediate knowledge of the status of commands output from the OCC and permits rapid re-transmission if necessary. The Decommutation Software passes the command status data to the OCC computer immediately for decoding and display to the command controller. Once the header data and flag bit checks are made, this data is discarded and only the telemetry data bits are retained. The Decommutation Software then proceeds with the sync, verification, and other processing just as in the case of the aerial input data described above.

The communications processor and Decommutation Software can function with or without the OCC computer. In the event that the computer were to malfunction, the Decommutation Software would continue to output selected telemetry data to the strip chart and event recorders. This provides the OCC with an internal backup mode for meaningful telemetry data display.

On-Line Processing and Analysis Software

The On-Line Processing and Analysis Software (ONPAS) runs in the OCC computer and operates in conjunction with the Decommutation Software. ONPAS accepts and processes decommutated data, either real-time or playback and performs those frame-by-frame processing functions which are common to both data types.

There are several differences in the processing of real-time and playback by ONPAS:

1. When operating on real-time data, ONPAS makes the processing results available immediately, on a frame-by-frame basis, for real-time evaluation of spacecraft status, health, and performance. Playback data is processed after the pass, normally, and the results are saved until the entire playback is processed. The playback data is processed at the full 24 kbps input rate and processing of a complete 400 frame playback will require only four to five minutes.

2. The real-time data is processed and displayed in real time, and only that data required for further processing is extracted and retained. The remaining and major portion of this data is discarded. On the other hand, all of the playback data is processed and retained and this data becomes the input source for the in-depth evaluation processing. The rationale for this is the fact that only the playback data fully describes the behavior of the spacecraft throughout the orbit, and each dump of playback data contains the telemetry output by the spacecraft during the last acquisition. This results from the fact that in normal operation the spacecraft narrow band recorders are used alternately to record and playback so that when one goes into playback, the other begins to record. Hence, the real-time segment of data is actually contained within the next playback.

3. ONPAS processes telemetry data output by the spacecraft while the on-board telemetry system is in the command verify, matrix verify, or memory verify modes. This data differs from the normal mode telemetry in content and/or format (see Section 6.1.1) and requires specialized processing. These modes are normally used only during real-time acquisition and would not apply to playback data. Nothing in the software design precludes processing this type of data in the playback, however, if that should be required.

ONPAS consists of five Telemetry Processing Packages (TPP's) operating under the control of the PCM Acquisition Supervisor (PAS) as shown in Figure 6.1-4.

PAS is designed to accept input decommutated data, either real-time or from the playback, determine the appropriate processes to be performed, and call the necessary TPP(s). PAS operates on each frame of data as it is input, and references only those TPP's required. As each TPP completes its processing, it returns control to PAS.

PAS is normally co-resident in the computer, with software from the Command Generation Subsystem and Status Data Control and Display Subsystem as shown in Figure 6.1-4. Each spacecraft command output to NASCOM by the command software is also input to PAS, where command execution is verified from telemetry. All report and display data generated by PAS or the TPP's is transferred to the display software which controls the formatting and routing of all display data to the operations consoles or printer.

Each of the ONPAS TPP's is designed to perform a unique and separate processing function or set of functions on the input data. Collectively, the TPP's provide the full complement of on-line processing software required. Not all TPP's are required for each frame, but, rather, are called individually by PAS depending upon the telemetry data type and spacecraft operating modes. This design approach affords flexibility in the process flow and minimizes on-line core requirements. The function of each TPP is described below. Further discussion is found in Section 6.1.1. Design specifications for the software are contained in Books 4, 5 and 6.

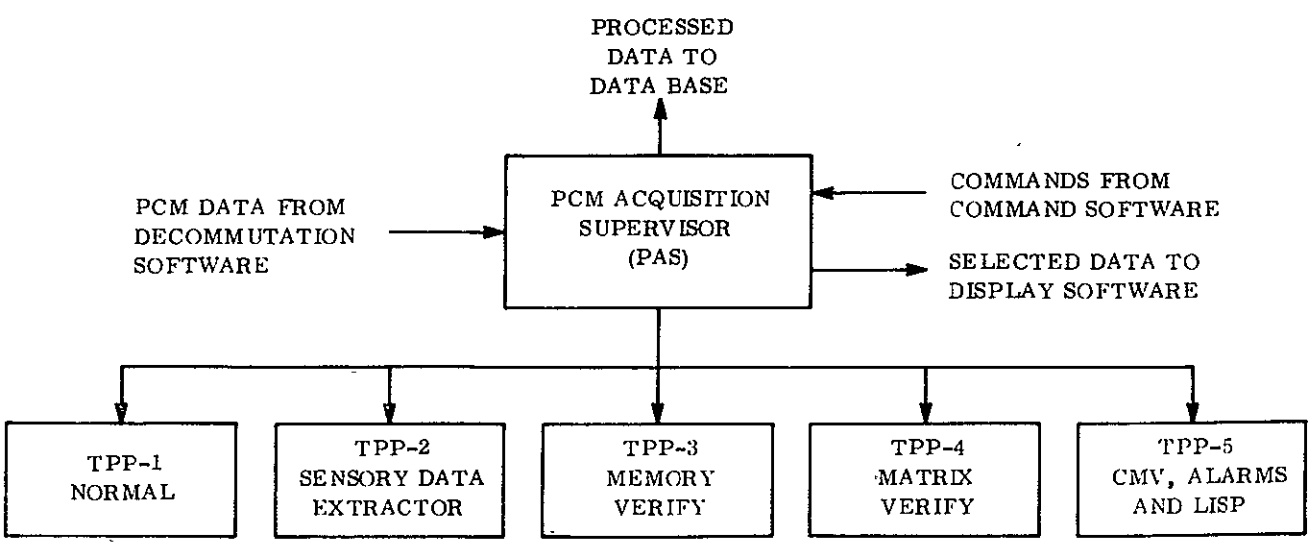


Figure 6.1-4. On-Line Processing and Analysis Software

TPP-1 Normal - TPP-1 performs the six initial and essential processing operations required for each frame of normal real-time or playback data:

1. Reformat - TPP-1 reformats the data in the matrix by storing sequentially all multiple samples of the same telemetry function, unpacking the one-bit digital samples of the same telemetry function, unpacking the one-bit digital samples, and re-ordering the entire matrix in a predefined sequence of telemetry function numbers. This reformatting greatly simplifies all subsequent processing by making the telemetry data readily accessible through direct, data processing table lookup procedures.

2. Range Check - Selected analog function values are compared against predefined range values to determine in which, if any, range the sampled value lies. Range checking is used primarily for the next process, status determination.

3. Status Determination - The status of the spacecraft is described by determining the operating mode of each of the 100 or more status indicators. Each indicator may have served modes of operation, for example:

Status Indicator	Operating Modes
PCM Recorder No. 1	OFF ON/STANDBY ON/RECORD ON/PLAYBACK

   The logic necessary to define each mode of each indicator is predefined and involves selected combinations of range checked and/or digital functions.

4. Calibration - Each analog and ten-bit digital telemetry sample is converted to engineering units. The conversion is accomplished by means of stored calibration tables containing calibration curves for each telemetry function.

5. Pseudo Function Generation - Pseudo functions are spacecraft performance values which cannot be measured directly by the telemetry. These are, typically, operating efficiencies, power output, and similar values which are computed from the available telemetry. The pseudo functions generated by TPP-1 are used primarily in the Off-Line Processing and Analysis Software.

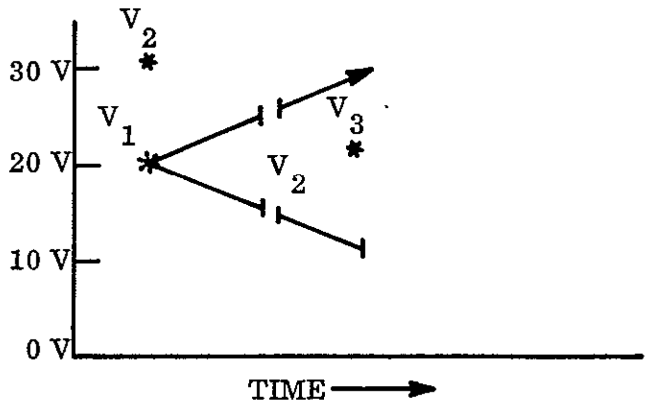
6. Smoothing - Data smoothing is designed to remove transient noise from the telemetry data before further processing. A rate smoothing technique is employed. For each function all the data samples of that function are compared to determine if their rate of change exceeds a predefined allowable rate of change. If it does, the sample is assumed to be in error due to noise and is replaced with the last good value of this function. The allowable change for this function is then adjusted to spread the acceptance cone for the next sample.

Given a function "V" which is sampled three times a frame as in the graph below, where:

V_1 is at 20 volts

V_2 is at 30 volts

V_3 is at 24 volts



The allowable rate of change for this function is defined 5 volts/sample. Therefore the V_2 sample would be replaced with the V_1 sample in the telemetry matrix. The V_2 sample is counted as bad and the acceptance cone is spread to allow 10V charge from samples V_1 to V_3.

V_2^1 = Resultant Value of V_2 after smoothing.

All data values flagged "bad" in preceding processing will be unconditionally smoothed.

TPP-2 Sensory Data Extractor - TPP-2 operates after TPP-1, but only for data from orbits which include RBV and/or MSS operations. The function of TPP-2 is to extract the RBV shutter times and MSS on and off times from either the real-time or playback data. TPP-2 will examine each frame of data in which either of these sensors is on, based upon the results of the status determination processing of TPP-1. If an RBV shutter pulse or MSS start pulse is present within the frame, TPP-2 will extract the telemetry samples of the high resolution timing register and the spacecraft time code for the related second as well as any pertinent S/C attitude data. This data is then saved for inclusion in the Spacecraft Performance Data Tape by the Off-Line Processing and Analysis Software.

TPP-3 Memory Verify - TPP-3 is designed to process the data output by the spacecraft telemetry system when it is operating in the memory verify mode (reference Section 6.1.1). In this mode, the telemetry system outputs the contents of its programmed sequence memory in lieu of telemetry data samples. TPP-3 accepts this data and compares it with the predefined memory data. Discrepancies are identified and presented for display. Only TPP-3 is used for memory verify data.

TPP-4 Matrix Verify - TPP-4 is designed to process data output by the spacecraft telemetry system when it is operating in the matrix verify mode (reference Section 6.1.1). In this case the telemetry system outputs telemetry gate numbers in lieu of sample values. TPP-4 operates in the same manner as TPP-3, except that this data is compared against pre-stored gate numbers. Only TPP-4 operates on matrix verify data.

TPP-5 CMV, ALARMS, and LISP - TPP-5 runs after TPP-1 and performs three major functions on both real-time and playback data:

1. Limit Checking - Each analog function value is compared against pre-defined sets of limits to determine if it is within its specified operating values. Limit checking is mode dependent, and up to four sets of limits can be used for any function, the selection depending on the operating mode of the spacecraft.

2. Command Verification - Each command transmitted to the spacecraft by the Command Generation Subsystem is also input to ONPAS and processed by TPP-5. For each command input, TPP-5 predicts the status change(s) which should occur, and examines each frame to determine if this has, in fact, occurred. If the status change is not found within a pre-defined number of seconds, TPP-5 reports the command as being unverified. If the status change is detected, the command execution is reported verified. After looking for all of the predicted status changes in the frame, TPP-5 examines any other status changes which have occurred. These changes are identified and output for display in the Orbital Profile Report as shown in Figure 6.1-5.

3. Alarm Generation - Alarms are defined as critical spacecraft events or conditions which must be reported on a frame-by-frame basis during real-time processing, and immediately after the processing of the playback data. All of the possible alarm conditions are predefined. When an alarm condition is detected from the telemetry, TPP-5 outputs the data for an Alarm Report which defines the specific alarm condition and the time of occurrence. A sample Alarm Report is shown in Figure 6.1-6.

Off-Line Processing and Analysis Software

The Off-line Processing and Analysis Software (OFPAS) accepts playback telemetry data which has been processed by ONPAS and performs the in-depth processing required for detailed evaluation of system and subsystem performance. OFPAS also creates the Spacecraft Performance Data Tape (SPDT) for use by the NDPF.

OFPAS operates in either a batch or multi-processing mode and, like its on-line counterpart, consists of five individual processing packages operating under the control of the Off-Line Supervisor (OLS) as shown in Figure 6.1-7. OLS establishes the processing order, controls the linkages, and brings in the data from data base. Unlike the on-line processing all of the off-line packages are used to process the playback data. These packages each process all of the data on a frame-by-frame basis and collect the necessary information from each frame as required. When the last frame has been processed, the statistical and

ORBITAL PROFILE

EVENT	MODE	OBSD	PRED	SOURCE	REMARK
RCD2	OFF	12:15:16	12:15:00	CMD 165	OBSERVED
SBAN	ION	12:15:16	12:15:00	CMD 355	OBSERVED
BATT	1OFF		12:17:00	CMD 210	***NOT OBSERVED***
BATT	2OFF	12:17:32	12:17:00	CMD 210	OBSERVED
SAT	NITE	12:23:30			NOT PREDICTED

Figure 6.1-5. Orbital Profile Report

ALARMS DATA NOR FRAME 487 12:01:16 00:00:04 ALERTS A.. L..

	NAME	START TIME	END TIME	DURATION
1.	MSS MIRROR STOP	11:11:15	11:30:00	00:18:45
2.	PITCH FW SPD HI	11:58:30	11:59:59	00:01:29
3.	PITCH FW SPD HI	12:01:00		00:00:16
4.	BAT 1 TEMP LO	12:01:05		00:00:11

Figure 6.1-6. Alarm Report and Real Time Header

other calculations are made and the results compiled for display by the display software. With the exception of the Generalized Statistics Routine (GSR), the processing packages may be run in any order. The GSR computes the minimum, maximum, mean, and standard deviation for a pre-defined set of analog functions. These statistics may be computed unconditionally for a function over the entire orbit span and/or may be computed unconditionally for a function over the entire orbit span and/or may be computed on an operating mode basis. GSR computes statistics for subsequent display, trend plotting, historical archiving, and for use by the other OFPAS processing packages.

The remaining processing packages operate on and compute data for the analysis of specific spacecraft functions or subsystems, as their titles imply. At the conclusion of this processing the OLS compiles the results of these individual processing functions and wraps up the off-line processing by:

1. Writing the payload operations and processed PCM data to the SPDT.
2. Compiling the data to be plotted on the OCC plotter. The plot data is generated by the GSR and the other processing packages of OFPAS. The plot data compiled by OLS transferred to the display software where it is formatted into magnetic tape for output to the plotter.

A detailed discussion of each of the OFPAS elements appears in Section 6.1.1 and in the Design Specifications, Book 4, 5 and 6.

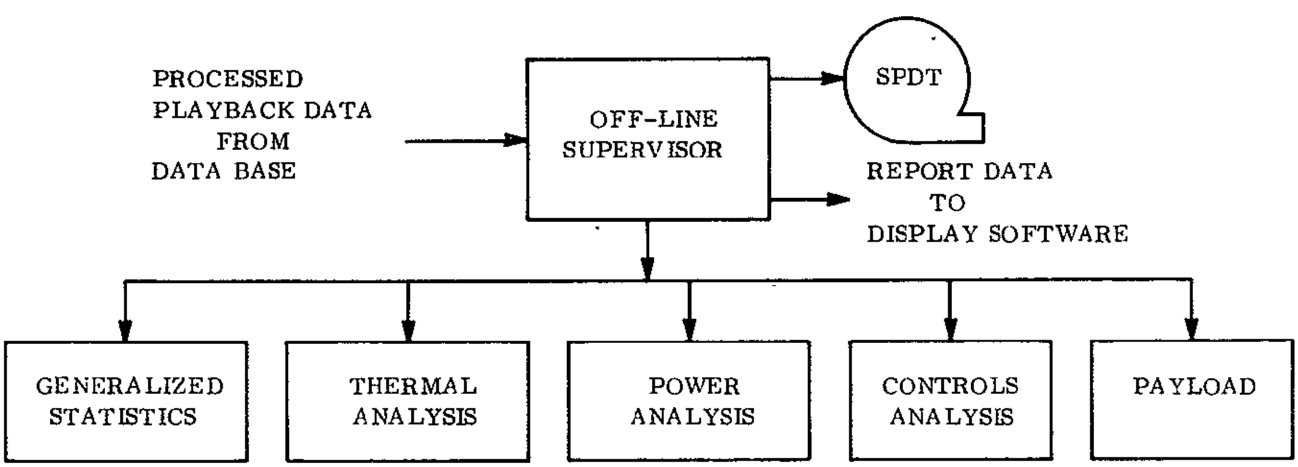


Figure 6.1-7. Off-Line Processing and Analysis Software

6.1.1 DCS PREPROCESSING

DCS Preprocessing is a stand alone functional element within the PCM Data Processing Subsystem. It consists of DCS Preprocessing Software, Convolution Decoder, and utilizes elements of the Communications and Data Distribution Subsystem and Computing Services Subsystem.

6.1.1.1 Functional Description (Figure 6.1-8)

The DCS preprocessor software will function as the key link in the data input to the OCC. This software operates in the OCC Computing Services Subsystem (Section 6.7) and is used to input, strip, route, compress, quality-check, and format data for output to the DCS Sequential Decoder or NDPF. The input will be in a near real-time mode from three ground stations based at Alaska, Corpus Christi, and NTTF. This data will be placed into NASCOM format at the receiver ground station and transmitted to the OCC. The input rates from Alaska and NTTF will be the same but those from Corpus Christi will differ. The OCC computer will accept the data through the OCC switch, check its validity by transmitted validity indications and route the data to the sequential decoder via the OCC switch on a clocked output resume basis. The data, when returned from the decoder via the OCC switch, must be again validity-checked and compressed using a buffer format. The buffer contents will be time-tagged, identified by ground station code, headed with number of words including validity information from the decoder. The buffer contents will then be written on magnetic tape.

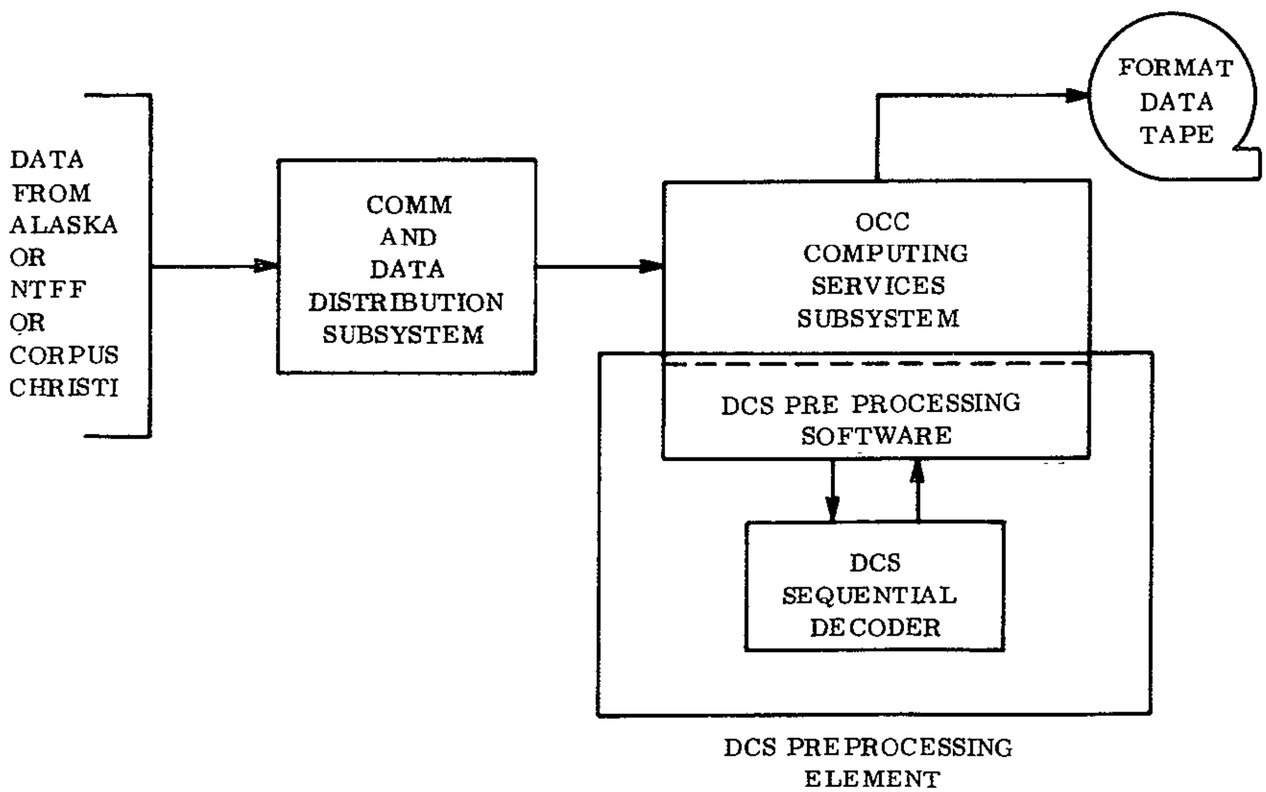


Figure 6.1-8. DCS Data Flow in the OCC

DCS data is transmitted to the OCC from three ground stations: Alaska, Corpus Christi, and NTTF. The data rates and formats for the data from NTTF and Alaska are the same, i.e., <20 kbs blocked to 2400 bits. The blocks contain NASCOM header information indicating the originating ground station, time, synchronization words, destination code and format. This data will be blocked from a continuous serial source. However, some data blocks will not be completely filled, i.e., they will contain invalid data. Corpus Christi data is transmitted from a Univac 642B computer via a 203 MODEM to a 494 computer and then through a 303 MODEM to the OCC switch. This data is of the same format, including NASCOM header information, as from the other two ground stations. A difference does exist, however, in data transmission rate. The rate for all data from Corpus Christi to the OCC is 50 kbs in two 2400 bit blocks. Figure 6.1-9 indicates the NASCOM DCS data format to be used.

Outputs are of two types: 1) the initial type of output is clocked, stripped data transmitted to the sequential decoder; the rate of transmission is semi-dependent on reception and process rate of the decoder; and 2) the data returned from the decoder is compressed, formatted in a buffer (with its validity indication) and the buffer contents are tagged with identification, number of words in the buffer satellite fly-by time, and class of data. Figure 6.1-10 indicates the format to the output data tape.

6.1.1.2 Operations

It is anticipated that OCC DCS preprocessing requires approximately 20 minutes during each 100 minute period. Since the incoming data is recorded, the preprocessing operation can be reinitiated at any point.

6.1.1.3 DCS OCC Preprocessing Software

The software will perform the following functions:

1. Synchronization with the input data.

2. Stripping the NASCOM header information from the input DCS data.

3. Timing an output rate to the decoder via the OCC switch provided the data is not identified as "Void" i.e., from a null transmission period. If a null transmission period occurs, the data must be compressed to effect a continuous data stream. On a non-fixed basis, i.e., decoder-determined, it must receive the returned data, coincidental with quality indication, and compress this data into a buffer, the contents of which are tagged with identification, number of words, time, and quality content indication. Upon completion of filling a pre-determined buffer size (at this point assumed to be 500 data words), the buffer will be output to digital magnetic tape. An indication of end-of-valid data on the tape will be a double end-of-file. If the final buffer of the tape is not filled prior to end-of-transmission, a forced output will occur and an indication of last valid data word will be included.

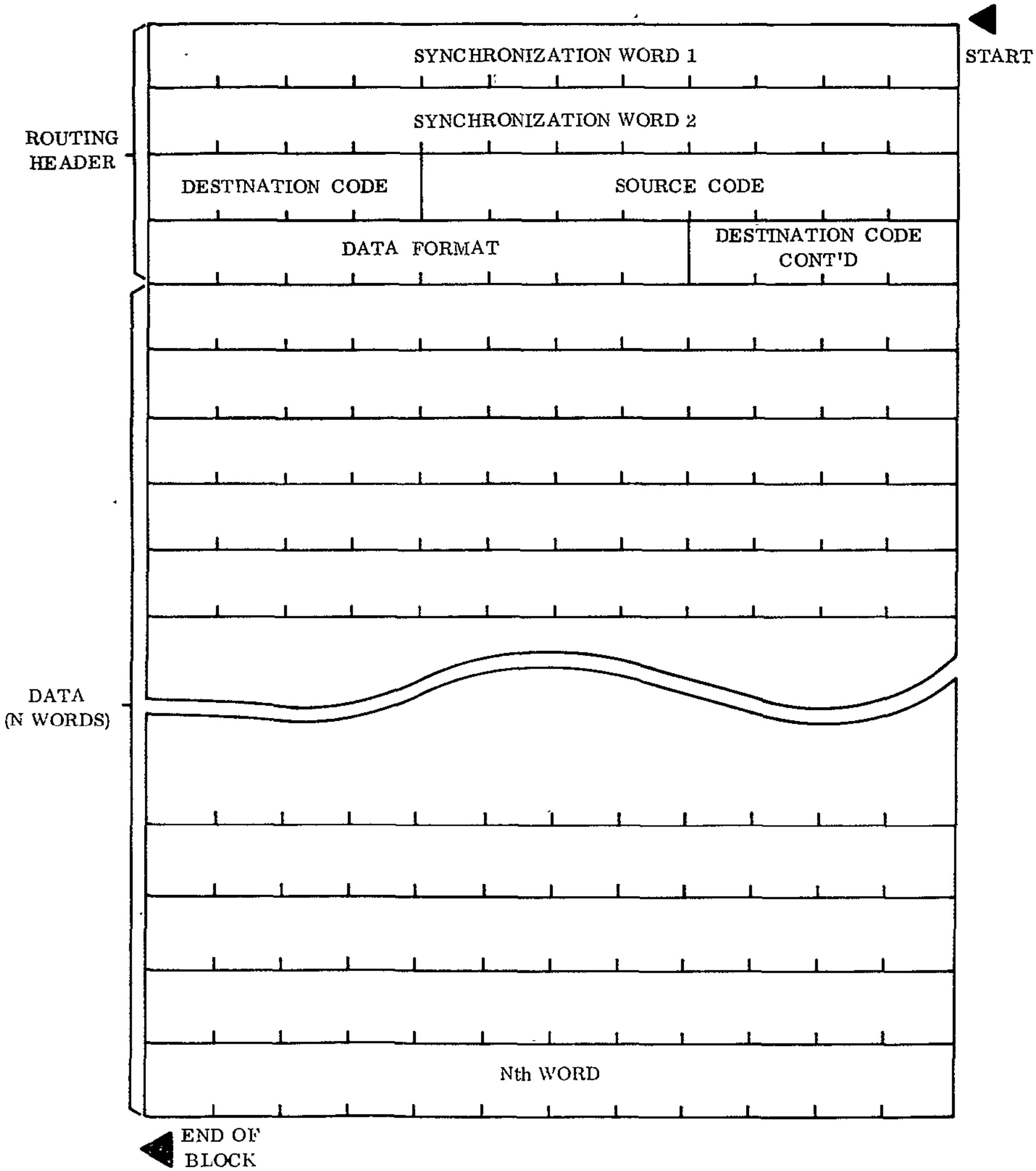


Figure 6.1-9. NASCOM MSP Basic High Speed Data Format

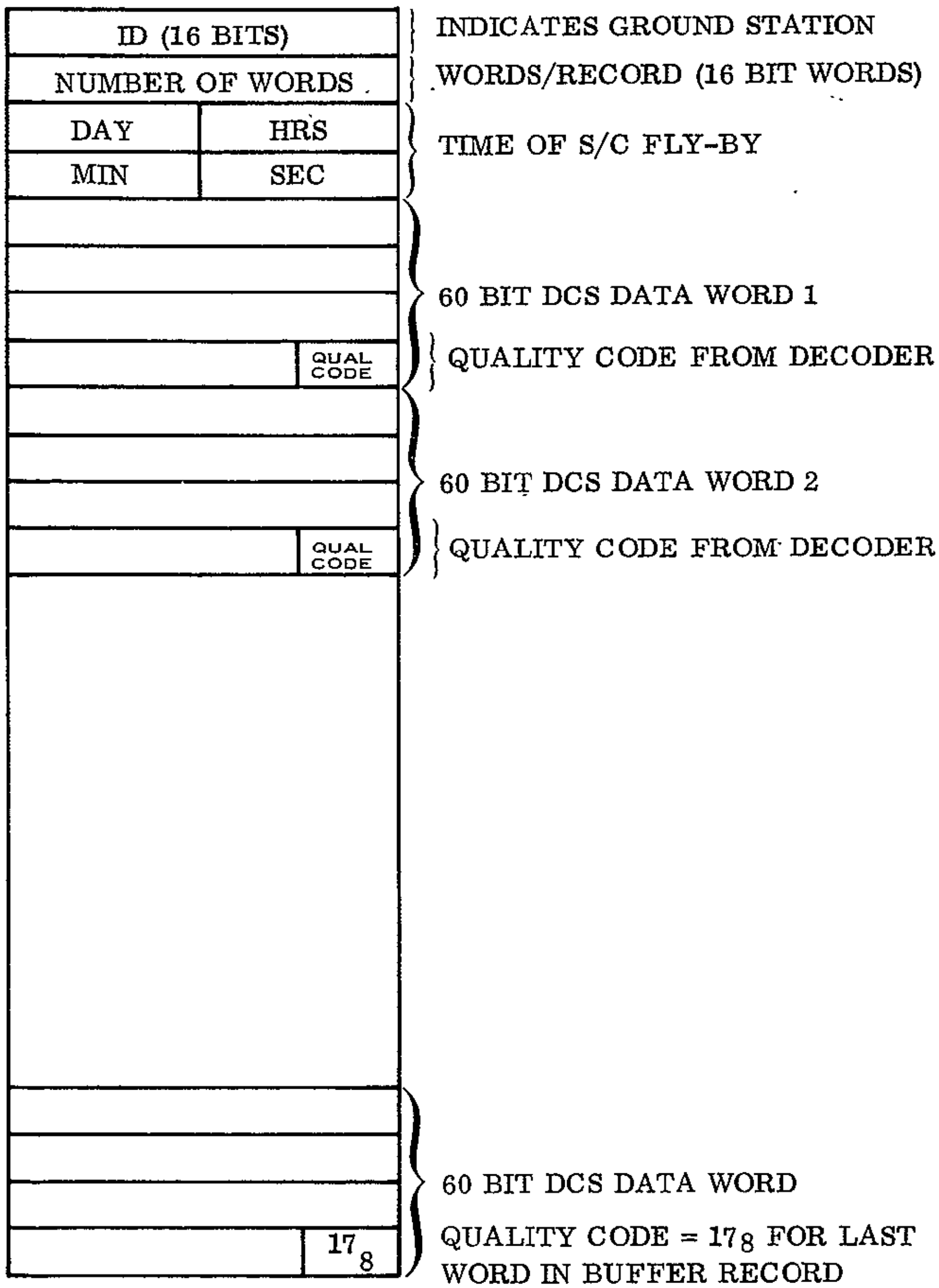


Figure 6.1-10. Formatted Data Record as OCC Output to Magnetic Tape

6.1.1.3.1 OCC Sequential Decoding

Special purpose hardware at the OCC is used to implement the Viterbi algorithm for sequential decoding of the received data stream; to detect and correct bit errors and to flag bit erasures* prior to the formatting of the DCP messages on tape for processing by the CPU. The decoder accepts input bits serially, in increments of three (as output by the bit demodulator) and determines maximum likelihood correlation over a span of 48 bits to sequentially output a correct** message.

As a part of the decoding process, all redundant (code) bits are discarded. Consequently, the original message, comprising only the preamble, the DCP's ID and the 48 bit data block 1 output to the OCC computer via the OCC switch. Since the original message was doubled (in length) by the encoder and tripled by the 3-bit quantized output of the bit demodulator, the decoder actually outputs one message bit for each 6-bits input.

When the algorithm is unable to correct errors, or to establish a maximum likelihood correlation path (due, for example, to long burst errors or signal "drop-out") the errored bit positions are flagged so that the computer can identify these positions (and the messages containing the known errors) during the message formatting process. Thus, the message blocks output to the NDPF can be categorized as "correct" or "known to contain errors, as indicated". The presence of identified bit errors will not, in general, negate the utilization of the remainder of the message.

The sequential decoder is capable of processing data, under control of the DCS Preprocessing Software.

6.1.1.4 DCS Hardware Description

6.1.1.4.1 OCC

Viterbi Algorithm Decoder***

The Viterbi algorithm provides a maximum likelihood technique for decoding convolution codes. The algorithm is optimum in the sense that the most probable transmitted channel sequence is selected given the received channel sequence. Unfortunately the complexity of this optimum algorithm grows exponentially with the constraint length codes if real-time decoding using a general purpose computer is required. However, special purpose hardware can be used to implement longer constraint length decoding in real time in a relatively inexpensive manner.

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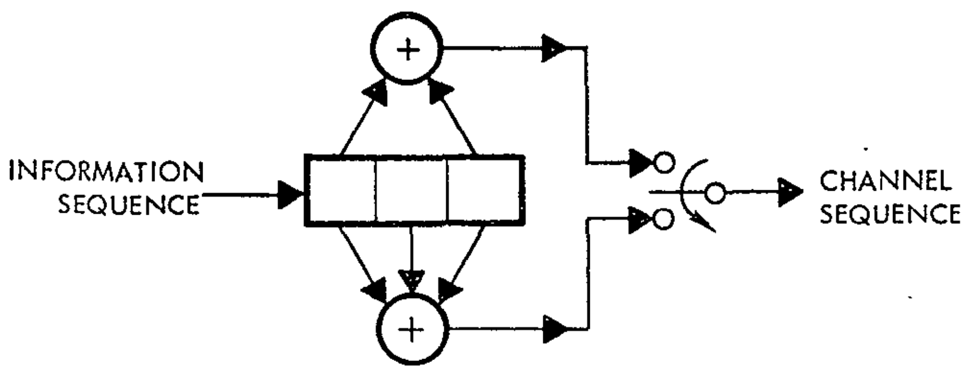
*Erasure" refers to the identification of bits that are in error and that cannot be corrected by the algorithm.

**Correct" within the capabilities of the code and the decoding algorithm used. Random bit errors are corrected with a very high probability; burst errors of length 6 or more are not.

***"A Digital TV Demonstration Test Set with Data Compression and Error Correction Coding". Technical Report 33, December 1969, Advanced Technology Department, Radiation Incorporated.



K = 3, RATE 1/2 CONVOLUTION CODER

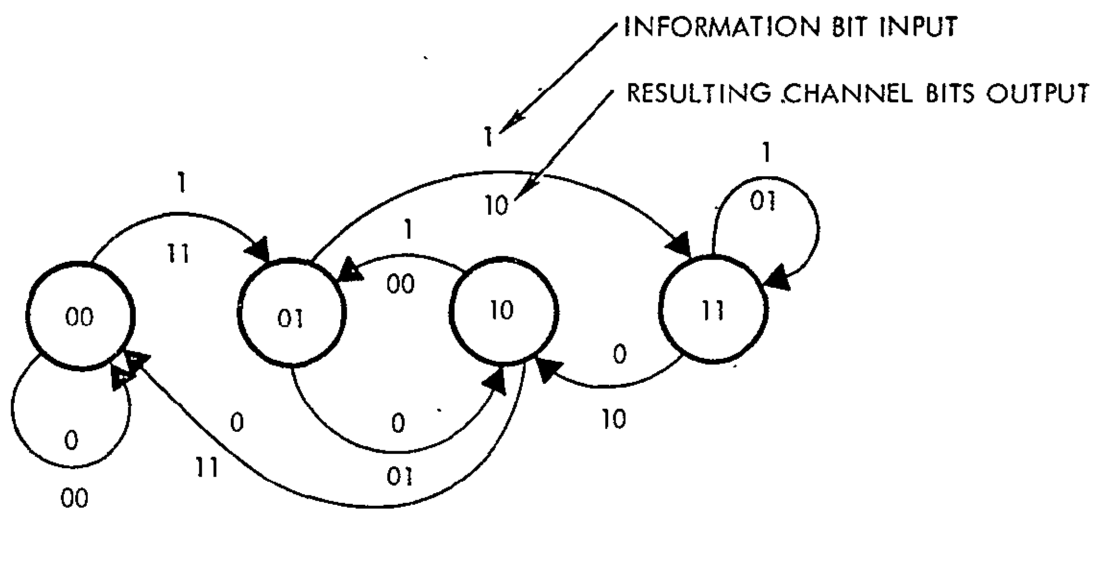


Figure 6.1-11. State Diagram for a K-3, Rate 1/2 Convolution Code

Although the DCS described will utilize an encoder of constraint length 8, a constraint length 3, rate 1/2 convolution encoder is shown in Figure 6.1-11 to illustrate the decoder operations. The constraint length is equal to the number of stages in the shift register that feeds the mod-2 adders. The encoder is completely characterized by the state diagram also shown in Figure 6.1-11. The state of the encoder is determined by the most recent (k - 1 bits of the information sequence input to the encoder (k = constraint length). Thus there are 2^{k-1} states of the encoder. Given the state that the encoder is in, the next bit input from the information sequence determines the state to which the encoder progresses and also the bits generated at the output of the encoder. After each bit is entered into the encoder the outputs of the mod-2 adders are sequentially sampled to form the channel sequence. Thus for a rate 1/2 code, 2 channel bits are generated for each information bit. On the state diagram for the encoder the state transitions and the resulting channel bits are shown. Given any information bit sequence, one can trace out on the state diagram the resulting channel sequence that would be generated. From the state diagram one can observe that once two paths are in the same state, both paths have identical extensions out of that state. This is the crucial property of a convolution code utilized in the Viterbi algorithm decoding procedure.
The output of the encoder will generally be communicated over a noisy channel and as a result some of the bits in the channel sequence will be decided in error. The function of the decoder is to determine the information sequence fed into the encoder given the noisy received channel sequence and knowing the encoder state diagram. Assume that initially the encoder is loaded with all zeros. One may call the group of channel bits put out by the encoder for each input bit a "branch". For rate 1/2 codes the number of bits/branch is 2. The Viterbi algorithm now computes the correlation of the first k received branches with each of the 2^k possible code words that could have been generated at the encoder. There are 2 of these 2^k code words in each of the 2^{k-1} states. One corresponds to an information bit "zero" for the initial bit and the other corresponds to a "one". Since these two paths have identical extensions out of the state they both will correlate equally well with the received sequence hereafter so the correlations may be compared and the hypothesized sequence with the smaller correlation may be discarded (along with the smaller correlation). This procedure is followed for each of the 2^{k-1} states and results in 2^{k-1}correlations. Note that the information sequence is retained, not the channel sequence. The information sequences that "survive" the correlation comparisons are called survivor sequences. There is one survivor sequence in each of the 2^{k-1} states can be computed. These branch correlation increments are added to the previous correlations to form cumulative running correlations. Thus 2^k new "running" correlations are formed and again there are two hypothesized paths in each of the 2^{k-1} states. The correlations representing two paths in the same state are again compared and the smaller correlated paths discarded. This doubling and then halving process continues as each new branch is received. By eliminating the smaller correlated path in each state only paths which can never be candidates for the highest correlated path in the state diagram are discarded. Thus the highest correlated path at any time is the surviving path with the highest correlation.

Note that as each successive branch is received the length of the survivor sequences increases by a bit. One obviously would like to make a decision on a bit after some finite length of time. Up to this point the process has simply been storing all 2^{k-1} contending sequences along with their associated correlations. One may now make the registers for storing the survivor sequences B bits long. It turns out that if B is large enough the 2^{k-1} survivor sequences will, with high probability, all be unanimous as to the initial bit in the sequences. This unanimity on a bit in the survivor sequence is the way that the Viterbi algorithm inherently makes bit decisions. Suppose that one wishes always to make a bit decision with finite length storage registers for the survivor sequences. In this case the following decoding strategy may be adopted. A decision is made on the ith information bit by taking the ith bit of the survivor sequence with the highest cumulative correlation at the (i + B) th branch, producing a B bit delay in decoding.

In summary, the implementation of the Viterbi algorithm must include the following functions:

1. The correlation of a received branch with each of the two possible branches out of each of the 2^{k-1} states must be formed. These are called the branch correlation increments.

2. The branch correlation increments must be added to the preceding 2^{k-1} survivor correlations to form 2^k running correlations.

3. The two running correlations in each state are compared and the larger is stored as the new survivor cumulative correlation in the state.

4. The survivor sequence in each state is stored in a register of length 6k bits. This necessitates discarding the oldest bit (which has already been decoded) to make room for the newest bit.

5. The oldest bit of the highest correlated survivor sequence is output as the bit decision.

Since the Viterbi algorithm decoder described maintains cumulative correlations of the survivors, the bit decisions are determined by the best correlated path going all the way back to the beginning of the message. Since only the most recent 6k bits of each of the survivor information sequences are stored, however, one cannot change decisions on bits older than 6k. The result is that the sequence of bit decisions the decoder makes may not be along a connected path through the code tree. The probability of this happening though with a survivor sequence storage register 6k bits long is very low. The important thing is that the decoder is not forced into making its decisions along a tree path that is connected. In other words the Viterbi algorithm decoder is a feedback-free decoder.

6.1.1.4.2 Remote Stations

A. FM Subcarrier Demodulator. The FM subcarrier demodulator is a phase-lock system. Its characteristics are listed as follows:

Subcarrier input	1.024 MHz plus or minus 5 percent
Power input	0DBM, limited
Modulation	FSK, plus or minus 25 kHz, 4.2 kbits

B. Bit Demodulator Description. A functional block diagram of the bit demodulator is shown in Figure 6.1-12. The sequence of events is as follows:

1. When only noise is present the VCO operates at a frequency determined by the random phase measurements obtained from the phase detector. The bit decision device supplies random bit decisions made upon the noise each bit time as defined by the timing generator. The squelch circuitry, however, indicates no signal and prevents the A/D from operating. At this time the phase detector makes two separate phase measurements per bit (Mode 1 operation). Each measurement is held for 1/2 bit period and is either passed directly or inverted by the polarity correction device.

2. When a command signal first appears the squelch circuit remains in a no signal condition (for the first five bit periods on the average). During this time the phase loop is receiving proper signals so that the VCO locks either in phase or 180 degrees out of phase with the incoming square wave. As before, the phase detector outputs two phase measurements per bit, each delayed by one-half bit. If the VCO timing signal to the phase detector is within one quarter bit of the preamble square wave when It first appears, the bit decision device will output zero. The loop polarity correction will pass the phase measurements unmodified to the VCO and it will lock in phase with the preamble square wave. If the VCO timing signal is greater than one quarter bit displaced in time when the preamble square wave appears, the bit decision device will output a one level which will cause the loop polarity correction to invert the phase detector outputs causing lock 180 degrees out of phase rather than in phase. The message decoder during this period, is still inhibited by the squelch.

3. When the squelch circuit indicates signal presence, the bit detector output is examined in the ambiguity resolver. If the bit decision outputs is zero at this time, the VCO is locked in phase rather than out of phase which indicates that the timing throughout is proper. If the decision is one, however, it indicates that the VCO is locked one-half bit out of phase and the timing generator is stepped one-half bit period. In either case the timing to the phase detector is modified so that phase error measurements are made once per bit (Mode 2) rather than twice per bit. This causes the phase measurements to be delayed one bit rather than one-half bit. Since the bit decisions which control the polarity correction are also delayed one bit period, this causes the polarity correction signal to act upon the phase measurement made during the proper bit times. During the preamble this is not important, but when data appears, this is necessary for proper operation.

4. Upon loss of signal presence the timing generator is reset to its initial state.

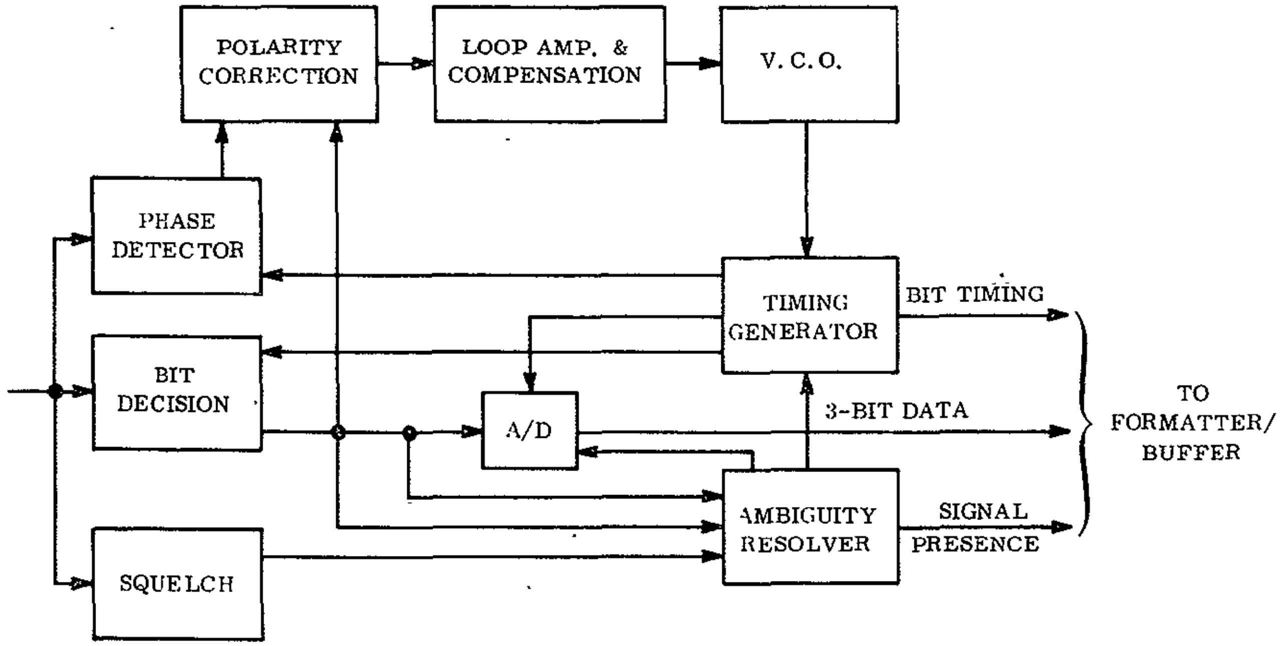


Figure 6.1-12. Functional Block Diagram of Bit Demodulator

C. Formatter/Buffer. A functional block diagram of the formatter/buffer is shown in Figure 6.1-13. The sequence of events is as follows:

1. When the formatter/buffer operation is started, fixed routing header (48 bits) is placed in the output shift register. This header is then shifted out at a 17.8 kHz bit rate.

2. After the Header has been transmitted, 4-bit words are removed from the buffer and shifted out at the 17.8 kHz bit rate. The buffer is loaded by sampling the 3-bit data word and squelch lines at a 4.2 kHz rate, determined by the bit timing.

3. Once the 565 4-bit words have been transmitted, the time of DCS data reception is placed in the output shift register and transmitted.

4. Following the time information the sequence is repeated by loading the header is the output register.

6.1.2 PROCESSING REQUIREMENTS STUDY

The telemetry data transmitted from the spacecraft is the primary source of information for assessing the status, health, and performance of the spacecraft and its subsystems. The real-time telemetry data is available to the OCC on-line during each acquisition via the networks. Alaska and Corpus Christi data will normally be input via the NASCOM 494 Communications Processor, while NTTF data arrives by hard line. Playback data may be acquired at all three stations but only Alaska and NTTF can supply the data to the OCC without reduced speed playback.

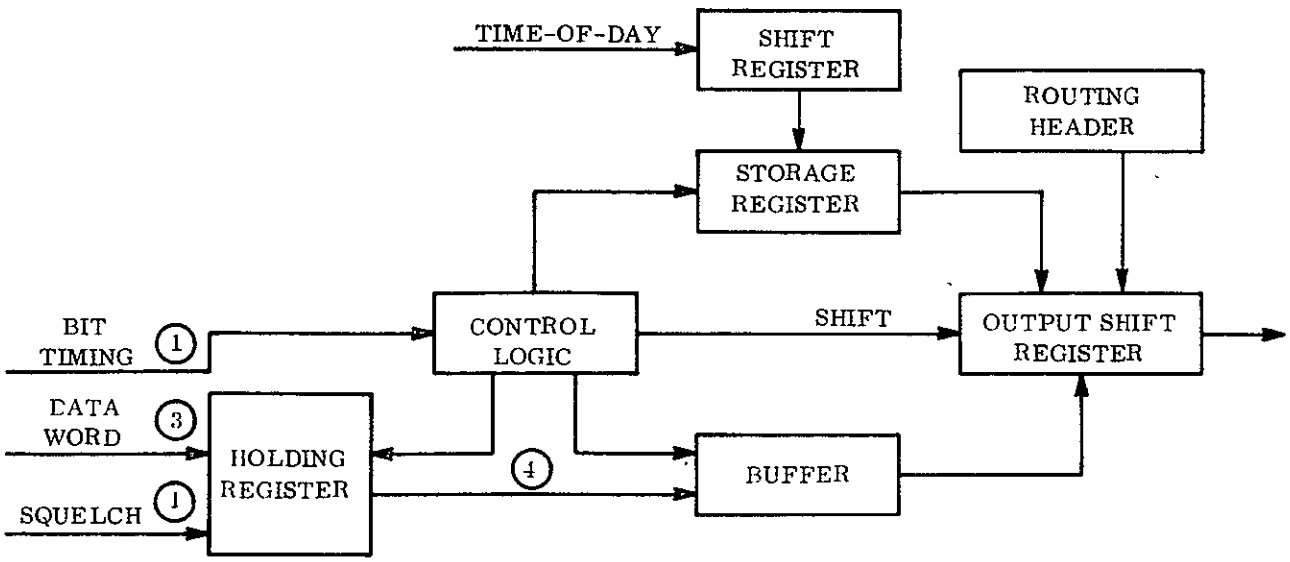


Figure 6.1-13. Functional Block Diagram of Formatter/Buffer

In its normal mode of operation the spacecraft telemetry matrix consists of 20 columns, each 80 rows deep. Two columns are used for synchronization, one for spacecraft time, and one for minor frame identification. The columns remaining contain sampled input data.

Each of the 1600 words in the matrix is 10 bits long. One complete matrix is generated each 16 seconds and the data is output in real-time at a 1 kbps rate. The output data is output in real-time at a 1 kbps rate. The output data may be transmitted to the ground directly and/or stored on the narrow band PCM recorder on-board the spacecraft. The stored data is played back at a 24 to 1 speedup and the data is output newest data first, (i.e., "reverse" order). Playback of one orbit (approximately 108 minutes or 405 frames) of PCM data would require 4.5 minutes.

In addition to the normal mode, the spacecraft telemetry system may be commanded into several other modes of operation:

1. Comstor Verify
2. Matrix Verify
3. Memory Verify
4. Emergency

Comstor Verify mode causes the contents of the Command/Clock memory, that is, the stored command load, to be input to the telemetry matrix in lieu of the spacecraft time code. This mode is normally entered after a new load has been transmitted to the spacecraft and permits verification of the load prior to activation.

Matrix Verify mode causes the telemetry system to output data gate addresses instead of the actual sampled data. This permits rapid confirmation of the matrix format and assists in test and isolation of telemetry system memory problems.

The Memory Verify mode allows the system to output the contents of its on-board memory in place of telemetry. This mode is used to evaluate the stored program used in generation of the matrix.

The Emergency mode causes all data channels to be sampled sequentially at a reduced rate. This allows data to be received at the ground station even though a major failure has occured in the telemetry system.

It is important to recognize that the format of the matrix generated in the Comstor Verify and Matrix Verify modes is the same as that for Normal Mode telemetry data; that is, 1600 word frames, with each word containing 10 bits. The format for Memory Verify and Emergency modes are each different.

Ground station handling of the PCM data will differ depending upon the station involved and the type of data received (real-time or playback). A detailed discussion of this subject and the related studies is found in Section 5.4.1.

6.1.2.1 Real-Time Processing

The real-time PCM data must be processed on-line by the OCC in order to determine and monitor spacecraft and payload status and health for routine operations and to detect and identify any anomalies in performance which may occur. This processing must also verify the execution of real-time commands and the proper loading of the stored command sequence in the command memory.

The PCM Data Processing Subsystem must be capable of accepting the various modes of real-time telemetry data input from either the NASCOM 494 Communications Processor or NTTF hardline. In both cases the telemetry data must undergo sync, verify, and lock processing in order to identify and re-establish the ten bit word structure output from the spacecraft.

At this point, selected words may be routed to analog displays within the OCC Status Control and Display Subsystem (Section 6.5). Each major frame of telemetry must be processed further, however, in order to develop the full range of information required within the OCC. This processing is intended to operate the incoming telemetry data and make the results available for display by the control and display subsystem. This processing must include the following:

1. PCM Quality Checking – Telemetry frame sync, subframe ID will be quality checked. All data in a subframe determined to be of poor quality will be flagged "BAD" and subsequently not processed by other telemetry software.

   Statistics reflecting sync and subframe ID quality for data received this acquisition, and indicators reflecting current frame sync quality will be computed and made continually available for display.

2. Reformatting - The PCM matrix will be reformatted to make its handling by subsequent telemetry processing packages more economical in terms of tabular information required to locate the data. Relocation data, in the form of tabular constants will be required.

3. Range Checking - Selected analog function values are compared against a series of up to four predetermined ranges to determine which, if any, of the four ranges the function value is in. Typically, range checked functions may be used for other processing as well.

   Functions which are range checked may also be limit checked after status determination. Tabular information is required to range check each function.

4. Status Determination - Nearly all meaningful modes of the spacecraft can be determined and described via the telemetry data. Approximately one hundred unique spacecraft events will be defined. The purpose of the status determination software is to monitor the spacecraft and subsystem configuration and assign one of several predefined states to each event. For example, the status of an on-board recorder may be shown as:

Event		Mode
Recorder 1		Record
	or	
Recorder 1		Rewind
	etc.	

   A binary coded descriptor, showing each operating mode, is appended to the PCM frame. This allows other processes to determine the operating mode of the S/C. The data block containing the S/C status indicators for this, the current, frame are also made available to the display software for generation of the S/C Status report as shown in Figure 6.1-14.

5. Limit Checking - Each analog function will be limit checked to determine if it is within its specified operating values.

SBNA	OFF	BAT1	ON	MRCM	OFF	IRIS	ON	SIRS	ON	YAWC	GYR
SBNA	OFF	BAT2	ON	RTCM	OFF	IRHT	EN	SOBS	A	YAWP	EN
		BAT3	ON	CSCM	OFF	I-HT	OPR	SLMP	ION	SYSP	EN
EAR	OFF	BAT4	ON	IRIC	OFF	ICAL	SWE	SCAL	DAT	SADM	LO
TERM	DAY	BAT5	ON	SICM	OFF	IPOS	EN	SMTR	ON	SYRS	NOR
SAT	DAY	BAT6	ON	IRLC	OFF	IMCC	EAR	RMP	ON	SUNB	OUT
		BAT7	ON			IMIR	OPR	RMHT	ON		
10KC	A	BAT8	ON	TROV	OFF	RTTS	IDC	RMOD	RUN	ARAY	NOR
FREQ	A			PWMR	ION	HAX	OFF	RBV	ON	REGI	NOR
FMDM	NOR	CMD	EN	RTG	A	IDGN	AUT	MSS	ON		
AUX1	ON	TMPW	ON	HDTA	REC	SH-A	ON	BCN	ION	RTME	10K
AUX2	OFF	RCD1	REC	HDAR	H-M	SH-B	ON				
AUX3	ON	RCD2	OFF	HDTB	OFF	SH-C	ON	FUS2	GD		
AUX4	OFF	PMUX	ION	HDBR	IND	SH-D	ON				
AUX5	OFF							EMPW	OFF	DCS	ON

Figure 6.1-14. Spacecraft Status Report

Limits will be mode dependent, that is, one function may have more than one set of limit values depending on the spacecraft status. Event status and limit values corresponding to that status must be defined. Each function may have up to four mode-independent sets of limits. As each function is checked, appropriate flag bits will be inserted into the telemetry word to indicate out of limits low, out of limits high, or in limits.

Functions which are out of limits will be made available for display at the operations consoles. This information will include:

a. Function number and name

b. Predefined limits

c. Duration of out-of-limits condition

d. Number of samples out of limits

The results of the limit checking are available to the display software for generation of the Limit summary report. This report is shown in Figure 6.1-15.

LIMIT SUMMARY

FUNCTION NAME	EVENT	#1		EVENT	#2		EVENT	#3	EVENT	#4	
TOTAL	HI	LO	R	HI	LO	R	HI	LO	HI	LO	R
SAD MTR TEMP	SADM	ON		SADM	OFF		------------		------------		
17	100	3		14							
RBV ELECT TEMP	RBVE	ON		RBVE	OFF		RBVE	WRM			
23	0	0		5	0		0	18			
BATT 1 VOLTS	SAT	DAY		SAT	NIT		------------		------------		
4	0	4		0	0						
RBV ELECT VOLTS	RBVE	ON		RBVE	OFF		RBVE	WRM	SAT	DAY	
12	0	2		0	0		6	0	0		
REG BUS CURRENT	SAT	NITE		SAT	DAY		------------		------------		
			6			3	-				

Figure 6.1-15. Limit Summary Report

6. Calibration - The purpose of calibration is to convert the PCM counts carried in the telemetry matrix into engineering units for display at the operations consoles. Each analog function is calibrated in one of four ways depending on its type.

   a. Type I. Telemetry Volts Calibration. This is a straight line calibration between two fixed end points, 0 and 6.3 volts.

   b. Type II. Straight Line Calibration. This is a straight line calibration between two variable end points as specified in the data base. Values beyond either end point are set equal to the closest end point value.

   c. Type III. Seven Point Calibration

   d. Type IV. Ten Point Calibration. The calibration formula used for Type III and IV functions is as follows:

$$Y = \frac{X - XL}{X_h - X_L} \left((Y_H - Y_L) + Y_L \right)$$

where Y = value in engineering units

X = value in PCM counts

H = value of point in curve higher than compared value

L = value of point in curve lower than compared value

The seven and ten point calibrations have been found most suited to precise definition of the full range of engineering calibration curves.

The calibrated data may then be formatted into various spacecraft system and subsystem displays for presentation at the operations consoles.

7. Alarm Processing - Alarms are defined as those conditions or combinations of conditions which are predefined as critical and must be reported immediately. This processing will test for and report the presence of those conditions. The alarm exists after "N" occurrences of the specific conditions, where "N" is predefined for each alarm. Alarm checking is done on a frame-by-frame basis. The presence of an alarm will generate information which will be available for display.

   The conditions which can identify an alarm are:

   a. An analog function in a specific range or out of range

   b. An analog function out of limits

   c. A specific mode of an event

   d. Any combination of the above

   The information collected and used in reporting alarm occurrences include:

   a. Alarm name

   b. Start time

   c. Duration in minutes and seconds

   d. Limits of range of an analog function if one was used in alarm definition. (See Figure 6.1-6.)

8. Real-Time Command Verification - For each command transmitted to the spacecraft, the appropriate spacecraft status change is predicted. The occurrence of that change within a predefined time interval verifies the command execution. The failure of that change to occur is reported as a "not observed" (see Figure 6.1-5).

9. Stored Program Load Verification - A duplicate image of the stored program sequence transmitted to the spacecraft is maintained in the processing subsystem. The contents of the spacecraft command storage memory are read out in the telemetry matrix (replacing time code) transmitted to the OCC and compared bit-for-bit with the ground image. Failure to compare would be reported immediately and permit retransmission of the sequence. Full comparison verified that the memory is properly loaded and the command countdown times may be activated.

Telemetry processing performed on other than normal mode telemetry data will be as follows:

a. In the Memory Verify Mode, the spacecraft telemetry system will output the entire contents of its memory in lieu of actual spacecraft data. Processing performed on this data will compare the memory contents received with expected memory contents and generate reports of discrepancies.

b. In the Matrix Verify Mode, the airborne subsystem will output gate numbers in lieu of decoding gate numbers and selecting them to output data. Telemetry processing for this type of data compares the received gate number matrix with an expected gate number matrix and generates reports of discrepancies.

c. Emergency Mode data from spacecraft telemetry system is one sample of each function telemetered per frame. Processing for this type data will be the same as for normal data except tabular information would have to reflect different data locations.

6.1.2.2 Playback Processing

Playback data is the basis for the in-depth performance evaluation and trend analysis required in the OCC. This data describes the performance of the spacecraft throughout the orbital period. Both the power and thermal control functions of spacecraft are performed on a cyclic basis which is almost completely asynchronous with the acquisition cycle. Adequate evaluation and effective management of these functions is dependent upon the timely availability of the playback data which describes the operation.

The playback data also contains information regarding significant activities which are specifically programmed to occur outside of real-time coverage areas. These activities include certain routine spacecraft events, especially in the Attitude Control Subsystem, as well as payload and WBVTR operations. Many of these events can be unique to the non-real time period in which case a malfunction might not be readily apparent in the real-time data.

As a result, routine post-pass processing is required in the OCC. This processing must be done immediately post-pass and in considerably greater depth than for the real-time data The Alaska and NTTF stations provide sufficient coverage for the playback data and are able to transmit it to the OCC in the shortest time. Playback data from Corpus Christi is not required, nominally.

The processing requirements for the playback data fall basically into three categories:

1. System evaluation
2. Subsystem evaluation
3. Trend and historical data analysis

System Evaluation

The processing required for system evaluation is almost identical to that described for real-time data although there are both real and philosophical differences. In the case of real-time data the results of the processing are made available for display immediately on a frame-by-frame basis. This is not the case for playback data which contains some 400 frames of telemetry information. The function of the processing here is to process each frame as described for real-time, and to develop summary report information which clearly identifies anomalies or other problems in the data. These summary reports serve to initiate more detailed investigation if this is warranted. The processing to be performed on the playback data should include:

1. Limit and range check for all frames
2. System and subsystem status from each frame
3. Stored command verification
4. Calibration in engineering units
5. Alarms
6. Pseudo function generation
7. Payload telemetry data extraction

Each of these processing functions is described in Section 6.1.2.1. The summary report data resulting from the limit and range check processing, for example, would be organized by subsystem, and would identify each telemetry function which exceeded the predefined extremes, its value at that time (or times), and the status and mode of the spacecraft subsystem at that time.

Subsystem Evaluation

Subsystem evaluation processing is designed to provide a tool for in-depth performance analysis of a particular subsystem or set of subsystems. The processing performed here is generally unique to each subsystem but also draws upon and utilizes the results of the system evaluation processing. The results of subsystem evaluation processing, then, would be reported as a complete subsystem report package which incorporated the limit check summary information, alarms summary information, and other similar data relevant to that subsystem. Subsystem evaluation programs are required for the following:

1. Power

2. Thermal

3. Controls (including the Orbit Adjust Subsystem)

4. Payload (RBV, MSS, and WBVTR)

Power - This processing would be used to monitor and evaluate the power balance and overall operation of the power subsystem. The PCM data would be reconstructed into power management data orbits from which specific subsystem parameters are computed. These would include battery temperature and voltage profiles and other pseudo functions relating to:

1. Charge/Discharge ratio

2. Shunt factor

3. Load sharing

4. Charge sharing

5. Thermal balance monitoring

6. Battery conditions monitoring

Subsystem evaluation data will be displayed in the Power analysis reports Figures 6.1-16 through 6.1-18.

Thermal - The in-depth processing of thermal data from the spacecraft can provide an extremely effective tool. This processing provides the capability of organizing, evaluating, and presenting the thermal data in a variety of ways. Temperature data may be presented for each subsystem, for components within a bay, for each bay, or for the entire ring. Temperature data is generally presented ir terms of minimum, maximum, and mean values, computed over the orbit. Alternatively, provision should be made for mode-dependent calculations, i.e., averages over satellite day or night, subsystem on or off, etc., if these are meaningful. This processing will also report on shutter position, sensor plate temperatures, and predicted shutter positions, as well as selected pressure values and other related parameters as shown in Figure 6.1-19.

Controls - In-depth processing of controls data is intended to provide a complete orbital profile and analysis of controls activity and to identify status and performance trends. Similar processing would be done for the orbit adjust subsystem for those periods when it was active with considerable off-time monitoring of temperatures and pressures within the subsystem as well as calculations of predicted impulse and other required parameters.

POWER ANALYSIS PROGRAM
ORB 00251 26 MAY 68 TIME 16:16:10(005) TO 18:03:38(408) 0.0 BAD DATA 0.1 SMOOTH

POWER DETAIL REPORT BY MAJOR FRAME N = 40

BATTERY STATUS CHARGE

SATELLITE DAY — BATTERY VALUES---AMP MIN — . . . . CURRENTS . . . .

FRAME	TIME	1	2	3	4	5	6	7	8	TOTAL	RGB	SA I	RTGA	RTGB	UNRG VOLT	SHUNT I FACTOR
19	16:19:54	1.64	1.58*	1.59*	1.64*	1.37*	1.37*	1.29*	1.33*	11.80	8.19	6.6	.9	0	-31.9	2.186

BATTERY STATUS DISCHARGE

SATELLITE NIGHT — BATTERY VALUES---AMP MIN — . . . . CURRENTS . . . .

FRAME	TIME	1	2	3	4	5	6	7	8	TOTAL	RGB	SA I	RTGA	RTGB	UNRG VOLT	SHUNT I FACTOR
59	16:30:34	9.40	10.02	10.66	11.07	9.62	10.31	9.25	10.53	80.87	7.77	0	.9	0	-29.3	-.246
99	16:41:14	18.90	20.70	21.25	21.48	19.72	20.68	19.00	21.54	163.28	7.93	0	.9	0	-28.7	-.134
139	16:51:54	26.62	31.53	32.02	32.05	30.11	31.47	29.09	32.83	247.92	7.92	0	.9	0	-28.0	.051
150	16:54:50	31.62	34.50	35.03	34.73	32.75	34.17	31.65	35.66	270.11	7.92	5.8	.9	0	-28.9	-4.867

BATTERY STATUS CHARGE

SATELLITE DAY — BATTERY VALUES---AMP MIN — . . . . CURRENTS . . . .

FRAME	TIME	1	2	3	4	5	6	7	8	TOTAL	RGB	SA I	RTGA	RTGB	UNRG VOLT	SHUNT I FACTOR
190	17:06:30	5.61	6.01*	6.17*	5.67*	6.11*	5.80*	5.99*	6.08*	47.45	8.58	13.4	.9	0	-31.4	-.609
230	17:16:10	10.75	12.13	12.06	10.97	12.11	11.25	11.62	12.11	93.00	8.37	13.4	.9	0	-32.0	-.681
270	17:26:50	15.71	18.50	18.12	16.40	17.95	16.66	17.21	18.36	138.91	8.34	13.4	.9	0	-32.5	-.726
310	17:37:30	21.04	24.79	24.27	22.26	23.29	22.40	22.87	24.53	185.46	8.35	13.4	.9	0	-33.1	-.861
350	17:48:10	26.34	31.00	30.40	28.49	28.64	28.40	28.57	30.81	232.64	8.28	13.4	.9	0	-33.8	-.843
390	17:58:50	31.80	37.19	36.72	35.23	34.09	34.34	34.02	36.86	280.24	8.44	13.3	.9	0	-34.9	-.954
408	18:03:38	33.70	39.15	38.87	37.57	35.98	36.33	35.87	38.72	296.19	7.92	13.2	.9	0	-37.2	-1.134

Figure 6.1-16. Power Report

POWER ANALYSIS PROGRAM
ORB 00261 28 MAY 68 TIME 16:16:10(005) TO 18:03:38(408) 0.0 BAD DATA 0.1 SMOOTH

POWER SUMMARY

SEGMENT	FRAMES	TIME INT	RTG A AM	RTG B AM	ARRAY I	ARRAY AM	AUX AM	SHUNT AM	LOADS FLAGS	UNREG V	REG.BUS I	REG.BUS AM	SHUNT AM	FACT I	CHGE I UNREG V	K ARRAY I
SN	6 TO 137	32MIN	26.1	0	0	0	0	0	GGGGGGGG	-28.9	8.08	284.3	-5.9	-.184	0	0
SD	138 TO 418	72MIN	64.6	0	13.3	996.7	102.0	.6	GGGGGGGG	-32.4	8.40	633.4	-48.2	-.730	-32.3	13.4
*SD	5 TO 10	4MIN	3.8	0	12.8	51.4	6.7	2.3		-36.0	8.79	35.2	-4.6	-1.139	-35.6	13.3
TOT	0 TO 0	108MIN	90.5	0	13.3	1048.1	108.7	2.8		-32.7	8.50	952.9	-58.7	-.752	-32.4	13.4
*SN	20 TO 150	35MIN	33.1	0	.0	1.5	0	0	GGGGGGGG	-29.0	7.95	277.9	-7.8	-.221	0	0
*SD	151 TO 409	69MIN	64.9	0	13.4	916.9	105.9	8.6	GGGGGGGG	-33.0	8.23	563.7	-57.6	-.834	-32.5	13.4
INT	0 TO 22	6MIN	0	0	13.4	78.6	0	0		-33.9	9.50	55.7	0	0	0	0

SAT DAY

BATTERY NUMBER	1	2	3	4	5	6	7	8	SYSTEM TOTAL
CHARGE	1.64	1.58	1.59	1.64	1.37	1.37	1.29	1.33	11.80 AMP MIN
CHARGE SHARING	13.87	13.39	13.44	13.98	11.60	11.57	10.92	11.29	100.00 PERCENT
MAX CHG VOLT	-33.85	-33.74	-33.66	-33.75	-33.88	-33.62	-33.80	-33.87	-33.77 VDC
BATTERY TEMP	15.30	19.95	19.25	18.11	18.51	17.41	16.04	17.14	17.71 DEC
DELTA BATT VOLTS	0	0	0	0	0	0	.0	0	0 VDC

TOTAL SEGMENT

BATTERY NUMBER	1	2	3	4	5	6	7	8	SYSTEM TOTAL
CHARGE	37.36	41.64	42.09	40.20	38.65	38.11	39.10	41.97	319.31 AMP MIN
DISCHARGE	32.89	35.24	35.57	36.41	33.69	35.10	32.82	36.68	278.40 AMP MIN
C/D RATIO	1.14	1.19	1.18	1.10	1.15	1.09	1.19	1.14	1.15 C/D RATIO
CHARGE SHARING	11.70	13.10	13.18	12.59	12.10	11.93	12.24	13.14	100.00 PERCENT
LOAD SHARING	11.81	12.66	12.77	13.08	12.10	12.61	11.79	13.17	100.00 PERCENT
DELTA BATT VOLTS	-1.19	-1.02	-1.20	-1.20	-1.20	-1.20	-1.03	-1.20	-1.15 VDC
BATTERY TEMP	17.35	21.43	21.11	20.33	19.94	18.87	17.95	18.80	19.47 DEC
TIME GTR THN K I	44.00	44.00	45.00	14.00	44.00	42.00	44.00	44.00	40.00 MIN
MAX CHG VOLT	-33.85	-33.74	-33.66	-33.75	-33.88	-33.79	-33.80	-33.87	-33.79 VDC
END OF NITE VOLT	-28.77	-28.82	-28.71	-28.76	-28.73	-28.65	-28.83	-28.73	-28.75 VDC

Figure 6.1-17. Power Report

SAT NIT

BATTERY NUMBER	1	2	3	4	5	6	7	8	SYSTEM TOTAL
DISCHARGE	31.62	34.50	35.03	34.73	32.75	34.17	31.65	35.66	270.11 AMP MIN
LOAD SHARING	11.71	12.77	12.97	12.86	12.12	12.65	11.72	13.20	100.00 PERCENT
END OF NITE VOLT	-28.77	-28.82	-28.71	-28.76	-28.73	-28.65	-28.63	-28.73	-28.75 VDC
BATTERY TEMP	15.36	19.95	19.25	18.59	18.79	17.64	16.67	17.77	18.00 DEC

SAT DAY

BATTERY NUMBER	1	2	3	4	5	6	7	8	SYSTEM TOTAL
CHARGE	33.70	39.15	38.87	37.57	35.98	36.33	35.87	38.72	296.19 AMP MIN
CHARGE SHARING	11.38	13.22	13.12	12.66	12.15	12.26	12.11	13.07	100.00 PERCENT
MAX CHG VOLT	-34.02	-33.74	-33.84	-33.93	-33.88	-33.79	-33.98	-33.87	-33.88 VDC
BATTERY TEMP	13.55	18.46	17.78	16.79	17.26	16.06	14.27	15.81	16.22 DEC
DELTA BATT VOLTS	-1.19	-1.02	-1.20	-1.20	-1.20	-1.20	-1.03	-1.20	-1.15 VDC

NOTE *** VALUE USED TO CALC. TIME GTR THN K 1 .45

POWER LIMIT SUMMARY

FUNC NO.	FUNCTION NAME	---LO	---HI	---R	------LIMITS OR RANGES IN PCM COUNTS AND ENGINEERING UNITS		UNITS
204	BATT 1 TEMP	190	0	0	48 14.60	77 34.90	DGC
237	BATT 7 TEMP	141	0	0	48 14.60	77 34.90	DGC
261	LT PADL VOLT G	0	43	0	0 0	111 -41.95	VDC
265	LT PADL VOLT J	0	44	0	0 0	111 -41.95	VDC

Figure 6.1-18. Power Report

THERMAL ANALYSIS PROGRAM

PAGE 1

TAP ORB 0058E 4 MAR 68 TIME 23:54:11(003) TO 01:26:27(349) 0.2 BAD DATA 0.3 SHOOTH

SENSORY RING

T = DGC
P = PSIA

BAY NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	BAT-1	IRLS XMTR RCVR 4WCL	IRLS ELECT BAT-2	HAX RTTS BWCL	B-CLK	4WCL	BAT-3 IF BX	BAT-4 B RCDR	CMD K BCN X ASB X	A-CLK	A RCDR BSB X	BAT-5	BAT-6 4WCL	RMP 4WCL	PWR CONT MOD	BAT-7 TME	BAT-8 ALC	TME + CONVS
SH POS DEG	87.5	10.4	2.5	9.9	14.9	9.8	9.4	1.3	12.1	-1.7	10.4	7.7	23.8	29.8		22.4	7.4	4.5
SH TH NO			42	43		44		45	46		47		48	49		51	52	
SH TEMP			11.0	12.8		10.4		7.8	6.8		8.6		18.7	15.9		16.7	19.1	
PRE SH POS			0.0	0.0		0.0		0.0	0.0		0.0		0.0	0.0		0.0	1.2	
MAX BAY T	21.2	21.2	13.7	13.7	10.5	10.5	9.9	6.8	7.4	8.0	9.9	18.1	20.6	19.3	20.6	20.4	18.1	18.7
AVG BAY T	13.9	13.7	11.7	10.5	9.2	9.0	7.8	5.7	5.9	5.8	7.6	13.5	17.2	17.4	17.9	16.4	16.0	15.2
MIN BAY T	8.0	8.7	8.7	6.2	8.0	7.4	5.5	4.9	4.9	3.0	6.2	7.4	13.7	16.2	16.2	13.9	14.3	11.8
MAX COMP T	19.	-2048.0	16.5	17.4	15.1	20.9	10.9	10.0	11.9	10.9	13.2	21.2	22.5	22.3	23.7	18.1	19.3	17.1
AVG COMP T	18.6	0.0	15.6	6.0	13.0	14.2	10.0	8.9	9.3	8.7	10.6	16.6	19.7	17.3	20.8	13.7	18.6	15.4
MIN COMP T	17.	2048.0	13.7	-1.5	11.0	7.9	8.9	7.7	6.8	6.4	8.0	12.4	15.6	13.1	17.6	8.8	16.4	13.3
MAX BAT T	19.5		16.5				10.9	10.0				17.4	19.0			18.1	19.3	
AVG BAT T	18.6		15.6				10.0	9.7				16.3	17.8			17.4	18.6	
MIN BAT T	17.4		13.7				8.9	9.3				14.0	15.6			16.7	16.4	

MAX SYS BAY TEMP	21.2	MAX SYS COMP TEMP	23.7	MAX AUX LOAD PANEL NO 1 TEMP	-20.0
AVG SYS BAY TEMP	12.5	AVG SYS COMP TEMP	13.0	AVG AUX LOAD PANEL NO 1 TEMP	-28.4
MIN SYS BAY TEMP	3.0	MIN SYS COMP TEMP	-1.5	MIN AUX LOAD PANEL NO 1 TEMP	-30.0

		MAX AUX LOAD PANEL NO 2 TEMP	-20.0
AVG SHUTTER OPENING	15.5	AVG AUX LOAD PANEL NO 2 TEMP	-20.0
		MIN AUX LOAD PANEL NO 2 TEMP	-20.0

CENTER SECTION

LOCATION	OUTBD HDRSS MUX A	OUTBD HDRSS ELF A	INBD IDCS CAM	MID CROSS BEAM	NEAR BAY 17	NEAR BAY 2	NEAR BAY 8	NEAR BAY 11	AVG CTR SEC
THERM NO	53	54	55	56	57	58	59	60	
MAX TEMP	45.0	13.0	36.8	21.2	19.9	18.7	12.4	14.9	45.0
AVG TEMP	32.8	9.1	29.8	19.4	18.5	17.8	11.2	13.8	19.1
MIN TEMP	27.4	7.4	26.8	16.8	16.2	15.6	9.9	12.4	7.4

Figure 6.1-19. Partial Thermal Analysis Report

Controls analysis processing will also include the generation of a large number of pseudo functions to be computed on a frame or orbital basis. Those required on a frame basis are:

Composite RMP Signal

Pitch Flywheel Momentum

Yaw Flywheel Momentum

Composite Roll Flywheel Momentum

$(\text{Roll Mom})^{2} + (\text{Yaw Mom})^{2}$

Pitch Composite Error

Roll Composite Error

Those required on an orbital basis include:

Average Flywheel Momentum (all three axes)

Night Terminator Average of $\sqrt{R^2+Y^2}$

Day Terminator Average of $\sqrt{R^2+Y^2}$

Night Ecliptic Crossing Average of $\sqrt{R^2+Y^2}$

Day Ecliptic Crossing Average of $\sqrt{R^2+Y^2}$

Gas Tank Temperature Pressure

Gas Tank Impulse Remaining

Gas Tank Mass Remaining

The results of this processing will be made available for plotting.

Subsystem evaluation data will be reported in the Controls Analysis Report Figure 6.1-20.

Payload - The processing of the payload subsystem PCM data, like that of the preceding subsystems, is designed to evaluate and report on performance and health. RBV telemetry processing will develop an orbital profile of subsystem activity, determine that the cameras operating sequence is properly maintained throughout, and trends.

INITIAL/FINAL STATUS SUMMARY

	Initial	Final		Initial	Final
1. Subsystem Pneumatics	XXXXXXXX	XXXXXXXX	5. Pitch Momentum Bias	XXXXXXX	XXXXXXX
2. Low Voltage Interlock	XXXXX	XXXXX	6. Pitch Position Bias	XXXXXXX	XXXXXXX
3. Interlock Bypass	XXXXX	XXXXX	7. Gravity Gradient Rod Position	XXXXXXX	XXXXXXX
4. Yaw Mode	XXXXXXXX	XXXXXXXX			

EVENT PROFILE

Main Frame	Time	Fine Roll	Roll Gain Tach	Scanner Video	Left SAD	Right SAD	G/G Mtr Excitation	G/G Lim Override	Sw G/G Emer. Retract
XXX	XX XX XX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
XXX	XX XX XX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
XXX	XX XX XX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
XXX	XX XX XX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
XXX	XX XX XX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
XXX	XX XX XX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
XXX	XX XX XX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX

ORBITAL PROFILE

Main Frame	Time	Submode 1 2 3 4 5 6 7	Gates	P. FW	Diff R. FW	Y. FW	Pitch Error	Roll Error	RMP Output	L. SAD Cos Pot Out	R. SAD Cos Pot Out
XXX	XX XX XX	X-X-X-X-X-X-X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXX	XX XX XX	X-X-X-X-X-X-X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXX	XX XX XX	X-X-X-X-X-X-X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXX	XX XX XX	X-X-X-X-X-X-X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXX	XX XX XX	X-X-X-X-X-X-X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
XXX	XX XX XX	X-X-X-X-X-X-X	XXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

(ORBITAL SUMMARY - NOT SHOWN)

Figure 6.1-20. Control Analysis Report

Much the same is true for both the MSS and WBVTR's, although individualized computations and pseudo functions will be required in each case. The results of this processing is summarized in a report at the computer printer and passed immediately to the operations personnel for use in the detailed off-line evaluation of sensor performance described in Section 6.2.

Trend and Historical Analysis

Trend and historical analysis processing are required to support the in-depth performance evaluation effort. This processing must be capable of assembling data computed on a frame-by-frame or orbital basis and integrating this into historical records for plotting, display, and subsequent storage and retrieval. The information involved is of value in comparative analysis with recent data and is used in establishing long term trends and evaluating and redefining certain engineering values such as limits, ranges, and possibly calibration data.

One of the most valuable of these processing functions is the development of generalized statistical data.

One of the most valuable of these processing functions is the development of generalized statistical data. This includes the generation of the average, minimum, and maximum values and the standard deviation of any selected telemetry function or function set. This processing will be performed routinely for all playbacks and for each analog function. The results will then be made available where necessary in the subsystem evaluation processing and will also be readied for plotting. This same processing capability will also be available in a utility mode where any selected function from the current orbit can be processed. The statistical computations must be performed on a mode dependent and/or time dependent basis, since many of the statistics are not meaningful when computed across the entire orbit span. For example, the capability must exist for developing statistics on a telemetry function such as Solar Array Current during satellite day and satellite night, independently.

In addition to the above, the option should exist to develop histograms for each single or set of functions. The histogram is amenable to display at either a CRT or on the computer printer and is an extremely meaningful visual representation of value spread. A ten-level histogram will be presented, with the lower and upper limits predefined. The number of samples which are equal to or less than the lower limit value and the number of samples greater than the upper limit value will be indicated. An example of a single function histogram is shown in Figure 6.1-21.

6.1.3 PCM PROCESSING DESIGN STUDY

The purpose of this study was to assess the impact on the GDHS design resulting from the processing of real-time data in the OCC is required for routine flight operations.

The requirements for timely, routine processing of the playback data for the OCC were established in the study described in Section 6.1.1. These requirements include those processing functions performed on the real-time data with some slight modifications.

FUNC. NO. 513
THERM NO. 6 TEMP
UNITS: DEG. CENT.

VALUE	RANGE	SAMPLES
EQ/LESS	20.0	000
	20.5	005
	21.0	009
	21.5	021
	22.0	163
	22.5	187
	23.0	019
	23.5	187
	23.0	019
	23.5	002
	24.0	000
	24.5	000
GREATER	25.0	000

Figure 6.1-21. Sample Histogram

The NDPF requires telemetry data for two functions: generation of the Image Annotation Tape (IAT), and generation of the Master Digital Data Tape (MDDT). The first of these, the IAT, actually requires only information pertaining to sensor operating times and the correlative spacecraft attitude data.

The MDDT is an archival tape to contain all PCM data plus orbit and attitude data. In neither case is the timing at all critical. The payload data for use with the IAT is not being transferred in real-time from the remote sites, but is being mailed, and the MDDT will not be generated until best fit ephemeris data is available.

An assessment was then made of the impact of this processing requirement on software in the OCC and NDPF. As noted in the previous study, the playback data processing requirements for the OCC included those processing functions performed on the real-time data. It was then determined that these common functions could be accomplished for both the real-time and playback data by a single software package with virtually no increased cost or complexity.

The impact on NDPF software is negligible only if the OCC and NDPF computers are identical or software compatible. In this case, it was assumed that the OCC real-time software could be carried over to the NDPF and modified there. If this is not the case, the impact on software would be significant and would result in a large amount of duplication.

The impact on computer sizing and loading was most significant. The OCC computer is sized for the real-time requirements for telemetry processing, commanding, and display. These combined requirements establish the maximum size condition, and are greater than those imposed by playback processing. Loading on the OCC computer was not a problem either, since the anticipated processing load in the immediate post-pass period was not great. As a result, the OCC computer was not affected in either size or loading by these requirements and could readily satisfy all throughput requirements.

This was not the case for the NDPF computer. In order to satisfy previously defined throughput requirements plus those imposed by the OCC for playback processing, the NDPF computer would require a 20 to 30 percent increase in core memory size and a similar increase in mass storage.

Lastly, it was determined that the OCC can easily extract the data required for the IAT from either the real-time or playback data. The input to the MDDT could be the PCM playback data processed in the OCC. Both of these inputs could be efficiently provided on a single tape on a per-orbit or per-day basis.

As the result of this study, the decision was made to process both real-time and playback telemetry in the OCC. The OCC will routinely provide the NDPF with the Spacecraft Performance Data Tape (SPDT) which contains the inputs to both the IAT and MDDT.

Several distinct benefits accrue from this decision. The OCC/NDPF interface is made extremely simple and the duplication and division of PCM processing responsibility is eliminated. The network interfaces required for PCM data acquisition are centralized within the OCC which minimizes both the interfaces and the equipment required. In addition, and no less significant, is the fact that the large amounts of tabular engineering data required for PCM processing - time slots, limits, ranges, calibration data, acronyms, sample rates, and the like - are all confined to the OCC. This eliminates the need for additional computer system storage overhead in the NDPF and centralizes within the OCC the task of configuration management of this data. Lastly, this allocation of processing responsibility offers a better balance in the work load between the OCC and NDPF by more effectively utilizing the capability already available within the OCC computer by virtue of other requirements, and by eliminating additional sizing requirements on the NDPF computer.

6.1.4 SPACECRAFT PERFORMANCE DATA TAPE (SPDT)

The SPDT was mentioned above and is the primary data interface between the OCC and NDPF. This tape will contain the payload operating times extracted from both real-time and playback data and all of the calibrated spacecraft telemetry data. The tape format has not been defined in detail at this time but will contain:

1. A header recorder which includes:

   a. Orbit number

   b. Time span

   c. Number of PCM frames

   d. Percent of good data

   e. System tape number

   f. Source station ID

   g. RBV exposure times

   h. MSS on time(s)

   i. MSS off time(s)

   j. WBVTR on time(s)

   k. WBVTR off time(s)

   END OF FILE

2. N number of PCM data records each containing a PCM frame header and the calibrated and flag annotated PCM data.

   The frame header includes:

   a. Frame number

b. S/C time at start of frame

c. Status and event flags for this frame

d. Data type identification

An SPDT covering a normal playback will contain approximately 400 such records. Planning calls for the generation of one SPDT per orbit. The SPDT will be available in the OCC approximately five minutes after receipt of the playback data.

6.2 IMAGE DATA PROCESSING AND DISPLAY

The Image Data Processing and Display Subsystem in the OCC provides the ability to monitor sensor operation during real time NTTF station contact. This capability will allow real time evaluation of payload operation and response to command. The location of this equipment in the OCC has a direct effect on many of the studies; i.e., facilities, operation, etc. The presently planned configuration is as shown in Figure 6.2-1.

The RBVC will image a 100 by 100 nm scene in three spectral bands on a storage-type photoconductor. This image content, with a maximum theoretical resolution of 3200 TV lines, will be readout in 3.5 seconds. RBVC imaging is done by utilizing an exposure shutter. The individual picture-frames will be spaced 25 seconds apart to ensure between frame overlaps of about 10 percent. Although the three RBV cameras make a simultaneous exposure, the readouts are time multiplexed to increase the system readout efficiency. This results in a stream of data 11.5 seconds long, with the beginning of each frame spaced 25 seconds apart.

The MSS images the same scene as the RBVC, but in four spectral bands (five for ERTS-B). In turn, each spectral band utilizes six detectors and the scanning is done continuously at a sweep rate of 15.2 Hz, thus covering the 100 nm of sub-set track in about 28.6 seconds.

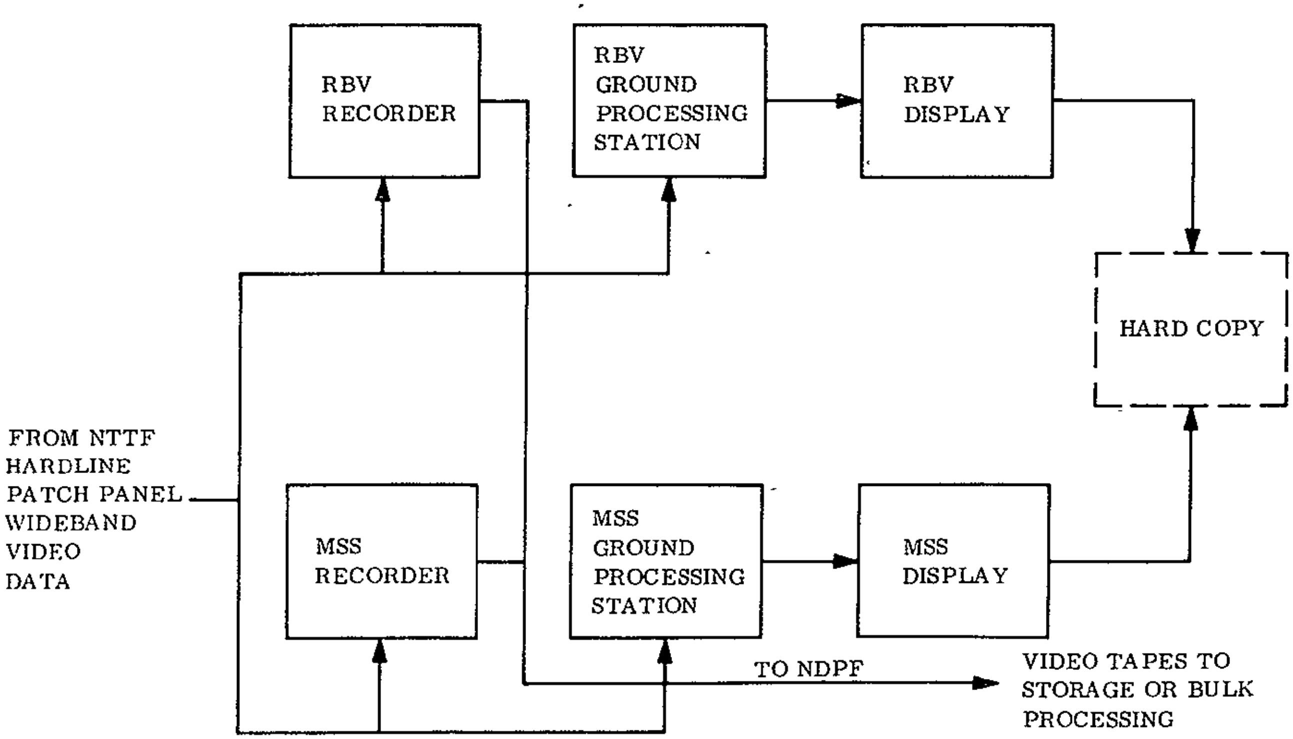


Figure 6.2-1. Image Data Processing and Display Subsystem

Because of continuous scanning, the imagery will not be interrupted as in the case of RBVC, but will be in a form of a continuous strip, without interrogation from the system turn-on to the turn-off.

The forming of the four spectral images, in contrast to that of RBVC where the three pictures were sequential, must be done simultaneously.

From the aforementioned, one can clearly see, the RBVC and MSS methods of picture display will be different.

6.2.1 RBVC IMAGERY DISPLAY

Considering the slowness of RBVC video signal, i.e., about 1250 lines/second, a coherent display of images is very difficult if high resolution pictures are desired.

From a supervisory applications point of view, the imagery does not have to be a very high resolution, as long as the condition of cameras focus will not be assessed or adjusted in orbit. This assumption does appear to be valid because the command listing does not include such functions for the RBVC. Based on the previous assumptions, two methods of RBVC imagery display can be indicated, namely:

1. Cathode Ray Tube and Polaroid Camera

2. Cathode Ray Tube, Storage Type

6.2.1.1 Cathode Ray Tube with Polaroid Camera

The simplest and probably least costly method of RBVC image display is to use a high resolution CRT and an optically coupled large size film pack Polaroid camera. The elementary block diagram of such a system is shown in Figure 6.2-2.

Basically, this system would require a high resolution CRT, such as Fairchild KC2619 or equivalent. This type CRT can maintain a very high resolution because of 7.5 micrimeters spot size in conjunction with a well-regulated power supply and focus current regulator.

The round faceplate of the CRT is flat and is 5.25 inches (134 mm) in diameter. These features can accommodate a 1:1 aspect ratio image to a size of 3.5 inches without undue corner distortions. Considering the spot size, corner defocusing effects, aging, etc., one can see that average resolution compatible with that of RBVC can be assumed for this display. On the other hand, the flat CRT faceplate enables good quality Polaroid camera pictures to be taken.

The RBVC composite video signal is applied to the input buffer amplifier with a level adjustment capability subsequently amplified to the necessary level and applied to the cathode of the CRT with the dc component preserved. A portion of the composite video signal is applied to the sync separator circuitry to generate the necessary horizontal and vertical sync waveforms, as well as providing the drive to the regulated high voltage power supply and generator.

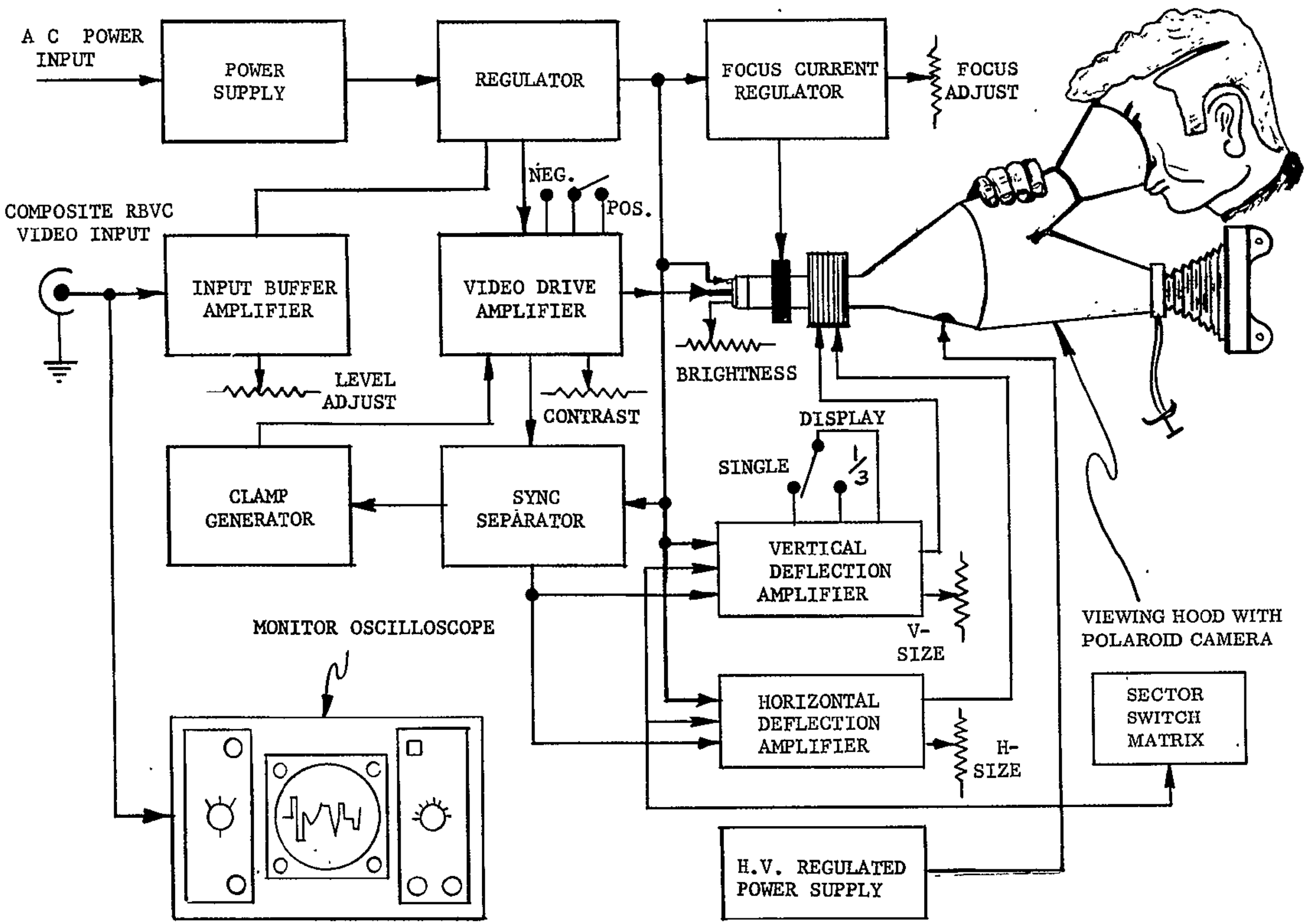


Figure 6.2-2. RBVC Video Display CRT and Polaroid Camera

The dc power supply is regulated to minimize drifts and also supplies the precision focus current regulator required to maintain the focus and prevent spot size variations.

Coupled to the CRT is a large size film pack Polaroid camera mounted on a light tight cone with a viewing port for simultaneous monitoring purposes.

After performance optimization/check with a convenient test pattern generator, before a satellite pass, the display device will be ready for acceptance of the RBVC signal. Because the CRT screen in absence of video is blanked (i.e., dark), the Polaroid camera shutter release can be depressed, thus enabling the picture to be taken.

The incoming signal with its vertical sync interval will enable the drive and deflection circuitry, thus starting a picture on the CRT face. Simultaneously, the incoming video can be monitored for quality, etc., in an A-scope mode on an associated wide-band oscilloscope, which can also have a Polaroid camera attachment for visual record purposes.

At the end of each RBVC picture frame, the shutter is closed and one frame of RBVC video is obtained for a quick-look evaluation.

The three RBVC frames are separated by the 0.2-second-wide vertical interval signal packet, too short to enable an operator to start the next frame.

To overcome this difficulty, it is proposed to adjust the vertical sweep to 1/3 speed, of 11.5 seconds. This method will enable obtaining all three camera images on one Polaroid positive hard copy. Because this method will produce geometrically distorted images, a switch must also be provided to set vertical deflection to normal, single sweep, in order to be able to assess other vital imagery properties in a normal aspect ratio presentation.

Another variant of CRT display should incorporate an expanded mode, to examine in detail the individual sectors, as delineated by the RBVC reticle pattern. This approach involves a selective display which operates by means of sweep expansion and a step-adjusted centering bias. Because of the needed X and Y selective shifts, both the vertical and horizontal deflections must be involved.

Operationally, the most convenient method would be to utilize a pushbutton switch matrix. Depressing one switch within the whole "frame" could recall only that sector of the whole display. This approach is illustrated in Figure 6.2-3. The numbering of switches follows perhaps the most convenient method; i.e., that of a matrix numbering convention (Rows 1 to 8, Columns 1 to 8). The remainder of the area is not intended to be displayed, but this could be done in the same manner, by adding the appropriate number of switches. The resultant new matrix would similarly be renumbered.

11	12	13	14	15	16	17	18
21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38
41	42	43	44	45	46	47	48
51	52	53	54	55	56	57	58
61	62	63	64	65	66	67	68
71	72	73	74	75	76	77	78
81	82	83	84	85	86	87	88

Figure 6.2-3. RBVC Display Sector Switch

This activation of display should be interlocked to the vertical sync occurrence. This will prevent destruction of an "already" being displayed frame, but will preset the circuitry for the correct display in the next following frame.

The usefulness of the A-scope presentation, as previously indicated, will be configured for the inspection of signal qualities, such as:

1. Vertical sync interval contents (200 msec)

    a. Horizontal sync with 1.6 MHz (40 msec)

    b. Horizontal sync with Black Level (40 msec)

    c. Horizontal sync with 50 kHz (40 msec)

    d. Horizontal sync with Time Code (80 msec)

2. Individual Video lines (800 micro-sec)

   a. DC-level stability

   b. Black clipping

   c. Peak white clipping

3. Signal-to-Noise assessments

4. Proper sync-signal characteristics checks.

The checks of calibration can also be made on the basis of Polaroid prints in a normal 1:1 aspect mode. This will be possible since all signals in the video input period will be visible on the print.

Knowing the prevalent Polaroid paper resolution characteristics, the following checks will be possible.

1. Time Code

2. 1.6 MHz waveform

3. 50 kHz waveform

4. Grey levels in "Calibrate" mode

5. Field flatness in "Calibrate" mode

Should transparencies be desired, the Polaroid camera could be reloaded with this type of film and transparencies produced.

6.2.1.2 Cathode Ray Tube, Storage Type

This type display method is more convenient than the previous one, but it offers low resolution capability. On the other hand, its property to retain the image for over a period of RBVC frame duration is very attractive.

Currently the best resolution capability of this type of CRT is in the order of 4 lp/mm. The diameters are in the order of 10.5 inches (larger tubes are in existence but resolutions are poorer, thus, no net gain is realized in this approach). To accommodate the 1:1 aspect ratio image, a 7.5-inch screen is available, which at best will produce a total resolution of only 1,400 TV lines.

In addition the dynamic range of storage of CRT's is shallow. At best, it will accommodate only six to seven 0.16 density steps. The block diagram is very similar to the previously described and is shown in Figure 6.2-4.

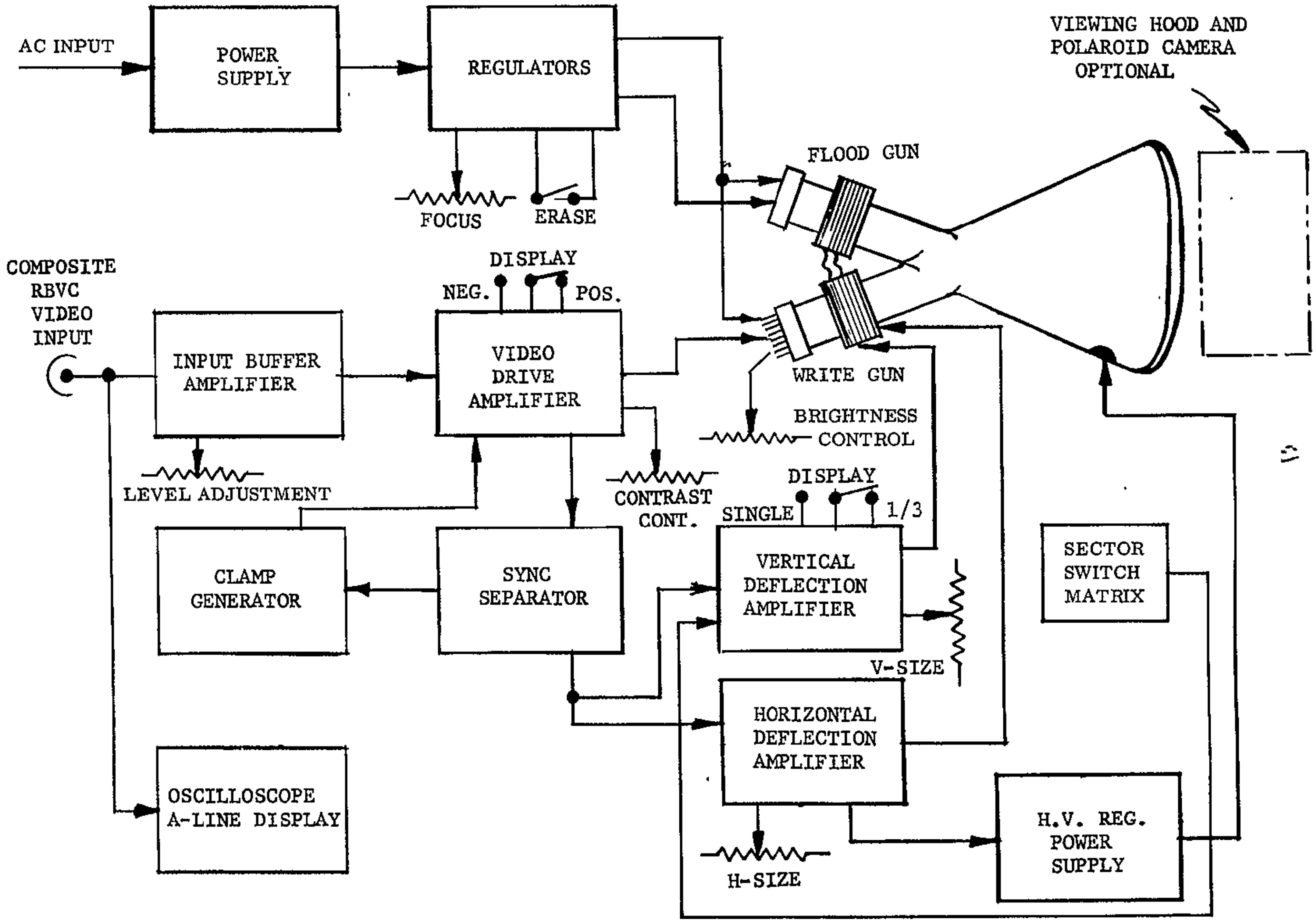


Figure 6.2-4. RBC Video Display, Storage Type CRT

The descriptions and functions of individual blocks are very similar in nature to those described in the previous approach, and therefore are omitted.

As in the previous case, an A-line oscilloscope will be hooked-up for supervisory checks and will serve the same purposes.

Although at a first glance this type of display appears to be very attractive, its use will be limited to a very coarse Go/No-Go type subsystem performance evaluation. Therefore, it is far less desirable.

To overcome the difficulty of low resolution performance, the video may be displayed in a "sector" form as to obtain and display only 1400 elements, or simply a portion of the frame at full resolution. This approach is fully explained in the section on the RBVC (6.2.1.1) and would perform in exactly the same manner.

For data recording purposes, a viewing hood with a Polaroid camera will be of benefit.

At this point, it should be noted that this type display is not an off-the-shelf item, and as far as it could be determined, other similar equipments do not exist in a readily adaptable system configuration.

6.2.2 MSS IMAGERY DISPLAY

Referring to the scan characteristics of MSS as indicated in Section 6.2, one can see that the MSS Imagery will arrive at a much slower rate than that of the RBVC. In addition, the total requirements on horizontal resolution element display are also lower, usually only 2640 cells. On the other hand, the vertical raster is continuous and is certainly of a small inconvenience in view of the OCC functions. As a result, the MSS display technique must be appropriately chosen to be able to maximize its utility. The possible methods of MSS imagery display can be as follows:

1. Facsimile strip

2. CRT partial display with Polaroid Camera

6.2.2.1 <u>Facsimile Strip Display</u>

In essence, there are two basic facsimile display methods. The first method uses an electrochemical process on paper with an electromechanical video write and paper advance of one continuous paper strip. The length of a paper strip is limited only by the roll size; and, therefore it is regarded as unlimited, which simply means a full recording of about 30 minutes in duration can be made quite easily.

One deficiency of this process is its limited dynamic range of density. But, in view of its use only as a supervisory type activity, it can be regarded as adequate. This display method, although feasible, required modifications, mainly to make it compatible with the required data flow and to convert the parallel inputs from the six detectors to a single serial video.

This approach would involve a multitrack tape recorder (Ampex FR-1900 modified or equivalent) with a slow down playback capability and a suitable memory unit.

Should a simultaneous display of all four MSS spectral bands be desired, it can be accomplished by a partial display of each band or by providing four individual facsimile printers, with parallel to serial converters.

The facsimile equipment is of the type manufactured by Muirhead Instruments, Inc., under the name of "Pagefax."

The second type of facsimile equipment uses a crater lamp light source to write a regular photographic paper in sizes up to 22 by 16 inches.

One significant feature of this equipment is its high resolution capability (about 70 elements/nm). Another feature caused by the first is the ability to accommodate up to four spectral band images in parallel on one sheet of paper. A special digital memory and associated electronics is required to accomplish this. The equipment has a capability of 15 grey scales of 0.16-density increments, but it is limited by the photographic paper to only 9 to 10 steps.

A significant advantage of this equipment is the photographic process that can produce either positives or negatives. The image must be developed externally to the instrument before it becomes stable and visible. Similarly, it cannot record the full pass of MSS imagery. This fact is not significant in view of OCC's supervisory function, thus not resulting in a continuous image display requirement.

One limitation of this equipment is the requirement that it be located in a darkroom, because the rotating drum, with attached photosensitive material, is unprotected except for a dust cover. In addition, loading and unloading must be performed in total darkness because the rotating drum is not removable, but is an integral part of the facsimile. As a result, an adequately equipped dark room (film storage, water, drainage, air conditioned and intercomm are required) will have to be provided and this will certainly decrease the efficiency of an overall payload supervisory function. As in the case of the RBVC display, an on-line switchable A-scope is strongly recommended.

A representative example of facsimile equipment is the one manufactured by Litten Industries, Litcom Division, under the name of "Pressfax."

6.2.2.2 CRT Partial Display with Polaroid Camera

The method is similar to that described under RBVC displays, except that the scan speeds must be compatible with the MSS and vertical deflection, which should be proportionate to the 15.2 Hz rate of MSS scan.

The compressed frame feature is considered undesirable. Instead, it requires a vertical scan recycle in order to print out the continuous MSS video in a form of frames. This will introduce losses of data due to camera paper pulldown time and shutter triggering requirements. This is, however, not regarded as a serious drawback.

Of a more troublesome nature is the fact that the four (or eventually five) spectral bands cannot be simultaneously accommodated on the same CRT screen. A solution to this problem would be to switch through the spectral bands during the satellite pass, completing always one full "frame" of image. The system will also require a parallel to serial video data converter, as do the facsimile machines described earlier.

Signal quality evaluation can be performed by A-line oscilloscope display, in a similar manner to that described for the RBVC.

The storage CRT type display is of extremely low value for MSS image display; therefore, it has been dropped entirely from the MSS applicability considerations.

6.2.3 SENSOR PAYLOAD PERFORMANCE EVALUATION

Evaluation of the performance of the RBV and MSS spaceborne payloads will be based on the utilization of three data sources.

1. Quick look video display from the OCC Image Data Processing and Display Subsystem

2. Narrowband PCM Telemetry Data from Payload Telemetry Points processed by the OCC PCM Processing Subsystem

3. High quality imagery generated by the NDPF Image Processing Subsystem.

The following paragraphs describe how each of the data sources will be utilized to provide maximum confidence in payload status, health and performance.

6.2.3.1 Evaluation Using Quick-Look Display

One of the most effective supervisory tools for assessing sensor performance is the formed image from the sensor itself. Unfortunately, the types of sensors used feature a low line rate video and do not lend themselves to a real-time display. Expedients, such as open lens camera attachments must be used to circumvent the inability of human eye to integrate the slow scan signal and permit evaluation of the quality of the image and, therefore, sensor performance.

A camera, most conveniently a Polaroid system camera, coupled to a CRT display, can provide the integration of the data into picture information for evaluation by the human eye. Unfortunately, the time elapsed from the initial signal arrival to that of a completed picture is significant, but it is nearest to real-time evaluation of a full coherent frame.

Because a picture frame is composed of individual "lines" of electrical signals assembled on a basis of synchronizing signals, a correctly appearing picture will assure the supervisory personnel of proper operation of the camera. Any other displeasing effect in the obtained pictures is indicative of difficulties. A number of operational problems can be detected to some extent:

1. Geometric distortion (large percentages only)

2. Sync failures

3. Line dropouts

4. Interference of various kinds

5. Calibration signal status

6. Gray scale calibration (if provided in the sensor)

Other problems more or less obvious, but quite evident, to an experienced sensor performance evaluator can also be detected.

The second supervisory tool is certainly an on-line oscilloscope display, setup to show on its CRT screen the individual incoming signals. Based on familiarity with "good" signals, the anomalous signals can be easily spotted. Nevertheless, once the oscilloscope display shows defective signals, the hard copy picture will also be improper.

6.2.3.2 Evaluation Using PCM Telemetry Data

The second source of performance evaluation data is the processed sensor telemetry. Telemetry evaluation, in general, is simple once the past history of given equipment is known and familiarity with it exists.

During the integration tests, strip chart recordings of sensor telemetry are made on a routine basis. Telemetry and calibration compendiums are compiled and do contain waveforms that do appear under all possible modes of operation. Similarly, during the real orbital playbacks, the strip chart recording is performed for both real-time and off-line directing and inspecting for signs of abnormal conditions.

More comprehensive data describing the overall operation of the payloads is generated by the PCM processing software described in Section 6.1. This software processes the payload telemetry in both real-time and from the playback produces a report of sensor performance which defines the operational profile of all sensor activities. In addition, the playback data is used to compute statistical and trend data required for long term performance evaluation.

6.2.3.3 Evaluation Using NDPF Imagery

The evaluation described previously was concerned primarily with the identification of anomalies in sensor performance which could endanger the spacecraft or could permanently impair the performance characteristics of the payload if timely corrective action was not taken. More detailed evaluation techniques are required to determine the correctness of the exposure time, or to examine jitter caused by degraded WBVTR performance. These factors cannot be detected at the quick look level of evaluation, but all the precise must be done from an examination of high quality image.

The guidelines for evaluation will be firmly established once the real imagery from the respective sensors will become available and in-test and integration experience will be gained.

Similar tasks were performed on Nimbus A. The sensors, the Advanced Vidicon Camera Subsystem, Automatic Picture Taking Subsystem, and High Resolution Infra-Red Subsystem were all considered the "state-of-the art" sensors and their image performance parameters were just as big unknowns as these of ERTS payload today.

In spite of these unknowns, a comprehensive data evaluation manual was assembled and used for data evaluation personnel training. This manual was subsequently expanded and updated to include additional sensor equipments for Nimbus C. (Nimbus C Sensory Data Evaluation Guide, Contract NAS 5-9589, General Electric Spacecraft Department, Document No. 65SD4290, 15 April 1966).

A detailed sensor payload evaluation handbook will be prepared for the ERTS Program. Both RBVC and MSS sensors and their operation will be described, as well as the functional meaning of miscellaneous defects that can occur in their images. The detailed description of how to identify these will be given and possible corrective measures will be provided. In addition, the correlation of these anomalies with the telemetry printouts and waveforms will be described.

6.3 COMMAND GENERATION SUBSYSTEM

The Command Generation Subsystem is designed to compile, format, transmit, and verify spacecraft commands at the OCC. Commands are compiled in advance of each spacecraft contact from the activity plan generated by the System Scheduling software (reference Section 6.7.2). During the real-time acquisition the command messages are formulated, verified, and transmitted automatically, but under command operator control. All commands generated by the OCC are routed to the remote sites by the NASCOM 494 Communications Processor for RF transmission to the spacecraft.

The Command Generation Subsystem consists of two software packages, the Command Compilation Software (CCS) and Command Management Software (CMS) which operate in the OCC computer. The CCS operates off-line and is used by the command operator to compile the command list from the activity plan, and to edit and insert additional commands and/or command sequences into the list, based upon the results of the spacecraft performance evaluation. The CMS operates primarily during the real-time spacecraft acquisition and provides the command operator with the full capability to transmit both real time and stored commands to the spacecraft from the command panel at his operations console. Figure 6.3-1 depicts the Command Generation Subsystem flow.

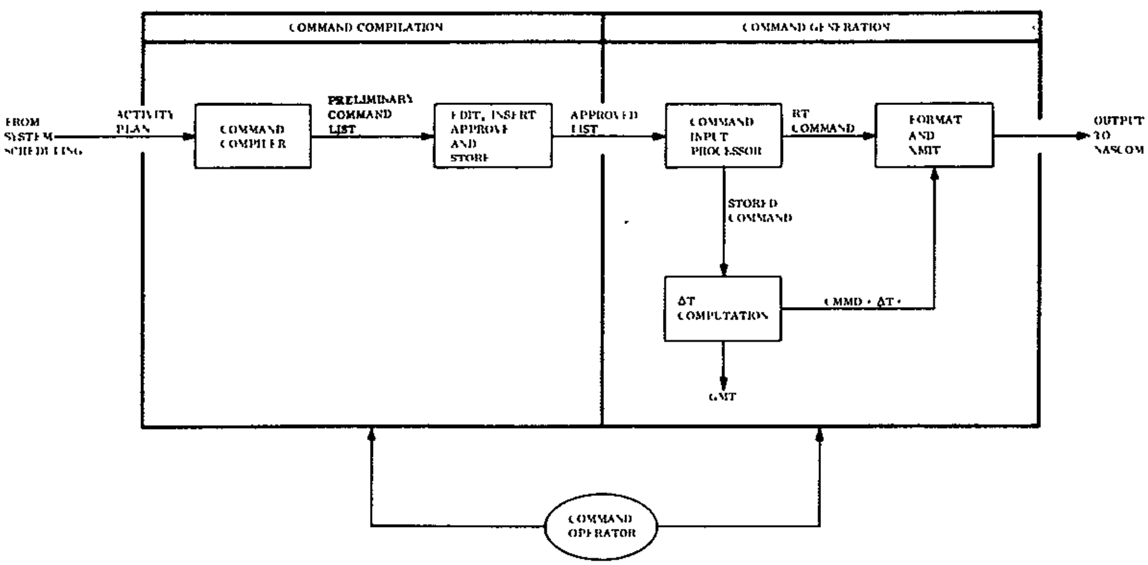


Figure 6.3-1. Command Generation Subsystem Flow

6.3.1 COMMAND COMPILATION SOFTWARE

The function of the CCS is to translate desired spacecraft events, defined in the activities plan (generated by System Scheduling Software) into the appropriate spacecraft command sequences which will cause those events to occur. In addition, this software permits the editing and insertion of additional commands into the command list, based on inputs from the command console. The CCS functions in the nonreal-time environment only, as it provides no functions required during the on-line command transmission.

The input to the Command Compiler is the Activity Plan generated by the System Scheduling Software. This Activity Plan resides in the OCC data base and will be accessed at program execution time. For each event listed in the Activity Plan, the CCS will generate the required command or sequence of commands to perform that event. The output of the Command Compiler will be a report which defines the spacecraft events and their activity, the desired time of occurrence will be compared with the predicted RT acquisition window of this orbit. If the event is to occur within this window, real-time commands (RTC's) will be generated. If the activity is to be performed outside the RT acquisition window, stored commands will be provided. Critical commands included in the list will be flagged for the operator.

Optimization of command lists is designed to exclude transmission of commands which would put the spacecraft into a configuration which should already exist. This will be done by predicting the status at the next acquisition based upon the last known status and the commands transmitted during the past acquisition. Further optimization will be done to ensure that two or more stored commands would not be transmitted to perform a function which could be accomplished using one stored command with a repeat time.

The preliminary command list resulting from this processing is then displayed for the command controller. The CCS affords complete capability to edit, delete, and insert both single commands and command sequences from the command console. Throughout this, however, the CCS will identify and flag any operator inputs which would violate prescribed operational sequence requirements or otherwise jeopardize the safety of the spacecraft.

At the conclusion of this process the complete command list is displayed for review and approval. The command operator then organizes the commands in terms of command transmission sequences. The command list, with its sequence annotation, is then stored within the OCC computer for subsequent call-up by the CMS during the real-time acquisition period.

6.3.2 COMMAND MANAGEMENT SOFTWARE

The CMS performs the processing required to transmit command to the spacecraft under control of the command operator. This software is normally co-resident with the ONPAS of the PCM processing subsystem (Section 6.1) and the status data control and display subsystem software (Section 6.5) and operates in conjunction with this software as shown in Figure 6.3-2. The CMS has the highest computer system priority in terms of central processor time, resource allocation, and report display processing.

CMS operations are initiated for the most part by command operator inputs from his operations console.

6.3.2.1 Command Transmission

In order to send a command or command sequence, the operator first inputs the three digit command number of command sequence number to the CMS via the command input keyboard. CMS interprets the keyboard input and outputs the requested command or sequence to the display software for immediate presentation at the command operator's CRT display. CMS automatically flags any critical commands for the operator. A sample command sequence display is shown in Figure 6.3-3. After this operator verifies from the display that the proper command or sequence has been presented, he presses the transmit button on the command panel. If the command has been flagged as critical, or if any command in a sequence is critical, the operator must use the Critical Transmit button.

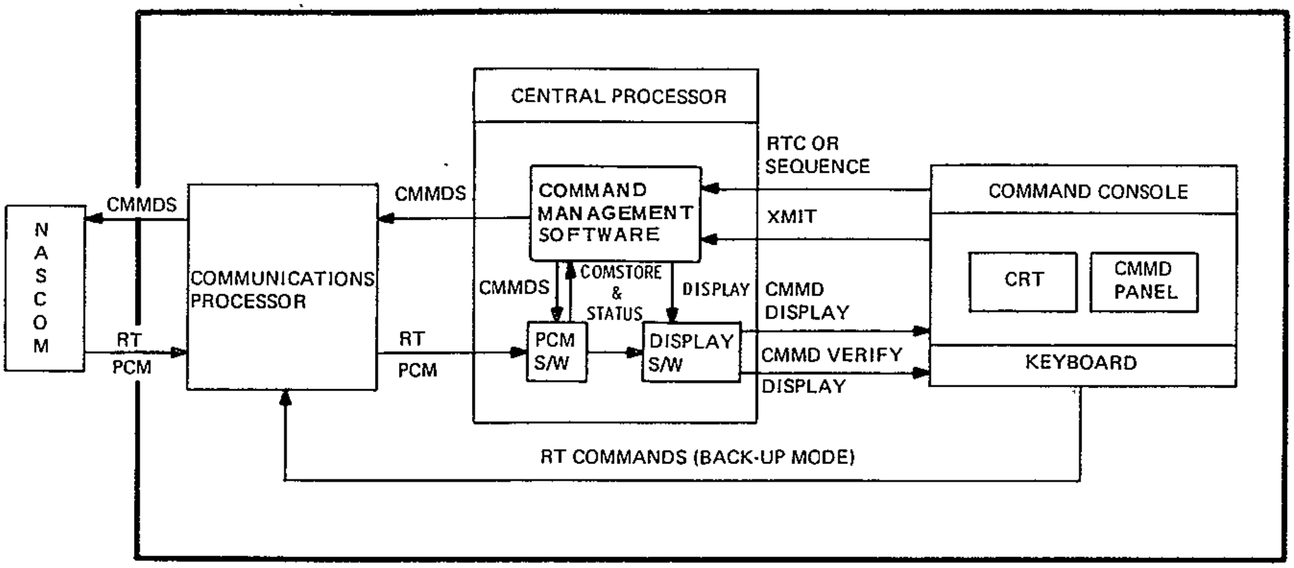


Figure 6.3-2. Command Transmission Processing

SEQUENCE 011

TURN ON SEQUENCE - 7 COMMANDS

LINE	COMMAND	TYPE	EXECUTE TIME	REPEAT TIME	NAME	STATUS
1	101	RT			A ON + FIL	
2	300	ST	12:00:00	00:00:16	RBV WARM UP	
3	350	ST	12:00:00	00:00:16	MSS WARM	
4	360	ST	12:10:00		SBAN A ON	
5	125	ST	12:00:00	00:00:15	ALL LOADS OFF	
6	435	RT			PNEUMATICS OPE	CRITICAL

Figure 6.3-3. Sample Command Sequence Display

Once the operator initiates transmission, the CMS performs several functions. If the command is a stored program command, the CMS will compute the delta time tag. This delta time is the time difference in seconds between the current GMT and the GMT at which the command execution is desired. This computation will also include the addition of a delay factor which compensates for command transmission time through the NASCOM network and uplinks to the spacecraft. This subject is discussed further in Section 6.3.3.

At this point, the real-time commands and/or the stored program commands with their execution deltas and repeat times, if any, are compiled into the proper command message formats. Figure 6.3-4 describes the format for each of the spacecraft command/clock messages. The following definitions and operating constraints apply:

Sync. All messages are preceeded by a sync word consisting of a minimum of 13 "zeros" and a single "one" bit. Once sync is established, the command message must immediately follow. The first word of the command message must be a real time command.

Address Bits. The first word of each command must start with the 7-bit ERTS address designation. A separate address will be assigned to the primary and redundant command decoders.

Mode Bits. Consist of three bits to designate the five types of commands. The single bit M1 is associated with real time commands and designates the command for internal command clock operations or external real time operations.

Parity Bit (P). Odd parity is associated with all commands. Commands failing to comply with the odd parity bit are not processed. For commands other than real time, M1 is utilized as a parity bit.

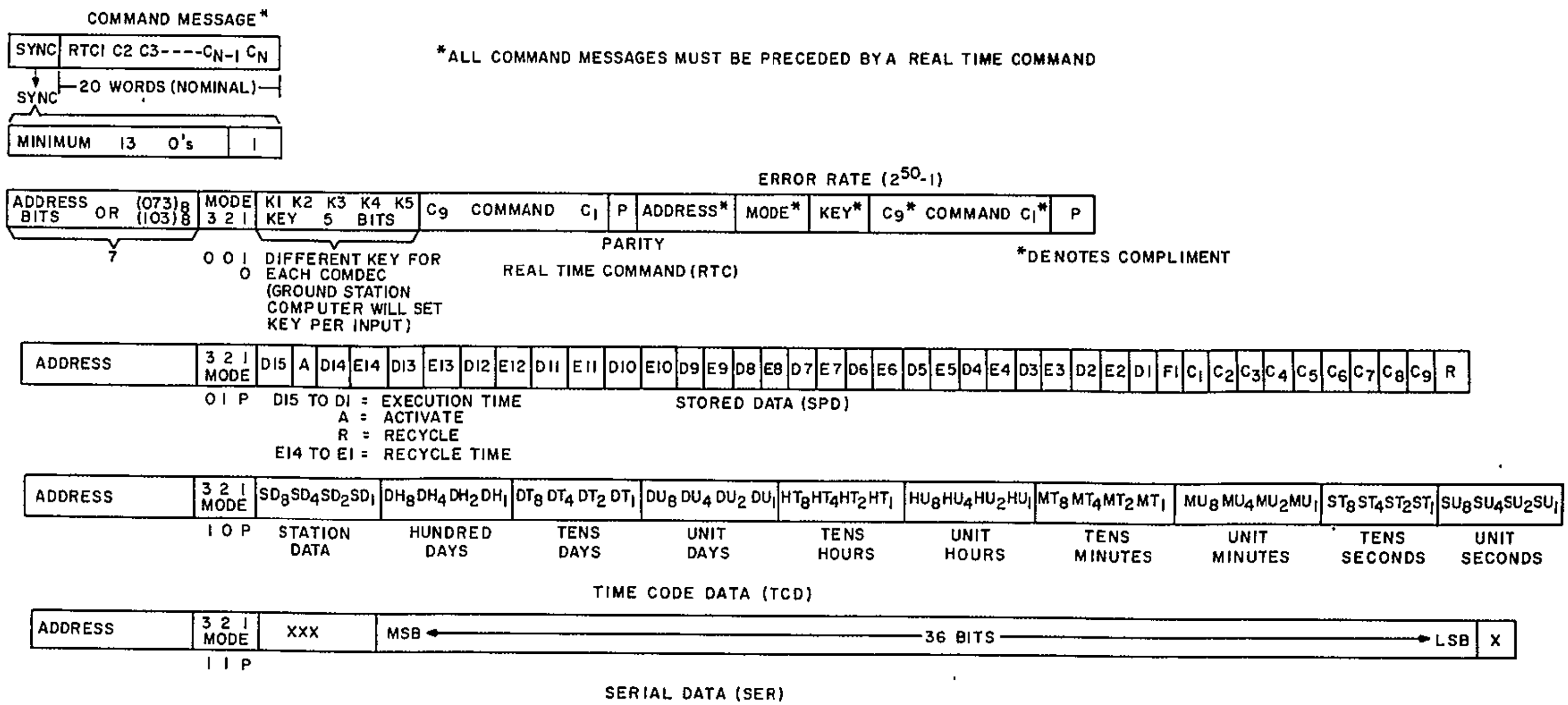
Key. Five bits that indicate which of the two command decoders will process the message. Each command decoder is assigned a different key in the Nimbus program since all Nimbus spacecraft have the same spacecraft address word $(026)_8$. However a different spacecraft address will be assigned to the primary and redundant command decoders, in the ERTS program providing a dual means of selecting the desired Comdec unit for real-time commands.

Command Bits (C_9 through C_1). Nine bits utilized to designate the 512 possible commands

Execution Time Bits (D_{15} through D_1). Fifteen bits utilized to designate the time span after loading when the associated stored command is to be executed. The 15 bits provide for execution times from one second to over 18 hours after storage.

Activate Bit (A). Must be a "one" to enable stored command execution. After execution, the activate bit is set to zero to disable the command from subsequent execution except as described under Recycle Bit (R).

Recycle Bit (R). When in "one" state, enables re-execution of the stored command at the time interval specified by Recycle Time Bits. After command execution the status of R is examined and if a "one," the Recycle Time Bits are transferred to the Execution Bit time positions and the Activate Bit is set to "one".



NOTES

1 ONLY THE 40 LEAST SIGNIFICANT BITS OF EACH COMMAND ARE STORED FOR THE SPD COMMANDS.

2 MODE

M3	M2	M1	
1	1	1	REAL TIME COMMAND EXTERNAL (RTCE)
1	1	0	REAL TIME COMMAND INTERNAL (RTCI)
0	1	P	COMSTOR DATA (SPD)
1	0	P	TIME CODE DATA (TCD)
–	–	P	SERIAL DATA (SER)

3 ALL COMMANDS CONTAIN 50 BTS

Figure 6.3-4. Command/Clock Message Formats

Recycle Time Bits (E_{14} through E_1). Fourteen bits define the time span between the first time the command is executed and the time when the command is to again be executed. The 14 bits provide for recycle times of from one second to over nine hours.

Time Code Data (SD_8 through SU_1). Forty bits of data are arranged into 10 BCD character groups. The 10 characters allow for GMT specification of time in hundreds, tens, and units for days; tens and units for hours, minutes and seconds; and a four bit word (SD_8, SD_4, SD_2, SD_1) as an identifier or station data.

Serial Data (MSD--36 Bits--LSB). Thirty-six bits that define three 12-bit memory words intended for the reprogrammable PCM telemetry memory (external to the command clock.

Asterisk Bits. Twenty-four bits associated with real-time commands provide a redundant basis for checking each of the Address, Mode, Key, and Command bits.

In computing the compliment portion of the real-time command message, CMS utilizes the original command data input by the operator rather than simply complimenting the first portion of the commanded word. It then checks further to ensure that this independently generated complement is, in fact, the complement of the first 24 bits before transmitting the command.

Once a command message has been formatted, it is then polynominally encoded and formatted into 600-bit blocks of the prescribed NASCOM format with the appropriate routing header for transmission to NASCOM. The polynomial encoding is performed by algorithm to provide protection against the transmission of garbled commands to the spacecraft. The polynomial decoding is performed at the command site. Command messages which fail the decoding are not transmitted. RF echo checks are performed on commands which are transmitted, and an echo check failure immediately halts the command transmission. The Go/No/Go status of both the polynomial decoding and RF checking are immediately returned to the OCC via the PCM link. The PCM software relays this data (Section 6.1) to the CMS for display to the operator. This closed loop flow provides the command operator with almost immediate uplink status on the command he has just initiated, and permits rapid retransmission of a command, should this be necessary. This subject is discussed further from an operations viewpoint in Section 8.2.5.2.

6.3.2.2 Verification of Command Execution

The execution of real-time commands is verified by the PCM processing subsystem. Unencoded copies of all commands transmitted by the CMS are input in real-time to the PCM processing software which is co-resident in the OCC computer system. The PCM processing software scans the incoming spacecraft telemetry data for verification of real-time command execution as described in Section 6.1. The verification of the command execution initiates a display at the command operator's console. If the command execution is not verified within a predefined time limit, the operator is presented a display which notifies him that the command is not verified.

A study was conducted to determine the delay which will be encountered from the instant a real-time command is initiated in the OCC until the verification display is presented at the command operator's console. The study is described in detail in Section 8.2.5.2 and considered the computation, transmission, and propagation delays through each major element of both the up-link and downlink, as well as the best case and worst case sampling conditions for the command verify PCM in the spacecraft telemetry system (see Table 8.2-0). The results of this study define the minimum delay time to be less than 2 seconds, while the maximum delay is approximately 16 seconds. This maximum is for the worst case in which the command is executed just after the telemetry point(s) used to verify the command has been sampled. If this point is sampled only once per major frame it will not be output by the spacecraft for another 16 seconds.

The execution of the stored commands is also verified by the PCM processing subsystem software, operating on the playback telemetry data. The PCM processing software retains the command data (both real-time and stored commands) input to it by CMS during the real-time acquisition. The stored commands are used to predict spacecraft status changes which the PCM processing software looks for in the playback data in the same way that it performs the real-time verification. The results of the stored command verify processing are compiled together with an identification of all status changes observed in the playback data and presented in the form of a comprehensive Spacecraft Orbital Profile Report.

6.3.2.3 COMSTORE Load Verification

CMS automatically verifies that the stored command load has been entered properly into the COMSTORE before the load is activated. As the stored load is transmitted, CMS computes an image of the load configuration as it should appear in the COMSTORE (COMSTORE Image). The last command transmitted with the load is a real-time command which initiates the COMSTORE Verify mode in the spacecraft and in CMS, itself. In this mode, the spacecraft telemetry system outputs the contents of the COMSTORE in the telemetry matrix in lieu of the spacecraft time code. The PCM processing software strips out the COMSTORE data and transfers it to CMS which performs a bit-by-bit compare with the COMSTORE Image. The results of the comparison are displayed at the command operator's console. If the match is not perfect, he will retransmit the load. If the match is good, he will initiate COMSTORE activation. A sample COMSTORE Verify display is shown in Figure 6.3-5.

6.3.2.4 Command Management Software Operating Modes

CMS is capable of operating in any one of six modes, some of which have already been mentioned in the preceeding discussions. Each of the six modes is summarized below:

1. Sequence Mode. The sequence mode of operation is entered by the command operator when he selects one of the predefined, prestored sequence of commands for display. In this mode of operation the selected sequence can then have a number of operations performed on it. Those operations include transmission to the spacecraft, editing, deletion, or merely display.

COMMAND MEMORY VERIFY

COMSTORE A STATUS = GOOD
CYCLE 6

TRANSMITTED						RECEIVED					STATUS
MEM LOC	CMD	EXEC TIME	RPT TIME	BITS A	BITS R	CMD	EXEC TIME	RPT TIME	BITS A	BITS R	
01	165	11:21:08	00:00:00	A		165	11:21:08	00:00:00	A		OK
02	214	11:27:40	00:00:00	A		214	11:27:40	00:00:00	A		OK
03	237	11:28:00	00:00:00	A		237	11:28:00	00:00:00	A		OK
04	222	13:12:10	00:01:10	A	R	222	13:12:10	00:01:10	A	R	OK
05	401	13:20:50	00:50:00	A	R	401	13:20:50	00:50:00	A	R	OK
06	452	13:21:00	00:00:00	A		452	13:21:00	00:00:00	A		OK
07	401	13:22:00	00:00:00	A		401	13:22:00	00:00:00	A		OK
15	010	13:04:51	00:00:00	A		010	13:04:51	00:00:00	A		OK

Figure 6.3-5. Sample COMSTORE Verify Display

2. Real-Time Command Mode. This mode of operation allows real-time commands to be transmitted to the spacecraft from the command console keyboard. This mode of operation is entered in one of two possible ways:

   a. By direct request for this mode via a function key dedicated to this purpose

   b. By function key dedicated to the time set function

   The basic difference in the two operations is that this mode is exited immediately after the time set initiation of the mode. In the case of operator initiation of this mode, the mode is terminated by the operator.

3. COMSTORE Verify Mode. In this mode, the Command Management System will compare stored command data, extracted from telemetry, with the expected COMSTORE memory contents which it maintains. A report of any discrepancies will be made to the command operator. This mode of operation is entered automatically by the Command Management software as a result of transmitting a COMSTORE verify command, and detecting COMSTORE verify status in the returning telemetry.

4. Edit Mode. This mode is initiated by the command operator and allows him to edit existing sequences or create new sequences.

5. Test Mode. The test mode is initiated by the command operator. When in the test mode, the Command System software will perform as it normally does. However, when commands are transmitted, a bit will be set in the command message block which will inhibit actual transmission to the spacecraft by the remote site hardware.

6. Copy Mode. The copy mode is initiated from the command operations console. This allows the currently selected command sequence to be duplicated on either paper or magnetic tape for backup use at the remote sites. A detailed discussion of the processing in each mode is presented in the Command Generation Subsystem Specification, Books 4, 5 and 6.

6.3.3 COMPUTATION OF STORED COMMAND TIME TAGS

The stored command time tag is, basically, the time difference, or delta time, between the ground time at command transmission and the ground time at which command execution is required. The time tags are computed in the OCC for each stored command at transmission time and are transmitted to the spacecraft as part of each stored command message in the COMSTORE load. Each time tag in the COMSTORE is decremented by the command/clock, and a particular stored command executes when its time tag decrements to zero.

The computation of each command time tag is performed by the CMS. The CMS time tag processing considers several other factors which affect the required tag values beyond the simple ground time difference. These include delays:

1. In message routing through the NASCOM network.

2. At the remote site and in RF transmission to the spacecraft.

3. Encountered in initiation of the time tag decrementing in the spacecraft command memory.

6.3.3.1 System Delays

6.3.3.1.1 NASCOM Transmissions

These delays are caused by the throughput switching time of the NASCOM 494 Communications Processor and the transmission rates of the 203 and 303 modems. The 494 Communications Processor delay is the only significant variable in the link. Based upon information provided by GSFC NASCOM personnel, the delay through the 494 could vary from 15 milliseconds to a maximum of 750 milliseconds, the mean being approximately 200 milliseconds. The delays through the 203 and 303 modems at fixed at 125 and 12 milliseconds, respectively, for each command block.

6.3.3.1.2 Remote Site Transmissions

These delays result from the uplink transmission rates of the remote site command equipment. The delay from MSFN is 250 milliseconds for each command in the load. The STADAN transmission delay is 390 milliseconds.

6.3.3.1.3 Spacecraft COMSTORE Loading

This delay is caused by the fact that the time tags are not decremented in the spacecraft while the stored load is being entered. Decrementing begins with the receipt of either the verify or activate real-time command, one of which always immediately follows the stored command load.

6.3.3.2 Time Tag Computation

The method by which the Command Management Software calculates the stored command time tags is based upon the fact that time tags entered in the spacecraft command system are not decremented until either a COMSTORE verify or COMSTORE activate real-time command is received. As a result, the tags can be computed relative to the time at which either of these commands is sent, and the only delay involved is time required to actually transmit the real-time command to the spacecraft. Our operational philosophy, and the software logic required to create stored command sequences, dictate the presence of either a COMSTORE activate or verify command in each sequence.

CMS assembles each stored command load prior to transmission and establishes the minimum time at which the real-time verify or activate command can follow the load. This is based on the time required for the stored load to reach the spacecraft and enter the memory. The real-time command may be sent at any time beyond this. This minimum time can be fixed for routine operations, and serves as the basis for the time tag computations. Assume, for example, that the load is assembled and the verify command is to be sent at the current GMT plus 8 seconds. CMS computes the time tags by subtracting this from the desired execution GMT for each stored command. CMS will then transmit the stored load to the spacecraft via NASCOM, followed by the real-time verify command at the end of eight seconds. The transmission time of the real-time command, of course, determines the accuracy of stored command execution, and CMS will account for this by manipulating this transmit time to compensate for the NASCOM 494 delays.

6.4 COMMUNICATIONS AND DATA DISTRIBUTION SUBSYSTEM (C&DD)

The C&DD Subsystem configuration is shown in Figure 6.4-1. The C&DD Subsystem consists of the input/output signal conditioning and switching equipment, the OCC/NDPF computer switching equipment, the timing equipment, the maintenance and operational console for the OCC, the voice communications equipment, the magnetic tape recorders, and the simulation equipment. The voice communications equipment is expected to be government furnished equipment, with the remaining portions of the subsystem furnished by the contractor. The C&DD Subsystem acquires data inputs, provides signal conditioning where necessary, and provides for the switching/patching and recording of PCM signal inputs, command outputs, timing signals, simulated PCM signals, and Computer Subsystem input/output channels to the OCC and NDPF Computer Subsystems and the Control and Display Subsystem. Coordination of OCC operations with the ERTS system is provided by use of voice communication equipment.

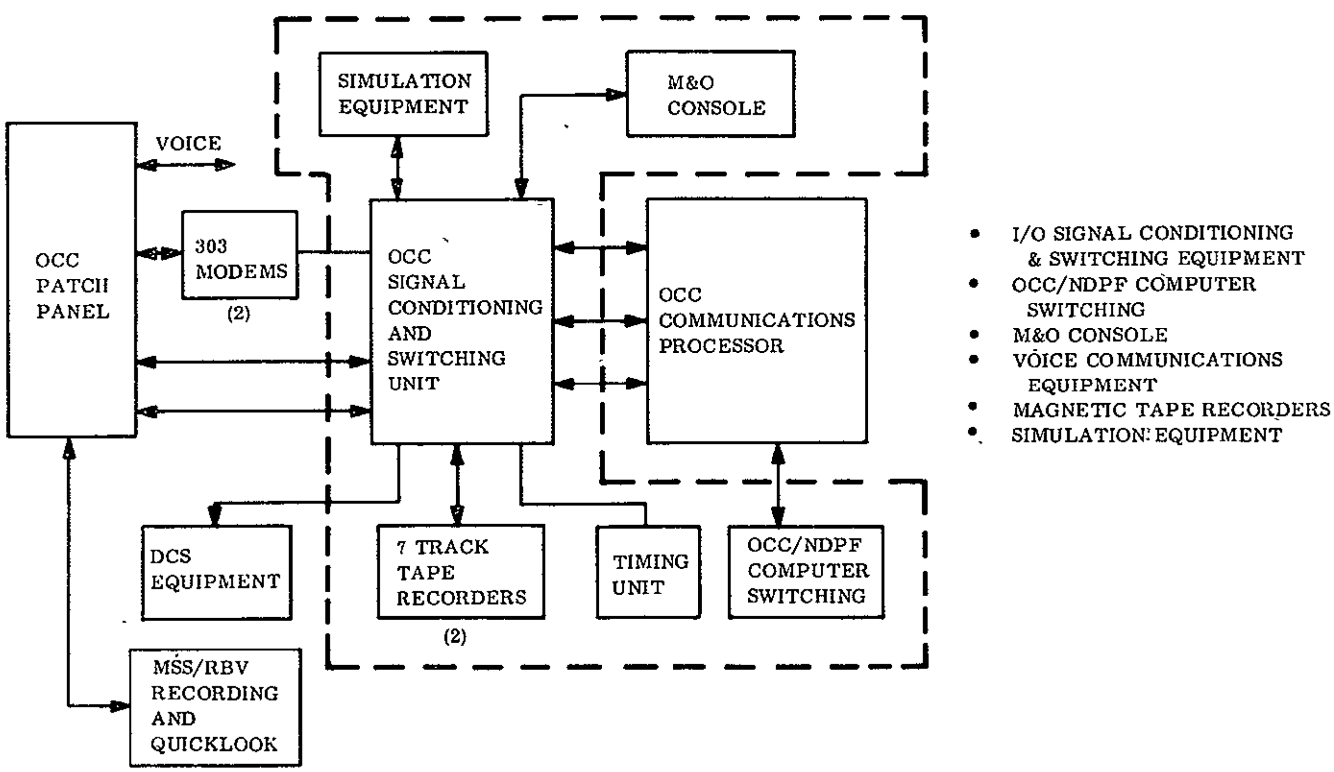


Figure 6.4-1. OCC Communications and Data Handling Distribution Subsystem

The C&DD Subsystem consists of several functional groups of equipment. These groups are:

1. Signal Conditioning and Switching (SCS)

2. Timing

3. Computer Subsystem Switching (CSS)

4. Magnetic Tape Recording (MTR)

5. Maintenance and Operational (M&O) Console

6. Voice Communications

Figure 6.4-2 provides a detailed signal flow diagram for the C&DD Subsystem and its interfaces with other equipments.

6.4.1 SIGNAL CONDITIONING AND SWITCHING

The Signal Conditioning and Switching (SCS) equipment acquires data, provides signal conditioning where necessary, and provides for the switching and/or patching of PCM signal inputs, timing signals, simulated PCM signals, command outputs, and Data Collection System outputs to the magnetic recording equipment, the M&O console, the timing equipment, the Computer Subsystem and the Control and Display Subsystem, as required. The SCS will be remotely controlled from the M&O console described below.

6.4.1.1 SCS Input and Output

6.4.1.1.1 GSFC/NASCOM

The SCS equipment will acquire real-time PCM data from the NASA Communications Terminal (NASCOM). Serial data in 50-kbps bursts will be received from either of two GFE model 303 modems and data links.

The SCS equipment will acquire command data from the Computer Subsystem and provide this serial data to the same model 303 modems and data links as described above. Command data will be transmitted in 600-bit blocks.

Switching and/or patching will be provided to connect the Computer Subsystem to either the 303 modem, the magnetic tape recorder, or the simulated real-time PCM signal.

6.4.1.1.2 GSFC/NTTF

The SCS equipment will acquire the following PCM signals from the NTTF (Building 24) NASCOM:

1. Real-time PCM data at a 1-kbps rate

2. Playback PCM data at a 24-kbps rate

The format of the real-time PCM data will be as follows:

Word length	10 bits
Minor frame size	20 words
Major frame size	80 minor frames

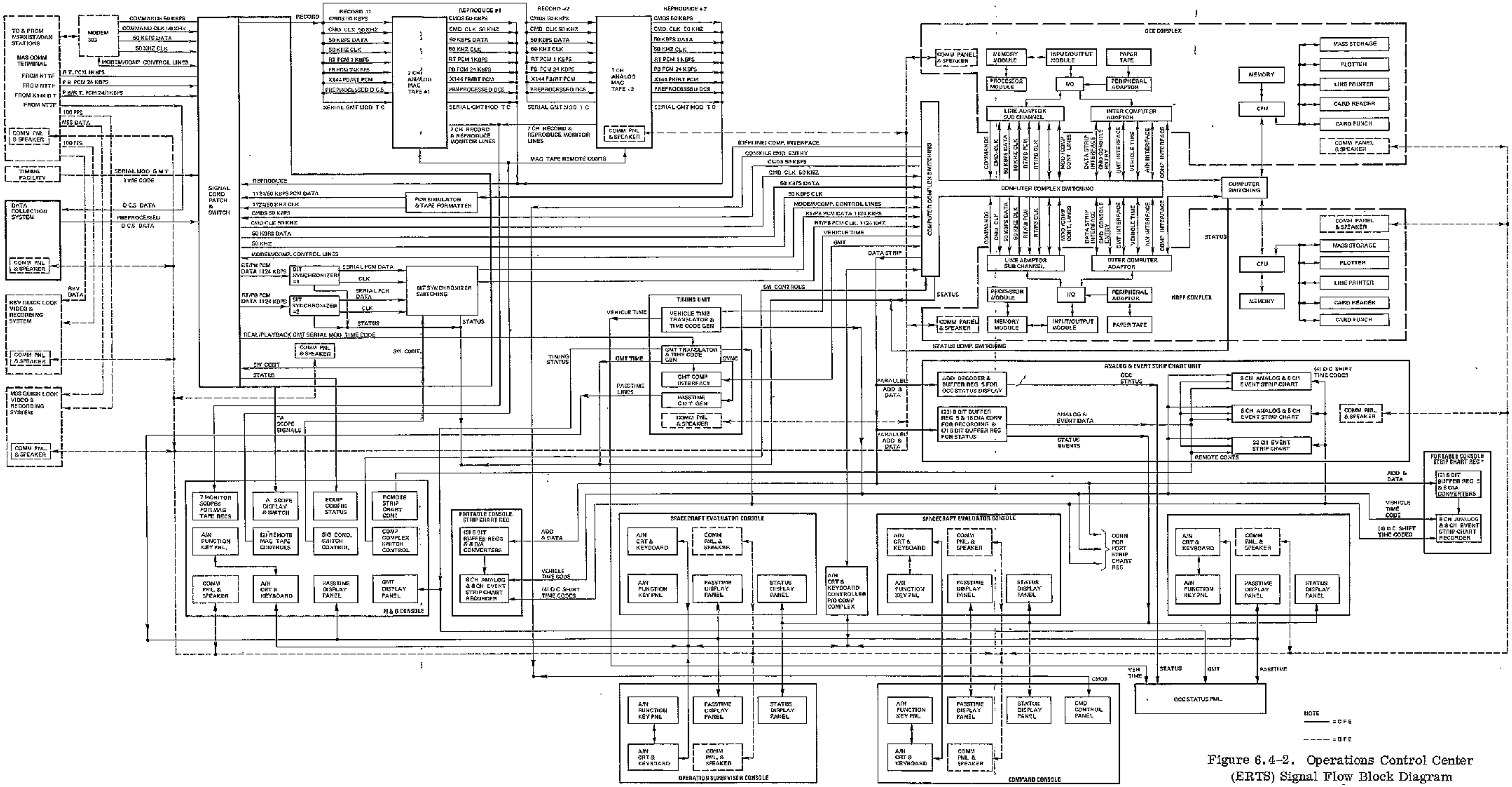


Figure 6.4-2. Operations Control Center (ERTS) Signal Flow Block Diagram

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

Frame synchronization	2 words
Minor frame ID	1 word
Major frame rate	1 frame/16 seconds

The format of the playback PCM data will be as follows:

Word length	10 bits
Minor frame size	20 words
Major frame size	80 minor frames
Frame synchronization	2 words
Minor frame ID	1 word
Major frame rate	1 frame/1.5 seconds

The playback data will be reverse ordered when received.

The SCS equipment will acquire DCS data from the DCS preprocessor. Switching and/or patching will be provided to connect the bit synchronizers described below to either the real-time PCM, the recorded playback, or the simulated PCM signals.

6.4.1.1.3 X144 Data Modem
The SCS equipment will acquire Alaska playback/real-time PCM data at a 24/1 kbps rate from a GFE model X144 modem and data link. This playback/real-time PCM data will have the same format as the playback/real-time data described for GSFC/NTTF. The playback data will be reverse ordered when received. Switching and/or patching capability will be provided to connect the bit synchronizer to either the playback/real-time data, the recorder playback, or to a simulated PCM data signal.

6.4.1.1.4 Simulated PCM Data
The SCS equipment will acquire a simulated PCM data stream from the PCM simulator (described in Section 6.4.1.2) which will furnish data in one of two formats: 1-kbps real-time PCM data, and 24-kbps playback PCM data.

6.4.1.1.5 Timing Signals
The SCS equipment will acquire ground station GMT timing signals from the GSFC timing facility and vehicle GMT timing signals from the Computer Subsystem via its switching equipment. Both timing signals will be in the NASA 104-59 signal format.

6.4.1.1.6 Remote Control and Display
The SCS equipment will receive remote control signals from the M&O console for switching control, the SCS equipment configuration status, and isolated input data lines to the M&O console for display.

6.4.1.2 SCS Signal Conditioning

6.4.1.2.1 Bit Synchronization
The SCS equipment will include two bit synchronizers to signal condition the raw, noisy 1-kbps real-time PCM data and 24-kbps playback data. The bit synchronizers will provide serial data and clock signals to the Computer Subsystem. Any two of the four incoming PCM data streams may be switched into the bit synchronizers.

6.4.1.2.2 PCM Simulator
The PCM simulator will contain a signal modulator to simulate signal/noise conditions, jitter, and blanking. The simulator will receive serial data from the computer communications processor, combine signal modulator output and data stream, and format the data and clock for output to the analog magnetic tape recorder. Simulated outputs will be provided for the 1-kbps real-time and 24-kbps playback serial data streams. The real-time and playback data formats will be stored in memory and output via the Computer Subsystem under program control. Simulation of the 50-kbps serial data stream will be provided utilizing a data format stored in memory and output with the proper header data from the Computer Subsystem to the magnetic tape recorder equipment and played back to the computer via the SCS for simulation purposes.

6.4.1.2.3 Level Converters/Line Drivers
Level converters/line drivers will be provided in the SCS equipment as necessary to match equipment/subsystem interfaces.

6.4.1.3 SCS Equipment Requirements and Functions
The SCS equipment requirements and functions are as follows:

1. Input Patch - selects the source for data to be processed by OCC System.

2. Bit Synchronizer - signal conditions raw, noisy PCM data and generates bit clock in sync with data.

3. PCM Simulator - provides a simulated PCM data stream for testing SCS/Computer Subsystem PCM data channels at 1- and 24-kbps data rates.

4. Level Converters/Line Drivers - provide signal compatibility within the OCC equipment and between the OCC equipment and external interfaces.

5. Facility - provides space for voice communication panel (GFE).

6.4.2 TIMING

The timing equipment receives timing reference signals from the GSFC timing facility and from the Computer Subsystem. In addition, the timing equipment receives pass time Set/Start/Stop/Hold commands from the Control and Display Subsystem. The formatted timing equipment outputs will be sent to the magnetic tape recording equipment, the Computer Subsystem, and to the Control and Display Subsystem for time correlation purposes.

6.4.2.1 Timing Equipment Input/Output

6.4.2.1.1 GSFC/NASCOM Inputs

The timing equipment will receive the 36-bit NASA GMT 104-59 time code from the GSFC timing facility via the SCS equipment.

6.4.2.1.2 Computer Subsystem Inputs

The timing equipment will receive the 36-bit NASA 104-59 vehicle GMT time code from the Computer Subsystem via the SCS equipment.

6.4.2.1.3 Pass Time Control Inputs

The timing equipment will receive pass time Set/Start/Stop/Hold time control signals from the operation supervisors console in the Control and Display Subsystem.

6.4.2.1.4 Recorded Time Code Input

The timing equipment will receive the 36-bit NASA 104-59 time code from the magnetic tape recorder equipment via the SCS equipment when the recorders are operated in the playback mode.

6.4.2.1.5 Vehicle Time Displays

The timing equipment will provide formatted signals to drive the vehicle time displays located on the operations consoles and the M&O console.

6.4.2.1.6 GMT Time Displays

The timing equipment will provide formatted signals to drive the GMT time displays located on the operations consoles and the M&O console.

6.4.2.1.7 Pass Time Displays

The timing equipment will provide formatted signals to drive the pass time displays on the operations consoles and the M&O console.

6.4.2.1.8 DC Shift Codes

The timing equipment will provide dc shift time codes rates to the strip chart recorders in the Control and Display Subsystem.

6.4.2.1.9 Serial Time Code

The timing equipment will provide the ground station GMT time to the Computer Subsystem and to the strip chart recorders via the SCS equipment for time recording. The SCS equipment will provide either the NASA facility time code or the recorded time code to the timing equipment.

6.4.2.2 Timing Equipment Requirements and Functions

The timing equipment requirements and functions are as follows:

1. Ground station GMT translator shall drive clock displays, a serial time code generator and computer interface equipment. Local control and display of time will be required for the translator. The translator will count real/playback times.

2. The ground station GMT time code generator shall provide four dc shift time code rates to the strip chart recorders.

3. Vehicle GMT translator shall drive clock displays and a serial time code generator. Time control and display of time will be required for the translator. The translator will count real/playback times.

4. Vehicle GMT time code generator shall provide four dc shift time code rates to the strip chart recorder.

5. Ground station GMT computer interface shall provide parallel ground station GMT to the computer.

6. Vehicle GMT computer interface shall accept parallel vehicle GMT from the computer and drive the vehicle GMT translator.

7. Pass-time generator shall provide pass-time to the Central and Display Subsystem. Time display for 30-minute countdown interval will be required for the pass-time generator.

6.4.3 COMPUTER SUBSYSTEM SWITCHING

The Computer Subsystem Switching (CSS) equipment switches the OCC input/output signals and the OCC Computer Subsystem alphanumeric terminals between the OCC Computer Subsystem and the NDPF Computer Subsystem. In normal mode, all data inputs are transferred to the OCC Computer Subsystem input channels via the CSS equipment. The command data output channels and timing output channels are transferred to the SCS and timing equipment via the CSS. The alphanumeric output channels are transferred via the CSS to the alphanumeric terminals located in the M&O console and operations console. In the backup mode of operation, the CSS equipment switches these functions to the input/output channels of the NDPF computer. Control of the CSS equipment will be remoted to the M&O console.

6.4.3.1 CSS Input/Output

6.4.3.1.1 Data Inputs

The PCM and DCS signal inputs to the Computer Subsystem are described in the SCS equipment.

6.4.3.1.2 Time Code Input

The GMT time code signal for timing reference is described in conjunction with the timing equipment.

6.4.3.1.3 Vehicle Time
Vehicle time code will be received from the Computer Subsystem selected by the CSS and transferred to the timing equipment.

6.4.3.1.4 Alphanumeric Terminal Signals
Alphanumeric terminal signals to be transmitted between the Computer Subsystem and the alphanumeric terminals will be switched by the CSS equipment.

6.4.3.1.5 Command Data
Command data will be received from the Computer Subsystem selected by the CSS and transferred to the SCS for transmittal through the NASCOM network.

6.4.3.2 CSS Equipment Requirements and Functions
Switching equipment and signal conditioners (as necessary) are used to connect the OCC data interfaces to the OCC or the NDPF Computer Subsystem.

6.4.4 MAGNETIC TAPE RECORDING
The magnetic tape recording (MTR) equipment provides for the recording and reproducing of the PCM command and simulated PCM data from the signal conditioning and switching equipment, the DCS data from the Data Collection Subsystem, and the time code from the timing equipment. The MTR equipment will contain two recording/reproducing units. One unit will be used for normal operation, with the other unit available for backup capability. Monitoring and control of the recorder operation will be remoted to the M&O console.

6.4.4.1 MTR Input/Output

6.4.4.1.1 PCM Data
PCM and simulated PCM will be transferred to and received from the operational recorder via the SCS equipment.

6.4.4.1.2 DCS Data
DCS data will be transferred to and received from the operational recorder via the SCS equipment.

6.4.4.1.3 Time Code
GMT time code will be transferred to and received from the operational recorder via the SCS equipment.

6.4.4.1.4 Command Signal
Command signals will be received from the Computer Subsystem via the SCS equipment and recorded for OCC station history purposes.

6.4.4.1.5 Remote Control and Display
Remote control signals for control of the operating status of the recorder will be received from the M&O console. The record/reproduce inputs/outputs of the recorders will be sent to the M&O console for monitoring.

6.4.4.2 Equipment Requirements and Functions
Two 7-track magnetic tape transports with record/reproduce electronics capable of handling data with a 50-kbps maximum rate will be used.

6.4.5 MAINTENANCE AND OPERATIONS CONSOLE
The maintenance and operation (M&O) console will be used to control the OCC system configuration, to select the OCC data input, and to monitor the OCC system performance/status. The M&O console operator will provide the interface between the operations supervisor and the NASA data handling and scheduling organizations.

6.4.5.1 M&O Inputs/Outputs

6.4.5.1.1 Alphanumeric Terminal
The M&O console will receive the transfer alphanumeric data and control signals to the Computer Subsystem via the CSS equipment.

6.4.5.1.2 Timing Signals
The M&O console will receive ground station GMT timing signals, vehicle GMT timing signals, and pass-time timing signals from the timing equipment for display.

6.4.5.1.3 Recorder Control
The M&O console will receive operational status data from and send remote control signals to the magnetic tape recording equipment and the analog and event strip chart recording equipment of the Control and Display Subsystem. The M&O console will provide the capability of monitoring the magnetic tape recorder signal input/output lines.

6.4.5.1.4 Signal Conditioning and Switching
The M&O console will receive operational and configuration status and input signal monitoring lines from the SCS equipment. The M&O console will provide switching controls to configure the SCS equipment.

6.4.5.1.5 Computer Subsystem Switching
The M&O console will receive operational status data from and send remote control signals to the CSS equipment.

6.4.5.1.6 Status Display
The M&O console will receive computer developed status display information via the Control and Display Subsystem.

6.4.5.2 Equipment Requirements
The equipment requirements are as follows:

1. Ground station GMT, vehicle GMT, and pass-time display panel

2. Magnetic tape monitor oscilloscope panel

3. A-scan oscilloscope (to monitor PCM and DCS data)

4. Magnetic tape recorder remote control panel

5. Strip chart recorder remote control panel

6. OCC configuration status display

7. Status display panel (to display computer generated data)

8. Alphanumeric terminal and keyboard (part of OCC Computer Subsystem)

9. Provision for voice communication panel (GFE)

6.4.6 VOICE COMMUNICATIONS

The OCC voice circuits, associated hardware, and interfaces will be Government Furnished Equipment. Several operational positions will need Private Branch Exchanges (PBX), Switching Conference and Monitoring Arrangement (SCAMA), interfaces to remote ground networks, and Closed Circuit Loop (CCL) channels for GSFC internal communications.

Installation of key sets and communications panels will be accomplished under the auspices of the NASA Communications (NASCOM) organization at GSFC. Standard communications panels will be furnished to the designated operational and maintenance positions. For the most part, operational positions will use the standard communications panels, accommodating 30 or 60 pushbuttons. Table 6.4-1 shows a matrix of operational positions and their required communications needs. Figure 6.4-2 shows emplacement of communications panels and speakers on various pieces of hardware in the OCC. The various OCC communications loops and equipment, together with their operational utilization, are described below.

6.4.6.1 <u>Switching Conference and Monitoring Arrangement (SCAMA)</u>

The two SCAMA loops required in the OCC will be controlled by GSFC voice control. These SCAMA circuits will allow communications between the OCC and the designated remote facilities in the STADAN and MSFN networks. Two SCAMA circuits provide the capability of independent conversations and provide redundancy for a primary SCAMA loop used during remote station contacts. The prime use of these SCAMA loops will be for briefings and reports handled by the operations supervisor and the M&O with the remote facilities.

6.4.6.2 <u>Closed Circuit Loops (CCL)</u>

These communications circuits are those which will be used by the personnel located at GSFC. Voice interfaces necessary for ERTS operations at GSFC will utilize this type of circuit.

6.4.6.3 <u>Private Branch Exchanges (PBX)</u>

Standard telephone circuits will be provided for all operational positions in the Operations Control Center's control room and for the M&O console operator. An internal PBX for GSFC use and an external PBX will be provided at each.

6.4.6.4 <u>Other Communications Hardware</u>

As shown in Table 6.4-1, several operational positions will require the use of speakers, headsets, handsets, foot pedals, and public address control. Also included in the matrix is the number of plug-in receptacles required at each key set location.

Table 6.4-1. OCC Communications Loops

Position	SCAMA 1	SCAMA 2	OPSCON	NETCON	OS	AOS	S/C Systems	P/L Systems	NTTF	OCC Comp.	M&O	Display	NDPF Cord.	PBX (GSFC)	PBX	Speaker	Headset	Handset	Foot Pedal	PA System Control	No. of Plug In Receptacles
	SCAMA				CLOSED CIRCUIT LOOPS (CCL)										PBX		OTHER COMMUNICATIONS HARDWARE				
*Operations Supervisor	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	X	X	X	X	X	2
*Command Engineer	TM	TM	M	M	TM	TM	TM	TM	M	TM	TM	TM		TM	TM	X	X	X	X		2
*Spacecraft Evaluator	M	M	M	M	TM	TM	TM	TM	M	TM	TM	TM		TM	TM	X	X	X	X		2
*Spacecraft Evaluator	M	M	M	M	TM	TM	TM	TM	M	TM	TM	TM		TM	TM	X	X	X	X		2
*Spacecraft Evaluator	M	M	M	M	TM	TM	TM	TM	TM		TM	TM	TM	TM	TM	X	X	X	X		2
OCC-NASA Communications Terminal	M	M			TM	TM			TM	TM	TM					X	X				1
DCS Preprocessor					TM	TM					TM					X	X				1
Payload Recorder					TM	TM		TM	TM		TM					X	X				1
*M&O Supervisor	M	M	M	M	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	TM	X	X	X	X		1
Simulator-Formatter					TM	TM	TM			TM	TM					X	X				1
Recorders (Narrow-band)					TM	TM	TM		TM	TM	TM					X	X				1
Timing					TM	TM				TM	TM					X	X				1
*OCC Computer					TM	TM	TM	TM		TM	TM					X	X				1
Display					TM	TM					TM	TM				X	X				1
M&O Position 1					TM	TM					TM					X	X				1
M&O Position 2					TM	TM					TM	TM				X	X				1
M&O Position 3					TM	TM					TM	TM				X	X				1
Observation Area	M	M			M	M	M	M								X					0

* - Indicates Operational Positions
T - Talk
M - Monitor
X - Required

6.5 STATUS DATA CONTROL AND DISPLAY

The Status Data Control and Display Subsystem consists of the hardware and software necessary to present, maintain, and update the mission system and spacecraft system status data essential to flight operations. A block diagram of the subsystem is presented in Figure 6.5-1. The major components of this subsystem are:

1. OCC operations consoles
2. Strip chart and event display recorders
3. Display control and report generation software which operates in the OCC computer

6.5.1 OPERATIONS CONSOLES

Five consoles are required within the OCC Operations Control Room. The five consoles have been identified as:

1. Operations Supervisor (OS) console
2. Command console
3. Spacecraft Evaluator console (3)

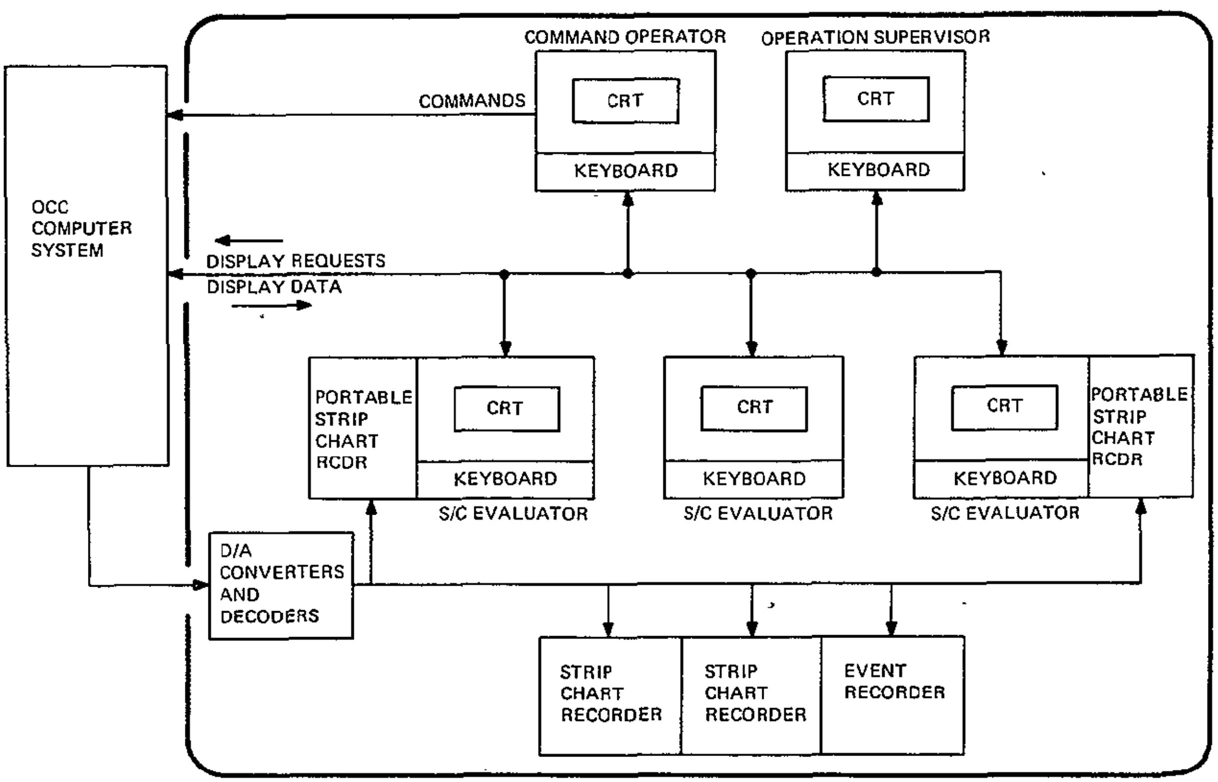


Figure 6.5-1. Control and Display Subsystem Block Diagram

The OS console, Command console, and Spacecraft Evaluator consoles will all have the same basic configuration. The addition of special panels and associated cabling to the basic configuration will produce the OS and Command consoles. Each console is equipped with a CRT display and a standard input keyboard and programmable function keys which permit access to the OCC computer. In addition, the consoles are equipped with a spacecraft time clock, GMT clock, pass time clock, communications panel, and a small matrix of status and alarm indicators driven by the computer which can be programmed according to each console's function. Both the Command and OS consoles also contain a Command panel for the initiation of commands. This panel is provided at both consoles for backup. The computer will only permit command inputs from one panel or the other at any time. Finally, each console permits connection with one of the two portable strip chart recorders in the Operations Control Room. Using the computer input keyboard at the console, any operator may request selected analog displays to be presented at the associated recorder. An artist's conception of an operations console is shown in Figure 6.5-2.

6.5.2 STRIP CHART AND EVENT RECORDERS

The strip chart and event recorders provide the capability for displaying dynamic analog data in a more meaningful manner than the CRT's permit. This is especially true in the case of certain attitude control and other subsystem parameters. In addition, these recorders present the data in recognizable and repeatable patterns which can be readily interpreted as performance signatures from which anomalies are readily detectable. In other cases, these recorders serve as short term trend plots which, again, permit rapid identification of anomalies.

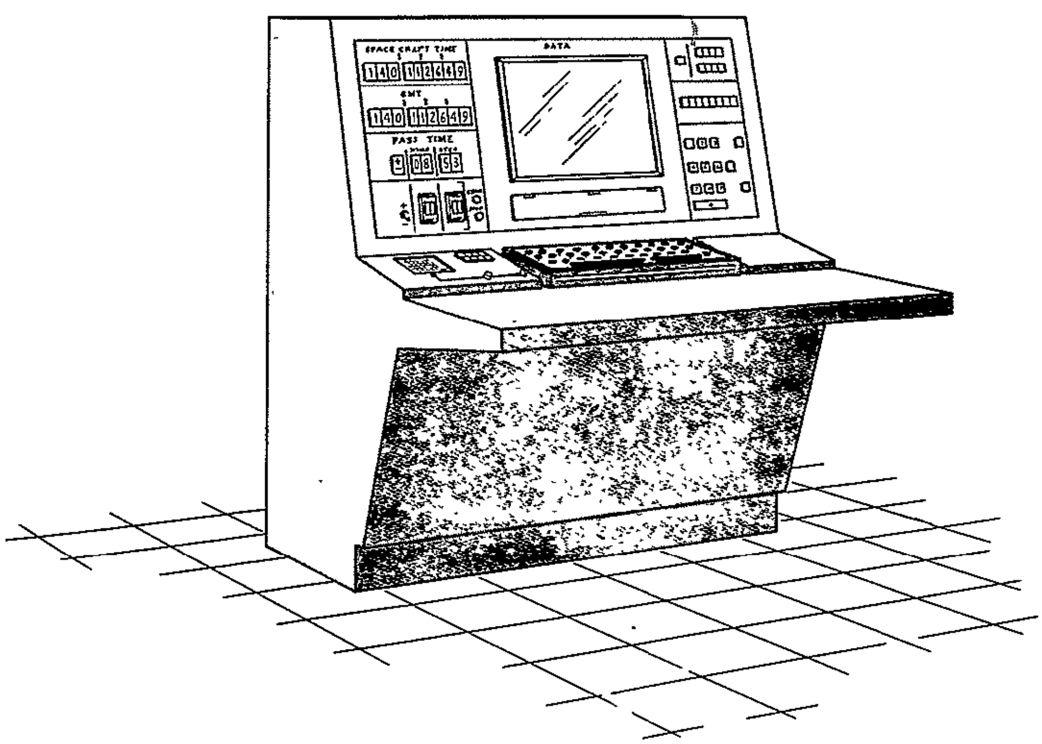


Figure 6.5-2. Artist's Conception of Console

Under normal conditions two portable strip chart recorders will be located in the Operations Control Room, and two strip chart recorders and one 32-channel event recorder will be located in the OCC equipment room. Each of the strip chart recorders has the capability of displaying eight analog and eight discrete signals. The portable recorders are used in conjunction with spacecraft and payload evaluation functions conducted at the operations consoles. The recorders in the equipment room are used to supplement this evaluation and to generate additional analog and event displays routinely required off-line from playback data. This arrangement affords full benefit from the multiprocessing mode of the OCC computer system and the interactive capability of the consoles. The system can operate on several processing requests simultaneously and can present the results of this processing to any of the appropriate devices. That is, displays may be output to the consoles and the strip chart recorders, while other data from a different process request is displayed simultaneously at the recorders in the equipment room.

The strip chart and event recorders also serve as a critical backup display capability within the OCC. In the proposed computer system configuration described in Section 6.6, these recorders are driven by the system's communication processor. This processor is capable of operating in a stand-alone mode without benefit of the OCC central processor. In the event of CPU failure during real time spacecraft operations, the communications processor would continue to present selected PCM data to these recorders, thus providing a significant backup PCM display capability for spacecraft evaluation.

6.5.3 DISPLAY CONTROL AND REPORT GENERATION SOFTWARE

Display generation and control within the Control and Display subsystem are performed primarily by two software packages, the Report Data Supervisor (RDS) and the Report Generator Supervisor (RGS). The purpose of the RDS is to collect the report information generated by the various telemetry processing and analysis packages, and control the flow of this information to operating system display and retention software. The RDS will also retrieve previously stored report information from the data base and make this information available to report generation software.

The purpose of the Report Generator Supervisor (RGS) is to supervise the presentation of requested displays at the operations consoles by:

1. Supervising the loading of the required Report Generator Packages (RGP)

2. Requesting linkages to the required display data via the RDS.

Requests for displays and display options are communicated to the RGS via the System Request Executive (SRE). The SRE is described in Section 6.7. These requests include new reports, page changes, page freeze/unfreeze, and hard copy printouts.

The Report Generator Packages will contain all of the formatting statements, device handler interfaces, and tabular and columnar information required to display the report information in a meaningful presentation at any of the operations consoles or printer.

Figure 6.5-3 defines the information exchange for this processing.

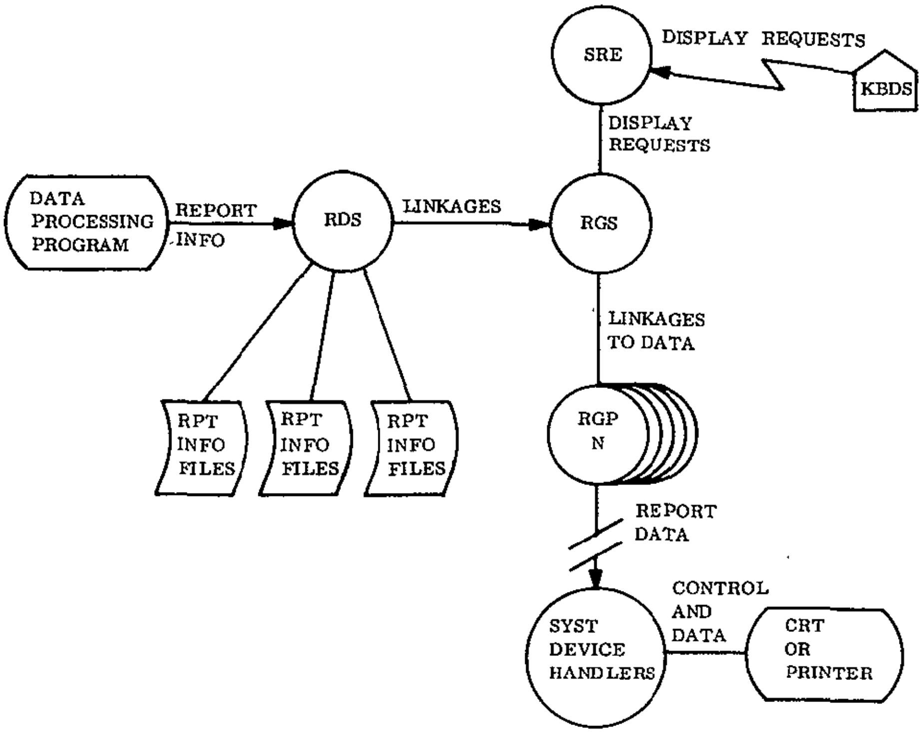


Figure 6.5-3. Report Generator Packages Processing

Analog and digital PCM data, displayed on strip chart and event recorders located at the operations consoles, will be processed by the data decommutation section of the Decom program.

The Decom program will reference PCM display set tables, contained internally, to extract the data required at each console. Each PCM display set table will define eight analog and eight digital functions. The Decom will use one set table for each operations console and extract and display, at that console, the data identified by the set table.

Any data set defined in the system can be displayed at any operations console. Requests for data set displays will be input to the system via the alphanumeric keyboard at that console. This display set request will be processed by the Systems Request Executive which will load the requested display set table and communicate it to the Decom. The Decom will then use the new display set table for the requesting console to extract and display the PCM data at that console.

Data required for trend analysis will be extracted post-pass from the playback telemetry file for this orbit. This data will be extracted, converted, and formatted in the codes appropriate for input to a stand-alone plotting device. The software required to do the extraction, formatting, and conversion is the Plot Data Formatter (PDF). This program will run under control of the Off-Line Supervisor in the post-pass environment.

6.5.4 DISPLAY SELECTION STUDY

The choice of a primary system display media for the OCC was generally between hard-copy printers and some form of CRT display. The decision was made based upon the functional requirements and the overall operational philosophy.

The OCC is the focal point for ERTS flight operations. Although some capability for telemetry data display and commanding is provided at the remote sites, the OCC alone has the responsibility for evaluating the data, making the judgments, and commanding the spacecraft. The control and display subsystem is an integral part of the mechanism by which the OCC fulfills the responsibility, satisfying the processing requirements of all four major functional areas. The operational design philosophy and specific functional requirements define an environment in which the computer must interact bi-directionally with one or more users simultaneously. This interaction must be easy and effective and must afford the user a high degree of flexibility in his ability to selectively request the processing and/or display of selected data.

To describe this in more specific terms, consider the interaction required during real-time operations. The operations team consists of five key individuals: the operations supervisor, who has overall responsibility and authority; the command operator; and three spacecraft data evaluators. Past experience in Nimbus operations and other spacecraft programs has shown that the data required by these individuals to perform their functions during this real time period could easily comprise as many as 30 to 50 different reports. These include, for example:

1. Commands transmitted
2. Commands verified
3. Spacecraft status (consists of several reports)
4. Subsystem status (consists of several reports)
5. Out-of-limits
6. Alarms

Some of this information is updated every telemetry frame, especially considering the amount of activity anticipated during this period, and a new telemetry frame is input once every 16 seconds. On the other hand, many reports are "reports by exception" and only describe anomalies. To satisfy these needs, the output of real time reports should not be scripted according to some predefined display sequence but, rather, should allow members of the operations team to individually select the displays to be presented depending upon the conditions which exist. Throughout this period, the system should continue to overtly notify them that critical display data exists, and present this display upon request.

Based upon this concept and the degree of interaction, flexibility, and response time implied, it became evident that alphanumeric CRT displays with multipage, multiposition capability and keyboard input are required as the primary OCC display media.

These displays also satisfy the nonreal time requirements for multiuser operations. This allows greater utilization of the capability of the computer system by permitting that system to operate in what amounts to a time-shared mode.

A printer will be employed within the system for generating a hard copy of selected real time display data. It will also be employed routinely for lengthy off-line report generation, program listings, etc.

6.5.5 OCC OPERATIONS CONSOLE DESIGN STUDY

The design concept for the OCC operations consoles is predicated on the need to provide the flight operations team with the information necessary to make rapid command and control decisions and the means to implement these decisions in an effective and timely manner. The consoles are designed as functional work stations. Each console is equipped with a CRT, standard input keyboard, and set of programmable function keys which permit access to the OCC computer. In addition, the consoles are equipped with a spacecraft time clock and pass time clock, communications panel, and a small matrix of status and alarm indicators also driven by the computer which can be programmed according to each consoles function. The command console is identical to the other consoles but also contains a command entry panel which affords direct access to the computer.

During real time operations, each console operator may access any one of 50 or more displays for immediate callup at his console. Display requests are made via the keyboard. The display software in the computer will also notify the operator of any alarm conditions that have been identified in data which he is not currently viewing.

During the off-pass periods, the consoles provide multi-user access to the computer. This permits the console to be used for spacecraft performance analysis, anomaly investigation, or processing required in preparation for the next orbit.

This approach permits the design of a single, standard operations console which has the flexibility to satisfy virtually all operational needs at minimum hardware cost. The impact upon computer hardware is not significant since the CRT's required are relatively inexpensive compared to other display devices such as printers. The impact upon software does not appear to be significant since the basic CRT control and display software required is generally provided as part of the computer operating system.

Figure 6.5-4 is an artist's conception of the OCC Operations Control Room.

6.5.6 CONTROL ROOM WALL DISPLAY STUDY

Figure 6.5-5 depicts a wall-sized status display within the OCC control room. The display is comprised of two end panels which would present pertinent mission and spacecraft system data generated within the OCC or derived from the PCM data and driven by the

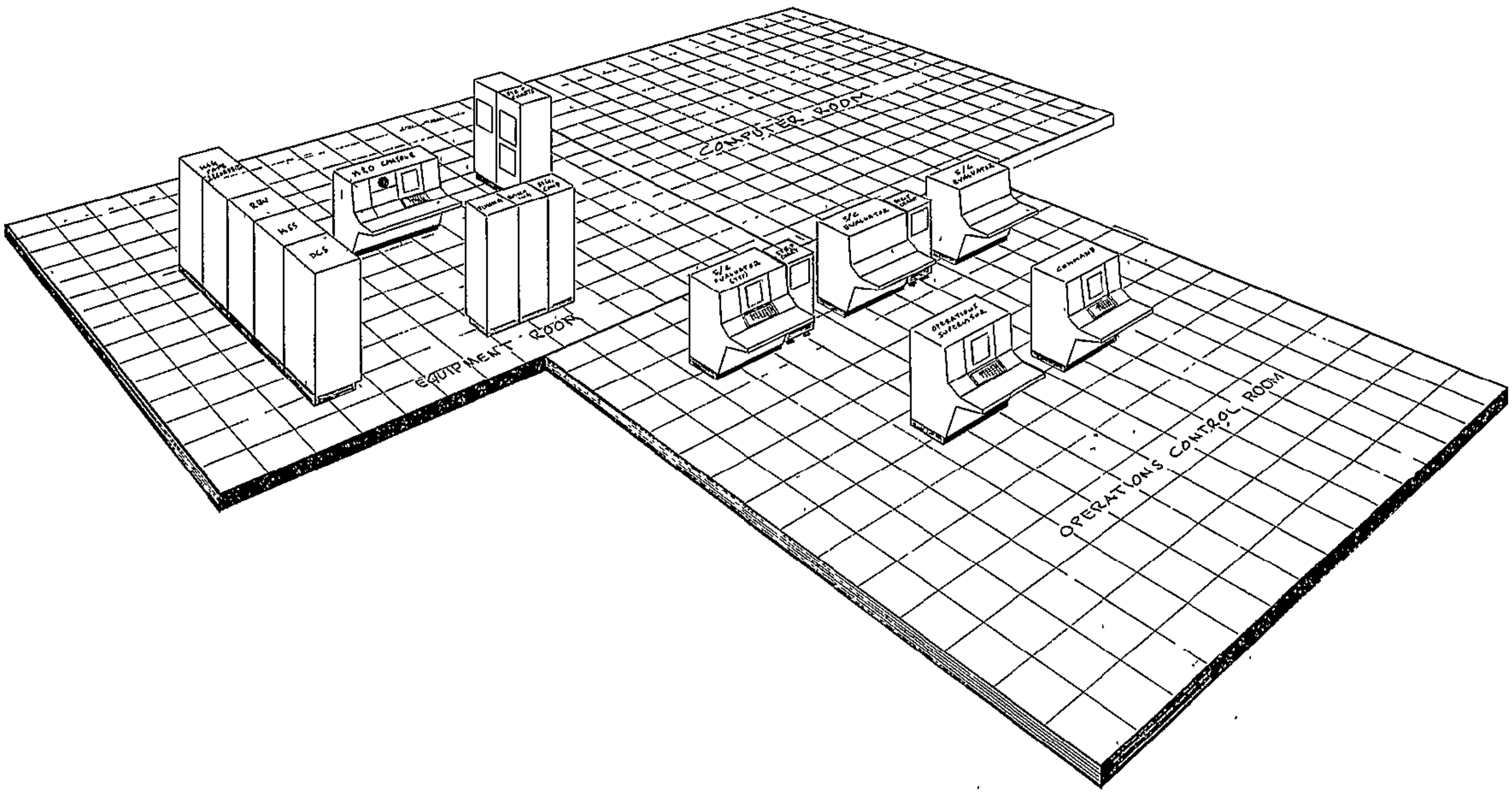


Figure 6.5-4. Artist's Conception of OCC Control Room

computer. The center of the display is a projected TV image in either black and white or color. This portion of the display would offer wide flexibility to display data generated within the computer, data generated by input at a console, or data generated by closed circuit TV camera coverage.

The motivation behind a display of this type is derived from several factors:

1. It permits a situation overview at a glance by presenting commonly required mission and spacecraft status data continually. This would serve not only the operations people but those in the viewing area immediately outside the control room.

2. The versatility afforded by the projection display permits the display of data not readily available by other means. This would include large scale map displays as shown in the artist's drawing, and could also include displays of payload imagery at reduced resolution.

3. The projection display also permits presentation of information sent to or input from the operations consoles via the computer. This would allow displays of subsystem status or alarm conditions to be presented for common viewing and evaluation by the operation's team without requiring them to change the displays at their individual consoles. In addition, the operations supervisor, for example, can create a pre-pass briefing display at his console for presentation on the wall display and use this as a common denominator for briefing the operations staff.

As a result of the study, it was determined that this type of display would be of value in the OCC. It must also be recognized, however, that the CRT displays already in the system provide much the same capability. A final decision will have to be made primarily on the basis of cost, and the results will be proposed in the Phase D Proposal.

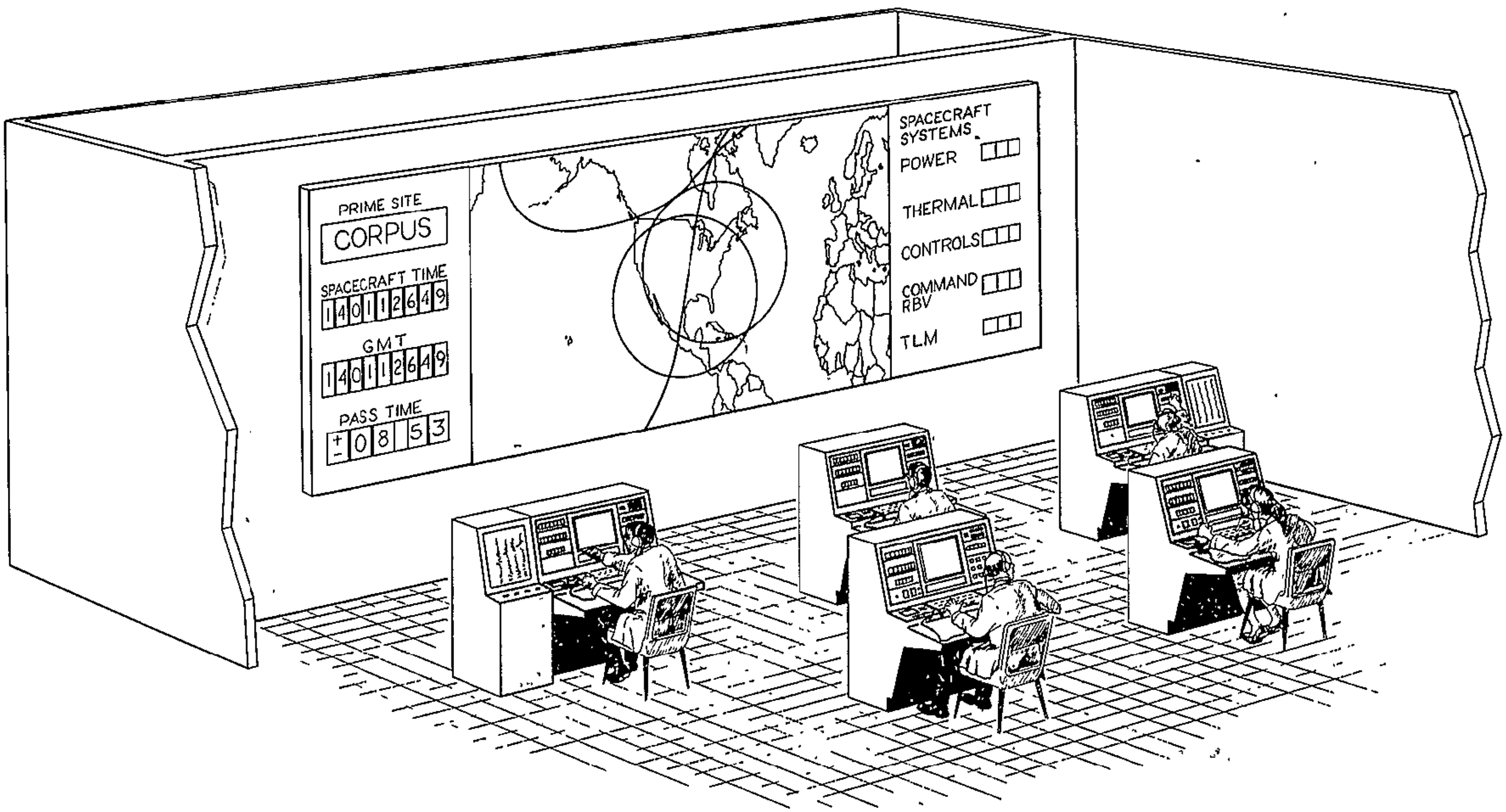


Figure 6. 5-5. OCC Control Room - Wall-Sized Status Display

6.6 SYSTEM SCHEDULING SUBSYSTEM

6.6.1 INTRODUCTION

The System Scheduling subsystem defines the scheduling of sensor operations that will effectively use the data collection capability of the spaceborne observation system, and the scheduling of necessary ground system support operations such as tracking, orbit maintenance and ground station contacts.

System Scheduling generates an overall system activity plan based on coverage requirements, spacecraft and payload status, network availability, and environmental constraints. The activity plan produced must be a time-ordered list of spacecraft, payload and network events that do not violate any operational constraint imposed on the ERTS system. The subsystem is primarily a nonreal-time, data-base oriented, software system.

Figure 6.6-1 is a functional flow diagram of the System Scheduling subsystem illustrating the functional requirements which must be satisfied. Sections 6.6.2 through 6.6.9 describe a series of studies that were carried out to evaluate alternate design approaches for implementing the System Scheduling subsystem of the OCC.

6.6.1.1 System Overview

The System Scheduling subsystem provides the mission planner with a computational and bookkeeping aide to assist him in the selection of a specific mission profile which efficiently uses the data collection capability of the ERTS system.

The requirement to incorporate timely weather predictions compounds the problem of selecting an effective system schedule by minimizing the time available between receipt of weather predictions and generation of commands. Thus, the problem is to determine an efficient system schedule without violating any operational, expendable, or environmental constraint within a limited computation time.

The subsystem represents a computer-aided approach to the system scheduling problem that facilitates the generation of overall system schedules within all of the aforementioned constraints. The key feature of the system is that it is computer-aided; e.g., the OCC computer is utilized to perform routine arithmetic data processing, and report generating functions while the mission planner is utilized in a decision-making role to resolve constraint conflicts identified by the computer. In all cases, manual intervention can override computer-generated decisions.

6.6.1.2 System Description

The System Scheduling subsystem is a highly flexible, easily controlled, interactive software system that aides the mission planner in selecting an efficient schedule of spacecraft, payload and network events.

1. Flexible planning cycle duration to facilitate effective use of weather data and efficient management of the wideband video tape recorders while minimizing the necessity for schedule updates.

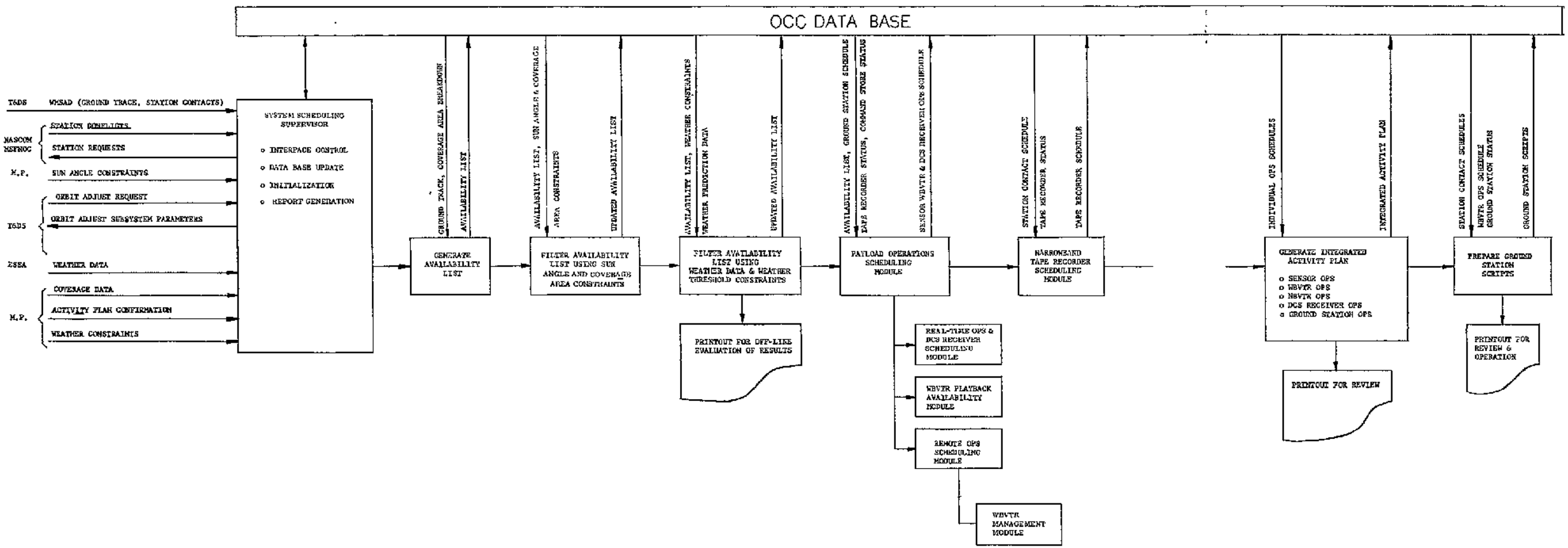


Figure 6.6-1. OCC System Scheduling Functional Flow Diagram

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME 3

2. Use of weather forecast data to eliminate both real-time and remote coverage opportunities with unacceptable probabilities of sufficiently cloud free sensing.

3. Provision of off-line software which integrates NDPF image evaluations and verified weather data from ESSA to determine the effectiveness of experimental techniques for converting weather forecast data into probability of successful data acquisition.

4. Performing as much of the required data processing as possible before receipt of predicted weather data to reduce the computation requirements immediately preceding a station pass.

5. The development of an efficient method of retrieving coverage area identification data from the disk, the supercell concept.

6. The design of files and data tables coupled with a sequence of parameter computations that minimizes the data handling problem and the necessity for recalculation of parameters.

7. The inclusion of the mission planner in the system to perform certain critical decision-making functions; e.g., resolution of computer identified constraint conflicts.

The System Scheduling subsystem may be considered to consist of three major sections (see Figure 6.6-2):

1. The system scheduling supervisor which provides overall system control, initialization, and report generation.

2. A data preprocessing section in which geometric coverage computations and filtering on coverage area characteristics and sun angle are performed.

3. The activity scheduling section in which coverage area availability is filtered by predicted weather, and then spacecraft, payload and network schedules are generated and integrated into a comprehensive activity plan.

6.6.1.2.1 Data Preprocessing and Filtering

The entire ERTS coverage area must be considered an aggregation of individual, subareas, or "area-cells," for the OCC computer to provide significant assistance in the system scheduling process. The sizing of these area-cells is the subject of the study presented in Section 6.6.3.

The area-cell availability and preliminary filter module, GALAF, generates the basic data required to determine actual payload, spacecraft, and network operations schedules. This is accomplished by generating the GAVAIL table which contains all of the availability data required by the scheduling routines.

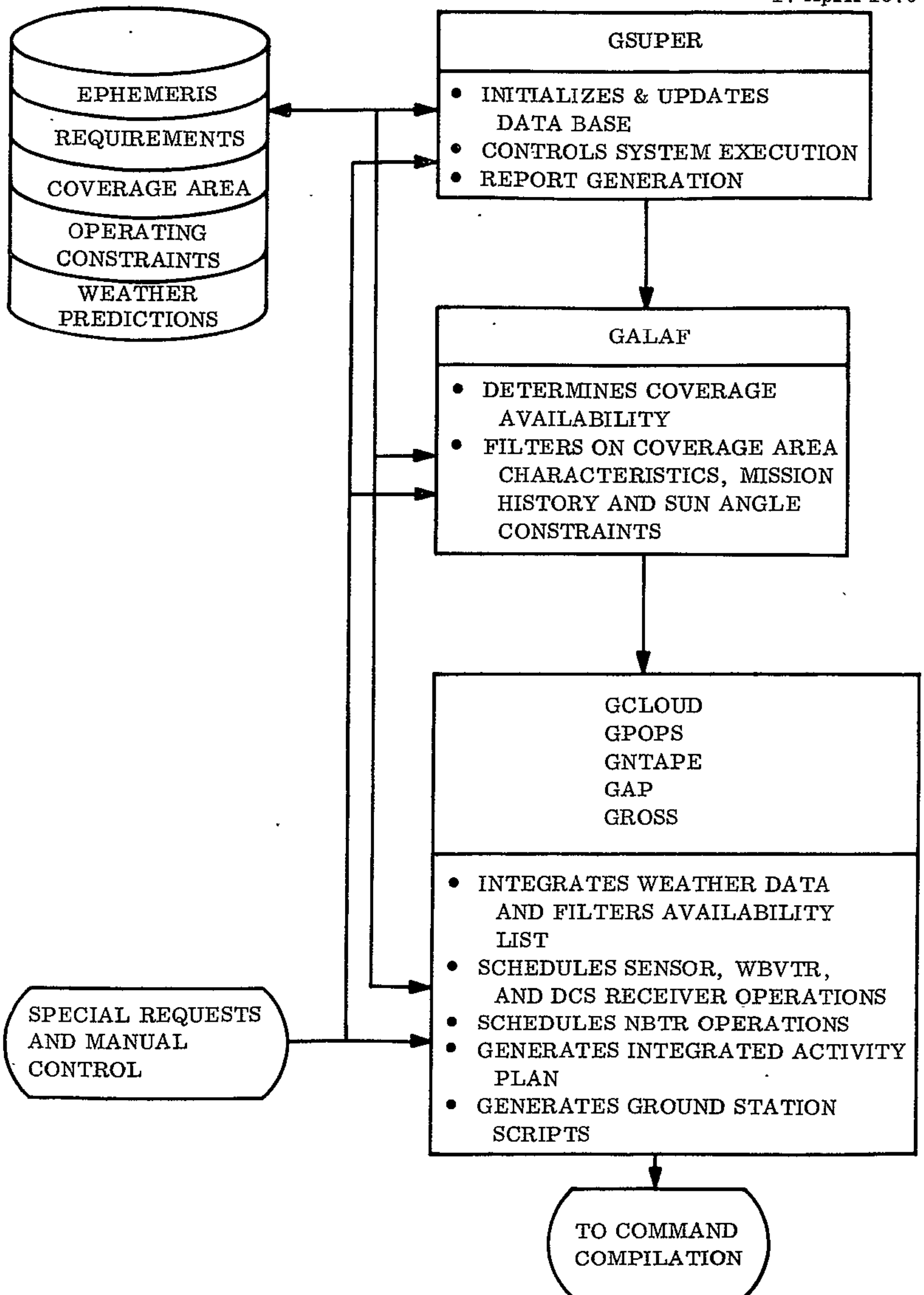


Figure 6.6-2. System Scheduling Subsystem

In order to minimize the mission planning computation time required immediately before a station pass, the availability and preliminary filtering computations may be performed during night-time passes or, more generally, whenever the computer is not in the dedicated mode to support another OCC function. To further reduce the load on the OCC computer, the supercell concept was developed to greatly improve the computation efficiency and disk-to-core data transfer of data required to generate the availability list.

When an area-cell is first retrieved from a supercell, it is filtered in response to input specifications, if such have been given, such as mission history, country code, and priority. This eliminates all processing for those area-cells in which there is no interest. Next, filtering is performed on the calculated sun elevation angle parameter. Again, this eliminates unnecessary processing by eliminating an area-cell as soon as it fails to meet a filtering requirement.

The final filtering based on predicted weather is done at the start of the activity scheduling subsection which immediately proceeds the station pass when the command load is to be transmitted to the spacecraft. In this manner the most current, and hence most reliable, forecast possible can be utilized.

After filtering has been done on predicted weather, the actual scheduling of payload, spacecraft, and network events is begun.

All possible real-time coverage events are scheduled and displayed to the mission planner for approval. At this time, he may manually override or alter the automatic scheduling of available area-cells. In order to conserve time consumed by transferring data to and from the disk, the DCS receiver schedule is generated concurrent to the scheduling of real-time sensor operations. The DCS receiver is normally scheduled to be turned on at AOS and turned off at LOS for each station contact.

After the real-time sensor operations have been scheduled, the remaining ground station contact time is considered available for playback of remotely acquired data stored on the WBVTR's.

6.6.1.2.2 Remote Sensor Operations and WBVTR Scheduling

Remote sensor operations are scheduled by sensor operating sequence (e.g., from the time the sensors are commanded on until the time they are commanded off) in order of area-cell availability. The length of a sequence is determined by area-cell availability. After a sequence length is determined, the WBVTR management module is called and an analysis is performed to see if the sequence can be recorded. If sufficient recorder capacity exists, the sequence is scheduled and the digital images of both the RBV and MSS WBVTR's are updated to reflect this action. The WBVTR management module (GWTAPE) maintains digitized images of both WBVTR's with a resolution of 1 foot of tape. Records are kept of what data is stored on the tape.

For purposes of tape recorder management it has been assumed that if both sensors are operable, and not specifically designated otherwise, they will both be commanded to operate simultaneously; e.g., they will record the same data. Because the MSS sensor requires more tape to record an image, the capability of the WBVTR's to record data is determined by evaluating the MSS tape recorder status.

If insufficient capability exists to record an available sequence of sensor operations, a message to this effect will be displayed to the mission planner along with a certain basic set of data to aid him in resolving this conflict.

The mission planner also has the capability to call up additional data displays that he feels may help him resolve the conflict, e.g., available coverage until the next station contact; descriptions of the sequences already stored on the WBVTR tapes (when the data was acquired and the what, where and priority of the data), etc. The corrective measures available to him are:

1. Deletion of previously scheduled sequences (or parts of sequences)

2. Suppression of specific area-cell priorities

3. Suppression of specific country coverage

Whichever corrective action the mission planner chooses, another iteration through the remote sensor operation scheduling module, GREMOP, is begun. If the correction was insufficient, additional action will be required on the part of the mission planner. If the corrective action was sufficient to eliminate the conflict, diagnostic data will be displayed to the mission planner to afford him the opportunity to restore some of the deleted coverage if he so desires.

Assuming that sufficient WBVTR capacity exists to record a sequence of data, verification of the spacecraft command storage capability must be performed. If the vehicles' command storage capability must be exceeded in order to schedule the sequence in question, then an error message will be displayed to the mission planner along with appropriate diagnostic data to help him resolve the conflict. He may also call up additional data displays at this time, e.g., WBVTR capacity available; available coverage until the next station contact, etc. The corrective measures available to solve this problem are:

1. Total deletion of previously scheduled sequences

2. Combining previously scheduled sequences by scheduling the sensors to remain on during previously scheduled off times.

Again, whichever form of corrective action the mission planner choses, another iteration through GREMOP is required to verify the validity of the corrective measure selected.

While sequentially stepping through the planning cycle to schedule remote sensor operations station contact may be encountered during which there is some time available for video data playback (e.g., real-time operations have not been scheduled). The WBVTR management module, GWTAPE, also performs the function of determing what stored data sequences should be dumped during a playback opportunity. Partial sequences are accurately maintained. Because of the different patterns of data storage on the RBV and MSS tape recorders, two playback event lists (on/off sequences) must be generated.

6.6.1.2.3 Narrow Band Tape Recorder Scheduling

Another function performed by the system scheduling subsystem is management of the ground station WBVTR's used to record playback data. This is done to eliminate the need for the mounting of new tapes before each station pass scheduled to receive playback data; that is, to allow for the packing of readout data from more than one playback cycle onto a single tape. The schedule for mounting new tapes will be incorporated into the ground station scripts transmitted to each station during the prepass briefing. When a new set of tapes is mounted at a ground station, a report must be made to the OCC before the next planning cycle, as to the recording capacities of these new tapes. In addition, the ground station script files generated will be converted into tables of contents for the data stored on each ground station tape.

At the conclusion of GREMOP execution, remote sensor operation and WBVTR operations will have been scheduled without violating any expendable or operational constraints.

At this point, the narrow-band tape recorder module, GNTAPE, is executed to generate the activity schedule for the two narrow-band tape recorders. Normal use of the narrow-band tape recorders is to record telemetry data at all times. While one recorder is being dumped over a ground station, the telemetry, in addition to being received on the ground in real-time, is also recorded on the other spacecraft recorder. This operational approach ensures a continuous stream of telemetry being available via dumped data. The GNTAPE module performs a simple bookkeeping function based upon the ground station contact profile.

6.6.1.2.4 Activity Plan Generation

The integrated activity compilation is accomplished by sorting on the basis of time, and merging the following data files:

1. Real-time sensor operations list

2. Remote sensor/WBVTR record operations list

3. MSS tape recorder playback operations list

4. RBV tape recorder playback operations list

5. DCS receiver operations list

6. Narrow band recorder operations list

The results of the integration of these event lists is output for review by the mission planner. At this point, he may manually input any additions or alterations to the activity plan. One such addition that will be made is the addition of orbit adjust events based on the input data received from T&DS. The final, approved, activity plan is then ready for command compilation.

6.6.1.2.5 Ground Station Scheduling Scripts

The last function performed during on-line system scheduling is generation of individual ground station scripts for the rev span planned. The module, GROSS, integrates the real-time operations scheduled in GRETOP with the playback operations scheduled in GWTAPE and GSTAR. Included in each station script is the time sequence of events required to support the spacecraft during the planning cycle, plus a listing of the playback data expected to be received; e.g., how much data, when the data was acquired, and the country code and priority identifiers for the area-cells covered. These scripts are output in hard copy form for verification by the mission planner and in machine-readable form for the M&O to transmit via TTY to the station sites.

6.6.2 PLANNING CYCLE LENGTH STUDY

6.6.2.1 Requirements

The length of the planning cycle in terms of what span of revolutions must be considered in generating the activity plan has a significant impact upon the overall design, accuracy, and operating cost of the System Scheduling subsystem of the OCC for the following basic reasons:

1. Execution time increases at least as fast as directly proportional to the length of the planning cycle.

2. The reliability of the weather data incorporated into the payload operation scheduling portion of the planning cycle is roughly inversely proportional to prediction time (see Section 6.6.9, Weather Studies).

3. Required planning cycle updates impact OCC operations, and places increased processing demands on the OCC computer.

4. Specification that the Case B coverage requirement is, "Same as Case A plus an additional one (1) hour per day of video data obtained by the WBVTR. . . ".

5. The WBVTR's have limited recording capacity and efficient management of this resource must be accomplished.

The problem then, is to plan for a sifficiently long enough time so that efficient WBVTR management can be achieved, but not so long a period that excessive updating of activity plans is required due to changing weather predictions.

6

6.6.2.2 Assumption

Case B coverage of one hour per day of video data outside of the U.S. impacts the WBVTR if this additional one hour must be entirely recorded. The results of extensive mission simulations made of the ERTS A and B system operation reveal that even ignoring the impact of cloud cover, there is a significant portion of the year (winter time) that this one hour's coverage cannot be achieved due to geographic and sun angle constraints. Furthermore, these studies, in conjunction with the weather studies performed, indicate that the inclusion of cloud cover effects will eliminate this one hour daily constraint as a problem a large portion of the time.

Therefore, it appears that the objectives which led to the imposition of the constraint would be satisfied by the very nature of the problem. That is, that the system should operate whenever geographic, sun angle, coverage requirements, and weather conditions dictate that it should operate regardless of the daily remote coverage acquired. The total resultant tape recorder operation during a year's operation would be less than an average operation of one hour per day of video data recorded on the WBVTR. Thus, in effect the expected lifetime of the WBVTR would still meet the one year requirement. In fact, fewer but longer operating periods would undoubtedly increase the tape recorder's expected lifetime.

6.6.2.3 Discussion

The results of the mission simulations presented in Section 4.5.2 indicate that typical ERTS operations would include the following types of WBVTR recorder usage:

1. Record data remotely during an orbit and completely dump this data at the next available station pass.

2. Record data remotely during an orbit, or a series of orbits, but be unable to dump all the recorded data during the available station passes on these orbits.

To ensure efficient utilization of the WBVTR capabilities, planning must be carried out for a long enough period of time so that the recorder starts empty and finishes empty. Based on mission simulations which excluded the effects of weather, one typically finds a group of Case 1 orbits, and a group of Case 2 orbits in any given day. A portion of the Case 2 revs will be "dead" revs; e.g., there will be no ground station contact. The occurrence of each of these cases is determined by orbit and geographic constraints, and hence is predictable.

Figure 6.6-3 illustrates the two cases of orbits.

For Case 1 orbits planning could be carried out on a rev-by-rev basis. This would maximize the effectiveness with which weather data is used, minimize the execution time required for a planning cycle, maintain effective use of the WBVTR, and eliminate the requirement for any activity plan updating.

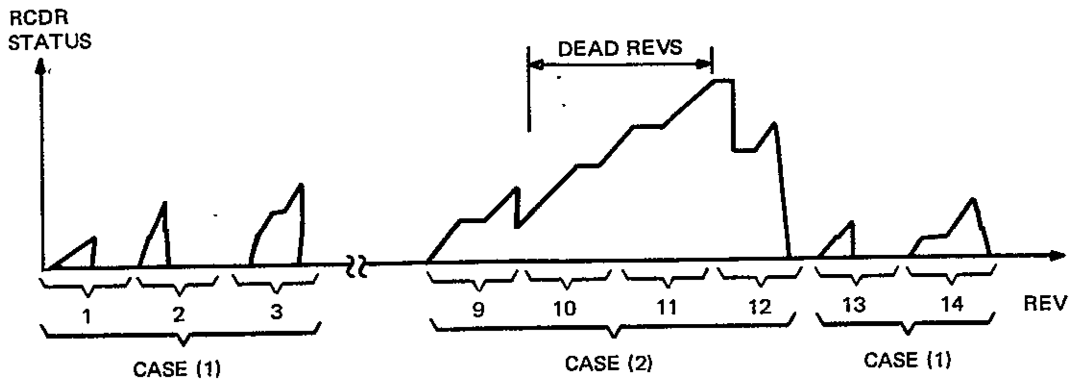


Figure 6.6-3. Two Cases of Orbits

For Case 2 orbits, planning must be done on the basis of the entire Case 2 rev span in order to achieve efficient WBVTR usage. However, by rescheduling, or updating, the activity plan on each rev possible (excluding dead revs) during the Case 2 rev span one can still maximize the effectiveness with which weather data is used.

Table 6.6-1 illustrates the planning cycles that would occur for the example shown in Figure 6.6-3.

Table 6.6-1. Planning Cycles

Prior to Rev	Generate Activity Plan for Rev(s)
1	1
2	2
3	3
.	.
.	.
.	.
9	9-12
10	10-12
12	12
13	13
14	14

At this point, one last factor must be addressed: contingency planning for when the OCC computer is unavailable. Most computer malfunctions are repairable in less than 1-1/2 hours. Therefore, it is proposed that each planning cycle (as described previously) be extended one rev.

Table 6.6-2 illustrates the impact of this contingency planning on the previous example.

Table 6.6-2. Contingency Planning

Prior to Rev	Generate Activity Plan for Rev(s)
1	1-2
2	2-3
3	3-4
.	.
.	.
.	.
9	9-13
10	10-13
12	12-13
13	13-14
14	14-1

The penalty incurred by adding this contingency planning is an increase in the execution time required to generate an activity plan. However, sufficient time exists in the OCC timeline to accommodate this reduncancy.

6.6.2.4 Conclusion

Each planning cycle will be an integral number of revs. The length of each specific planning cycle will vary, but will be as short as possible to facilitate the use of current weather data while being consistent with orbit, geographic, and contingency requirement constraints. Based on mission simulations, the shortest planning cycle will be for two revs, while the longest planning cycle will be for seven revs. Longer planning cycles can be performed using the operational software to provide simulation study data.

6.6.3 COVERAGE AREA PRIORITY STRUCTURE & IMPLEMENTATION STUDY

6.6.3.1 Requirements

The limited wideband video tape recorder capacity prohibits continuous operation of the ERTS sensor system. Therefore, data must be made available to the mission planner upon which he can intelligently base the decision-making processes required to eliminate some of the potential data gathering opportunities during the system scheduling exercise. It may also be assumed that the value of data acquired by the ERTS system will vary with the geographic area covered and the time of year of data acquisition. This variation in the potential value of data obtainable from various sensor operations represents the primary information source that the mission planner has available to him upon which to base his sensor operation scheduling decisions.

Therefore, a prioritizing technique to account for the relative values of data available over various geographic locations is required. This technique must be amenable to updating because of temporal variations in potential data value.

6.6.3.2 Discussion

With the need for a prioritizing scheme established, the next logical question that must be answered is, "how should prioritization be accomplished?" The geographic coverage area must be quantized into areas each of which can be considered to contain uniformly valuable information and hence can be assigned a single number denoting priority, or relative value. The problem is the determination of the geographic size of the area-cells which make up the ERTS coverage area.

The following factors must be considered when sizing the area-cells:

1. The data base storage requirement for area-cell information is inversely proportional to area-cell size.

2. The larger that area-cells are, the greater the nonuniformity of ERTS related data contained in the area-cell; hence, the greater the compromise in accuracy when assigning a single priority number to the area.

3. The ERTS sensors acquire data in 100 x 100 nm increments.

6.6.3.3 Area-Cell Size Evaluation

Whatever area-cell structure is chosen for quantization of the coverage area several parameters, in addition to priority, will be associated with each cell. Latitude and longitude data for each cell's center will serve as its identification. Other information which will be of use to the mission planner in his decision-making process is identification of the country containing the cell and the time of the last previous coverage attempt to acquire data on the cell. Therefore, at least five parameters must be stored in the OCC data base for each area-cell.

The 100 x 100 nm format of the ERTS sensors can be considered an upper bound for area-cell size. If cells were much larger in size than the data acquisition format, a problem of considerable magnitude would be the determination of exactly when to consider that an attempt was made to acquire data about a given area-cell, e.g., no single sensor operation could cover an entire area-cell. The rule adopted to determine when an attempt to gather data on a cell has occurred is to evaluate whether or not the sensor format has included the center of the cell; if it has, the cell is considered to have been "attempted."

There are approximately 1.5×10^8 square nm on the earth's surface and approximately 70 percent of the earth's surface is covered by water. Because inland water and certain coastal waters are of interest for the ERTS mission one can assume that the ERTS coverage area is roughly 1/3 the earth's surface area, or 5×10^7 square nm.

Table 6.6-3 illustrates the variation in the number of area-cells and hence data base storage required as a function of area-cell size.

Table 6.6-3. Area-Cell Data

Area-Cell Size (nm)	Number of Cells Required	Data Base Storage Required*
25 x 25	80,000	400,000
50 x 50	20,000	100,000
100 x 100	5,000	25,000

* Based upon the requirement to store five parameters for each area-cell

6.6.3.4 NDPF Interface Requirements

In addition to temporal changes affecting the relative values of the various portions of the coverage area's substructure, several other factors may also impact area-cell priority:

1. User requests
2. Previous coverage results
3. Time since last data acquisition

   etc.

The NDPF interfaces with the ERTS system users and performs the evaluation of the data acquired by the spacecraft. Hence, the determination of the area-cell priority structure and requirements for its modification will come from the NDPF.

No requirement is seen to exist for real-time updating of the coverage area priority structure; e.g., core-to-core communication between the NDPF and OCC computers. Seasonal variation and its impact upon the coverage area priority structure is known well in advance and may be incorporated into regularly scheduled priority updates. Because of the characteristics of the basic 18-day coverage cycle, the capability to instantly reflect the results of video data analysis into the coverage area priority structure appears to be an extravagant capability. Coverage overlap from day to day occurs only at the high latitudes which represent a relatively small portion of the coverage area. Rev-to-rev overlap may be neglected. Frequent data acquisition opportunities over an area-cell are required in order to effectively utilize the capability to instantly update the area priority structure. In addition, it does not appear reasonable to anticipate many changes in coverage requirements as a result of data analysis that cannot await generation of a regularly scheduled priority update. Such updates will be prepared routinely based on hardcopy and/or oral inputs from the NDPF. If an emergency situation should arise, and a delay in altering the priority structure cannot be tolerated, any kind of communication with the mission planner can result in the manual insertion or deletion of specific sensor operations during the system scheduling activity.

6.6.3.5 Conclusions

The area-cell size recommended is 50 x 50 nm. This represents an acceptable compromise between data storage requirements and coverage determination accuracy achieved.

Coverage area prioritization will be based on hard copy or oral data supplied by the NDPF. Coverage area priority updates will be routinely scheduled. Emergency priority changes will be implemented by having the mission planner manually input modifications to any activity plan generated.

There does not appear to be any justification for core-to-core data transfers from the NDPF and OCC computers to accomplish real-time coverage area prioritization.

6.6.4 WIDEBAND VIDEO TAPE RECORDERS MANAGEMENT STUDY

6.6.4.1 Requirements

Management of the use of the onboard wideband video tape recorders is necessary for three reasons:

1. The sensors can produce more data than the recorder is capable of storing
2. The full contents of the recorder cannot always be dumped during the limited time of a station contact
3. The lifetime of the recorder is limited

In order to effectively manage the use of the recorder, the System Scheduling subsystem in the Operations Control Center (OCC) must maintain an accurate status of the recorder at all times. The primary status information is:

1. How much, and what data is currently on the tape

2. The physical position of the tape at all times

3. The current status of the recorder capability (i.e., does a degraded mode exist, what are the actual tape speeds, etc.)

4. The current operational mode of the recorder

6.6.4.2 Discussion

The results of mission simulations that were conducted indicate that typical ERTS operations would include the following types of recorder usage:

1. Record data remotely during an orbit and completely dump this data at the next available station pass

2. Record data remotely during an orbit, or a series of orbits, but be unable to dump all the recorded data during the available station passes on these orbits

The first of these two cases is the simplest from a recorder management standpoint. The operational sequence would entail the recording of data for some period of time, a rewind of the recorder after recording has ceased by an amount corresponding to the recorded operation, and a dump operation during the pass during which all the previously recorded data is returned to the ground. The tape can either be rewound to the beginning of tape at this time and readied for the next recording operation, or not rewound but readied at its current position for the next recording operation, if sufficient tape still remains on the reel from this point to accept the next anticipated recorded operation. The latter of these two situations could be employed if one wants to wait to verify that the dumped data was received properly since the next record cycle would not erase this data a retransmission at a later time would still be possible. The approach might also be employed to limit concentrated usage of a specific section of the tape (the front end), thus possibly reducing potential tape failures attributed to effects resulting from multiple recordings on the tape.

The second operational sequence in which all previously recorded data cannot be transmitted to the ground during the station pass presents a more complex recorder management problem. It is anticipated that the majority of the remote operations will be between 2 and 10 minutes each. It is possible, however, to have more than one of these operational sequences occur during a single orbit. A typical station pass might be on the order of 10 minutes. Therefore, hopefully, all the data from at least a single operational sequence could be returned during a single station pass. However, it is likely that additional data will be recorded before all the data recorded on the previous orbit is played back. In this type of situation it becomes extremely important to ensure that the new data to be recorded does not in any way interefere with previously recorded data that still needs to be transmitted to the ground. To properly manage the recorder usage under these conditions requires that the OCC maintain an accurate image of the recorder tape situation at all times.

Figure 6.6-4 graphically depicts a typical operational sequence for two orbits. It was assumed that the tape was clean at the beginning of the pass in rev N. Two remote operational sequences (A&B) were scheduled on rev N. The available dump time during the station pass on rev N however was only sufficient to transmit the recorded data from operation A. Therefore, at the beginning of the remote operations planned for rev N+1 (operational sequences C&D), the recorder tape still contains untransmitted data from operation B. The recording of data from operations C and D must then be recorded on the tape exclusive of where operation B is contained. As is shown, it was elected to record operation C behind operation B and to record operation D over the area where the already transmitted operation A was contained.

The station pass on rev N+1 is such that only operation C can be transmitted to the ground. This, therefore, was scheduled and at the beginning of rev N+2, the tape contains recorded, but still untransmitted data from operations B and D.

This type of sequence will generally continue to occur for a period of a few orbits until sufficient dump time becomes available to allow all the recorded data to be transmitted to the ground. At this point the situation as described in Case 1, will again prevail for a series of counts until a Case 2 condition arises again. Typically, one finds a group of Case 1 orbits and a group of Case 2 series or orbits in any given day. The Case 2 condition arises generally around those orbits that contain no or very short station passes.

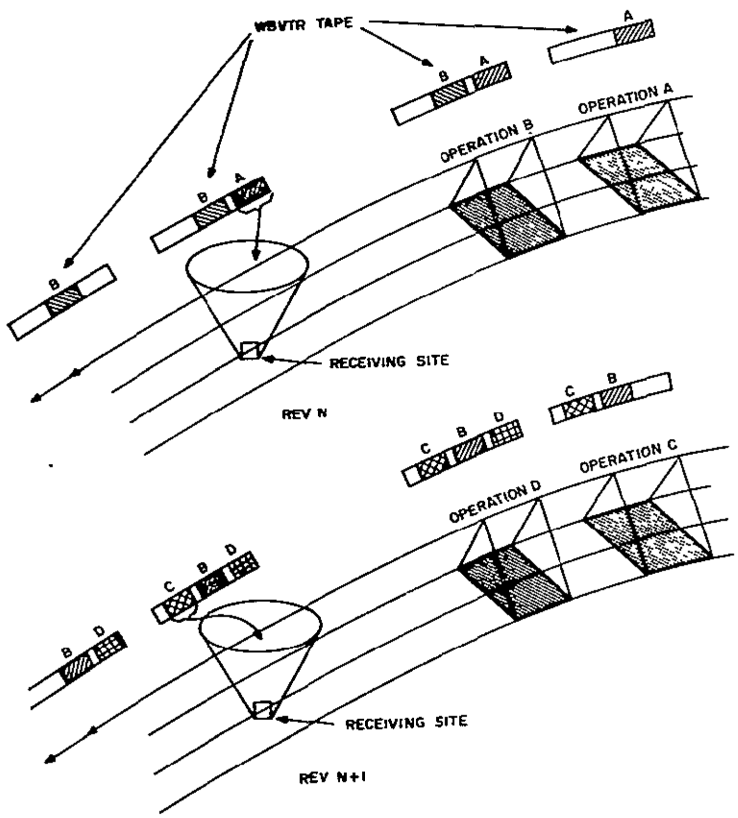


Figure 6.6-4. Typical Operational Sequence for Two Orbits

In the previous discussion the recorder management problem was examined from the standpoint of mission operations and recorder usage requirements. At this point some key considerations can be noted:

1. Since the recorder has a limited storage capacity, certain potential remote sensor operations over available coverage requirement must be inhibited. This implies that at times the full capacity of the recorder will be used and all the data on the resulting fully loaded tape will not as yet have been transmitted to the ground.

2. Generally, the data on the tape will be in segments related to specific operational sequences and these segments will generally be on the order of 2 to 10 minutes of data each.

3. The order of the individual segments on the tape may not necessarily be time-sequenced since, to maximize the efficiency of the use of the tape, data will be recorded on a space available basis (i.e., if a 3-minutes recorded operation is planned, the current tape content status will be examined to determine the best area on the tape to record the operation).

4. Since ground site contact time and the availability of station passes relative to desired recording cycles constrains what can be recorded, the efficient use of the available ground contact time is mandatory. The current content of the tape must be examined to determine which specific recorded data segment(s) are best scheduled for transmission during the anticipated pass. The transmission of partial segments is not desirable and therefore should not be scheduled, if possible.

The key to effective tape recorder management is the capability to have accurate knowledge of and control over the tape content. The system must have:

1. The ability to move the tape to a predetermined position before an operational record sequence

2. The ability to move the tape to a predetermined position before a recorder dump sequence over a data acquisition site

In order to position the tape to satisfy the two aforementioned conditions, the OCC will require knowledge of a tape position vs sensor operation history. This profile will allow for correlation of the video with tape position. The OCC must also maintain an accurate history of tape position versus video data dumped. Finally, the OCC must have accurate knowledge of the actual position of the tape at any point in time.

6.6.4.2.1 Tape Position and Content Monitoring

In order to realistically schedule remote sensor operations, accurate knowledge of the status of the onboard wideband tape recorder is necessary. The preliminary question which needs to be answered is:

> How accurately must the knowledge of tape position and content be for efficient planning?

Tape-positioning accuracy requirements are directly related to how the video data is recorded on the tape. The tape must be positioned properly to:

1. Allow recording of additional data without destroying previous records
2. Allow for readout of a total previously recorded operational sequence

Improper tape positioning in either the record or dump mode can result in the loss of data.

The configuration of data on the tape will be different depending on whether the data is from the RBV or the MSS. During RBV operations in the recorded mode, the camera controls the motion of the tape. The cameras are readout during part of the camera operating sequence. During the readout phase, the tape is set into motion and the data recorded. At the completion of the readout, the tape is stopped and not moved again until the next camera readout cycle. Figure 6.6-5 graphically depicts the configuration of the tape resulting from an RBV operating sequence.

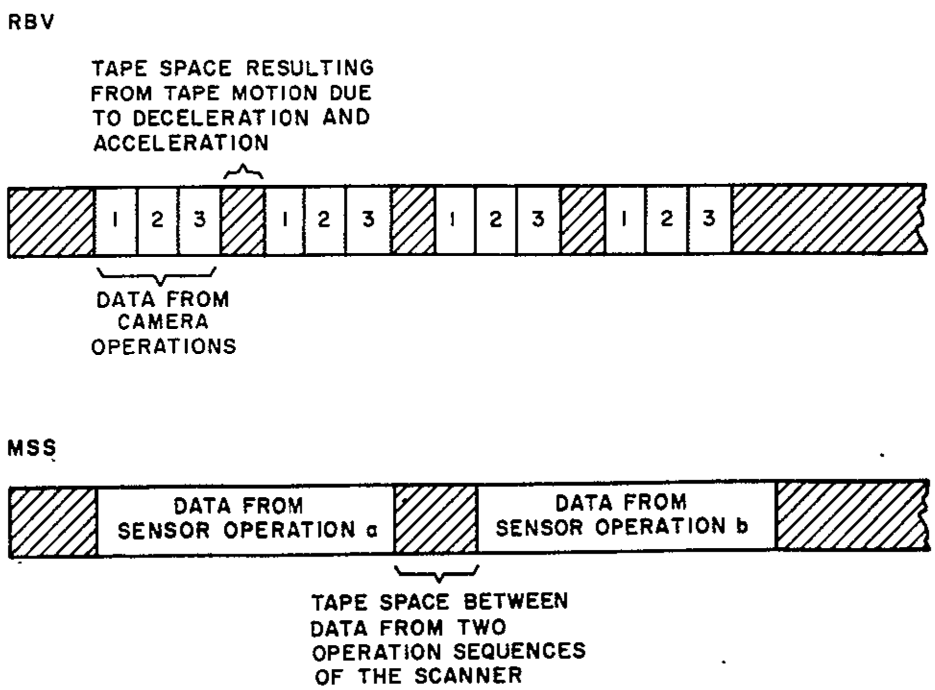


Figure 6.6-5. Wideband Tape Content Configurations

The operation of the MSS in the recording mode is such that data is continuously being outputed from the sensor. This data is continuously recorded for the duration of the operating cycle. The configuration of the resulting MSS tape is also shown in Figure 6. 6-5.

The tape is moving at 12 ips during all recording operations. The amount of tape required to record the readouts of the three RBV cameras is 126 inches. The space between camera readout data due to tape movement during deceleration and start up is 36 inches. For the MSS data, the data recorded from two operating sequences will contain a buffer area between them on tape. This can be assumed to be at least 36 inches which is also due to normal tape movement due to deceleration and acceleration of the tape.

The recorder management function will require that the tape be capable of being positioned to a point within a buffer area between recorded data such that the first data following the buffer area can be read out when the tape is up to speed. The characteristics of the recorder are such that it takes 0. 4 second from receipt of "record" command until the tape is up to speed and an additional 2. 8 seconds to synchronize the recorder so data can be recorded. A total of 33. 6 inches of tape is moved during this time period.

The amount of tape moved from the time the command to stop is received until the tape has stopped depends whether the tape was moving at the low or high rate. If it was moving at the 12 ips rate, then 2. 4 inches of tape is moved, if at the 48 ips, then 9. 6 inches is moved.

The total amount of tape moved during a record to standby to record cycle is 36 inches. It can therefore be expected that a buffer area of at least 36 inches will occur between any two segments of recorded data.

The positioning of the tape in anticipation of a data dump cycle requires that the tape be up to speed at the point data is encountered. To allow for normal start up movement, the tape position must be positioned to at least 2. 4 inches ahead of the data (Figure 6. 6-6).

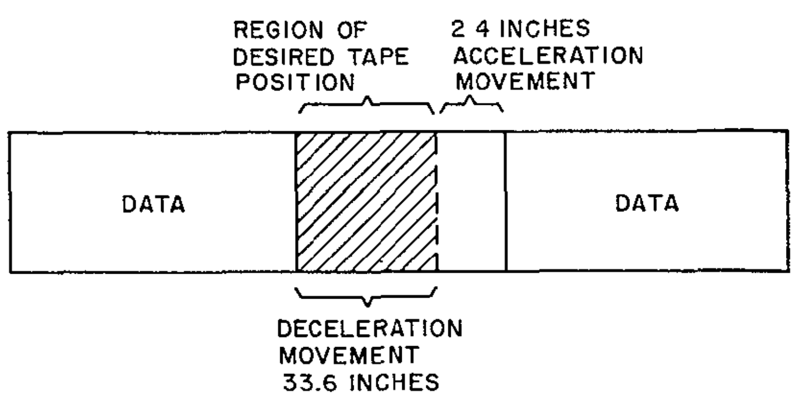


Figure 6. 6-6. Tape Position Regions

This results in a tape positioning procedure capable of positioning the tape within a predetermined 36-inch segment. Given that the midpoint of this segment will be nominally sought, the accuracy must be such that the tape can be positioned to within ±16.8 inches of the nominal.

6.6.4.2.2 Position and Content Monitoring Technique
The tape used by the WBVTR's must be considered to be comprised of discrete calls, or segments, in order for the OCC computer to maintain a record of tape content. How coarse the fragmentation of the tape should be must now be evaluated.

As was stated in Section 6.6.4.2.1, tape position must be able to be specified at least to within ±16.8 inches in order to ensure proper tape positioning before a data dump cycle. A desirable increment in which to store tape status data has been determined to be 12 inches, which at normal record speed is also equal to one second of operation. The convenience gained during software debugging and checkout using 12 inches (1 second) segmentation of the tape versus 16.8 inches (1.4 second) segments is felt to more than affect the slight increase in data base storage requirements.

A Current Coverage Data File containing frame number, rev acquired, area-cell priority and country data will be generated and maintained by the sensor scheduling module. Therefore, to satisfy the what and where questions regarding data and its location on the tape only two pieces of data are required to be stored for each tape segment; tape cell ID and a frame number/availability flag. The tape cell ID's correspond to location on the tape in feet. The frame number availability flag is used to provide two pieces of information:

1. If the number stored is equal to zero, then that particular tape cell has nothing recorded on it.

2. If, on the other hand, some video data is recorded on a tape segment, then the frame number to which that data belongs will be stored there.

This frame number, in conjunction with the Current Coverage Data File previously mentioned, can be used to determine the data source and data characteristics stored on the tape.

A total of 3600 data base cells are required to maintain the tape images for both the RBV and MSS tapes:

1. 1800 segments per tape

2. Frame number/availability flag per segment

Two additional words of data are required to specify the state of each of the video data tapes: a tape position word and the time that that position was attained. The position word is simply the cell ID described previously.

6.6.5 NARROWBAND PCM TELEMETRY RECORDER MANAGEMENT STUDY

6.6.5.1 Recorder Characteristics

The spacecraft contains two narrowband recorders employed to record the PCM telemetry information. Each recorder is capable of storing a total of 210 minutes of recorded data. The recorders are dumped in the opposite direction from recording (last-in-first-out method) and are read out at a dump to record ratio of 24:1. To dump a full recorder will require approximately 8.75 minutes. The specific recorder desired is selected via command from the ground.

6.6.5.2 Recorder Usage

The normal use of the recorders will be to record telemetry data at all times. While one recorder is being dumped over a ground station, the telemetry, in addition to being received on the ground in real-time, will also be recorded on the other recorder. This operational approach is desirable so that the continuous stream of telemetry is always available via dumped data.

6.6.5.3 Operational Considerations

Examination of the ground station contact profile for the four prime ERTS sites (Alaska, Corpus Christi, NTTF, and Rosman) indicates a basic daily coverage pattern allowing for nominal PCM telemetry dumps to be scheduled through Alaska and NTTF only. The use of these two stations as prime dump sites offers the added advantage that both the real-time dumped PCM telemetry can be transmitted to the OCC simultaneously and in real-time. The coverage pattern results in 10 to 11 Alaska passes per day. The pattern also results in 1 to 2 revs with no contact by the prime sites. The dead revs are immediately followed by an NTTF pass. Generally, the NTTF will be the prime dump site for approximately two revs per day.

The amount of data recorded at any one time is generally approximately 100 minutes. This occurs on all revs where a station pass exists on the next rev in addition to a pass on the current rev. When the dead revs are encountered, a total of approximately 345 minutes of data may be required to be recorded. This condition exists when two successive dead revs are encountered.

6.6.5.4 Recorder Management Requirements

The management of recorder usage will be discussed for two basic conditions:

1. When a station pass exists on each rev

2. When a series of dead revs (1 or 2) are encountered prior to a station pass

To facilitate the discussion, the recorders will be identified as recorder A and B.

Figure 6.6-7 graphically depicts the conditions related to the first case. Under this condition, the recorders will be switched each rev. At the beginning of the pass the recorder not being used will be switched on and the other recorder switched to standby. During the

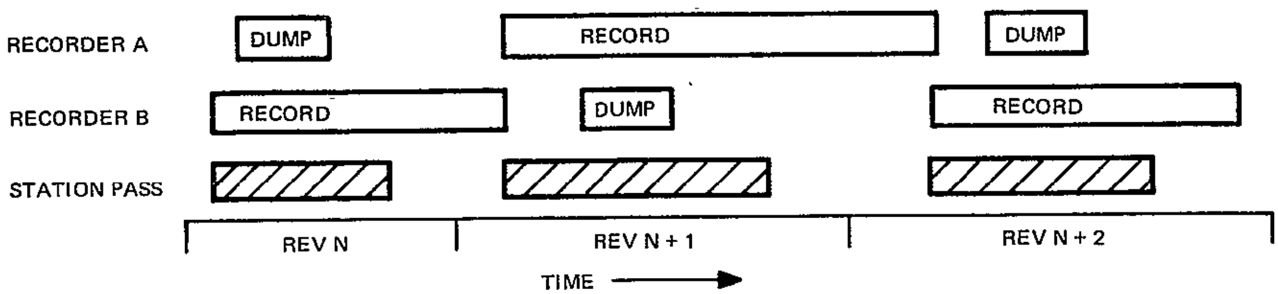


Figure 6.6-7. Case (1) Conditions (Station Contact Every Rev)

pass the previously recorded data will be dumped and the recorder made ready for its next record cycle. In this case all recorder control will be done via real time commands.

The second case will require a switch of recorders while out of contact of a prime ground site. Figure 6.6-8 depicts the recorder management function under this condition.

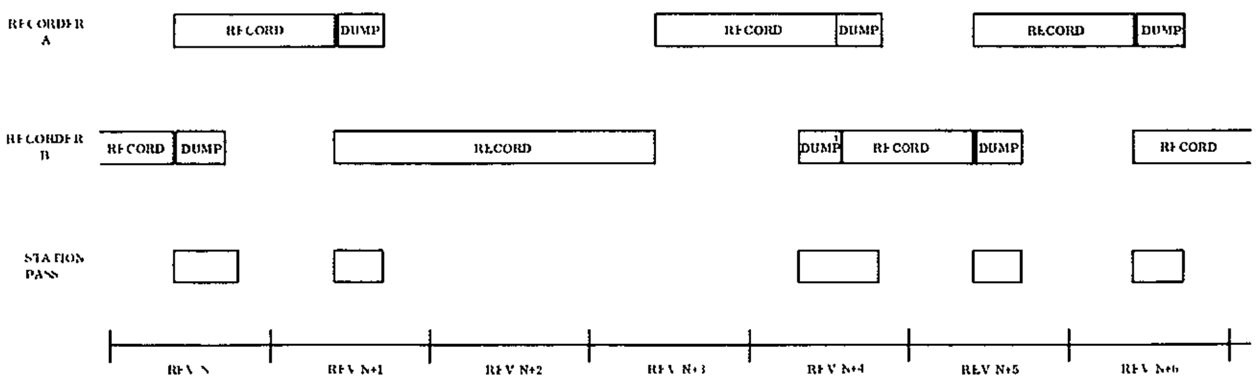


Figure 6.6-8. Case 2 Conditions (Station Contact Available for all Revs)

Since the total amount of data requiring recording exceeds the capacity of one recorder, a switch of the records must be effected when out of contact with a ground station. This switch is planned to occur automatically when a recorder reaches the end of its tape supply and hence does not reduce the command storage resource available on the spacecraft.

6.6.5.5 Conclusions

Sufficient narrowband recorder capacity exists to record and transmit all narrowband PCM data generated at any time during the ERTS mission. All narrowband tape recorder management can be accomplished via real-time commanding.

A simple bookkeeping type function is all that is required of the OCC's System Scheduling software to adequately plan and manage the narrowband tape recorder operations aboard the ERTS spacecraft.

6.6.6 EPHEMERIS GENERATION REQUIREMENTS STUDY

6.6.6.1 Requirements

In order to schedule sensor operations, or for that matter, any other system event constrained by, or a function of, the geometric relationship between spacecraft, earth, and the sun, a spacecraft ephemeris or data derived from such an ephemeris is required. Specifically, the System Scheduling Subsystem of the OCC requires three ephemeris-related sets of data:

1. Satellite ground track
2. Sun elevation angle along the ground track
3. Ground station contact profiles (AOS, LOS)

The satellite ground track is required to determine the actual area coverage capability of the spacecraft sensors. The sun elevation angle along the ground track is required to evaluate sensor performance capability. Ground station contact profiles are required to efficiently use the limited WBVTR capabilities so that the narrowband tape recorder and DCS receiver can be properly scheduled, etc.

6.6.6.2 Alternatives

An interface with NASA's T&DS group is required. The problem remaining is specification of the data type, format, and transfer frequency between T&DS and ERTS. The two alternatives considered were:

1. T&DS supplying ERTS with orbital elements from which OCC System Scheduling software would compute spacecraft ephemeris, ground track, sun angle, and station contact profiles. In addition to these computations, a validity or reasonableness check would have to be performed on the orbital elements as a check of T&DS and the data transfer process.

2. T&DS supplying ERTS with machine-readable WMSAD data tapes which would contain all of the information required for one-minute time intervals along the orbit track. This data is routinely produced by T&DS for all operational spacecraft. A validity check would also have to be performed on the WMSAD data.

If ERTS were to accept orbital elements from T&DS as the orbit data interface, the ERTS OCC would have to duplicate an ephemeris generation, etc., capability that NASA already possesses and will be exercising on a regular basis in support of an operational ERTS, e.g., producing ERTS WMSADS. Validity checks will have to be conducted in the OCC on the orbit data presented by T&DS to ensure that any new data is consistent with current data, e.g., no step-functions appear in any parameters unless, of course, an orbit adjust maneuver has taken place.

6.6.6.3 Conclusion
The System Scheduling Subsystem of the OCC will accept ephemeris-related data in the form of machine-readable WMSAD reports, e.g., ground track and ground station contact data will be provided at one-minute time intervals.

6.6.7 ORBIT MAINTENANCE STUDY

6.6.7.1 Requirements
The requirement to maintain equivalent ground traces on successive coverage cycles to within ±10 nm of each other requires the periodic adjustment of the ERTS orbit. The System Scheduling Subsystem of the OCC must integrate the required orbit adjust maneuvers into the system activity plans that it generates.

6.6.7.2 Discussion
The analysis performed in the study of orbit adjust requirements (see Final Report ERTS Spacecraft Design Studies, Volume I, Section 4.2) indicates a need for orbit corrections to be made nominally every 18 to 27 days. The results of this study also indicate little difference in energy requirements as a function of where in the orbit the adjust is made. Therefore, it has been decided to schedule the required adjust maneuvers while in contact with a ground station. In order not to interfere with possible sensor operations, orbit adjust maneuvers will nominally be scheduled during a night time pass over Corpus Christi. Corpus Christi was selected as the prime orbit adjust site for two primary reasons:

1. Prime tracking for orbit determination of the ERTS Orbit will be provided by this site; therefore, the spacecraft can be tracked during the burn.

2. An Alaska pass immediately follows an ascending Corpus pass and will provide an opportunity to continue monitoring the spacecraft after the orbit adjust maneuver in addition to providing an opportunity to transmit any desired stored program load.

6.6.7.3 Ground Support Requirements
The maintenance of the orbit requires that the ground system be capable of:

1. Evaluation of the current orbit and determination of when an orbit adjust is required

2. Determination of the detailed parameters of the orbit adjust maneuvers

3. Generation of the appropriate command message to implement the required adjust

The ERTS OCC will be supported by the NASA Tracking and Data System (T&DS) organization to provide orbit determination and prediction functions (see Section 6.6.2.6). Because of the existing capabilities of T&DS, they will also provide the generation of the detailed orbit adjust maneuver parameters. Upon request, orbit adjust subsystem parameters will be provided by ERTS to T&DS to facilitate the required computations.

The OCC will maintain a capability to assess the current orbit and to project the need for an orbit adjust. T&DS will provide the complete ephemeris generation capability and the OCC will require no capability in this area. The OCC will utilize the refined ephemeris provided by T&DS, and the predicted ephemeris from T&DS to generate plots for comparison with a nominal ephemeris. Figures 6.6-9 and 6.6-10 are examples of types of plots envisioned. Detailed explanations of these figures will be found in the previous reference to the Final Report ERTS Spacecraft System Design Studies. These plots will be kept and updated manually, thereby placing no demand on the OCC computer.

6.6.7.4 Conclusion

In summary, the OCC will rely on T&DS to provide all ephemeris and orbit adjust generation capability. However, the OCC will manually maintain plots and status information in order to allow OCC personnel to anticipate orbit adjust requirements and to verify orbit adjust maneuver parameters. Orbit adjust events will manually be inserted into the activity plan by the mission planner.

6.6.8 COVERAGE IDENTIFICATION STUDY

6.6.8.1 Requirement

Knowledge of coverage area availability, relative values, etc., is necessary in order to schedule effectively sensor operations. Hence, during each planning cycle, the determination must be made as to the availability of each area-cell, e.g., whether or not the spacecraft sensors can acquire data from each specific area-cell. This study was undertaken to find a technique that would minimize the computation time required to evaluate area-cell availability during system scheduling.

6.6.8.2 Data Retrieval Technique

Of the 20,000 area-cells, which make up the ERTS coverage area, only a maximum of about 1100 will be available on a single rev. Individual testing of each area-cell center to determine availability during a particular rev would be extremely inefficient because the remaining 18,900 area-cells are known to be unavailable. It is absolutely necessary to minimize the number of disk accesses in order to minimize the execution time required by the system scheduling subsystem. Therefore, the retrieval of any area-cells which are not available during a rev is a waste of time.

The approach to this problem is to group the area-cells into larger blocks, or super-cells. The data for all area-cells within a supercell is stored on a portion of a disk data cylinder. A data cylinder is defined as "n" tracks ("n" being determined by the OCC hardware selected), each on different disk surface and all with the same relative position on the disk surface. The "n" tracks can be read sequentially without requiring the read head to be repositioned, thus allowing the maximum data transfer rate from the disk.

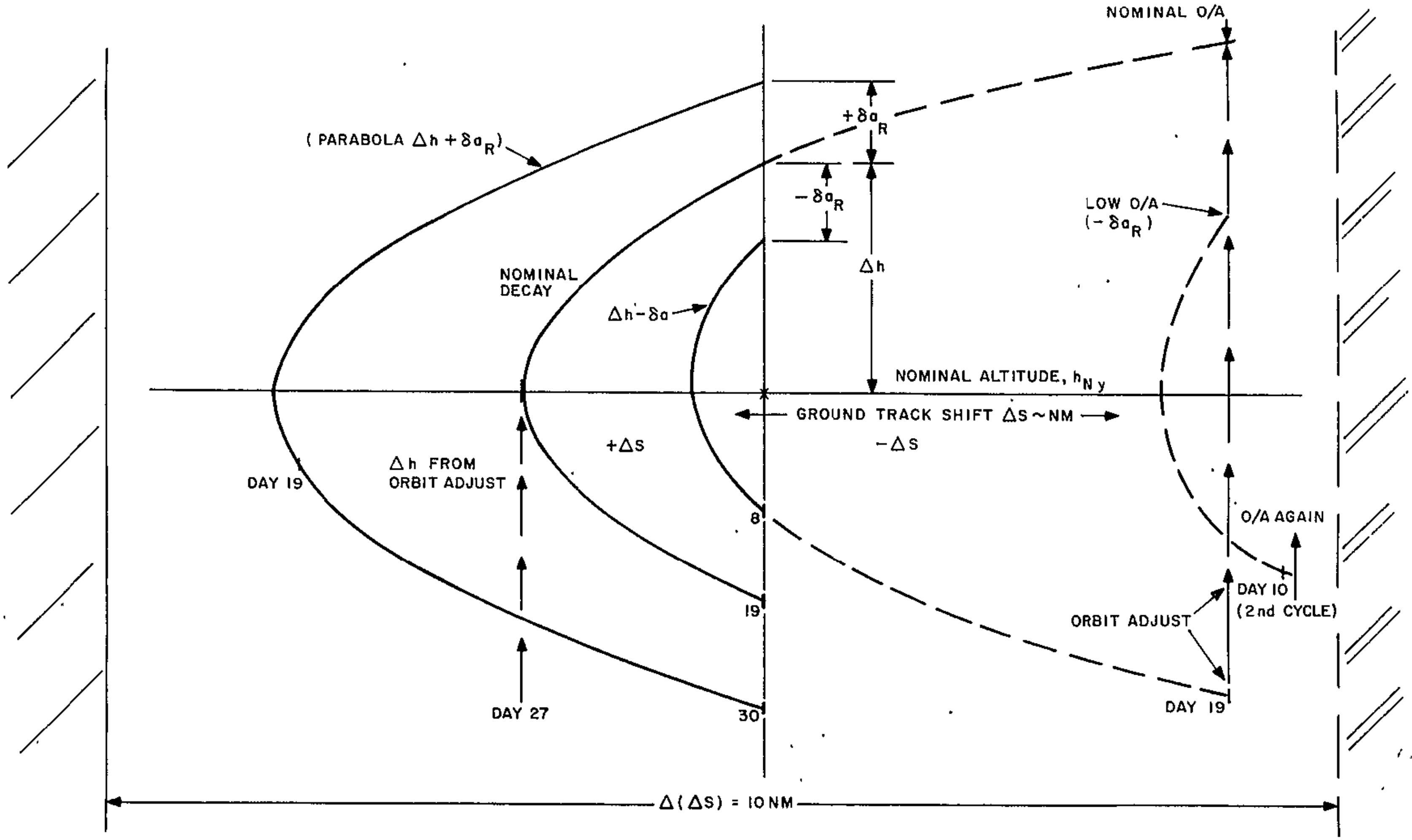


Figure 6.6-9. Orbit Adjust Control of Orbit Decay Cycle

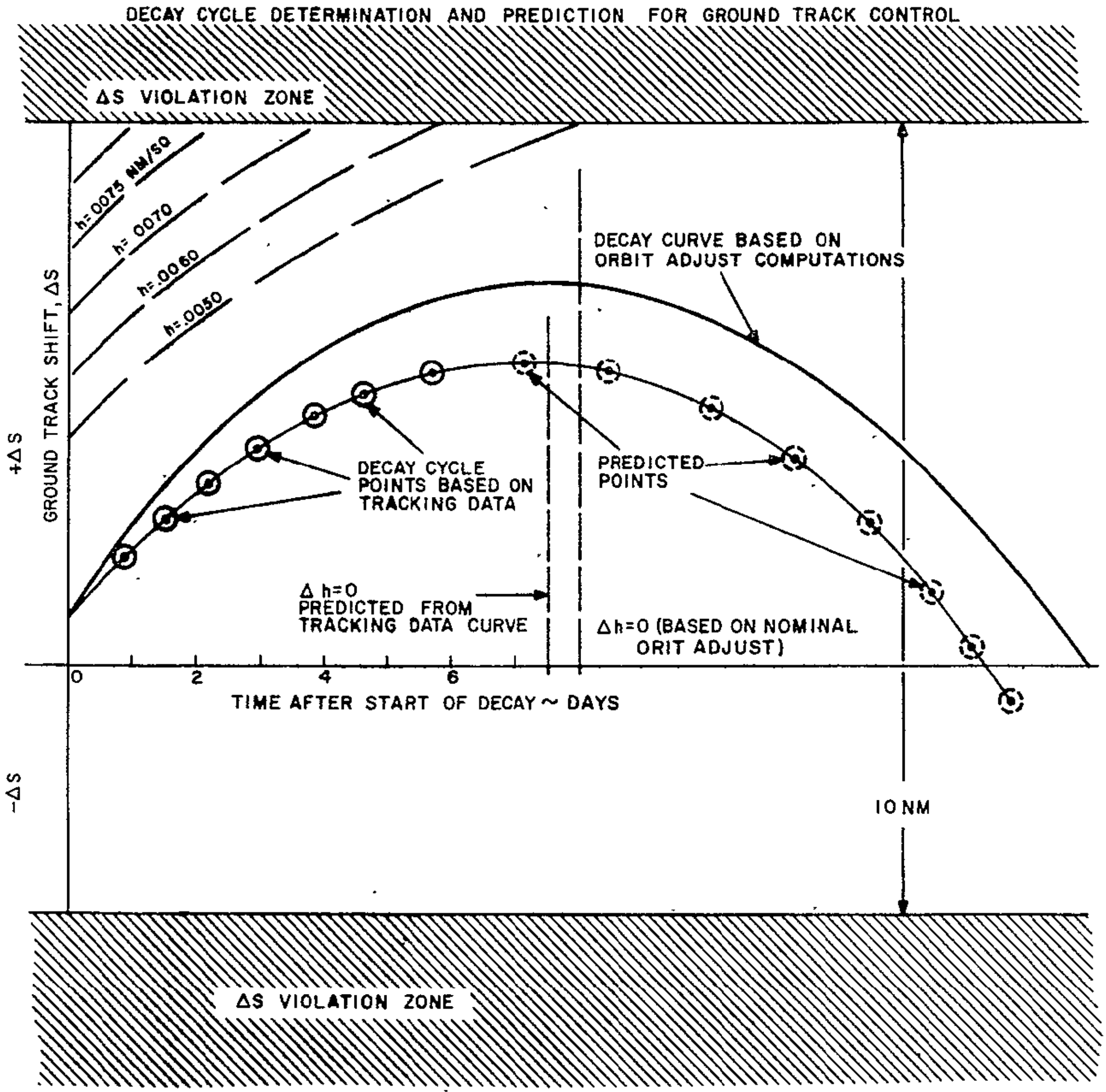


Figure 6.6-10. Decay Cycle Determination and Prediction for Ground Track Control .

Geographically, supercells are defined by a grid structure between latitude bands. The structure currently under consideration consists of a latitude-longitude orthogonal system.

GALS utilizes this structure to identify those area-cells which are probably within the payload sensor capabilities by accessing only those supercells that lie in the vehicle swath. The availability of supercells is determined through the use of a simple algorithm which converts the latitude and longitude of the vehicle subsatellite point, as it enters a particular latitude band, into a unique identifier (the number of the supercell covering that point). Knowing the satellite ground trace and the supercell structure, the total number of supercells in the latitude band can be computed. Because supercells are numbered sequentially in each latitude band, the numbers of the first and last supercells in the band under consideration can be obtained and all included supercells processed sequentially.

Utilization of any I/O - computation overlap capability that the OCC computer has will allow the availability computations required for the area-cells in one super-cell to be accomplished while the data for the next supercell is being transferred from disk to core.

6.6.8.3 Area-Cell Availability Computation

The time of closest approach is calculated by first calculating the time that the subsatellite point crosses the latitude of the area-cell center (t_{LAT}), then calculating the time it takes the vehicle to go from the point of area-cell center latitude crossing to the point of closest approach (Δt). Finally, Equation 6.6-1 is used to obtain the time of closest approach (t_{ca}). Figure 6.6-11 shows the geometry involved in this process.

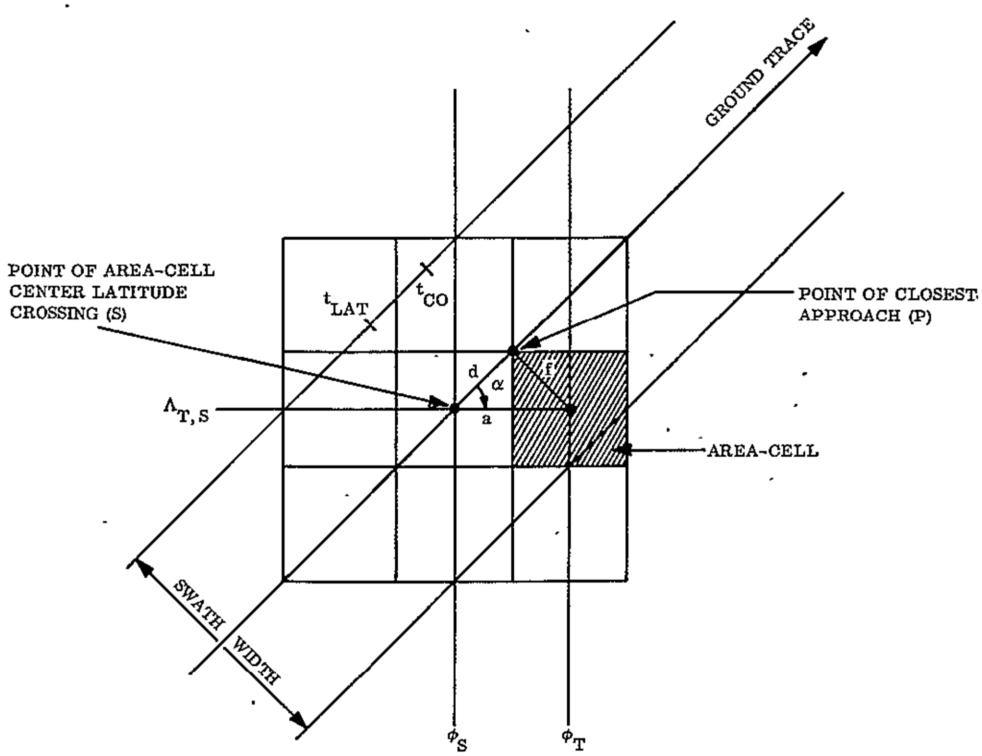


Figure 6.6-11. Time of Closest Approach Geometry

$$t_{ca} = t_{LAT} - \Delta t \quad (6.6\text{-}1)$$

$$a = \frac{\pi (\phi_T - \phi_S) R_T}{180} \quad (6.6\text{-}2)$$

where:

R_T = radius of earth at area-cell center latitude

ϕ_T = longitude of area-cell center

ϕ_S = longitude of point of latitude

$$d = a \cos \alpha \quad (6.6\text{-}3)$$

where:

α = complement of the ground trace azimuth angle at the area-cell center latitude

$$\Delta t = \frac{d}{V_x} \quad (6.6\text{-}4)$$

where:

V_x = in-track velocity (ft/sec)

f = $a \sin \alpha$ (6.6-5)

The time of area-cell center latitude crossing (t_{LAT}) is obtained by performing a linear interpolation in the GWMSAD table on the area-cell center latitude (Λ_T).

The time it takes the vehicle to go from the point of area-cell center latitude crossing to the point of closest approach (Δt) is calculated as follows using flat earth approximations. The distance from the point of latitude crossing to area-cell center (a) is found using Equation 6.6-2. Next the distance between the point of latitude crossing and the point of closest approach (d) is found using Equation 6.6-3. Then, the time to travel this distance is found quite simply by using Equation 6.6-4. The proper sign of Δt is taken care of by the sign of the cosine term in Equation 6.6-3.

Finally, the distance from the ground trace to the area-cell center at the point of closest approach (f) is found using Equation 6.6-5. If (f) is less than or equal to 50 nm the area-cell is added to the availability list.

6.6.8.4 Conclusion

The supercell concept of storing and retrieving area-cell data from the disk will greatly increase the efficiency with which the required area-cell availability computations can be accomplished. The error due to flat earth (plane trigonometry) as spherical earth (spherical trigonometry), straight versus slightly curved ground trace and linear interpolation are negligible.

6.6.9 STUDY OF WEATHER FORECAST DATA IMPACT ON ERTS SENSOR SCHEDULING

6.6.9.1 Purpose

The purpose of this study to present results of a study of the effects of weather upon an earth surveying space system and to outline a concept of weather support that can be used in system scheduling of the Earth Resources Technology Satellite (ERTS).

6.6.9.2 General

It has been shown, from weather satellite photography such as that returned by Nimbus, ESSA, ATS, and by the hand-held photography of manned space flights, that approximately 48 percent of the earth is cloud-covered.

Many areas of the earth experience only minor day to day variations in local cloudiness; however, seasonally oriented boundaries or mixing zones produce major weather and cloud systems. Several million square miles of the earth may be temporarily obscured by contiguous clouds associated with a single storm system, while large areas of the earth may be experiencing nearly cloud-free skies.

6.6.9.3 The Effects of Weather

6.6.9.3.1 Data Loss from Cloudiness

Most data observed by earth viewing sensors (photographic or electromagnetic) will be degraded, by the presence of cloud cover. If the data are photographic, uninhibited earth sensing by a satellite would result in about 48 percent of the area viewed being cloud covered. An additional 10 percent (estimated) of the viewed scenes will be degraded by the presence of fog, haze, and atmospheric pollution. Although it may be possible to construct a photographic montage of bits and pieces of cloud-free photography cut from overlapping or repetitive orbits of a required area, the magnitude and complexity of such an effort is immense. Additionally, elapsed time between such orbits might negate desired results.

6.6.9.3.2 Haze

In some industrial and population centers such as Los Angeles, California, for example, atmospheric haze and/or air pollution will frequently cause complete obscuration of the earth's surface as viewed by a satellite. In many other areas it will cause major attenuation and distortion of the sensor data. Despite this, the presence of significant haze/pollution may be undetected or unreported by surface weather observers who only report haze when the surface visibility (horizontal) is restricted.

Associated with the problem of haze/pollution detection and reporting is the difficulty experienced by a meteorologist in forecasting: (1) its occurrence, or (2) that it will affect satellite sensing. While the forecasting of haze/pollution within a layer from the surface to 10, 000 feet is difficult, it is possible and should be acceptable if the forecasters can study a quick-readout of the sensed data.

Several numerical models for forecasting haze have been proposed or developed. Most of these require considerable additional development or have not proven satisfactory. No such models are currently being tested operationally within ESSA or the Air Weather Service (U. S. A. F).

Because there is no indication that an obscured frame of photography will satisfy any stated requirement, cloud cover, haze, fog, pollution, etc., are considered to be operational elements that can limit the results and efficiency of an earth-viewing sensor system.

6.6.9.4 Application of Weather Forecasts in Mission Planning

6.6.9.4.1 Advantages of Using Weather Forecasts

Weather forecasts can be used as an input into the ERTS mission planning procedures to optimize sensor operation. This will:

1. Prolong the total life of the on-board recorder (nonreal time) by operating the sensors only when a desired area is expected to be cloud free.

2. Prevent the loss of desirable or high priority photography because the total capacity of the recorder has already been used on a lower priority or cloudy area.

3. Suggest inhibition of real time sensors over cloudy portions of the United States to increase the time available to read and/or dump previously recorded, non-United States data.

4. Reduce the workload and general logistics.

It is possible to expect 75 to 85 percent sufficiently cloud-free operations if weather forecasts are used to optimize ERTS payload operations, although priorities and hardware constraints may cause scenes to be viewed even though there is little chance of success (cloud-free).

6.6.9.4.2 Weather Support Capabilities

Weather forecasting of cloudiness, haze, fog, etc., on world-wide basis is a relatively new problem to most meteorologists. However, the experience gained in Apollo flights, aerial photographic operations, and Strategic Air Command (SAC) refueling and practice missions indicate that there are sufficient weather information, forecasting techniques, and skills available to make forecasts a valuable tool in ERTS System Scheduling. Additionally, continued development in the general field of meteorology can be expected to improve overall cloud forecasting capabilities.

System Scheduling, if it is to use weather data, should have the most accurate information possible.

Availability and Reliability of Data. Some ERTS operations will occur over areas of high data density and excellent communications. In the United States weather forecasters can use observed data that will be only about two hours old when the scene is viewed by ERTS. Unfortunately, dependent on what areas are being considered and the system capabilities – communications, command and control time, and the number of revolutions loaded at a time– the only weather observations available may be as much as 12 hours old when the ERTS passes overhead. Available South American data, for example, will be that observed shortly after midnight local time.

In most countries, weather observations that include total cloudiness within a maximum radius of about 30 miles of an observer are routinely recorded and reported. The spatial and temporal distribution of these observations and the frequency and timeliness of their dissemination are generally dependent on the industrialization and population concentration of the reporting countries. Surface weather reports from desert, jungle, mountains, polar, and other areas of extreme living conditions are either virtually nonexistent or so widely distributed as to give only a haphazard estimation of the general cloudiness condition.

Hourly observations are common within the United States, except for some western areas, and Europe. Some sites throughout the world are operational only during daylight hours and others do not make timely reports. The ocean areas have observations from some islands and randomly located ships at sea. Reports of weather and cloudiness over many areas of the world are relatively sparse. In addition, a surface observer frequently overestimates the cloud cover in situations of scattered or broken clouds. This has been studied by McCabe (1965) and Lund (1965 and 1966), among others. Observer reliability, personal initiative, and communication inadequacies incur additional data unreliability or loss.

A study of cloudiness observed during the darkeness of early morning versus that observed shortly after sunrise reveals that, high, thin, ice crystal clouds (cirroform), that are rarely reported during the night in an otherwise clear sky, are easily seen at the onset of twilight and subsequent sunrise.

Meteorological Satellite Data. The problems associated with surface observations of cloudiness suggest that meteorological satellite data should be used in mission planning. Since their inception, meteorological satellites have returned valuable scientific information about world-wide cloud cover. Studies by Sadler (1966) and Barnes (et al., 1967) demonstrate that cloudiness, as observed by a satellite, is generally less than that observed from the ground. This results, in part, from: the inability of the meteorological satellite to resolve small cumulus cells ("popcorn") and cirroform clouds, and overestimation of cloud cover by surface observers. Although computerized techniques are not yet available to merge surface and satellite cloud data, this is accomplished subjectively by weather analysts, and integrated into their analysis and forecasts.

The most accurate System Scheduling weather data for world-wide sensing operations must be a product of all the available weather data, numerical products, and statistics subjectively blended and integrated by a professional meteorologist.

6.6.9.4.3 Forecast Types

The type of weather forecast that will most effectively support an earth surveying space system is dependent upon the decision logic and the operational requirements. If success is defined as obtaining a 100 by 100 mile scene of 70 percent or more cloud-free photography, a forecast statement of the probability of such an occurrence would be indicated. This type forecast would be clearly understood by using personnel readily adaptable to objective decision making logic. If, however, success is a variable and is defined as obtaining a certain fraction of some candidate area cloud-free, for example 70 percent or more, and another area 90 percent or more, then the forecast should be in terms of what fraction of the viewed area will be cloud-free. Probability forecast statements could be easily provided by a forecaster's interpretation of the basic cloud cover analyses and forecasts.

6.6.9.4.4 Forecast Accuracy

A search of literature has not revealed any reported studies on the accuracy or reliability of cloud forecasts comparable with the probable requirements of an ERTS system. A separate study could be made to estimate what reliability and resolution can be expected in probability forecasts or the expected accuracy and distribution of cloudiness forecasts.

6.6.9.5 Weather Forecast Facilities

6.6.9.5.1 Existing Facilities

The Space Flight Meteorology Group, an ESSA organization, currently has the responsibility of providing direct support to manned space flight activities. Their location is adjacent to the National Meteorological Center (NMC) and the National Environmental Satellite Center (NESC) at FOB#4 Suitland, Maryland. This provides them with a timely source of all available data from:

1. Weather reporting stations throughout the world

2. Weather maps, analyses, and prognoses produced by NMC

3. Weather satellite data and analysis products from NESC

Communications exist directly with Goddard and Houston Space Flight Centers.

Figure 6.6-12 outlines the major segments of the overall weather support function within the weather forecast facility. Figure 6.6-13 shows the major tasks involved in preparing operational forecasts.

The Space Flight Meteorology Group is the only civilian organization that has experience in providing world wide operational weather forecasts. It is the logical organization to provide support to an ERTS System.

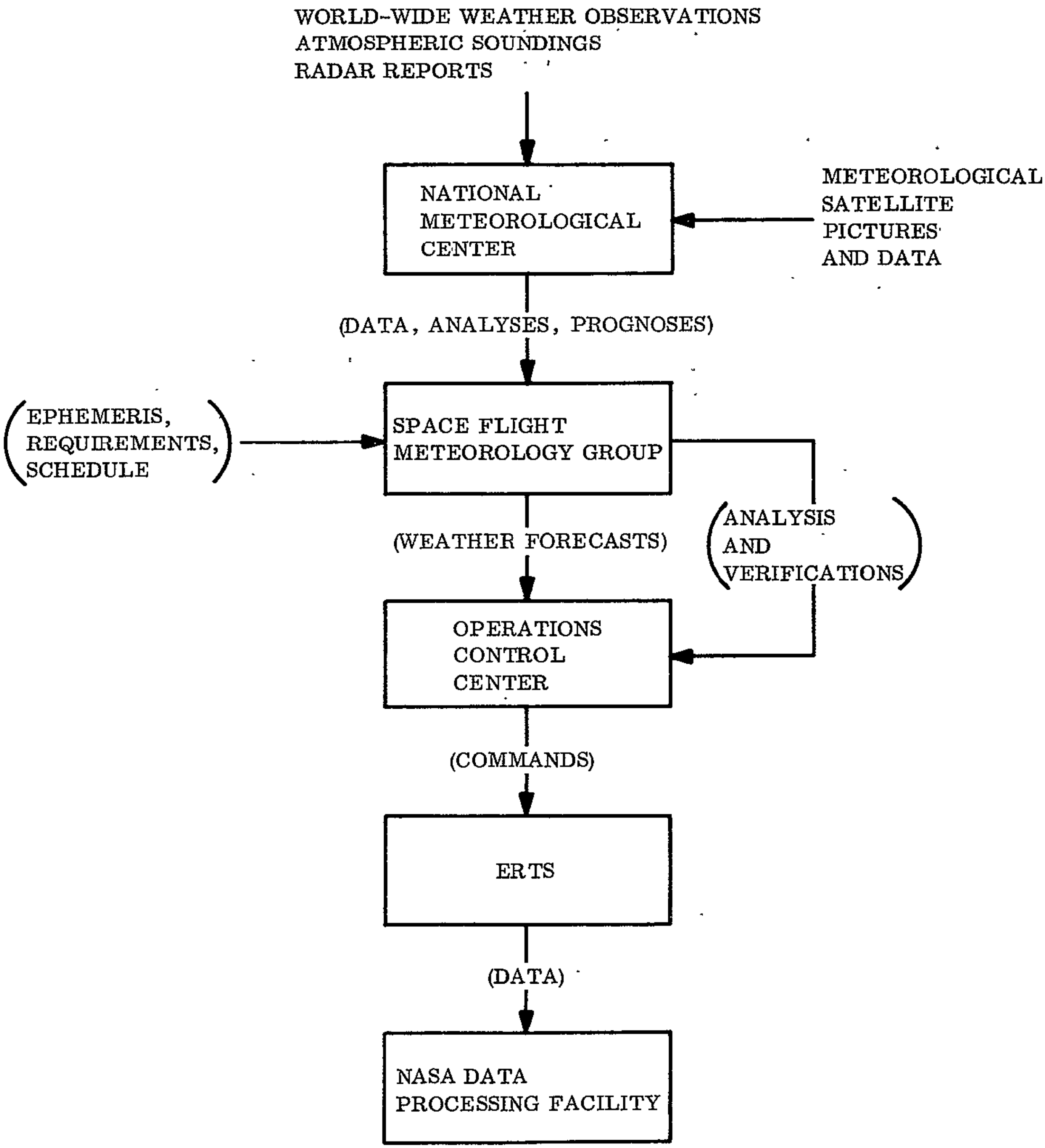


Figure 6.6-12. Weather Support Functional Diagram

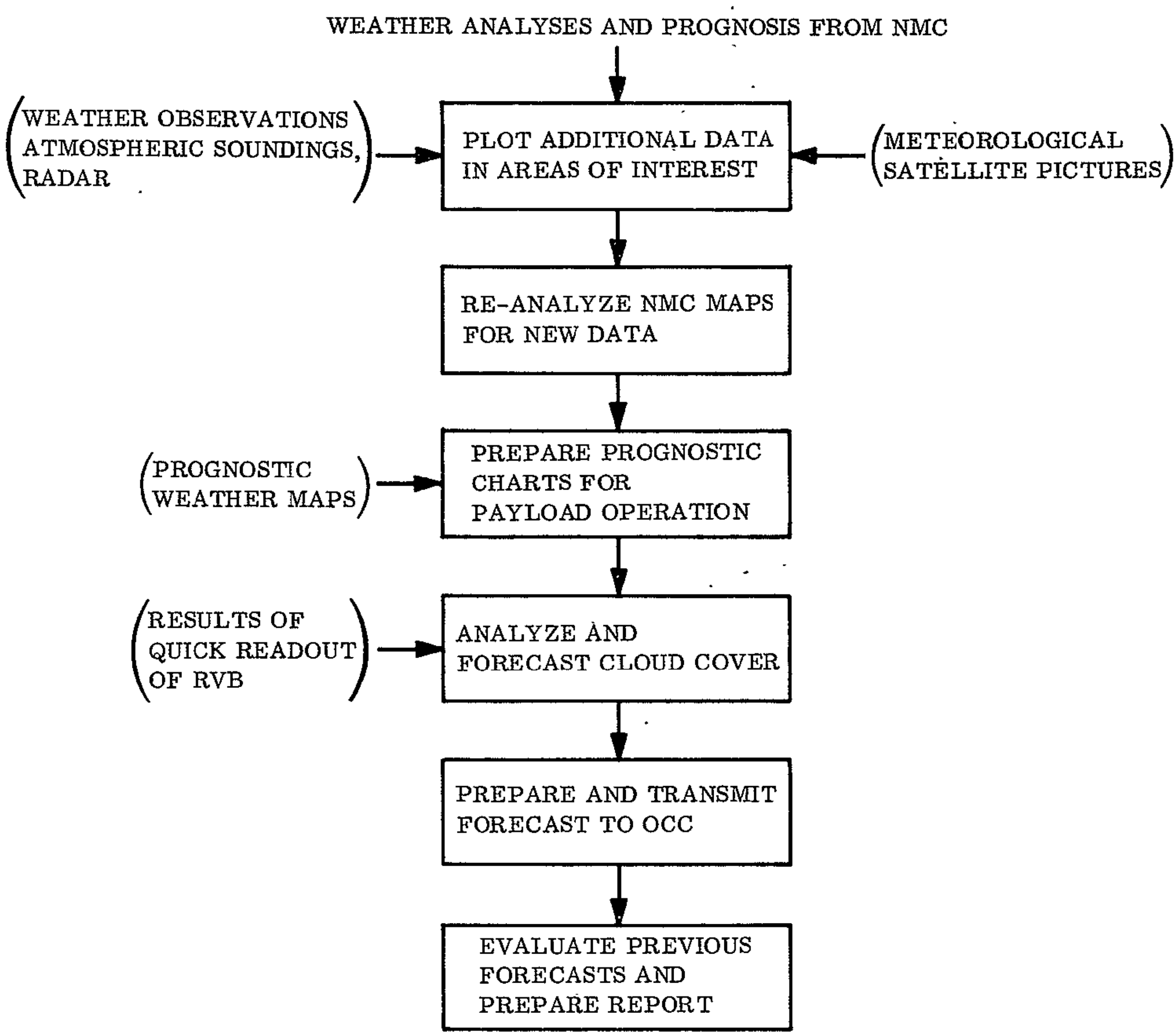


Figure 6.6-13. Function Within the Weather Forecast Facility

6.6.9.6 ESSA/OCC Interface

Operational weather forecasts relating to environmental conditions affecting the ability of the payload sensors to image the earth will be provided by ESSA. This interface consists of the OCC providing ESSA that information necessary to define the geographical region for which the forecast is required and the schedule against which the forecast must be transmitted to the OCC.

6.6.9.6.1 Operational Considerations

A weather forecast facility responsible for providing System Scheduling support would require data to schedule their activities for the following:

1. Nominal and updated ephemeris

2. Schedule of command loading to determine what revolution or portions thereof would be loaded at a specific time

3. Candidate areas of payload operation for each scheduled command loading

4. Deadline for receipt of each weather forecast at the mission planning facility

The ephemeris information will be needed primarily to identify geographically the location of the satellite ground trace. The stability and repetivity of the ERTS orbit is such that this information can be provided on an infrequent basis. Nominally, it should suffice to provide an 18-day cycle ground grace, with periodic updates dictated primarily by orbit adjust maneuvers.

Because sensor operations will primarily be scheduled over land mass areas, under conditions of acceptable illumination, only a portion of any given orbit will satisfy conditions. Therefore, a weather forecast is required to be provided only for these portions of the orbit where available coverage exists. It is planned to provide this information to ESSA in order to minimize the area for which forecasts must be made. It is expected that this information will be communicated on a basis of latitude bands per orbit.

The schedule by which forecasts must be generated is dictated by the planned schedule of vehicle commanding. The perishability of forecast information and the degradation of accuracy the further into the future for which a forecast is made dictates that the forecast be made as close in time to the planned operation as possible. The ERTS ground station contact profile is such that commands can be sent to the vehicle on almost every orbit. It is expected that full advantage of this acquisition capability will be used. This will require forecasts nominally to be provided on a rev-by-rev basis for the rev span being planned.

For those periods of the day when the spacecraft is out of contact with prime ground stations, a stored command message will be transmitted before entry of this period and will contain scheduled sensor operations for this period. In this case, a forecast will be required before the generation of this message and must cover the areas of potential sensor operations.

In order to provide forecast at the required time, it is planned that the OCC will provide ESSA with a schedule of forecast requirements and deadlines for receipt of the forecast at the OCC. Again, it is expected that these schedules will be very predictable and can usually be generated for long periods of time.

6.6.9.6.2 Cost of Operational Support

Several levels of forecast support can be supplied to the ERTS program by ESSA. The interface requirements remain the same in all cases. However, forecast accuracy and the cost for the operational support varies significantly.

The most accurate mission planning weather data for world-wide sensing operations must be a product of all available weather data, numerical products and statistics subjectively blended and integrated by a professional meteorologist. To achieve this type forecast requires around-the-clock support of ESSA personnel dedicated to the ERTS program. The cost for this level of ESSA support is estimated at $250,000 per year.

If purely objective forecasts provide sufficient prediction accuracy for ERTS sensor operation scheduling, then a totally automated cloud cover prediction technique could be employed. The cost for this level of ESSA support is estimated at $50,000 per year.

6.6.9.6.3 Forecast Format

Weather forecasts should be in a form that can be quickly transmitted to the System Scheduling facility by telephone, teletype, or data link. It will consist of:

1. Revolution number for which forecast is provided
2. Latitude where the forecast begins (center part of ground swath)
3. Forecast in terms of (a) Percent cloud-free skies within the latitude boundaries or the probability of some scene being cloud-free (b) The probability of significant haze or atmospheric pollution
4. Latitude at which the forecast changes or ends (center point of ground swath).

For example:

Forecast		Explanation
Rev 14		
50N		(Forecast start latitude)
10%		(Forecast in % cloud-free)
42N		(Forecast changes)
25%	Light Haze 50%	(50% probability of light haze)
40N		
40%		
30N		(Forecast ends)
05N		(Forecast starts again)

Forecast (Cont'd)		Explanation
05%	Moderate Haze 60%	(60% probability of moderate haze)
03S		(Forecast changes)
60%	Light 10%	(10% probability of light haze)
23S		(Forecast changes)
80%		(Forecast in % cloud-free)
30S		(Forecast ends)
END	End of Message	

6.6.9.6.4 Summary and Conclusions

A simple interface can be employed between the OCC System Scheduling Subsystem and ESSA in order to provide the required weather forecast information. The approach selected has minimized the data required to be transferred across the interface.

Weather forecast data will be required only to account for major weather systems when filtering the coverage availability list. Therefore, the recommended level of support required from ESSA is that of a fully automated cloud cover prediction model.

6.6.9.7 Use of Forecast Data in OCC

Weather forecast data will be used as an input to the process of scheduling sensor operations. Initially, it is anticipated to employ this data on a gross level, e.g., to account only for major weather systems in deleting potential coverage areas from the set of all geometrically possible coverage areas. This type filtering will be applied both to real-time and remote sensor operations. The ability to filter potential real-time operations can be scheduled by allowing for increased playback time available.

In order to develop confidence in, and a more sophisticated capability to use, weather forecast information in sensor scheduling, a weather forecast effectiveness evaluation experiment is planned.

This experiment will be designed to evaluate the effectiveness of alternative procedures and/or computations used to convert weather forecast data into the probability of successful ERTS sensor system performance, e.g., acquisition of useful data. Sensor operating schedules can be generated in an off-line operating mode, never actually be flown, and later checked against verified weather data and actual ERTS acquired imagery. In this manner, it is felt that increasingly efficient empirical algorithms can be developed for transforming weather predictions into ERTS system operating policy.

6.6.9.8 References

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2. Lund, I.A., "Estimating the Probability of Clear Lines-of-Sight from Sunshine and Cloud Cover Observations," Journal Applied Meteorology, 4(6), pp. 714-722, 1965.

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6.7 COMPUTING SERVICES SUBSYSTEM

6.7.1 SOFTWARE REQUIREMENTS

The OCC software requirements reflect the processing and computation requirements resulting from the functional design of the OCC. These requirements can be divided into four major areas:

1. Mission Planning and Operations Scheduling
2. Command Generation
3. Spacecraft Evaluation and Management
4. Operational Control

In addition to these four functional software requirements, there exists the requirement for a Data Base Generation and Maintenance System. The Data Base will serve as the repository for spacecraft engineering data and mission system data, as well as that information generated by one or more of the functional entities (e.g., data generated by the Mission Planning and Operations Scheduling Module).

6.7.1.1 Mission Planning and Operations Scheduling

The Mission Planning and Operations Scheduling element of the OCC generates an overall system activity plan based upon coverage requirements, spacecraft and payload status, network availability, and environmental constraints. The activity plan is a time-ordered list of spacecraft, payload, and network events that does not violate any operational constraint imposed on the ERTS system.

The Mission Planning and Operations Scheduling function is a nonreal-time, data base oriented, software function. In order to allow sufficient time to interface with NASCOM and MSFNOC, mission planning will be carried out on a sliding week basis, e.g., planning will be done daily for seven days into the future, with the capability for subsequent interaction as the situation demands. Several iterations of the initial plan may be required through the planning cycle to ensure compatibility of the payload operation schedule and network schedule, in addition to satisfying all operational constraints.

Portions of the Mission Planning and Operations scheduling software require too much processing time to be efficiently executed in an interactive time-shared mode of operation. Hence, the iterations required through the planning cycle will be executed as a series of batch submitted background processed jobs with the OCC computer required to operate in the time-shared mode.

6.7.1.1.1 Performance Requirements

The following specific functions are performed in the Mission Planning and Operations Scheduling element:

1. Maintain a mission planning data base

2. Command Management

The Command Management module will provide for the creation, storage, retrieval and transmission of all pre-stored command sequences. The module will be run in the on-line real time mode of the system. In addition, the following specific functions are performed by the command management module:

1. Examine for critical commands
2. Alarm for continuance or abort of transmission
3. Generate delta times for desired execution
4. Polynomially encode information for NASCOM 494 computer
5. Transmit to NASCOM 494
6. Verify command execution
7. Transmit commands from command console keyboard
8. Create, edit, and delete command sequences from the data base
9. Verify contents of spaceborne command memories
10. Generate Predicted Ephemeris
11. Maintain cloud cover model(s) and evaluate their impact upon the effectiveness of the ERTS system's operation.
12. Generate a station contact profile
13. Generate a payload operation schedule
14. Verify Orbit Adjust requirements
15. Generate a DCS Schedule
16. Data file integration

6.7.1.1.2 Interface Requirements

The Mission Planning and Operations Scheduling software system is data-base oriented. Therefore, there will be no direct communication of data between the major modules of the system; communication between modules will take place through the data base under control of a mission planning executive program.

6.7.1.2 Command Generation

Command Generation is divided functionally into two modules, Command Compilation and Command Management. The Command Compilation module provides for the automatic compilation of command sequences from orbital activity plans generated by the Mission Planning and Operations Scheduling. The Command Management module controls the handling and transmission of commands to the spacecraft via the NASCOM uplink.

6.7.1.2.1 Performance Requirements

A. Command Compilation. The Command Compilation module will use as input an activity plan generated by Mission Planning and Operations Scheduling. This activity plan will be a time tagged list of spacecraft events required to fulfill the operations plan for one orbit. For each event in the activity plan, the Command Compilation module will compile a sequence of commands to cause that event to occur. The required time of execution for each event in the activity plan will be compared to the expected acquisition window of the appropriate interrogation. If the event time falls within that window, real-time commands will be generated for that event. If the event time occurs outside the window, stored commands will be generated for the event. After all events in the activity plan have been compiled into commands, the resulting command list will be reordered into execution time sequence and optimized.

6.7.1.2.2 Interface Requirements

The Command Generation module will interface with the data base to access activity plans, tabular information defining commands used for events, and last known status of the spacecraft.

The Command Management module will interface with the data base to access command sequences, and tabular information defining critical commands under spacecraft mode dependent conditions. This module will also interface with the co-resident telemetry processing software to receive current spacecraft status information, spaceborne memory dump data and to provide copies of transmitted commands for verification.

6.7.1.3 Spacecraft Evaluation and Management

6.7.1.3.1 Telemetry Processing

The telemetry data transmitted from the spacecraft is the primary source of information for assessing the status, health, and performance of the spacecraft and its subsystems. Real time data is evaluated as it is received on-line in order to provide effective command and control of the spacecraft, and allow immediate corrective action in response to emergencies. Playback data, which covers the entire orbit period is processed for in-depth evaluation, detailed investigation of anomalies, and long-term trend analysis. Both real time and playback telemetry data are provided to the OCC via NASCOM at rates of 1 kbps and 32 kbps, respectively.

Telemetry data at either data rate may exist in one of four possible formats, each of which require special processing.

The four data formats are:

1. Normal telemetry
2. VIP memory data
3. VIP matrix verification data
4. Emergency mode telemetry data

A. Performance Requirements. The Telemetry Processing software will be required to identify the data type and, via the Operating System, load the appropriate processor packages to reduce the data.

On-Line Processing

The Telemetry Processor will be required to perform the following functions for each frame of normal data:

1. Annotate each frame of PCM data with ground time.
2. Telemetry frame sync, subframe sync and subframe ID will be quality checked.
3. Commands transmitted during this frame will be collected from the Command Management module and (1) appended to the PCM matrix for further processing and (2) stored in the data base as a historical list of commands transmitted.
4. Indicators relevant to the operation of the spaceborne command system will be extracted from the telemetry data.
5. The PCM matrix will be reformatted to make its handling by subsequent telemetry processing packages more economical in terms of tabular information required to locate the data.
6. Selected analog function values are compared against a series of up to four predetermined ranges.
7. Status Determination: Approximately 100 unique spacecraft events will be defined. The purpose of the status determination software is to monitor the spacecraft and subsystem configuration and assign predefined states to each event.
8. Calibration: The purpose of this software is to convert the PCM counts carried in the telemetry matrix into engineering units.
9. Limit Checking: Each analog function will be limit checked to determine if it is within its specified operating values.

10. Event and Command Verification Profile: This module will generate information which will form the basis of the Orbital Profile Report.

    Information required to generate predicts of spacecraft status changes for command verification will be supplied by the data base in tabular form.

11. Alarm Processing Routine: Alarms are defined as those conditions or combinations of conditions which are predefined as critical and must be reported immediately. This software will test for and report the presence of those conditions.

    Information required to detect alarm conditions will be supplied by the data base.

12. Pseudo Functions: Pseudo functions are values which can be computed from combinations of two or more telemetered functions. These functions are typically, efficiencies, power outputs, and other indirect relationships.

13. Data Smoothing: Data smoothing is performed to remove transient noise from the analog telemetry data. The technique used is rate smoothing. The information required to smooth data is supplied by the data base.

14. Selected telemetry functions will be extracted from the normal telemetry data and used in support of wideband video data processing.

15. Data processed in the manner described above will be discarded if it is real time data and retained in the data base if playback data.

Telemetry processing performed on other than normal mode telemetry data will be as follows:

In the Memory Verify Mode the spacecraft telemetry system will output the entire contents of its memory in lieu of actual spacecraft data. Processing performed on this data will compare the memory contents received with expected memory contents maintained in the data base and generate reports of discrepancies.

In the Matrix Verify Mode, the spaceborne subsystem will output gate numbers in lieu of decoding gate numbers and selecting them to output data.

Telemetry processing for this type of data compares the received gate number matrix with an expected gate number of matrix and generates reports of discrepancies.

Emergency Mode data from spacecraft telemetry system is one sample of each function telemetered per frame to a maximum of 1024 functions. Processing for this type data will be the same as for normal data except tabular information would have to reflect different data locations.

Off-Line Processing
Off-line processing of telemetry data will be performed on playback data retained during the on-line phase. Off-line processing deals with detailed analysis of spacecraft sub-systems and payloads to determine configuration, health and long range trends. Archival data is also computed and retained in the data base for historical display.

To facilitate trend analysis of spacecraft functions, statistics will be generated for all analog spacecraft functions. These statistics will form the basis of an archive from which selected information can be extracted and displayed. This information will be used in trend plots and summary reports.

The five latest orbits of playback data will be retained in the data base. Provision will be made for selectively displaying functions from this data either at work station consoles or system printer. The rapid availability of this type of data is useful in tracing anomalies detected in the data.

B. Interface Requirements. Telemetry Processing software will operate on telemetry data input by the OCC PCM Decommutation Unit.

Command transmission information will be supplied by the Command Generation software which is co-resident in memory with the telemetry processing software.

Spacecraft payload-related data extracted from real time telemetry will be supplied via the SPDT tape to the NDPF.

6.7.1.3.2 Display Generation
Decision making, relevant to the efficient operation of the spacecraft, will be based to a large degree on information contained in standard telemetry and command system reports. The availability of these reports in a timely and concise manner is a prime requirement of Operations Control.

The Display Generation module will provide the capability of selectively displaying these reports in the appropriate time frame as they are required by the evaluation personnel.

A. Performance Requirements. The Telemetry Processing and Command Management modules will compute indexes contributing to approximately 30 standard reports. The Display Generation module will provide the interactive control of data flow and report generation necessary to provide each user with the report he requires at the work station he is using.

This module will control the flow of this report information for report generation and display in the on-line environment. In the off-line environment, this package will supervise the retrieval of previously stored information from the data base for display.

The Display Generation module will interpret report display requests from keyboard consoles or other system device. The Report Generation software will provide all the formatting, conversion, and paging logic required to configure the report for the destination display device.

The Display Generation module shall also provide the ability to display succeeding pages of multipage reports.

Typical reports from on-line real time telemetry processing would be:

1. Spacecraft status

2. Spacecraft alarm condition

3. Orbital profile reports

4. Out of limits reports

B. Interface Requirements. The Display Generation module will interface with the data base for report information indexes computed from playback data, and report generation subprograms to generate reports. Requests for display of various reports will originate at evaluation work station consoles and other system input devices.

Report information indexes required for reports based on real time PCM data will be received from the Telemetry Processing and Command Management modules.

6.7.1.4 Operations Control

Operations control is the primary decision-making body with regard to spacecraft operations. The telemetry and command elements provide the information on which to base those decisions. To provide spacecraft management in a time critical environment, operation control must have essentially instantaneous access to this management information.

The ADPE, in conjunction with the applications software, must provide this real time command and control capability.

6.7.1.4.1 Performance Requirements

The Operations Control element requires current information regarding spacecraft configuration and health. This information is provided by the Display Generation module in an interactive mode in conjunction with the real time telemetry processing module. Requests for display of various reports will be made via the Display Generation module. The desired report is required within two seconds. The ability to change to a display of a totally different report allows a centralized facility for overviewing a number of spacecraft operations from a centralized station. The alphanumeric display of selectable reports, used in conjunction with graphic displays of analog signatures will provide selectable monitoring of all spacecraft functions.

The multiple work station concept for providing real time monitoring, command and control requires the ability of the ADPE to monitor and service those stations while simultaneously reducing the incoming telemetry data.

Spacecraft commanding will be performed in the real time environment via a work station designated as the command console. Operating simultaneously with and at a higher priority than the telemetry processing module, the command management module will provide the capability of altering spacecraft configuration via transmission of predefined and sequences or real time commands.

In the off-line environment, Operations Control requires detailed in-depth information regarding critical subsystem health, trends and performance. This information is provided by the analysis software of the telemetry system. Detailed information regarding spacecraft performance in a historical context will be required for the investigation of anomalies and prediction of future operation restraints and capabilities.

Automated management of spacecraft payloads and supporting subsystems to satisfy mission requirements will be provided by the Mission Planning and Operations Scheduling element in an interactive mode with Operations Control.

Management and modification of tabular information, controlling telemetry processing, will be required by Operations Control to reflect parametric changes in airborne spacecraft systems.

The multiplicity of operations carried out by various elements in the off-line environment dictates on-demand access to the ADP resources and software supporting these operations. This will allow a number of Operations Control components to pursue their activities in an unhindered and timely baseline with virtually all spacecraft management and analysis information available for their use.

6.7.1.5 Data Base Generation and Maintenance

The OCC computer system data base is that collection of mission system information used and generated by the OCC applications software system. The data base contains two different classes of information. The first is tabular in nature and consists of spacecraft engineering data, mission system data, and other related data, which is required by the applications software packages. This data is characterized by the fact that it is essentially a priori information which remains constant or is modified infrequently after mission operations begin. The most frequent routine update cycle presently anticipated for data in this category is once per week for the input of new ephemeris information for the Mission Planning and Operations Scheduling functions.

The second class of information in the data base consists primarily of information generated by one applications program for use by another, and/or by itself at a later time. The Mission Planning and Operations Scheduling software, for example, generates an activity plan describing the events required during a particular future orbit, and places that plan in the data base for retrieval later by the Command Generation software, just prior to that orbit activation. Spacecraft evaluation software generates performance reports after each orbit and outputs these reports to the data base, maintaining only the last five orbit reports in the data base at any one time (the older reports having been purged to archived history tapes). During the processing of the next orbit's performance, this same software will retrieve these reports and perform a short-span, comparative trend evaluation.

The data base will reside in the mass storage device which must permit random, relatively fast access to the mass of data involved. The data base is expected to require in excess of 25 mission characters of storage.

6.7.1.5.1 Performance Requirements
The data base generation module will be required to store, retrieve, catalog and control information generated by and for applications software of the OCC. The data base stored in the mass storage units will require access times on the order of 200 milliseconds. Software design must facilitate the organization, storage, maintenance and retrieval of information using mass memory storage media, and may require a centralized file system of hierarchical tree structured design to minimize the time required to certain real time operations. The data base must be accessible by programs operating in real time, batch, and/or time-sharing modes of processing. Catalogs and files must be secured by passwords for data base integrity. File access should be under control of the operating system. Several programs may be required to read a file concurrently while also dumping the file to another medium such as magnetic tape for backup purposes. The operating system shall provide the control to implement this dual access.

6.7.1.5.2 Interface Requirements
The data base will interface directly with the operating system software for all data storage and retrieval.

6.7.2 COMPUTER REQUIREMENTS

6.7.2.1 Functional Requirements
The OCC Computer System is designed to satisfy all of the processing and computation requirements which result from the OCC functional design. The OCC is divided into four major areas of functional responsibility:

1. Mission Planning and Operations Scheduling
2. Command Generation
3. Spacecraft Evaluation and Management
4. Operations Control

Mission Planning and Operations Scheduling involves the development of time sequenced activity plans for sensor, spacecraft, and ground system operations. Command generation converts these activity plans into spacecraft recognizable command messages which are compatible with the established command link transmission facilities. Spacecraft Evaluation and Management uses PCM telemetry data as its principal input in performing both on-line and off-line analysis of the spacecraft status, configuration, performance, and health. Lastly, Operations Control provides overall direction and monitoring of the OCC itself, and of the supporting elements.

The processing and computational requirements of the OCC fall into several categories, many of which can be satisfied by the capabilities of a third generation, general purpose computer system. Mission planning and operations scheduling are performed by applications software packages operating in a nonreal time batch or time-shared mode. The algorithmic operations to be performed include event prioritization, scheduling, expendables management, and some ephemeris computations.

Command generation requires both an interactive user mode and a semi-dedicated, real time operations mode. The interactive mode permits the applications software to operate effectively through the iterative steps required to develop and display the time sequenced spacecraft command list. These commands will then be processed and formatted for output to the spacecraft in real time via the NASCOM up-link. This aspect of command generation requires specialized software and hardware interfaces within the OCC in order to utilize the existing NASCOM up-link facilities.

The Spacecraft Evaluation and Management function is perhaps the most demanding in terms of computer system requirements. This results from the fact that considerable specialized hardware is required, and the various applications programs must operate in real time, batch, and time-shared modes. Further, a flexible, efficient capability for the display of results must be provided.

Operations Control imposes few unique requirements beyond those already described. In general, the requirements of this function have already been integrated with, and are fulfilled by, the other functions. Exceptions to this are Operations Control applications software programs which will be satisfied by the computer configuration to be specified.

The computer system concept, shown in Figure 6.7-1, provides the necessary operating environments required of the applications programs, with special emphasis on the use of CRT displays with input keyboards to satisfy the need for effective display in real time and user interaction in the time-shared mode. A mass memory device provides an efficient mechanism for rapid storage and retrieval of large amounts of often used information which comprises a significant percentage of the integrated OCC data base, and in conjunction with the operating system and applications programs, affords an effective means for interprogram transfers. Tapes provide media for mass memory purging, program storage, archiving of OCC data, NDPF interface, and plotter interface.

The transfer of command data from the OCC computer to the NASCOM 494 Communications Processor will be accomplished by means of specialized interface boxes designed for the purpose. Telemetry data handling from the various NASCOM sources is also accomplished by specialized interface and formatting units. This permits a single, standardized design to suffice for the PCM decommutation equipment.

Special mention should be given to telemetry data acquisition and processing in the OCC computer. Spacecraft telemetry data is the primary input to this computer. This data can exist in several modes and formats at different rates, and can be input via any one of several media at one time. The computer system must be capable of providing the necessary interfaces with the equipments supplying the input data. In addition, the computer system must

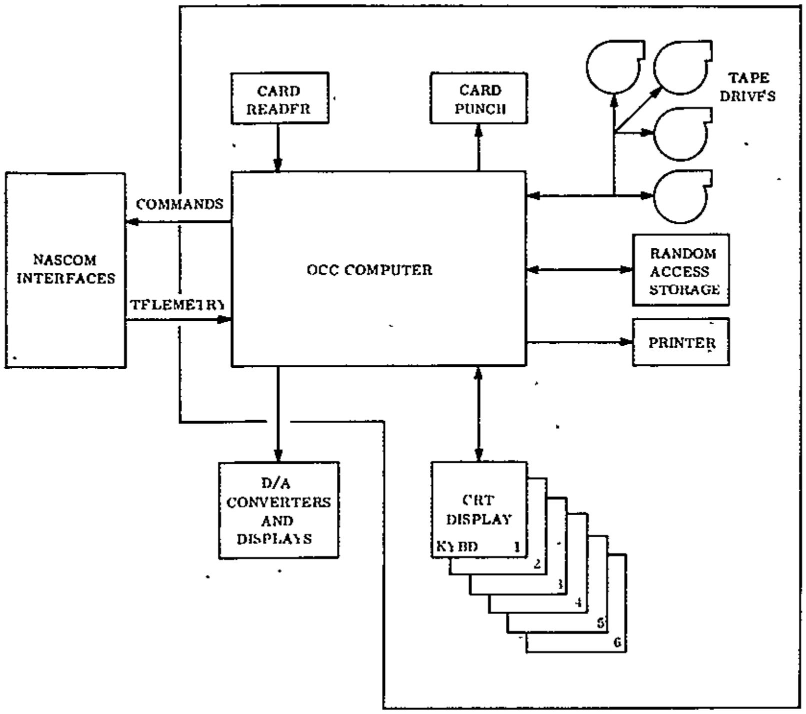

Figure 6.7-1. OCC Computer System Conceptual Block Diagram

provide an effective means by which the telemetry processing applications software can accept, sync, verify, lock, decommutate, and distribute the telemetry data to the various analog and digital displays to be employed. It is important to note further that this processing could occur in either a central processor unit, or in some form of programmable communications processor which functions as an integral part of the main computer system. In this later configuration, the preprocessor should be capable of stand-alone operation in the event of OCC-CPU failure in order to maintain analog display output.

6.7.2.2 Hardware Requirements

6.7.2.2.1 General Requirements

The Automatic Data Processing equipment needed to support the OCC system consists of the following:

1. Central Processor
2. Memory
3. Mass storage devices and controllers
4. Tape handlers and controllers
5. CRT display and controller

6. Printer

7. Card reader/punch

8. PCM decommutator

9. 494/command formatter unit

10. 494/PCM formatter unit

11. X144/PCM interface unit

The OCC computer is a medium to large scale third-generation system which will be dedicated to the execution of the functions described previously. The system will provide the OCC with three modes of operation:

1. Dedicated real time processing to support on-line flight operations.

2. Dedicated batch processing of the playback telemetry data for the detailed evaluation of system and subsystem performance immediately after each acquisition.

3. User-interactive multiprogram processing (time sharing) in the interorbit period to support the variety of analysis, evaluation, investigation, planning and other activities performed during this period.

Note that certain computer configurations allow modes 2 and 3 to be combined or run simultaneously in a foreground/background mode without a significant loss of turn-around time.

The mass storage device provides an effective storage and retrieval media for the large volume of tabular spacecraft and mission related data commonly used throughout the system for critical performance data from several past orbits to allow rapid comparative evaluation with current values, and for transferring information between the necessary interrelated and interdependent operations of the OCC. Alphanumeric CRT displays with keyboard and function key inputs are the primary system display media, although the system printer will be used routinely for hard copy reports and other output. The CRT displays will be physically located in the operations consoles located in the Operations Control Room. The displays will be controlled by keyboard inputs which will provide the capability of independently selecting the desired display at any console. This capability will greatly increase the effectiveness of command and control during real time operations by allowing a flexible and responsive spacecraft monitoring capability. In the time-shared mode, this capability allows the operations consoles to save their users as work stations which afford immediate, independent and versatile interaction with the computer system.

The NASCOM interface hardware provides the necessary interfaces between the NASCOM 494 Communications Processor output data modem and OCC ADP system. The interface hardware consists of the 494/PCM Formatter Unit and the 494/Command Interface Unit. The details of these interfaces are still being discussed with NASCOM personnel and the characteristics cited reflect the present level of information available.

The PCM decommutation hardware must accept and process the various telemetry data formats available from the spacecraft in real time and playback, and present selected data to analog displays and all of the data to the computer.

6.7.2.2.2 Specific Requirement

A. Central Processing Unit (CPU) Characteristics. The OCC computer CPU must have the characteristics normally associated with third-generation computers. The CPU hardware must provide for instruction control of data movement, fixed and floating point arithmetic using single and double word precision, and other normal logic functions, and also has additional hardware capability for binary/BCD and BCD/ASCII conversion, memory protection, and instruction formatting.

To support multiprogramming, the CPU associated hardware must incorporate a multilevel priority interrupt system with provisions for time rate and computer controlled interval interrupts to prevent programs from monopolizing the processor.

Further improvements to facilitate multiprogramming such as multiple register sets, multiprogramming hardware, or other functionally equivalent facilities would be desirable.

B. Memory System Characteristics. The minimum memory requirement for the OCC is 73k words. A word is defined in this report as a single instruction, a real number to 7 decimal digits of accuracy, 6 BCD or 4 ASCII characters. Operating system software and all associated storage overhead have not been included.

Memory characteristics should allow for character handling and for hardware memory protection.

Memory access and basic cycle time is in the 2-microsecond range. Improvements to memory throughput could be provided with double word fetch and simultaneous memory access with multiple controllers.

C. Input/Output System Characteristics. At least five independent direct memory access or equivalent I/O channels must be provided. Tentative assignment would be one for real time telemetry input, one for playback telemetry input, one for command message output, one for storage and associated peripherals, and one for CRT communications output. Data transfer rates will not be critical and will not require extensive high-speed I/O channels. The real time telemetry input into the computer will be 1000 characters per second. Playback telemetry is input at 32 times this rate. If I/O channels are shared by the hardware components, higher transfer rates may be required.

The peripheral equipment will include the following:

1. Card Reader. A 600-card per minute reader or faster will be utilized for general program development and in loading control application programs. Application programs can be loaded from the mass storage media for more efficient operations.

2. Card Punch. A low speed punch of approximately 100 cards per minute will be used primarily for producing object decks and for limited card reproduction.

3. Line Printer. A high speed line printer of approximately 1000 lines per minute will be required for generation of program data listings and for hard copy CRT output. The printer should have at least a 64 character set and 120 columns per line -- 136 columns are desirable. More characters per line would provide for larger displays of output. Another possibility would be a requirement for both 6 and 8 lines per inch capabilities.

4. Console. A standard system console capable of displaying register content and computer status under control of the operating system is required.

5. Digital Tape Drives. Four USASI standard drives will be required for permanent data storage and for system generation. Transfer rates up to 60 k characters per second are required. Tape drives will be dedicated to:

1. System and Library Tape
2. Journal Tape or Data Base Purge
3. Output Data Tape
4. Spacecraft Performance Data Tape

6. Random Access Storage. The total application program storage of 25 million characters should have a minimum access time of approximately 200 milliseconds to avoid unnecessary processing delays.

Additional random access storage will be required for library files, operating system and for general work area storage.

7. CRT Communications Terminals. Four direct entry terminals will be required to operate in real time mode to display spacecraft status information. Transfer rate should be sufficient to allow alphanumeric characters to be displayed in flicker-free operations. A page refresh capability is required for fast screen evaluations. An alphanumeric keyboard with function keys are necessary for real time and interactive operations.

6.7.3 COMMUNICATIONS PROCESSOR STUDY

The OCC Computing Services Subsystem is required to satisfy a variety of interfaces. The characteristics of these interfaces and the underlying requirement for operational reliability were the driving factors in establishing the interface equipment and configuration.

The principle interface considered was that for the telemetry data. This data can arrive at the OCC in several ways:

1. NTTF acquired telemetry will be input via hardline as raw, serial PCM. The serial rate is 1 kbps for real time and 24 kbps for playback.

2. Real time data acquired at Alaska and Corpus will be input via the NASCOM 494 Communications Processor and its 303 Data MODEMS. This data is input as a block of 600 bits containing NASCOM headers and source and address codes, come 500 telemetry data bits, and the necessary flag bits. Each block of data is input to the OCC as a burst input at 50 kbps.

3. Alaska playback data will be transmitted to the OCC via the X144 MODEM at 24 kbps. The output of the X144 looks much like NTTF; raw, serial PCM.

4. Corpus (and, in a back-up mode, Alaska) playback can be input via the 494. The tape at the remote station would be slowed down in this case, and the input would look like real time data accelerated to be compatible with the 203 MODEM rate capability.

In all of the cases described herein, the data is input in serial fashion and must undergo sync, verify, and lock processing before decommutation and distribution.

Were it not for the 494 interface, the selection of the processing equipment would have been relatively simple. The probable choice would be a PCM station with sync, verify, and lock hardware, with stored program decom capability to accommodate the variable ERTS telemetry data outputs.

6.7.3.1 PCM Ground Station Approach

The PCM ground station approach would readily satisfy the NTTF and X144 interface requirements, as well as those with the OCC computer. In addition, the ground station could operate without the computer and continue to output telemetry data to strip chart and event recorders for reliable back-up data display.

The 494 interface is the source of real time PCM data from two of the prime sites, Corpus and Alasks, and will also be used for real time inputs from other MSFN and STADAN stations. The difficulty arises from the fact that the 494 interface imposes certain restrictions and offers several advantages which the PCM ground station cannot accommodate. Most PCM ground stations require fixed rate, serial input data and cannot operate on burst inputs which the 494 generates. One initial approach to overcoming this was to insert a clocked buffer between the input 303 MODEM and the PCM ground station. The purpose of the buffer was to accept the burst input and clock the data out to the ground station at the 1 kbps second rate. Discussions with GSFC NASCOM personnel brought to light the fact that this type of interface did not afford the degree of processing intelligence required to fully utilize the 494 capability. This stems from the fact that the remote stations can utilize the 494 telemetry link to transmit vital command data back to the OCC. This data would provide almost immediate information on the results of the uplinked command message polynomial decoding and echo checks. This permits rapid command message go/no-go status and allows the OCC to retransmit if necessary without waiting for command verification from spacecraft telemetry. Transmission of this data to the OCC is relatively simple. The data will replace filler bits in prescribed locations of the 600-bit block.

6.7.3.2 Alternative Approaches Considered

The results of this area of study pointed strongly to the fact that a significant processing capability and flexibility are required within the OCC to handle the mechanics of the 494 interface and to intelligently interpret and process the incoming data. For this reason, the use of a PCM ground station was ruled out and two alternate configurations were considered. The first of these would interface the 494's, 303 MODEM with the OCC main computer directly; the second involves the use of a small communications processor.

The OCC main computer certainly satisfies the interface requirements in terms of processing capability and flexibility. At the same time, however, this approach has two distinct disadvantages:

1. The main computer must accept and decommutate the 600-bit blocks of serial data. While some configurations may accomplish this somewhat efficiently, for the most part it is an extremely inefficient use of the CPU.

2. A failure in the main computer leaves the OCC without a back-up telemetry display capability.

6.7.3.3 Communications Processor Approach

The use of a communications processor has been examined in some detail and has been selected as the preferred configuration. The term "communications processor" has been adopted to define the role this equipment plays within the OCC configuration and may not be the vendor applied label. This equipment is generally characterized by several factors:

1. It is designed to interface with, and process efficiently, serial input data at different rates and from different sources.

2. It is designed to interface with larger, general purpose computers.

3. Access times are generally fast, and on the order of 1 μsec or less.

4. It contains its own programmable CPU and core memory.

Almost all vendors manufacture this type of equipment and may refer to it as a communications processor, interface processor, input/output controller, or even mini-computer. Again, however, the architecture of the design is usually centered around input/output capability, efficient interaction with the main computer, and relatively low cost.

The term "communications processor" seems appropriate within the context of the OCC configuration depicted in Figure 6.7-2. The communications processor performs all interface processing required for incoming telemetry data, and in addition, for all outgoing command data. That is, all OCC/network interface processing is accomplished in this device. The main OCC computer is provided data in an efficient parallel manner, and is free of the time and processor overhead burdens which occur otherwise.

In more specific terms, the communications processor will perform the following functions:

1. Accept/provide the control signals from and to the 303 MODEM and 494.
2. Accept the burst serial telemetry data from the 494 and extract and forward the command message bits to the main computer.
3. Accept the 1 kbps and 24 kbps serial data from the X144 MODEM and NTTF via bit synchronizers in the OCC Communications and Data Distribution Subsystem.
4. Perform the sync, verify, and lock processing required to decommutate and distribute any one of the incoming telemetry data streams. For 494 inputs, this includes header verification and header and filler data stripping.
5. Transfer decommutated, synchronized telemetry data to the OCC main computer for detailed on-line and off-line processing.

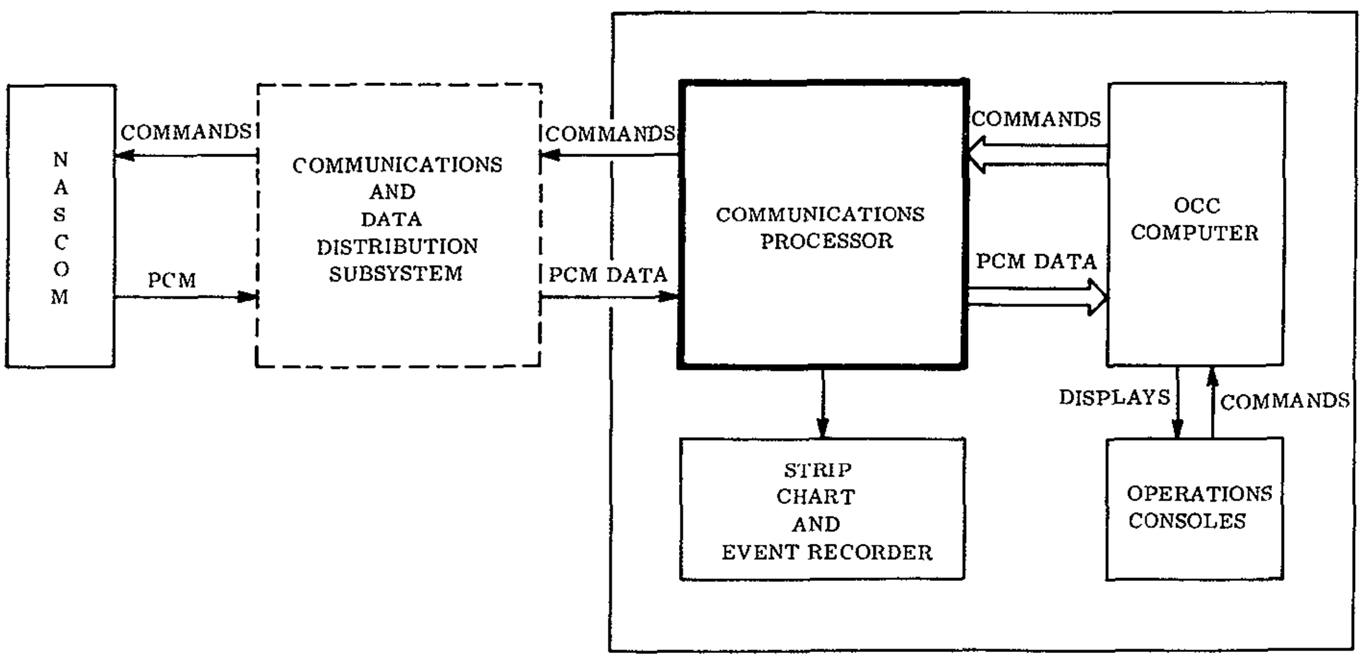

Figure 6. 7-2. OCC Computer System Configuration

6. Accept strip chart and event recorder display parameters from the main computer and output the appropriate telemetry data to the proper display. This processing must continue in the event of a main computer failure in order to provide a back-up display capability.

7. Accept command message data from the OCC main computer in the form of 600-bit blocks and output this data to the 494 at 50 kbps.

8. Accept real time command message data from the command console in the event of OCC main computer failure and format and output this to the 494 in order to provide a back-up real time command capability.

From this description, it can be seen that the communications processor centralizes all interface processing, relieves the OCC main computer of this overhead burden, and provides a significant back-up capability for both telemetry processing and commanding without the need to rely on the NDPF computer. In addition, this processor is capable of other small computational activities required by the OCC, such as DCS data pre-processing as described in Section 6.1.

Perhaps the most significant advantage described is backup. The reliability of these processors is generally quite high, and the final configuration decision will be based upon overall system reliability and cost effectiveness. These devices are quite inexpensive as compared to the larger machines and significant advantages can be gained by using two as shown in Figure 6.7-3.

One of these would be dedicated to incoming telemetry data processing and the second to outgoing command message processing. This configuration would afford considerable back-up processing for telemetry, commanding, and display in the event of main computer failure. Alternatively, one processor could fully satisfy the main computer requirements should the second fail.

6.7.4 OCC/NDPF COMPUTER INTERFACE STUDY

This study was directed at determining the need for, or desirability of, a direct interface between the OCC and NDPF computers. The primary purpose of this interface would be to permit the OCC computer to access the NDPF data base, which contains the coverage history file. This would also permit the transfer of telemetry, DCS, and payload operations data from the OCC to the NDPF without the need for magnetic tapes.

The results of the study concluded the following:

1. Direct interfaces between the OCC and NDPF computers are possible, and would probably make use of a shared memory configuration. The cost and complexity of such a system would suffer a marked increase, however, in terms of both hardware and software, and would be accompanied by a decrease in reliability as compared to the basic configuration. It also became apparent that such an interface would not appreciably increase the capability of the overall system.

2. The proposed OCC/NDPF computer configuration does not include a direct interface but would allow mission planners in the OCC to access the NDPF computer data base for coverage history information at virtually no increase in cost or complexity. This is accomplished simply by providing the capability for switching one of the operations consoles in the OCC over to the NDPF computer. The NDPF computer is designed to accommodate remote terminal inquiry and it would accept and process the keyboard inputs from the console in this same manner. The results of queries could be delivered to the console CRT or the printer. If the data were to be used subsequently by the OCC computer, the NDPF computer would write it to tape. The capability will exist in the GDHS computer room to switch and magnetic tapes and other selected peripherals including, perhaps, console CRT's, between the OCC and NDPF when necessary to maximize resource utilization and reconfigure when contingencies arise.

As a result, it was concluded that direct interfacing between the computers would increase system complexity and cost, without providing significant increase in capability. On the other hand, it also appeared that the reconfiguration of an OCC console to the NDPF computer will provide the degree of NDPF data base access required at virtually no cost in additional hardware and software, since this switching capability can be readily implemented as part of the peripheral switching network already required in the computer system configuration.

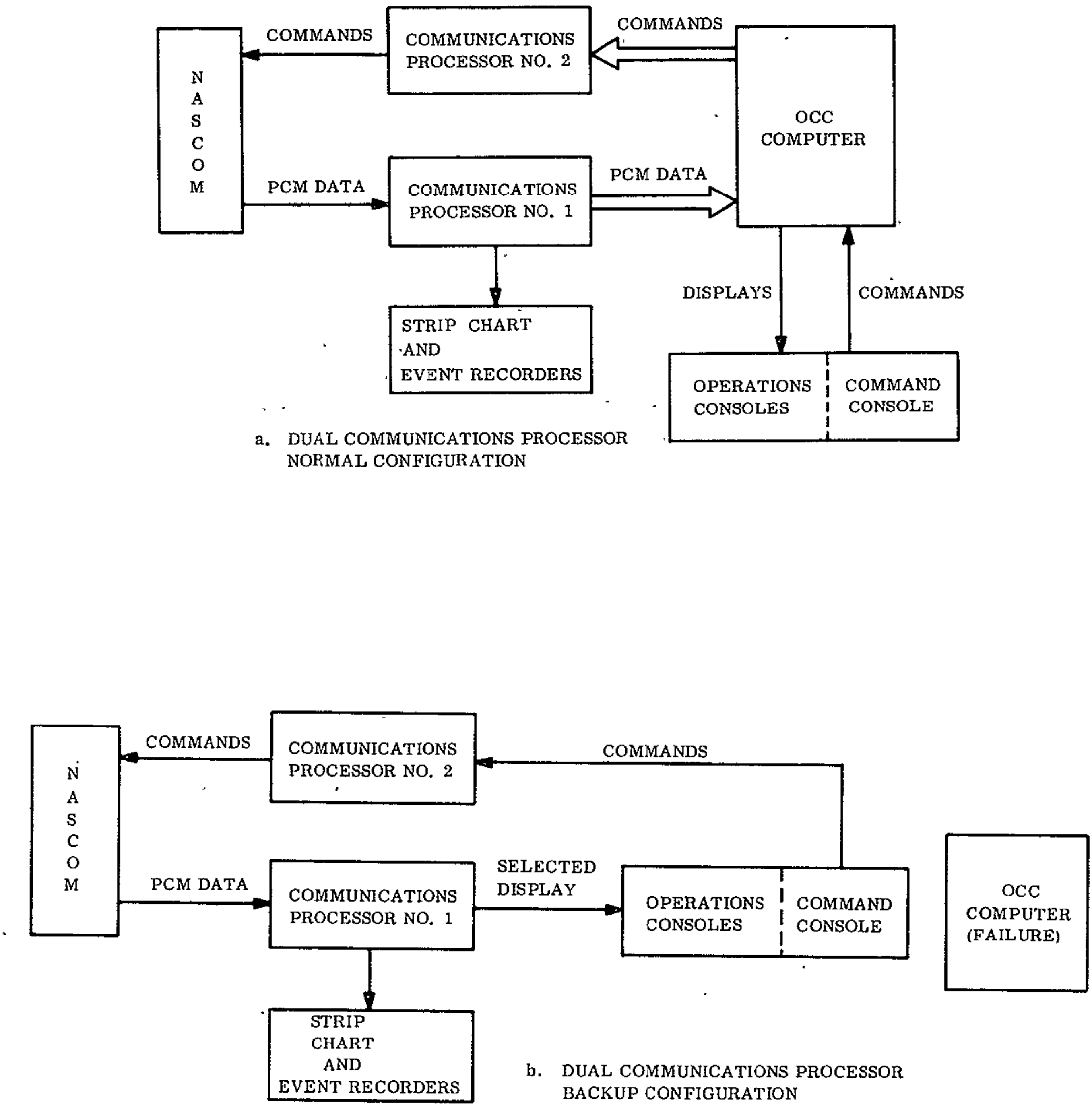

Figure 6.7-3. OCC Dual Communications Processor Configurations

6.8 OCC SOFTWARE

OCC software required for PCM Data Processing is discussed in Section 6.1, for Command Generation in Section 6.3, and for Status Control and Display in Section 6.5.

This section discusses the other OCC software study activities in the areas of:

1. Applications executive
2. Data base generation and maintenance
3. Test, diagnostics, and simulations.

6.8.1 APPLICATIONS EXECUTIVE SOFTWARE

Applications executive software is defined as specialized applications packages designed to establish effective and efficient interfaces between the computer operating system and the scientific subsystem software. Detailed design of this software must, of course, await the complete definition of the selected computer system operating software, but three areas of applications executive software have been identified:

1. Operating system interface software
2. System interface control software
3. System request executive software.

The first two of these areas are generally concerned with the routine interfaces between the vendor system and the applications software. This involves such processes as device handler interfaces, disc control interfaces, and operating connectors for chain and execute or overlays. It will also include the necessary interfaces for CRT display control and certain of the keyboard interfacing functions, as well as the applications controls required between the main computer and the communications processor.

The third area of applications executive software is concerned primarily with control over the co-resident real-time applications software. The applications executive software required has been defined as the System Request Executive (SRE). The SRE will interface with and control the operation of:

1. PCM Acquisition Supervisor (PAS)
2. Off-Line Supervisor (OLS)
3. Report Generation Supervisor (RGS)
4. Command System Supervisor (CSS).

All of the above are described in the preceding sections. The SRE will define the interrupt priorities for system operation and will schedule the execution of the software packages to satisfy requests for services by the PCM processing, command, and display subsystems.

The SRE will accept two basic types of requests for service. These request types are:

1. Data initiated requests
2. Operations console initiated requests.

Data initiated requests are generated by interrupts associated with equipment external to the CPU. The first of these is the interrupt associated with a complete frame of PCM data and signals its availability for processing. The second data initiated request is generated by an interrupt associated with command acceptance messages returning to the CPU from the NASCOM 494.

Operations console initiated requests will be in the form of alphanumeric parameter strings and/or function key actuations. Each of these parameter strings will be decoded, validated and assigned a processing priority by the SRE. Table 6.8-1 is a list of the system requests, their priority, and the originating device. These requests will then be compiled into calls to the appropriate Supervisory Packages to perform the requested function. Requests having a higher priority than the function currently being performed will cause that function to be suspended and placed in an interrupt queue. If the request is of a lower priority than that currently being performed, it will be placed in the request queue for later processing. As each request is satisfied, the interrupt and request queues will be interrogated to determine the next processing task of the CPU.

6.8.2 DATA BASE GENERATION AND MAINTENANCE

The OCC data base is that collection of mission/system information used and generated by the OCC applications software system. The data base contains two different classes of information. The first is tabular in nature and consists of spacecraft engineering data, mission system data, and other related data, which is required by the applications software packages. This data is characterized by the fact that it is essentially a priori information which remains constant or is modified infrequently after mission operations begin. The most frequent routine update cycle presently anticipated for data in this category is once per week for the input of new ephemeris information for the System Scheduling Subsystem.

The second class of information in the data base consists primarily information generated by one applications program for use by another, and/or by itself at a later time. The System Scheduling software, for example, generates an activity plan describing the events required during a particular future orbit, and places that plan in the data base for retrieval later by the Command Generation software, just prior to that orbit activation. Spacecraft evaluation software generates performance reports after each orbit and outputs these reports to the data base for subsequent retrieval for trend analysis purposes.

Table 6.8-1. System Request Priorities

Priority	Request	Source
1	Command Sequence Transmission	Command Operations Console
2	Real Time Command Transmission	Command Operations Console
3	Command Acceptance Message Processing	NASCOM 494 Computer
4	Command Sequence Selection	Command Operations Console
5	PCM Data Processing	Decommutation Device
6	Decommutation Parameter Updates	Decom System Operator (M&O)
	a. Data Source Device Change (MSFN/Bit Sync)	
	b. Data Type - Real Time/Paragraph block	
	c. Brush Display Format Change - Set 1 - N	
	d. Data Synchronization Parameter Changes	
	e. End of Acquisition Indicator	
7	Display Requests	Operations or Command Consoles
	a. Display New Report	
	b. Page Change Request	
	c. Inhibit Report Update	
	d. Generate Hard Copy	
8	Command Sequence Maintenance	Command Operations Console
	a. Create New Sequence	
	b. Delete Command from Sequence	
	c. Add Command to Sequence	

6.8.2.1 Data Base Software Requirements

The data base will reside in the mass storage device which must permit random, relatively fast access to the mass of data involved. The data base is expected to require in excess of 25 million characters of storage.

Data base generation software is required to store, retrieve, catalog and control information generated by and for applications software of the OCC. Software design must facilitate the organization, storage, maintenance and retrieval of information using mass memory storage media, and may require a centralized file system of hierarchical, tree structured design to minimize the time required of certain real-time operations. The data base must be accessible by programs operating in real-time, batch, and/or time-sharing modes of processing. Certain catalogs and files must be secured by passwords for data base integrity. File access should be under control of the operating system. Several programs may require the capability to read a file concurrently while also dumping the file to another medium such as magnetic tape for backup purposes. The operating system shall provide the control to implement this dual access.

The data base generation software will consist primarily of vendor supplied routines for storing and retrieving data from the mass storage device. In addition, however, applications programs are required for control, maintenance, and updating of the engineering data required within the OCC. This data is contained in what is referred to as the OCC Master Information File (MIF).

6.8.2.2 Master Information File

The MIF is that collection of information needed to process the ERTS telemetry data and includes:

1. Telemetry sample descriptors, i.e., time slot, sample rate, limits, ranges, etc.
2. Status logic
3. Command verification logic
4. Report formats
5. Decom tables
6. Strip chart routing tables
7. Matrix verification data
8. Memory verification data

Each telemetry sensor is defined by a telemetry function number. This is a unique four digit identifier in which the first two digits define the spacecraft subsystem and the last two the telemetry point within the subsystem. All engineering data is related to the telemetry function number. Other telemetry data within the MIF, such as spacecraft status and command verification logic, are also described in terms of telemetry function numbers.

The MIF is the source of all telemetry processing information within the OCC and is used to create the tables of engineering data required by the various applications programs. The generation of the MIF, and the subsequent creation of the required tabular data is a carefully controlled and monitored function throughout the program. MIF generation begins early in the spacecraft integration and test phase and the MIF subsequently becomes the primary mechanism for data configuration management and control. Changes and updates to MIF contents are made only through disciplined procedural channels, although the actual update of the file is simple and rapidly accomplished by card inputs. Each time a MIF change is made, the affected tables used by the applications programs are regenerated by the computer. Hence, changes made in the Master Information File are automatically reflected throughout the processing software. This is important for two reasons. First, the various applications software packages are always working with the same tabular information; this avoids the possibility that two programs which each require the limit values of a given function could be using two different limit values. Secondly, it is essential that the engineering data be as complete and up-to-date as possible; this involves a certain procedural definition as well as discipline. The automated MIF update and table generation capability provide a simple and effective means of maintenance and control over this data which minimizes and simplifies the human interfaces.

MIF generation and table construction are accomplished by two software packages:

1. Master Information File Generator (MIFG)

2. Master Information Table Generator (MITG)

A third program, Master Information File Lister (MIFL) is used to generate a hard copy catalog of the MIF contents.

The MIFG is a free standing program which accepts card inputs for file inputs, changes, or additions. The program outputs the MIF on magnetic tape. Both the records and files on tape are open-ended, and the number of tape files is variable. The functional flow of MIFG is shown in Figure 6.8-1.

The MITG is also a free standing program which extracts data from the MIF tape and generates tables required by the various applications programs. The MITG is run whenever changes are made to the MIF Tape. The tables generated are maintained in mass storage and are also written to magnetic tape for recovery purposes. The table structure is flexible and programmers may define a variety of table formats and organizations. The functional flow of MITG is shown in Figure 6.8-2.

6.8.3 TEST, DIAGNOSTIC, AND SIMULATION SOFTWARE

Various forms of checkout software are required throughout the implementation, integration, and operation of the OCC. These must satisfy the requirements for computer system test and diagnosis, application software checkout, and network compatibility and configuration testing.

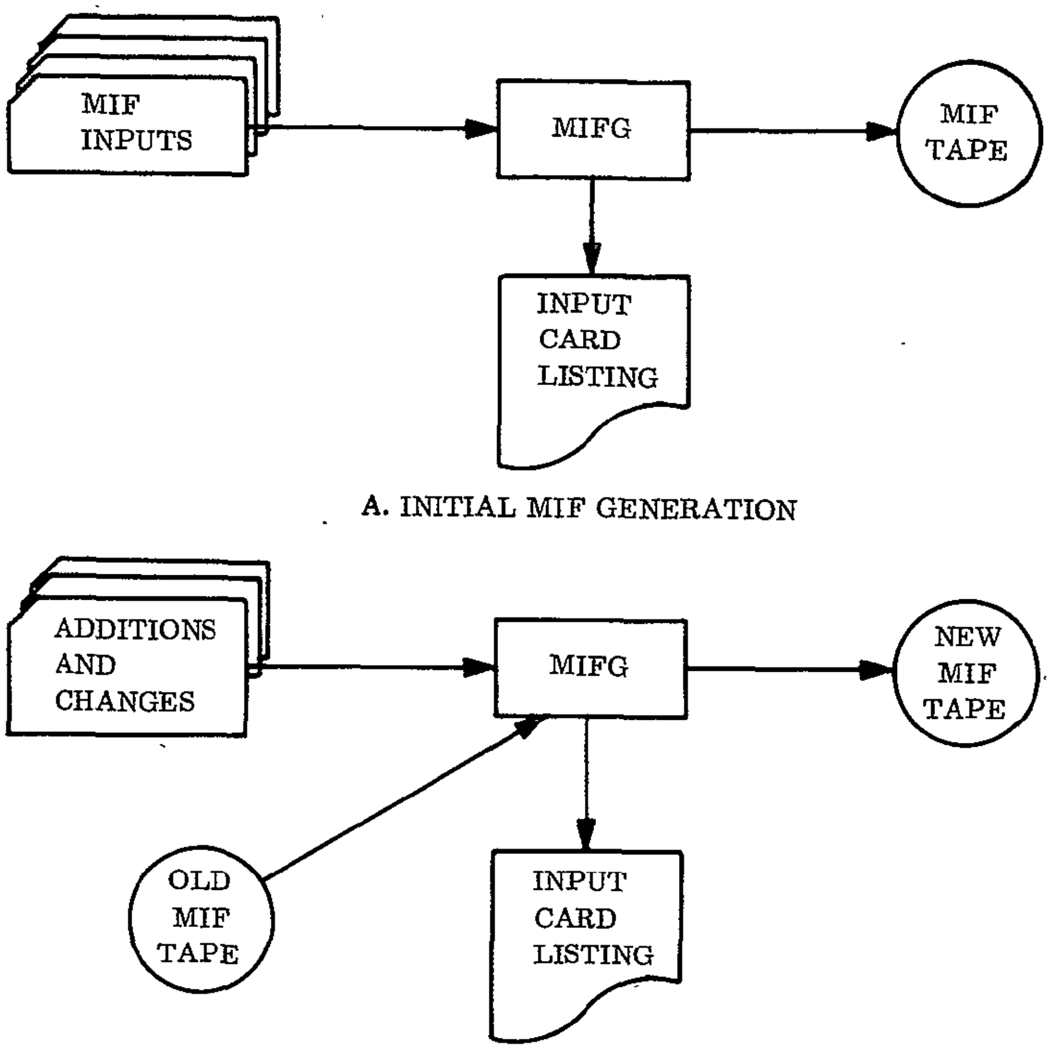

Figure 6.8-1. MIFG Functional Flow

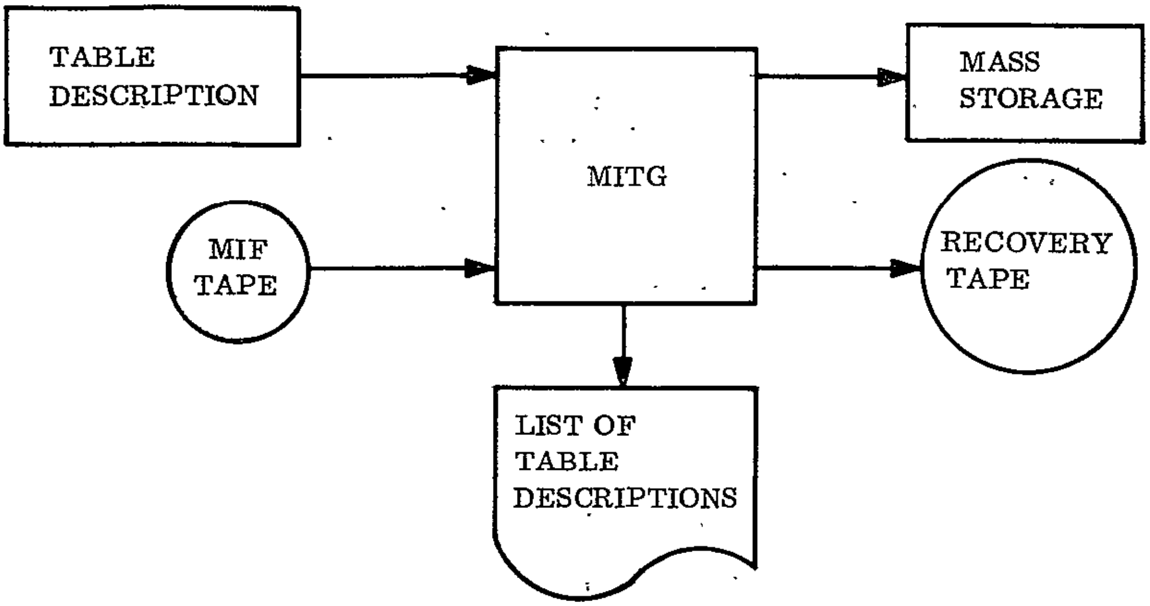

Figure 6.8-2. MITG Functional Flow

6.8.3.1 Computer System and Peripheral Test and Diagnostics

The purpose of test and diagnostic software used in the OCC Computer System is the rapid isolation and identification of anomalous conditions arising in the CPU or its peripheral equipment. Standard vendor supplied software will be used for this purpose. Separate diagnostic routines will be supplied for each peripheral unit in the system, as well as the CPU, and run as part of the daily preventive maintenance procedures.

Test and diagnostic software to exercise special peripheral equipment, not supplied by computer system vendors, will be developed. This software will provide for the calibration and testing of analog display equipment operated by the OCC Computer System.

The OCC GMT time standard interface will also require special test and diagnostic software.

6.8.3.2 OCC Applications Software Checkout

In order to facilitate the checkout of the OCC on-line and off-line applications software, a controlled source of simulated PCM data is required. The capability of creating this data will be provided by the PCM Simulation Tape Formatter (PSTF) in the Communications and Data Distribution Subsystem. This hardware will allow the OCC CPU to create an analog tape under software control. The PSTF will have the capability of recording this data at 1 kb or 24 kb continuous rates to simulate spacecraft real-time or playback data, respectively.

Additionally, the PSTF will record PCM data at the 50 kb burst rate to simulate the OCC/NASCOM 494 type real-time data.

The software required to operate the PSTF will be run in an off-line mode. It will initially contain all the spacecraft indexes defining a typical minimum satellite orbit which will then be modified, parametrically, to produce the required PCM characteristics to simulate various orbital configurations. The parameters modifying the simulated orbit will be defined in terms of a chronological sequence of predefined spacecraft events.

The simulated orbital tapes can then be injected into the OCC at a variety of points. The normal real-time and off-line software can be operated with this data and expected to produce predefined results. This will allow for the checkout and debug of the applications software, as well as providing a basis for developing confidence in modified or new OCC system capabilities.

Recorded PCM data generated live by the spacecraft during thermal vacuum testing will also be used to provide OCC system checkout. This data is desirable because it makes payload data available, as well as PCM.

6.8.3.3 Network Compatibility Testing

Network compatibility will be accomplished by injecting simulated PCM tapes into the decommutation process at the remote sites. This data will then be processed at the remote site in the standard fashion and transmitted to the OCC for further processing.

Operationally, in the preacquisition time frame, analog tapes containing recurring ramp count or predetermined fixed value PCM functions could be played at the remote site and transmitted to the OCC. A subset of the standard OCC on-line software will process this data, and generate a report of transmission quality in terms of the data expected. This would establish confidence in the system beginning at the remote site and continuing through the OCC in the final minutes before spacecraft acquisition.

SECTION 7

OCC INSTALLATION, INTEGRATION AND TEST

The primary OCC installation objective is to provide a facility available for network compatibility checking six months prior to launch.

Accordingly, the first OCC activation task will be to interconnect the computer subsystem and interfacing cables and to demonstrate a working computer subsystem. The intent of this priority is to expedite debug of the computer hardware and software prior to making further system connections. Other OCC cabling and subsystem connections and tests would then follow. The logical sequence of system connections and tests has been planned as shown in Figure 7-1 to develop incremental confidence leading to all systems test. The following specific steps are recommended as part of the sequence shown in Figure 7-1:

1. Connect the OCC Computer Subsystem equipments. Connect the alphanumeric terminals (unmounted in the consoles) to the Computer and Communications and Data Distribution Subsystems.

2. Debug computer hardware (power up, interconnect, operation).

3. Debug and evaluate computer software.

4. Debug and test the communications equipment.

5. Connect and repeat factory acceptance tests on all other subsystems (power up, interconnects, equipment operation).

6. Connect the Computer Subsystem to the Communications Data Distribution Signal Conditioning and Switching Unit and mount the alphanumeric terminal and associated cables in all of the consoles.

7. By use of test signals and test software, validate the operation of the Computer Subsystem with the units in the Communications and Data Distribution Subsystem and the Control and Display Subsystems.

8. Connect the Data Collection Subsystem (DCS) to the Communication and Data Distribution Subsystem - Signal Conditioning and Switching Unit. Using test signals from the preprocessor, validate the signal interface between the DCS, the Signal Conditioning and Switching Unit, the Magnetic Tape recorders, and the Computer Subsystem.

9. Connect the NASCOM equipment to the Communication and Data Distribution Subsystem. Using test programs and test signals, test all of the interfaces for NASCOM/MSFN/STADAN.

10. Conduct an overall OCC operations test (this includes the spacecraft operational data simulations).

11. Test the OCC/NDPF computer interface and backup features.

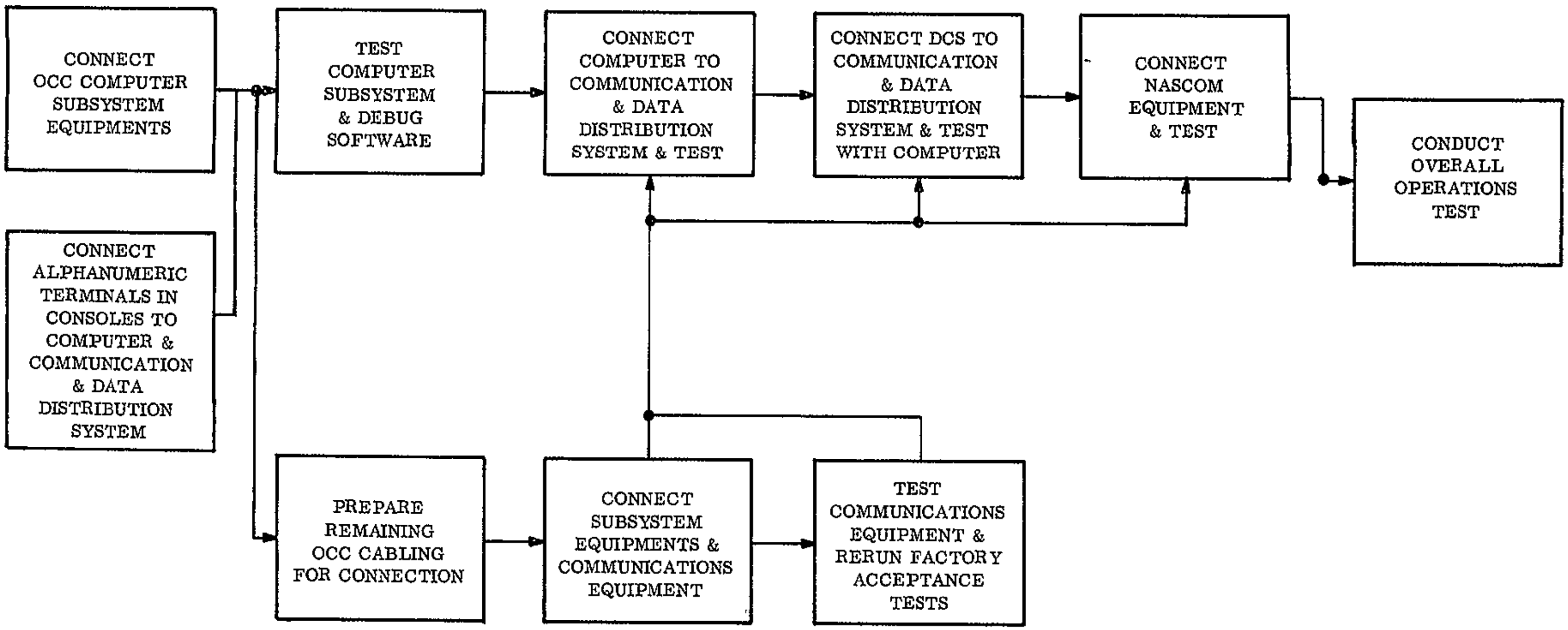

Figure 7-1. OCC Installation, Integration and Test Sequence

Scheduling of OCC Computer Subsystems integration and test will be done in consideration of NDPF Computer Subsystems activities to arrange a most efficient crew sequence for these similar subsystems.

Except as precluded by facility JOD and BOD constraints, all equipment and cable implacement should be completed prior to integration and test, to avoid installation/integration interferences. The OCC area can then be closed off from the other GDHS areas in which the installation contractor might still be working.

7.1 OCC INSTALLATION

The OCC installation work will consist of conventional under-floor cable laying and equipment emplacements on the false floor. In general, cables will be left tagged and unconnected by the installer. As mentioned earlier, the OCC area should be completely installed and vacated by the installation contractor as quickly as possible. Facility modification work in the OCC area should similarly be completed on a priority basis. A number of applicable facility interface considerations are given in Section 12.1. A preliminary equipment installation sequence is shown in the OCC Activation Schedule, Figure 7.1-1.

7.2 ACCEPTANCE TEST

7.2.1 COMPONENT TEST CRITERIA

Components comprising the various subsystems of the OCC will undergo performance evaluation by their manufacturer prior to integration into the next higher functional subsystem. This performance evaluation will consist of a final visual inspection of the article to determine compliance to the quality standards regulating its fabrication and a functional performance test to determine compliance to the operational requirements of the design specification. This performance evaluation will be performed at and by the responsible manufacturer and,in selected cases, will be witnessed by a Quality Assurance representative of the subcontractor processing the component.

Formal Acceptance Test, per se, will not be performed at the component level, but will be deferred to factory acceptance testing of subsystems in order to reduce redundant effort.

Each component performance test will be conducted in accordance with a previously prepared test procedure and inspection planning as proposed by the manufacturer.

Software provided as part of the OCC system will undergo performance testing by the developing agency on hardware similar or identical to the hardware it is being prepared for. Final acceptance of software modules and programs will be deferred to final subsystems or systems acceptance test to be performed at GSFC.

Government Furnished Equipment (GFE) supplied to OCC contractors for use during performance or acceptance testing will be considered as having successfully completed final acceptance test prior to receipt.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

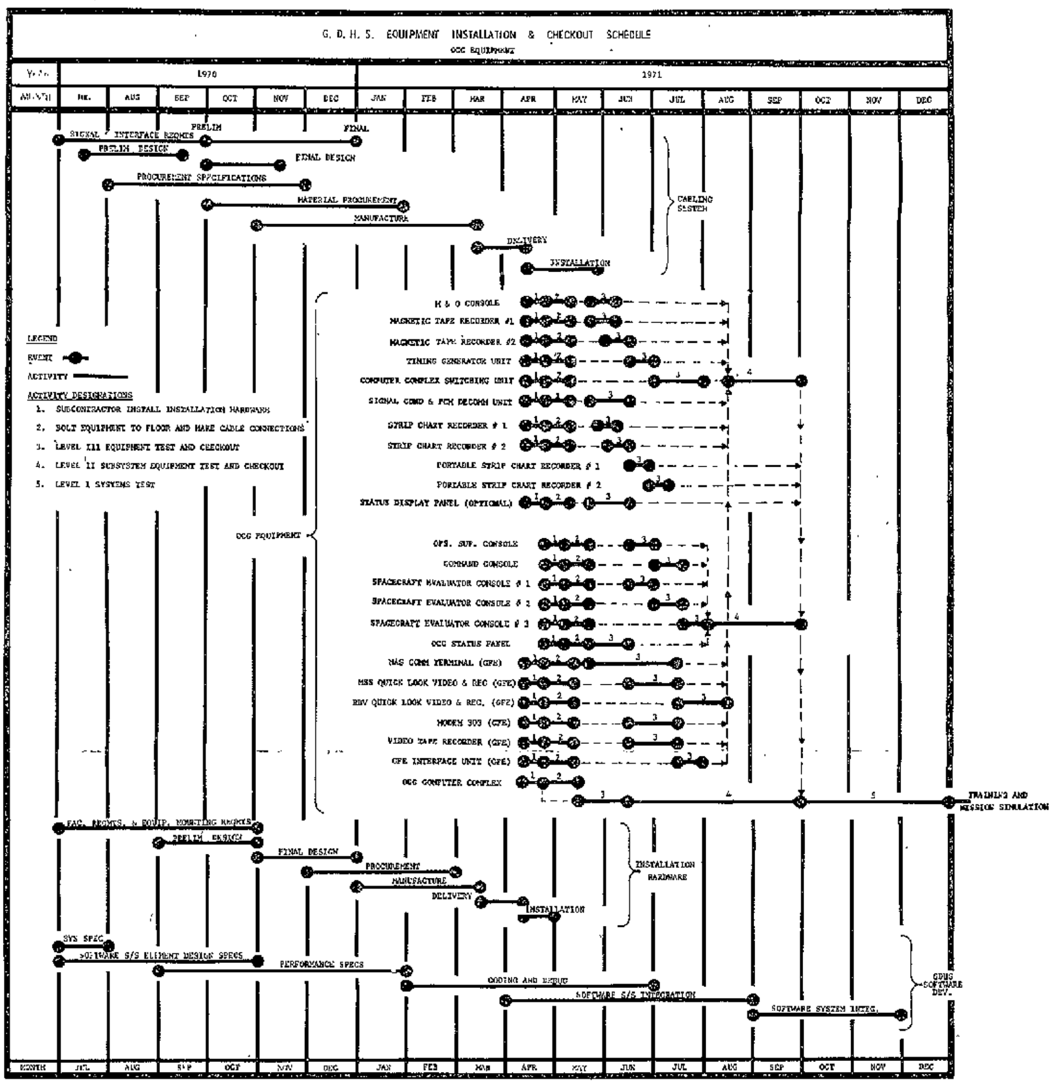

Figure 7.1-1. OCC Activation Schedule

Component Test Plan
Figure 7.2-1 shows in block diagram form the components comprising the OCC system and the planned flow from fabrication to integration into the next higher subsystem.

To reduce redundant testing and associated costs, those components which do not require in-plant integration will be shipped directly from the manufacturer's plant to GSFC for installation and integration. Other components, where required, will be shipped from the manufacturer's plant to the subsystems manufacturing facility for integration and test of the total subsystem.

7.2.2 SUBSYSTEM TEST CRITERIA

Functional subsystem tests will be conducted to obtain a confidence level in the equipment design and fabrication prior to higher level testing at GSFC. Tests will be performed with static test signals and will be conducted to verify that the OCC subsystems will meet the performance characteristics and requirements of all discrete functions, utilizing special test equipment and software where needed to simulate and/or record input/output data. All logic circuitry will be checked for proper performance relative to requirements with static input signals.

Upon satisfactory completion of these tests, a final factory subsystem acceptance test will be performed. These tests will consist of switching and interface tests as defined by test plans for subsystems working together. The test data will be recorded and will provide the documented evidence of the successful completion of the test and will be shipped with the equipment. This test will utilize the same approach for verification of the discrete and analog functions as noted in the preceding paragraph.

Subsystem Test Plan
Factory Acceptance test of the OCC equipment will follow the plan and sequence shown in Figure 7.2-2 and as defined in the previous paragraphs. The test program will be controlled through test plans and procedures developed to assure compliance to the requirements of the subsystem specifications. Functional testing or demonstration of performance characteristics will be reserved primarily for the higher level testing at GSFC to minimize the cost of redundant simulation. Before any equipment is shipped from the contractor, all operable components will be exercised and all interfaces monitored and evaluated for acceptability in accordance with the test plan requirements.

7.2.3 OCC SYSTEM ACCEPTANCE

7.2.3.1 Criteria

Final acceptance and buyoff of the OCC system will be based on the successful demonstration that all performance criteria specified in the OCC System Requirements Specification are fulfilled. The final acceptance test will be conducted at GSFC by contractor personnel and will be performed only upon successful completion of component and subsystem integration and test.

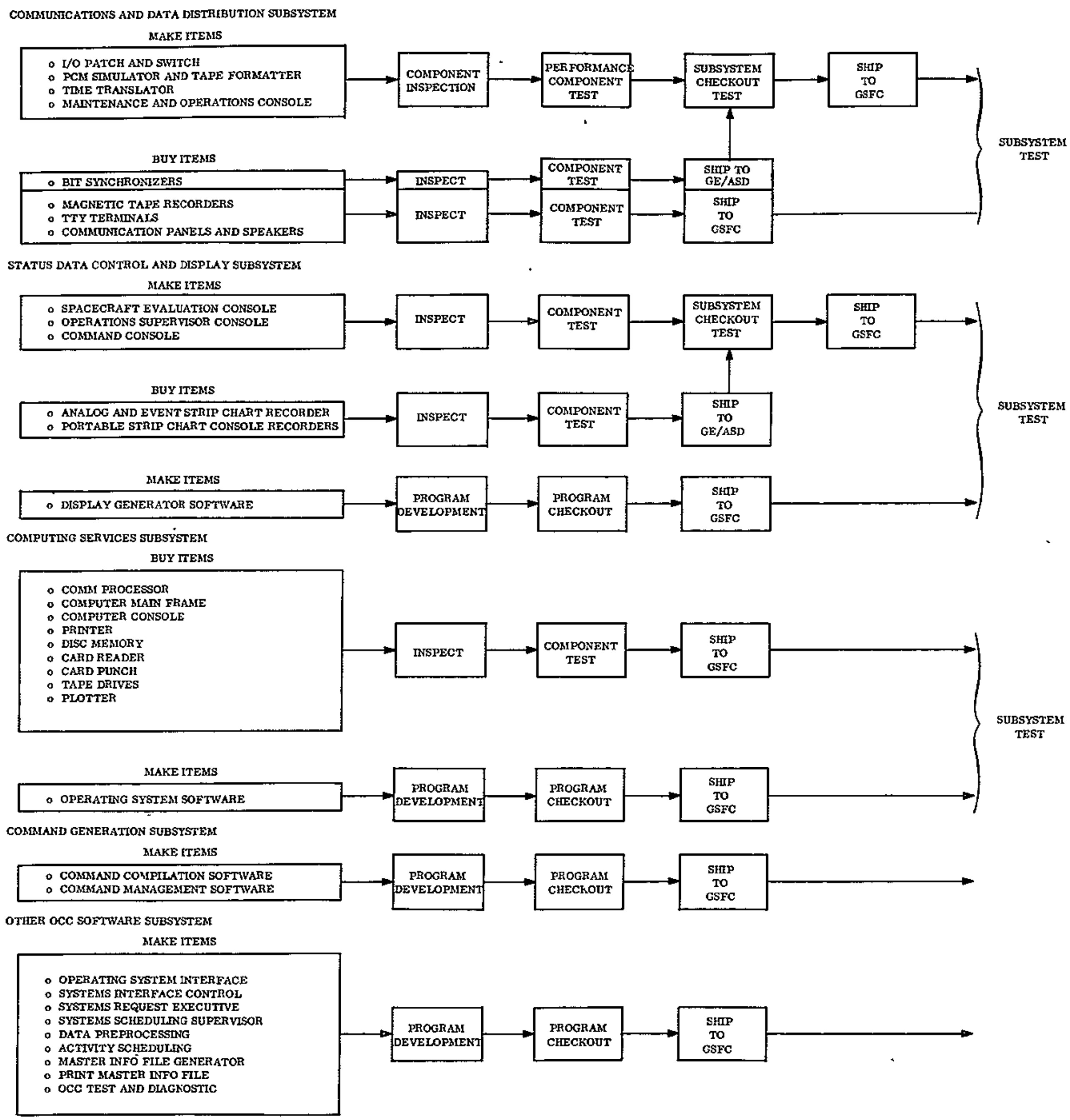

Figure 7.2-1. Component Test Plan

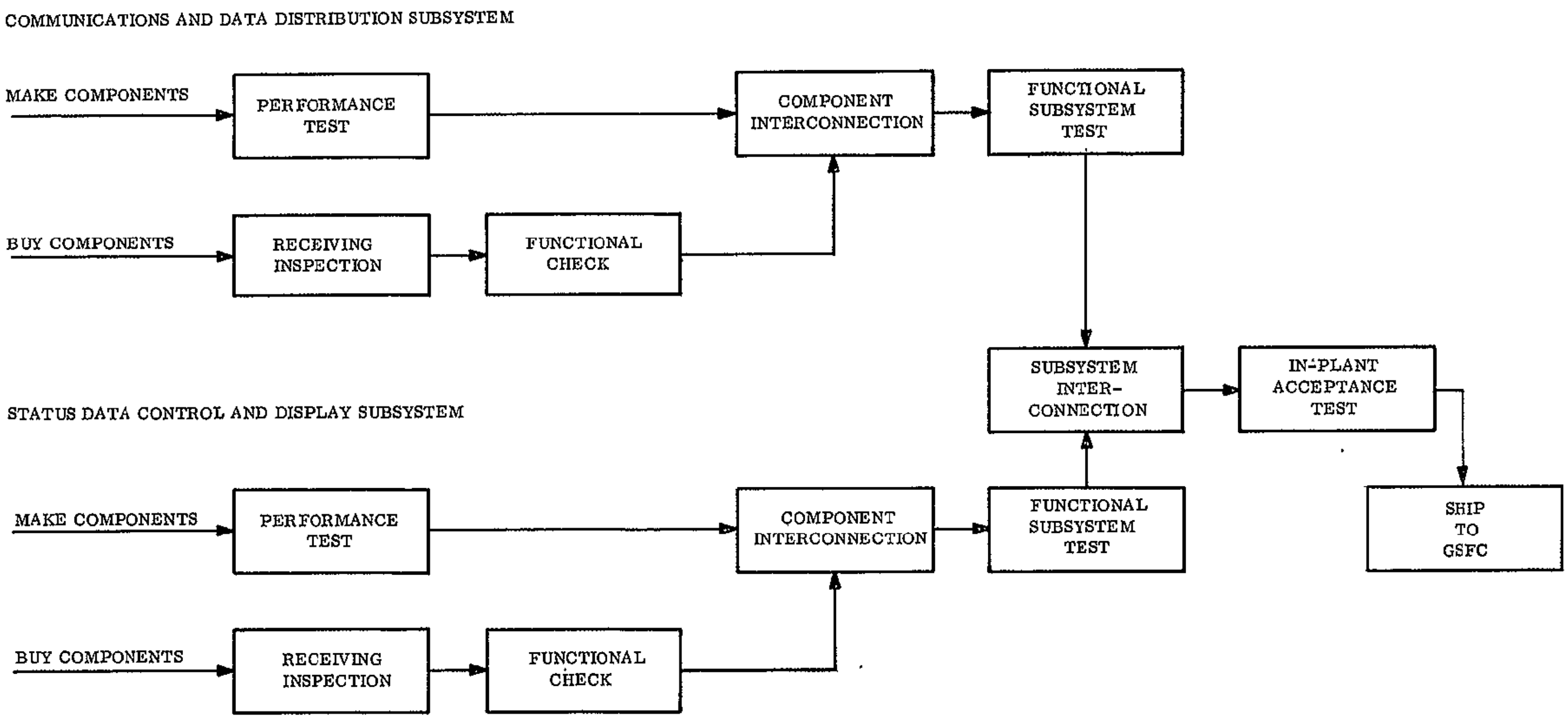

Figure 7.2-2. Factory Subsystem Test Plan

Test Procedures governing the system configuration, stimulus (live or stimulated), output data and supporting test equipment will have been generated and approved by the contractor and GSFC prior to test conduct and will be used, in addition to the test team, by the contractor and NASA/GSFC Quality Assurance personnel to verify adequacy and accuracy of the test and resultant data.

Upon successful completion of the OCC acceptance test, all data will be submitted to NASA/GSFC for approval and system buyoff.

7.2.3.2 Test Plan

Prior to any equipment interconnection and/or operation at GSFC, all interfaces will be verified mechanically and electrically. The following requirements of the OCC shall be verified by demonstrations and will utilize an acceptable spacecraft simulator system as stimulus:

1. Generation, display and verification of all spacecraft commands.

2. Receipt of simulated spacecraft data. Processing, display, distribution and storage of known simulated spacecraft data.

3. Analysis and evaluation of data for determinating spacecraft status and performance.

4. Generation of schedules.

5. Provision of back-up capability with computer shutdown.

6. Satisfactory demonstration of total system readiness.

Figure 7.2-3 shows in block diagram form all subsystems comprising the OCC system and the present plan for system acceptance flow.

7.3 OCC SIMULATION

The comprehensive simulation capability within the OCC supports OCC integration and testing in three major areas:

1. Software Test

2. Software/hardware Integration

3. OCC/network Integration.

This capability is centered primarily in the PCM Data Simulation program (PDS), contained in the OCC software subsystem. This program is designed to generate PCM data tapes which simulate the input data at any one of several key points in the PCM processing flow after the decommutation has occurred. This program is also designed for use in conjunction with the PCM Simulation Tape Formatter (PSTF) of the communications and data distribution subsystem.

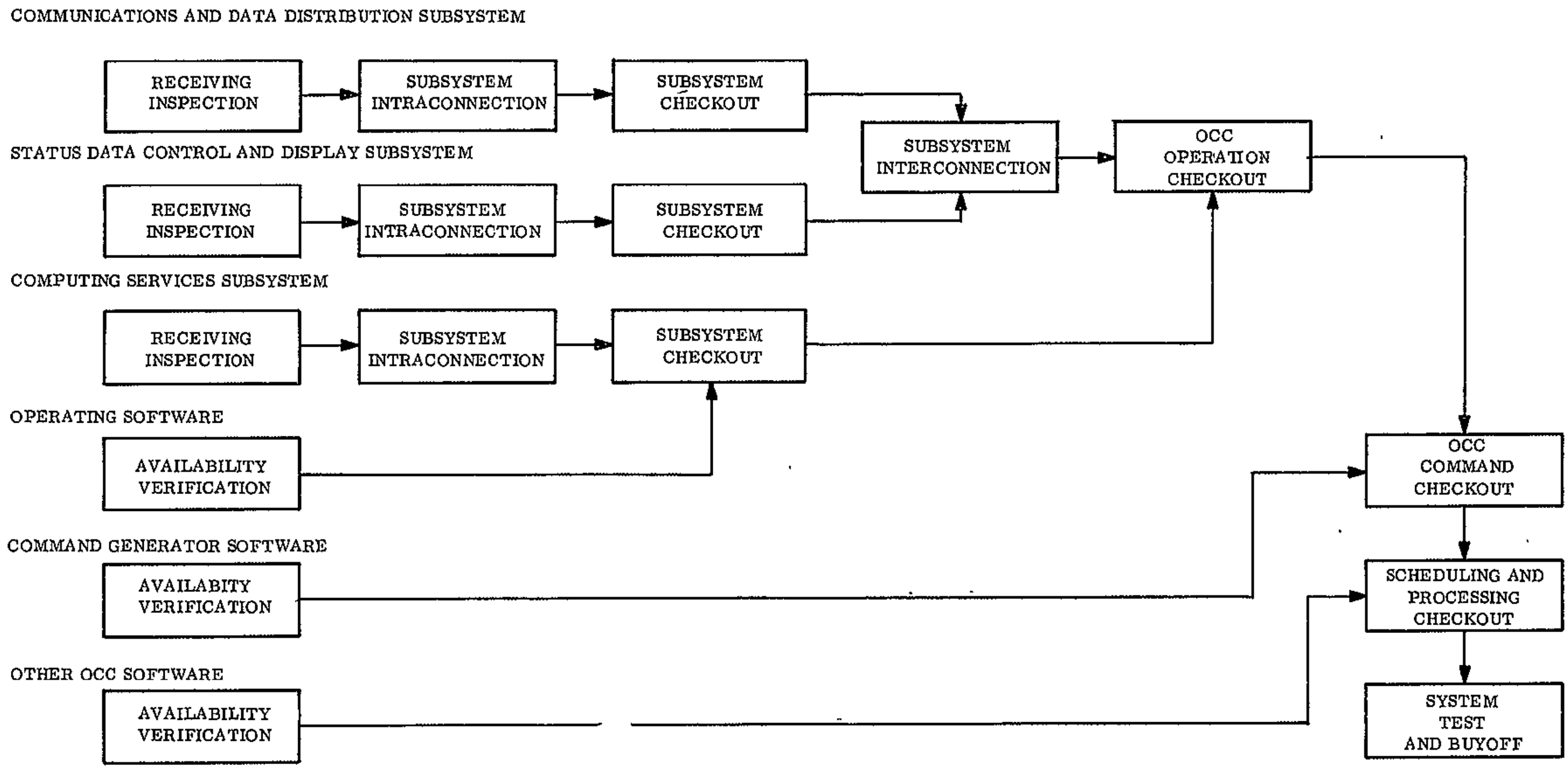

Figure 7.2-3. OCC System Acceptance Test

The PSTF accepts computer tapes of simulated PCM data from the PDS and generates analog magnetic tapes of PCM data at either the 1 kbps, 24 kbps, or 50 kbps rates. These tapes may be used within the OCC for software and hardware checkout, and will also serve as data sources at the remote sites for more comprehensive network/OCC testing.

Other critical elements of the OCC also contain internal provisions for simulation and testing. The command generation and status data control and display subsystems together provide a test and simulation capability for the generation of command messages which can be used within the OCC as well as for network testing. This simulation mode can also be integrated with the PCM processing software to permit full testing of these critical command and control functions.

Two other forms of simulation are used within the OCC. The first involves the use of data generated by the spacecraft during thermal vacuum testing. These tests are designed to simulate operational flight configurations and sequences and the resulting data tapes, containing both payload and PCM data, provide a realistic source of "simulation" data for both OCC and OCC/network interface and compatibility testing.

The second source of data is, again, the spacecraft itself, in thermal vacuum test, although in this case the data will be transmitted to the OCC live over hardwire from the thermal vacuum chamber. The OCC will process the incoming PCM data in real-time, and will generate "simulated" commands in its test mode. This permits operation in a realistic configuration and enables comparison of processing results with those obtained by the integration and test data system.

SECTION 8

OCC OPERATIONS SUPPORT

The objective of the ERTS OCC Operations Support study task has been to derive an efficient low cost operations support concept. During the study a careful analysis has been made of GSFC projects currently in an operational status. Operating philosophies, procedures, interfaces, facilities, personnel and organizations have all been analyzed. The operations concept thus derived utilizes or adapts operationally proven methods and procedures wherever practicable. Yet full allowance is made for the ERTS unique operational factors.

The study of OCC operations support requirements has concentrated on the areas listed below:

1. The functions the OCC must perform

2. The interfaces required to support these functions

3. The performance requirements and time constraints placed on the execution of these functions by the mission operations profile (orbit and sensor operation versus station contact availability)

4. The flow of operations in the OCC needed to meet these requirements

5. The organization and staffing required to execute these operations

8.1 OCC FUNCTIONS AND INTERFACES

The OCC plans, controls, and evaluates the ERTS spacecraft flight operations. The study effort to date has identified the subtasks implicit in these functions and has allocated them to the major time phases of pre-launch, launch and post-launch. These are summarized below. In the remainder of this section the procedures for implementing these functions are defined.

8.1.1 PRE-LAUNCH ACTIVITIES

During this phase, the OCC will perform the following tasks in preparation for the launch and post-launch phases:

1. Develop and update the baseline operating procedures.

2. Prepare the Spacecraft Activation Plan and establish the commanding philosophy for the upcoming flight.

3. Prepare the flight evaluation criteria.

4. Prepare the computer program and computer facility schedule requirements.

5. Participate in the spacecraft test and integration effort.

6. Participate in the system engineering tests and communication readiness exercises.

7. Direct the operational simulation exercises.

8.1.2 LAUNCH ACTIVITIES

During the launch phase, the OCC will monitor launch operations and will ensure that responsible personnel are informed of spacecraft progress.

The following information is required by the OCC before the first interrogation at Alaska to determine the proper spacecraft command sequence and subsequent flight operation.

1. Exact spacecraft launch configuration.

2. Report of selected telemetry values.

3. Time of last PCM tape recorder playback before launch.

4. Status of WBVTR's.

5. Time of final spacecraft-to-internal-power switching.

6. Time of liftoff.

7. Information on Delta launch vehicle second-burn performance.

8. Spacecraft time from beacon telemetry at separation, clock stability after paddle unfold is completed, and control and power subsystems monitoring as reported from JOBURG.

9. PCM data transmitted to GSFC from MADGAR.

10. Beacon power level, antenna X-Y coordinates, minitrack crossing time and angle, and PCM data transmitted to GSFC on pass from WNKFLD.

8.1.3 POST-LAUNCH

During the post-launch phase, OCC will:

1. Coordinate the interrogation schedule - with NETCON/MSFNOC based upon which MSFN/STADAN station can acquire and interrogate the spacecraft for each orbit.

2. Calculate the expected spacecraft power balance for each orbit if the automatic on-board power management control system cannot be utilized.

3. Originate spacecraft command sequences and determine necessary changes on an orbit-to-orbit basis.

4. Originate payload command sequence and determine necessary changes on an orbit-to-orbit basis.

5. Select and transmit courses of action to be taken by the OCC in emergency situations.

6. Monitor the spacecraft subsystems to determine operating trends and predict possible malfunctions.

7. Monitor ground equipment status and maintenance downtime to ensure that the MSFN/STADAN stations are prepared to acquire data from the spacecraft at the designated times.

8. Evaluate spacecraft and ERTS ground system performance.

9. Coordinate MSS/RBV coverage with NASA/NDPF.

10. Prepare and initiate outgoing teletype messages and receive a confirmation copy from NETCON/MSFNOC.

11. Distribute computer printouts to users.

12. Direct the DCS data to NDPF for distribution to the users.

13. Operate all displays in OCC.

14. Prepare routine and emergency reports.

15. Log all incoming and outgoing messages, reports, and requests.

8.1.4 OCC INTERFACES

Detailed descriptions of the GDHS interfaces for command, telemetry, and payload DCS and voice are discussed in detail in Section 4.5. This section describes how the OCC interfaces are used operationally by the personnel in the OCC. Emphasis is placed on the immediate OCC interfaces at GSFC. Figure 8.1-1 presents a simple block diagram indicating the key interfaces.

8.1.4.1 NASCOM Interface

Figure 4.5-1 illustrated the major data transfer functions for the MSFN/STADAN sites. Hard data transfer is shown by the dashed line going from the network sites to the GSFC. All data containing NASCOM headers will be routed through the GSFC Univac 494 Communications Processor (CP). This includes all uplink data generated by the OCC, MSFN real time and slowed dump PCM data, all STADAN RT PCM, backup STADAN slowed PCM data and DCS data from Corpus Christi. DCS data will be preprocessed at Alaska and Corpus Christi and transmitted to the OCC post pass. Also teletype data will be switched by the GSFC 494 CP. Alaska dump data and all data from the NTTF will bypass the 494 CP. Wideband payload data (MSS and RBV) will arrive at the OCC as hard data from both Corpus Christi, Texas, and Alaska. Hardlines will be used to transfer data from the NTTF. Voice circuits will be terminated using the SCAMA conferencing equipment, and other voice handling equipment. MSFN tracking and STADAN minitrack data will be sent to GSFC via TTY circuits.

8.1.4.2 ESSA Interface

Operational weather forecasts relating to environmental conditions affecting the ability of the payload sensors to image the earth will be provided by ESSA. This interface consists of the OCC providing ESSA the information necessary to define the geographical region for which the forecast is required and the schedule against which the forecast must be transmitted to the OCC.

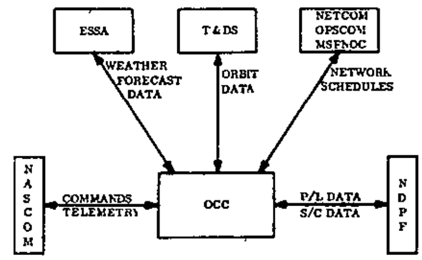

Figure 8.1-1. Block Diagram of Key OCC Interfaces

The ERTS OCC will provide ESSA with the ephemeris ground trace information including indication of regions of potential sensor operation. The stability of the orbit and the ground trace repeat each 18 days allows for ground trace to be provided in terms of an 18 day cycle, updated as required by orbit adjust maneuvers. In addition, a schedule of required times to transmit forecasts to the OCC will be provided. This will indicate the time weather forecast data must be received for specific areas of interest and by revolution numbers. Discussions with ESSA indicate that this interface is compatible with current support capability. The ground trace data will be furnished in the form of a map overlay with specific overlay positioning and update information sent as required via TTY. The schedule for forecast transmittal will be sent to ESSA on a weekly basis, updated as required, via TTY.

The forecast will be transmitted to the OCC via TTY. The format will be as described in Section 6.6.

It is also planned that the results of cloud assessment, both from the NDPF and from the offline OCC weather usage experiment will be provided to ESSA as feedback for assisting in the evaluation of the forecast methods.

8.1.4.3 T&DS Interface

The Tracking and Data System Organization provides the orbital ephemeris data required by the GDHS. The interface consists of T&DS providing the OCC with a computer readable tape in the form of World Map and Station Acquisition Data (WMSAD). This data will be provided for both predicted and refined ephemeris. The predicted ephemeris will be provided every five days and cover a time span of seven days. The refined ephemeris will be sent to the GDHS after all the tracking data has been reduced. Normally, it will be available at least three days after the actual sensor operation, but no later than five days. These data tapes and accompanying listings will be hand carried to the OCC. In addition to the normal ephemeris data, the T&DS will provide the parameters required to perform the required orbit adjust maneuvers. In order to enable T&DS to accurately calculate the parameters, the OCC will provide the necessary, current spacecraft status parameters prior to each orbit adjust planning cycle.

8.1.4.4 OCC Operational Interfaces - OPSCON, NETCON, MSFNOC

The OCC will interface with OPSCON, NETCON, MSFNOC in very much the same way existing projects are accomplishing their present needs. The prime interface with these agencies and the OCC will be via voice circuits in real-time. Handcarried or teletyped information exchange will also be required for real-time and non-real time mission phases.

Based on the operational interfaces, the OCC with these organizations are described below.

8.1.4.4.1 Operations Control Center (OPSCON)

The OPSCON, NETCON, MSFNOC interfaces as pertain to the ERTS mission were derived from three sources:

1. NASA documents dealing with other GSFC missions

2. Documents describing these organizations

3. As a result of meetings with NASA personnel

The requirements for these organizations are basically unchanged from what is presently being accomplished on other GSFC missions.

The Operations Control Center (OPSCON) is a facility located in the annex to Building 14 at GSFC. Its function is to oversee the operations being performed at the various Space Tracking and Data Acquisition Network (STADAN) stations and the interfaces with other functional units. OPSCON serves as the focal point for all operations, resolves all conflicts, and controls the STADAN operations schedule.

A. Operations. OPSCON is responsible for the performance of the following tasks:

1. Monitor imminent (within 36 hours) operations schedules.

2. Ensure that STADAN stations are supplied with spacecraft predictions, pass assignments, and other items necessary to support ERTS passes.

3. Coordinate the establishment of voice and data links required for ERTS operations.

4. Monitor all SCAMA coordination conferences between STADAN stations and the Operations Control Center (OCC).

5. Alter operation schedules to meet new requirements or changes as they occur.

6. Monitor all teletype traffic concerning operations.

7. Maintain an up-to-date status board on all STADAN equipments.

8. Participate in launch simulations.

9. Perform other duties necessary to support the ERTS mission.

B. Launch and Early-Orbit Special Activities. During the launch and early-orbit phases, control of the ground facilities used in support of the spacecraft will be exercised from the GSFC Operations Control Center (OPSCON), under the direction of the T&DS Operation Director. The following personnel will assist the T&DS Operations Director:

1. T&DS Manager (T&DSM)

2. Assistant Operations Director

3. Communications Manager (CM)

4. Orbital Computations Engineer (OCE)

5. Tracking and Telemetry Engineer (TATE)

6. Operations Controller

Additional personnel will be assigned as required by the T&DS Operations Director.

The launch and early-orbit phases will begin about three hours prior to launch with the establishment of the STADAN coordination circuit and will end when orbital parameters of sufficient quality for prediction purposes have been obtained, when the spacecraft health has been confirmed, and when the operations involving the spacecraft can be handled routinely. For OPSCON activities, the entire launch and early launch phase should last for about 12 hours.

C. Reports. The OPSCON will provide the OCC with periodic reports concerning the network tracking, telemetry, and command status. Unusual activities will also be reported in near-real-time, and a summary STADAN activity report will be prepared for the first three days following launch. The summary will include:

1. Number of tracking messages, by type

2. Minutes of data acquired

3. Unusual occurrences

OPSCON/NETCON will provide OCC with a copy of the initial command and telemetry acquisition schedules, any changes made, and updated or new schedules as they are completed.

8.1.4.4.2 Network Control Center (NETCON)
The Network Control Center (NETCON) is located in the OPSCON wing of Building 14 and is responsible for scheduling the tracking and data acquisition activities of the various STADAN stations. NETCON will perform all scheduling and control functions for STADAN operations until 36 hours before schedules operations begin, at which time control will be given to OPSCON.

A. Operations. NETCON will schedule the Spacecraft tracking and data acquisition operations at the STADAN stations in accordance with spacecraft priority listings, station capabilities, and schedules generated by the OCC. Operations are scheduled on a weekly basis with NETCON performing the following functions:

1. Receive explicit requests for STADAN station coverage for Spacecraft data acquisition.
2. Use the established ground rules to schedule requested Spacecraft passes.
3. Advise OCC of support requested in the schedule which is not possible to meet.
4. Schedule Spacecraft minitrack operations if required.
5. Send out detailed pass assignments for spacecraft passes when these are supplied by the OCC.

B. Launch and Early-Orbit Activities. NETCON will schedule Spacecraft simulations that are requested by the OCC and will distribute associated documentation. NETCON will also ensure that all stations are scheduled to perform the spacecraft tape exercises and will verify that all stations have received their copies of the spacecraft OPPLAN. Finally, NETCON will schedule the planned spacecraft early-orbit operations based on nominal launch information.

8.1.4.4.3 Manned Space Flight Network Operations Center (MSFNOC)
The Manned Space Flight Network Operations Center (MSFNOC) encompasses the following activities, functions, and facilities:

1. Operations Control (OPSCON) for the MSFN
2. Apollo Network Support Team (NST)
3. Scientific Network Support Team (SNST)
4. Scheduling
5. Network Test and Training Facility (NTTF) consoles and displays room

MSFNOC is located at GSFC in the Building 3 and Building 14 complex. Because of increasing operational requirements levied on MSFNOC, its facilities are expected to be expanded. This space will be obtained from the Buildings 3 and 14 additions, which are presently under construction. In addition, the consoles and displays room located at NTTF will be shared by the Simulations Group and the Test and Training Satellite (TETR) personnel.

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The MSFNOC is under the direction of the Network Operations Manager (NOM), who is responsible for:

1. Ensuring configuration control of the MSFN (including the Apollo launch data systems) to meet mission requirements. All reconfigurations, such as hardware and software changes, will be handled through the NOM with the concurrence of: (1) the network controller (NC) at MCC-Houston for manned flights, * and (2) the tracking and data systems (T&DS) manager at OCC-GSFC for the ERTS project.

2. Scheduling of all network activities in accordance with the procedures described in the Network Operations Directive (NOD). No scheduling of MSFN facilities will occur without the concurrence of the NOM.

   At the termination of the operationally manned condition, the NOM will release the stations to a standby manned condition on instructions from the NC or the project T&DS manager. At that time, NOM will inform the station when to return to an operationally manned condition.

3. Determining network status before finalization of the network configuration and completion of network readiness testing, and reporting this status to the NC or the project T&DS manager. The NOM is responsible for determining a station's status and readiness after it's release to standby manned condition and before its return to operationally manned condition, and for reporting the status to the NC or the project T&DS manager.

4. Conducting the network readiness testing before releasing the operationally configured station to the NC (or in the case of ERTS, the project T&DS manager).

5. Isolating and correcting of network equipment problems during the validation testing and and operationally manned conditions after coordination of these actions with the NC or or the project T&DS manager.

6. Issuing instructions to the network during premission and mission periods concerning instrumentation; network documentation; maintenance and operation (M&O) precedures; testing; and software. Prepass configuration instructions will be given by the NC or the project T&DS manager.

7. Directing the NST/SNST in support of a mission from the commencement of premission status until mission termination plus 72 hours.

8. Ensuring network compliance with the NOD.

9. Assisting the NC or the project T&DS manager in the performance of his functions.

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*Priorities: Manned flight support has priority except for TEX, which will provide dedicated support to ERTS. All other MSFN stations will also support ERTS as well as the manned space flight programs.

10. Preparing and coordinating of GSFC inputs to the terminal count

Other MSFNOC activities similar to the NST/SNST are under the jurisdiction of the NOM. NST/SNST is a group of systems and operations specialists stationed at MSFNOC. Their purpose is to aid the NOM, NC, and/or the project T&DS manager.

The GSFC communications manager also interfaces with the NOM. The communications manager is responsible for the actual operation and control of the NASA Communications (NASCOM) network. His responsibilities are detailed in the NOD.

8.1.4.5 NASA Data Processing Facility (NDPF)

The OCC and the NASA Data Processing Facility (NDPF) are operationally independent. The OCC does, however, provide certain data to the NDPF on a routine basis. This data consists of:

1. Spacecraft Performance Data Tape
2. RBV/MSS Video Tapes
3. DCS Data Tapes
4. Workload Estimates

The Spacecraft Performance Data Tape (SPDT) is prepared routinely by the OCC as part of the post pass telemetry processing function. This data is consolidated and sent to the NDPF once per day. The RBV/MSS video tapes are recorded in the OCC during NTTF passes where either real time sensor operations are scheduled or WBVTR is dumped. These tapes are then transferred to the NDPF in the form in which they were originally recorded. The DCS data will be preprocessed by the OCC following reception. The processed data will be placed on a computer readable tape and physically transferred to the NDPF.

As a result of mission planning and activity plan generation, the OCC will provide the NDPF an estimate of planned sensor operation activity in order to plan image processing loading.

The NDPF will provide the OCC with coverage requirements and sample products. The coverage requirements are approved by the ERTS project office and when received by the OCC are used to update mission planning files. The OCC receives these updates as they become available and factors them into planning at the earliest possible time. The sample products are provided to the OCC on special request basis compatible with the normal NDPF production processing operation. In special situations where quick turnaround is required in order to support payload subsystem evaluation, the NDPF is requested to process received video from NTTF within one orbit of time of receipt. This mode is expected to occur only a few times during the mission; and is the only instance where NDPF operations are scheduled to comply with OCC operations.

8.2 OCC OPERATIONS AND TIMELINES

The operation of the OCC in conjunction with these interfaces is discussed in the remainder of this section.

8.2.1 OCC DESCRIPTION

The OCC is the focal point for all ERTS unique mission operations and the command and control point for all spacecraft flight operations. The OCC operates on a 24-hour day, 7-days per week basis and is responsible for operational planning and scheduling, spacecraft commanding, spacecraft and payload evaluation, and flight operations control. Virtually all OCC activities are geared to the operations timeline dictated by the spacecraft orbit and network coverage capability. Using the three prime stations at Corpus Christi, Alaska, and the NTTF/Rosman, the OCC will have real time contact with the spacecraft on 12 or 13 of the 14 orbits each day. During the interorbit periods, the OCC performs the detailed evaluation of the spacecraft and payload subsystem performance, investigates any anomalies, and prepares for the next spacecraft contact.

8.2.2 OCC REQUIREMENTS

The baseline requirements for the OCC were presented in the Design Study Specification. These requirements define four major areas of responsibility for the OCC:

1. Planning and scheduling
2. Spacecraft command generation
3. Spacecraft performance evaluation
4. Flight operations control

The functional requirements of the OCC in each of these areas are as follows:

8.2.2.1 Planning and Scheduling

The OCC is required to perform those planning and scheduling functions which define the spacecraft and ground activities necessary to effectively satisfy the mission and flight operation requirements. The plans and schedules must be based upon sensor coverage requirements (including DCS), spacecraft and payload configuration, network availability, and environmental constraints. The resultant activity plan is a time-ordered list of spacecraft, payload, and network events.

Sensor coverage requirements will include those areas to be covered while in contact with a ground station, as well as those outside the contact area. In the latter case, the OCC must schedule and manage the use of the onboard wideband tape recorder. The useful life of this recorder is limited and its operation is specified to be used on the average of one hour per day. Further, precautions should be taken to avoid using the recorder to collect data over cloud covered areas.

Spacecraft and payload configuration must be considered in the development of the activity plan in order to ensure that the current resources of the spacecraft system are effectively utilized. Changes in the status or operability of the spacecraft or payload must be identified and input to the activity planning function in order to prevent any compromise to their health and safety.

Network availability must be determined for routine contact operations as well as tracking. Tracking requirements will be input to the OCC by the NASA Orbit Determination Group and will define requirements for both routine tracking and special tracking for orbit adjust maneuvers. Orbit adjust requirements will also be determined by this group and input to the OCC. The OCC must factor these requirements into the activity plan. The OCC must coordinate all network support requirements with STADAN and/or MSFN and be capable of iterating the activity plan as a result of network schedule conflicts.

Environmental constraints include those factors which affect or restrict payload operations, namely sun angle and weather. Cloud cover was also mentioned earlier as an important limiting factor in wideband tape recorder operations.

The planning and scheduling responsibilities of the OCC, then, cover all elements of the operational mission system and must be designed to make most effective use of the resources of that system.

8.2.2.2 Spacecraft Command Generation

The OCC is required to generate the commands necessary to operate the spacecraft and its payload. Command generation responsibility includes:

1. Compilation of commands which satisfy the activity plan and spacecraft system performance and configuration requirements.

2. Display and verification of commands prior to transmission to ensure that the command list is correct and does not violate prescribed operational procedures.

3. Blocking and formatting of commands and transmission via the appropriate support network.

4. Verification of command execution in the spacecraft for both real time and stored program commands.

8.2.2.3 Spacecraft Performance Evaluation

The OCC is responsible for the analysis and evaluation of spacecraft and payload data to determine configuration, health, and performance at both a system and subsystem level. This responsibility includes both real time and historical trend analysis. Real time processing and analysis are required to permit on-line command and control over the spacecraft. Historical trend and related analyses provide the capability for in-depth, long term performance evaluation and the investigation of anomalies. Implicit within these requirements is the fact that the OCC must be capable of receiving, processing, displaying, distributing, and storing the spacecraft data necessary to fulfill these responsibilities.

8.2.2.4 Operations Control

The OCC is defined as the focal point and control point for all ERTS unique operations. The OCC Operation Control Function, therefore, must have the ability to direct all internal OCC activities in order to ensure effective and efficient flight operations and rapid response to contingencies. Externally, the OCC must define the required network support activities to be performed and must be capable of determining the status and configuration of the support elements.

8.2.3 MISSION OPERATIONS SUPPORT

8.2.3.1 General

The overall operations of the ERTS OCC is paced by those activities required to support the spacecraft while being prepared for launch, during launch, and while executing its assigned mission in orbit. The primary role of the OCC is to provide the command and control support of the spacecraft and it executes these functions through use of the Spacecraft Command and Telemetry Subsystems. In addition to these primary functions, the OCC must also provide the service to handle and "process" the data received from the payloads. The processing referred to here is that limited processing of the signal necessary to transfer the data into a form acceptable by the NDPF and will vary for each payload.

The discussion of the operations and timelines will be segmented into two major areas, pre-launch phase and post-launch phase. Figure 8.2-1 summarizes this time period indicating spacecraft disposition and OCC role.

The baseline operations required to support ERTS through launch were assumed to be similar to those required to support Nimbus, modified to factor in the ERTS unique features and requirements.

The on-orbit support profile is considered to be ERTS unique and was generated based on an analysis of mission simulations. Typical orbital profiles and station contact schedules were evaluated such that an allocation of support activities as a function of station pass could be made. The specific support activities identified for the station passes were then employed to derive the necessary internal OCC activities in terms of pre-pass, on-pass, and post-pass support requirements.

8.2.3.2 Prelaunch Phase

The pre-launch phase is considered to include the period of time from launch minus 6 months through actual liftoff. The pre-launch phase will be discussed in two subphases:

1. From 6 months prior to launch up to 2 weeks prior to launch at which time the spacecraft arrives at VAFB.

2. The last 2 weeks prior to launch while the spacecraft is on the pad being prepared for launch.

t_L -6 MO			t_L - 3 MO	t_L - 2 MO	t_L - 2 WK	t_L	t_L +100 MIN	t_L + 3 DAYS	END MISSION
PRELAUNCH PHASE (t_L -6 MO to t_L)						POST-LAUNCH PHASE (t_L to END MISSION)			

	GDHS SYSTEM TEST AND NETWORK INTERFACE	ENVIRONMENTAL TESTING			PRELAUNCH COUNTDOWN	LAUNCH AND INJECTION	INITIAL ORBIT ACTIVATION	OPERATIONAL ORBITAL PHASE
S/C	FINAL FABRICATION, INTEGRATION AND TEST AT SITE	VIBRATION TEST	THERMAL VACUUM TEST	SHIPMENT TO VAFB	PRELAUNCH PREPARATION AT VAFB	LAUNCH TRAJECTORY AND INJECTION	SUBSYSTEM ACTIVATION IN ORBIT	OPERATIONAL ORBITAL ENVIRONMENT
OCC ROLF	• FINAL SUBSYSTEM TEST • INITIAL NETWORK INTERFACE • SYSTEM LEVEL TEST • TRAINING OF SUPPORT PERSONNEL	• SYSTEM LEVEL TEST • PROVIDE OCC PERSONNEL FOR SUPPORT AND TRAINING DURING THERMAL VACUUM TEST AT SITE • TRANSMIT COMMANDS AND PROCESS TLM VIA OCC SITE INTERFACE DURING THERMAL VACUUM TEST • DEVELOP INITIAL ORBIT ACTIVATION PLAN AND GENERATE REHEARSAL TAPES • CHECKOUT AND TEST ALL INTERFACING USING SIMULATED DATA			• GENERATE PAD LOAD • NETWORK INTERFACE TEST • MONITOR LAUNCH COUNTDOWN • REHEARSE INITIAL ORBIT ACTIVATION PLAN • VALIDATE DATA BASE	• MONITOR VIA VOICE S/C TLM REPORTS FROM VAFB • RECEIVE AND PROCESS RT TLM FROM MADGAR, WNKFLD, ALASKA • RT CMD VIA MADGAR, WNKFLD, AND ALASKA • STORED CMD LOAD ALASKA (AND WNKFLD IF DESIRED) • NB TLM RECORDER DUMP AT ALASKA • MONITOR S/C SEPARATION, INITIAL STABILIZATION, PADDLE DEPLOY	• EVALUATE PERF OF POWER AND THERMAL SUBSYSTEMS • ANALYZE CONTROL SUBSYSTEM • DETERMINE AND CORRECT INITIAL SPACECRAFT ORBIT • VERIFY VHF AND USB CMD LINES • DETERMINE TRANSMITTER POWER • DETERMINE S/C TIME IN PCM • CHECK AUX POWER LOADS • EVALUATE CMD SUBSYSTEM • VERIFY NB TLM RECORDER OPS • VALIDATE PAYLOAD OPERATIONS	• MISSION PLANNING • COMMAND GENERATION • TLM PROCESSING • DCS PROCESSING • S/C EVALUATION

Figure 8.2-1. Time Period Summary

As noted in Figure 8.2-1, during the initial part of the pre-launch phase, the OCC will be involved in completing final subsystem test and performing system level checkout and test. It is anticipated at start of this phase that all in-line operational equipment will have been installed and checked out (including the computers) and that the support software will have been completed and validated at least at the module level. The OCC staff will consist of primarily contractor personnel involved in the checkout phase.

At approximately 2 months prior to launch, the spacecraft will enter thermal vacuum test at the contractor site. This is the first time that the complete spacecraft in a simulated orbital environment can be operated as will be done in orbit. The OCC will participate in this test in the following ways:

1. OCC personnel will participate at the contractor site to provide support of the test and to obtain their first operational support experience with the actual flight hardware.

2. The development and rehearsal of the initial orbit activation plan will result in tapes of the actual spacecraft telemetry and simulated payload data that can be used as test input for OCC operational test.

3. The implementation of a data link between Valley Forge and the OCC could provide a live interface with the spacecraft during the test and be used for an on-line OCC operational checkout and training program. This interface would be handled through NASCOM and would, to the OCC, look like a typical remote site as far as telemetry and commanding is concerned. Although the OCC would generate and transmit spacecraft commands, it is not proposed that they be automatically transmitted to the spacecraft, but would be intercepted at the site and then relayed (after checking) to the vehicle. This will introduce an artificial delay in terms of the time from OCC and transmission to the time the command is received in the vehicle. However, except for the time delay, the interface will possess a behavior typical of an operational interface.

During this part of the pre-launch phase, a training program for the designated on-orbit flight support personnel will be held.

At approximately 2 weeks prior to launch, the spacecraft will be delivered to the launch pad. During this period, the vehicle will undergo final confidence test and be prepared for launch. The OCC will not be tied into the vehicle during this time other than by voice contact with the personnel at VAFB. The primary functions in the OCC during this phase will be the monitoring of countdown, and a final rehearsal of launch and initial orbit activation procedures. This will include network interface readiness testing and development and validation of pad load command message.

8.2.3.3 Post-Launch

The post-launch phase starts at the liftoff and continues through the termination of the mission. The discussion of this phase will be segmented into the three subphases:

1. Launch and injection phase

2. Initial orbits activation phase

3. Orbital Operations phase

8.2.3.3.1 Launch and Injection Phase

Spacecraft subsystems receive their final ground checkout during the spacecraft checkout phase of the launch countdown. During this time, all subsystems and components that can be checked are verified to be operational and functioning within established parameters. Temperatures, pressures, separation system status, etc., are also checked. These subsystems are verified through the monitoring of telemetry. At the completion of each subsystem checkout, it is placed in its launch mode. The exception to this is the Power Subsystem which remains on Pad power, and the narrowband tape recorder which requires dumping prior to launch.

The spacecraft subsystem status will continue to be monitored during the terminal count. However, the only spacecraft events that occur during this period are the switch from Pad to internal battery power and emptying the tape recorder.

The spacecraft is launched in a minimum configuration which is:

Power Subsystem	Launch Mode (Orbit Mode)
ACS	Launch Mode
Command Logic, Decoder, Clock, and telemetry processor	Launch Mode
Narrow Band Tape Recorder	One ON (record mode), one OFF
VHF transmitter	One ON (low power data mode) one OFF
VHF receiver	One ON, one OFF
USB transmitter	Both OFF
USB receiver	One ON, one OFF
Premodulation processor	Both OFF
UHF DCS receiver	OFF
RBV	OFF
MSS	OFF
WBVTR	Both OFF

Launch from WTR will occur at approximately 1000 local time, which results in the desired descending node time of 0930.

During the launch sequence, booster and spacecraft real time telemetry is recorded by Vandenberg ground stations through first stage separation, fairing separation and Stage II start. Ground station coverage (by JOBURG or MADGAR) is required over the Indian Ocean and Africa to cover, in real time, the second Delta burn through injection, Delta pitch-up, spacecraft separation, paddle unfold, and the start of spacecraft attitude stabilization.

The spacecraft is injected into a 492-nautical mile circular orbit by the second Delta burn. A launch sequence timeline is shown in Figure 8.2-2.

During the early part of the launch phase, VHF spacecraft telemetry will be received at VAFB. The OCC will receive reports of the spacecraft status via voice and will be in primarily a monitoring role. After exit of coverage by VAFB, the spacecraft is out of contact for ≈ 40 minutes. Overall status via voice link will be available for part of this time from reports by downrange ships (if scheduled for use) employed for monitoring booster performance.

The next spacecraft TLM data will be received via the MADGAR tracking station pass. During the MADGAR pass, the OCC will receive real time telemetry. Spacecraft separation will occur during the MADGAR pass and once it has occurred, the command system will be enabled and command capability from the OCC will exist. It is expected that real time commands will be sent during this pass to initiate certain functions deemed critical after the separation event.

The next contact will occur during the pass over Winkfield, England. The OCC will receive and process RT TLM during the pass and evaluate the spacecraft status. Real time commands will be sent to initiate sequences required to verify subsystems. A stored command load can be sent to update the pad load if required.

The acquisition by Alaska occurs approximately 88 minutes after launch. During this pass, the narrowband PCM tape recorder will be dumped. The recorder has been used to record all PCM TLM throughout the launch and injection phase. The OCC will process the real time TLM, and, if required, process the dump data during the pass to quickly assess the existence of any anomalous conditions that may have occurred during the launch phase. The processing of the dump data at this time is possible since it is received at the OCC simultaneously with the real time data. During the processing of the dump data, real time TLM processing is not possible. However, it will be monitored both at Alaska and at the OCC via brush and event recorders.

Based on pre-mission planning and evaluation of spacecraft status via telemetry received to date, a stored command load will be prepared by the OCC prior to the Alaska pass. This message will consist primarily of those commands necessary to effect spacecraft activity that allows for initial evaluation of system health and status and initiate the planned turn-on sequence of the systems.

Lat/Long	Day/Night	TLM	Time	Events
	DAY	VHF	T-X	Components in Launch Status
			T-11	Switch to Battery Power
			(Δ30)	Maximum Hold is 30 Minutes
VAFB			T-0	Launch (9053-0+30)
			T+220	Main Engine Cutoff
			T+224	Start Stage II
			T+241	Fairing Separation
			≈T+355	TLM 5 Degree Exit
≈15°N/125°W			≈T+590	Second Stage Cutoff
				Coast
	NIGHT	VHF	≈T+2900	MADGAR Acquire
11.8°S/41.6°E			≈T+3468	Restart Stage II
			≈T+3480	Stage II Cutoff (Injection)
			≈T+3550	Initiate Pitch Up
			≈T+3650	ERTS/Stage II Sep
			≈T+3652.5	Fire Pyros-Paddle Unfold
			≈T+3667.5	Remove ACS Inhibit
			T+3684	Start Ascending Node (Rev 1, 2130-2200 Local Time)
			≈T+3702.5	Remove SAD Inhibit
			≈T+3750	TLM 5 Degree Exit
	DAY		≈T+4650	Start Day (Sunat Equinox) (First Solar Array Power)
		USB/VHF	T+5274	Alaska Acquire
			T+6078	Alaska 5 Degree Exit

Figure 8.2-2. Launch Sequence of Events

8.2.3.3.2 Initial Orbital Operations

The objective of the first day(s) in orbit is to ascertain the fundamental operation of the basic spacecraft, to obtain tracking information, and to perform orbit correction.

Subsequent days will involve the complete checkout of the payload equipment. Nearly all of the operations to be performed will be in real time, for the purpose of observing functional performance as it is occurring, with the capability to immediately change or stop the operating mode if it should be necessary.

Since operations are, therefore, limited to the ground station coverage available (by Alaska, NTTF/Rosman and Corpus), Day 1 will probably be used entirely for checkout of the basic spacecraft subsystems, ACS, power, thermal, telemetry, command and OA. Checkout and continuing verification of these subsystems will continue in parallel with sensor subsystem checkout on subsequent days. Day 1 activities are summarized below.

1. Monitor spacecraft separation, initial stabilization, and paddle deployment
2. Evaluate the performance of the power and thermal subsystems to determine if normal activation can be used
3. Analyze the control system to determine if the Acquisition mode can be terminated and the orbital mode started
4. Determine spacecraft orbit
5. Verify VHF and USB commanding and receiving links
6. Determine transmitter power
7. Determine spacecraft time in the PCM format and correct if necessary
8. Check turn-off of auxiliary power loads and determine their needs based upon thermal analysis
9. Evaluate command capabilities, using all locations in each clock, both in real time and stored
10. Analyze both real time and stored telemetry regarding PCM matrix stability and validity of each telemetry value
11. Verify narrowband tape recorder operation
12. Obtain each subsystem turn-on signature from the recording of regulated bus current
13. Perform initial orbit adjust correction

Ground station tracking during this period will provide the information needed for orbit correction. Additional MSFN sites will likely support ERTS during initial orbit determination and correction.

Sensor and associated subsystem checkout could start as early as Day 2. (This time may be modified based on ground test results. Adequate time must be allowed for outgassing of the systems containing HV.) Initial turn-on sequences for the RBV and MSS, will conform to the best (safest) turn-on method verified during integration and thermal vacuum testing in order not to endanger the safety of the payload. This checkout is accomplished in real time. Operation of the RBV, MSS, the two S-band transmitters, the two WBVTR's and the DCS receiver will be checked. These turn-on sequences should be gradual and telemetry watched closely for anomalies. Detailed sensor operation will be determined from examination of the sensor data.

The S-band transmitters will be checked first. Power will be applied to one transmitter and its telemetry verified. Modulation will then be applied by placing the associated WBVTR in the playback mode. This recorder was launched with test patterns and go/no-go signals recorded on it. Recorder telemetry and the test patterns will be checked to verify transmitter and recorder opeational status.

The RBV will be checked in the following manner. Camera No. 1 will be energized by the on sequence and placed in the direct mode and the telemetry verified. Then the direct/record and record modes will be checked. This system will be turned off. The same sequence of events will be used for camera No. 2, and then for camera No. 3. Upon successful completion of the above tasks all cameras will be turned on and the total system verified in both direct and record modes. Prior to turn-off, the system will be placed in the preset mode for automatic system operation the next time it is turned on.

A similar turn-on sequence will be used for the MSS.

This initial operation period ends after the following major tasks have all been accomplished:

1. Complete spacecraft checkout

2. Sustained operation of spacecraft and sensors

3. Orbit correction

4. Ground station/spacecraft checkout of all stations (Alaska, NTTF/Rosman, Corpus)

5. Ground procedures checkout

6. Data handling and evaluation operation running smoothly

During the initial orbital operations phase, the OCC function in a mode quite similar to its normal orbital operations mode. The primary differences between the activities during this time period and those that occur in the later operational orbital phase are:

1. Detailed evaluation of spacecraft TLM by subsystem to establish its condition post launch

2. Scheduling and generating commands for special subsystem confidence tests and initial turn on sequences

3. Updating pre-mission planning to reflect actual spacecraft orbit and spacecraft status

4. Evaluation of response of ground support system and network

5. Extensive participation by technical subsystem support personnel

The basic OCC hardware and software will be used the same way as it is used for normal operational orbital operation. Detailed discussion of the flow and timing is covered in the discussion of orbital operational phase.

8.2.3.3.3 Orbital Operations Phase

During orbital operations, acquisition of multispectral imagery is scheduled to accomplish the primary mission objectives. Desired coverage is accomplished by operating the RBV and MSS sensors in a real time mode when ground station coverage exists, and in a record mode for all remote areas. Collecting and relaying data from the Data Collection Platforms is accomplished as the second ERTS mission goal. In addition, other routine tasks are the maintenance of the basic spacecraft through telemetry analysis and command, the tracking of the spacecraft, and orbit adjusts.

These normal system operations involve the cyclic execution of the following steps.

1. User Requirements - User modifications to stored requirements are inputs to the Operations Control Center (OCC) via the NDPF and the ERTS Project Office.

2. Mission Requirements - Mission requirements are established in the OCC to reflect user requirements.

3. Sequence of Events - An optimum sequence of events is selected in the OCC using ephemeris, cloud cover, sun elevation angle, and ground target availability data. Ephemeris is generated in the OCC with orbital elements supplied by the NASA Orbital Determination function. Cloud cover data is provided by the Environmental Sciences and Services Administration (ESSA).

4. Command Message Generation and Station Contact Predictions - Spacecraft command messages are generated and sent to the appropriate STADAN/MSFN stations. Station contact predictions are formulated and sent to OPSCON/NETCON and MSFNOC. These functions originate in the OCC.

5. Spacecraft Commanding - Under the overall control of OCC, the proper stations transmit messages to the spacecraft.

6. Spacecraft Operations - The spacecraft functions according to the command messages received. Payload and spacecraft operations are carried out in real time or by stored command.

7. Spacecraft Data Transmission to Ground Stations - The prime STADAN/MSFN stations receive real time and recorded P/L video data, DCS data, and narrowband telemetry data from the spacecraft.

8. Ground Station Data Transmission to GDHS - The P/L video data is recorded by the Alaska and Corpus stations and the video tapes subsequently shipped to GDHS. NTTF relays the P/L video data by hard line interface directly to the OCC for quick-look display and recording.

9. The preprocessed DCS data and narrowband telemetry data is sent from Alasks and Corpus via NASCOM interfaces to the OCC and NASA Data Processing Facility (NDPF). NTTF sends the DCS and narrowband telemetry data by hard line interface to the OCC.

9. Data Processing, Handling and Evaluation - In the OCC, some types of data, primarily narrowband telemetry, are utilized for spacecraft system evaluation. All verification, decommutation, and reformatting of this data necessary to accomplish the evaluation is performed in the OCC.

10. Tracking and Ephemeris Determination - The prime tracking function is accomplished using the USB system at the MSFN sites. The STADAN sites will employ the MINITRACK system as a backup to the USB. Tracking data from these remote facilities is sent to the NASA orbit determination group for processing. This data is relayed to the OCC in a future time frame as required for ephemeris updates.

8.2.4 OCC TIMELINES

8.2.4.1 Station Pass Timeline Analysis

The operational timelines within which the OCC must function are paced by the ground station contact schedule and planned operational schedule of the spacecraft. To establish a realistic baseline from which to evaluate support requirements, a simulation of the ERTS mission was generated. The simulations provided a schedule of sensor operations compatible with:

1. Ground station contact schedule

2. WBVTR capability

3. Land mass coverage requirement

4. Sensor operating restrictions

The simulations did not consider the effect of cloud cover nor did they consider any limitation on total amount of schedule operations per day. Thus, the total sensor operation times scheduled is compatible with the spacecraft operation capabilities, but exceeds what would normally be expected in orbit. The utilization of these profiles as a basis for determining ground support requirements is legitimate in that if the simulation resulted in sensor operations being scheduled for a particular revolution, it can be expected that sensor operations would be scheduled operationally for that revolution also. The effect of cloud cover and total operating time restrictions would appear only as a reduction in the specific sensor operations time as indicated by the simulation.

Employing this philosophy, it is then possible to examine the simulation results in detail and to obtain a realistic appraisal of the various support requirements allocatable to any given station pass. To establish some baseline, the simulation of Day 9 of a cycle for summer solstice conditions was used as a worst case.

8.2.4.1.1 Timeline Analysis

The station passes for typical revs as shown in the detailed timelines in Figure 8.2-3 were analyzed to determine the types of activity that would be nominally scheduled for each pass. The categories of station pass activities that were identified and tabulated are as follows:

1. Real time sensor operations
2. WBVTR dump
3. NBTR dump
4. Stored command load
5. Real time commands
6. Real time telemetry
7. DCS data acquisition
8. Orbit adjust (when required)

Table 8.2-1 summarizes the occurrence of these basic activities as a function of specific station passes encountered on a typical day.

The balance of this section defines what each of the basic activities requires in the way of ground station supporting operations during the station pass. They are referenced to AOS/LOS (acquisition and loss of signal) in relative time allocations.

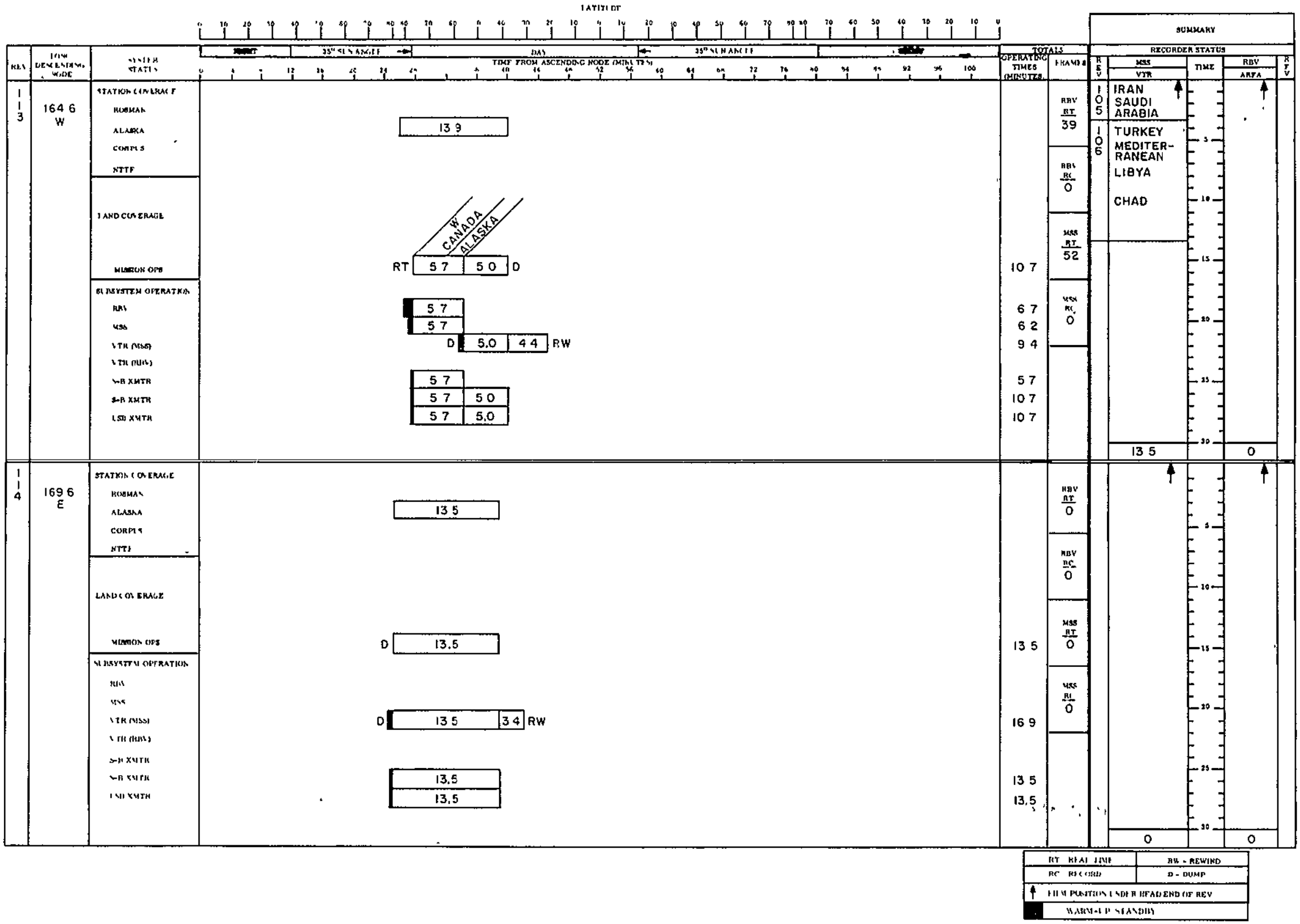


Figure 8.2-3. Typical Flight Operations Timelines (Sheet 1)

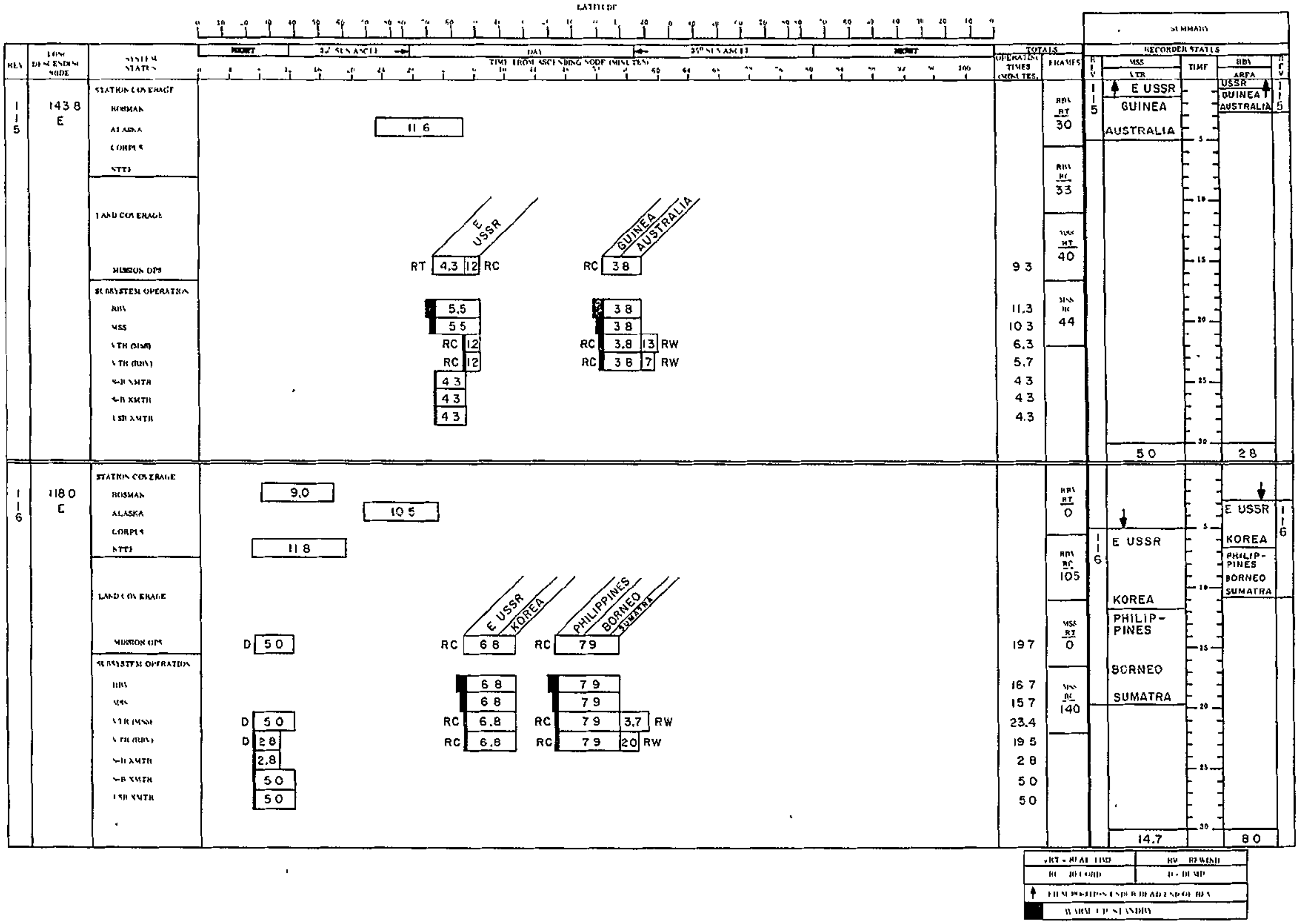


Figure 8.2-3. Typical Flight Operations Timelines (Sheet 2)

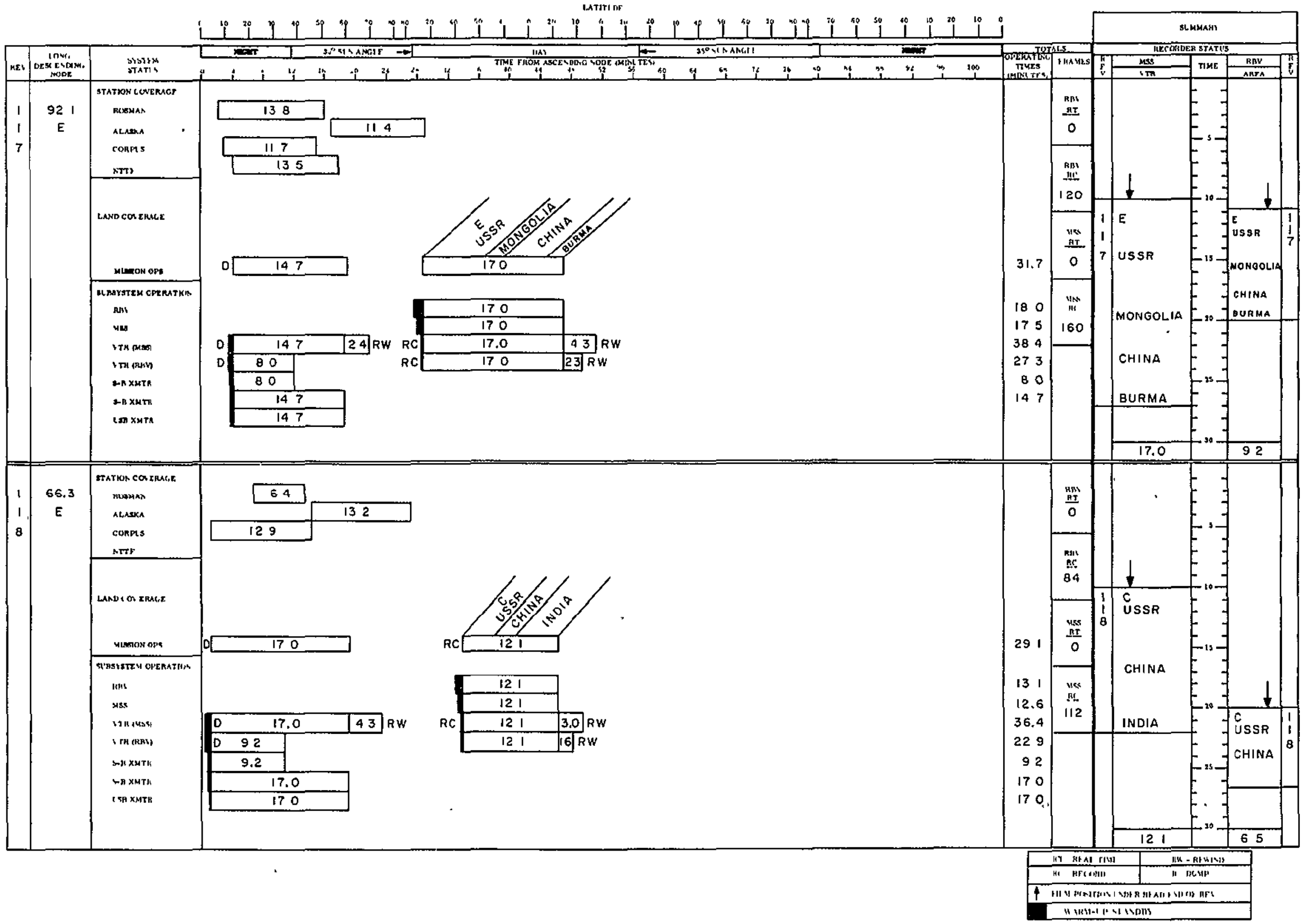


Figure 8.2-3. Typical Flight Operations Timelines (Sheet 3)

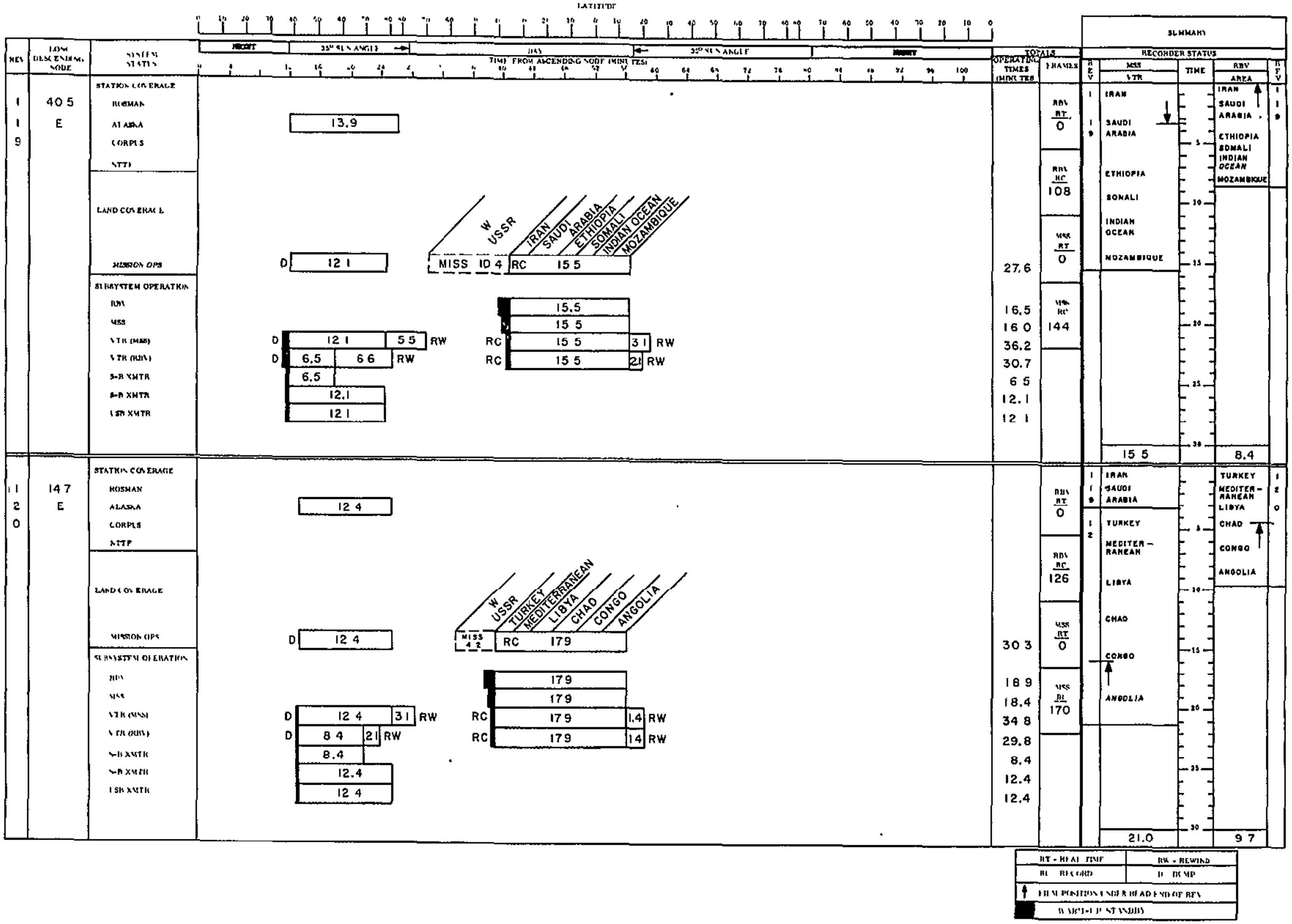


Figure 8.2-3. Typical Flight Operations Timelines (Sheet 4)

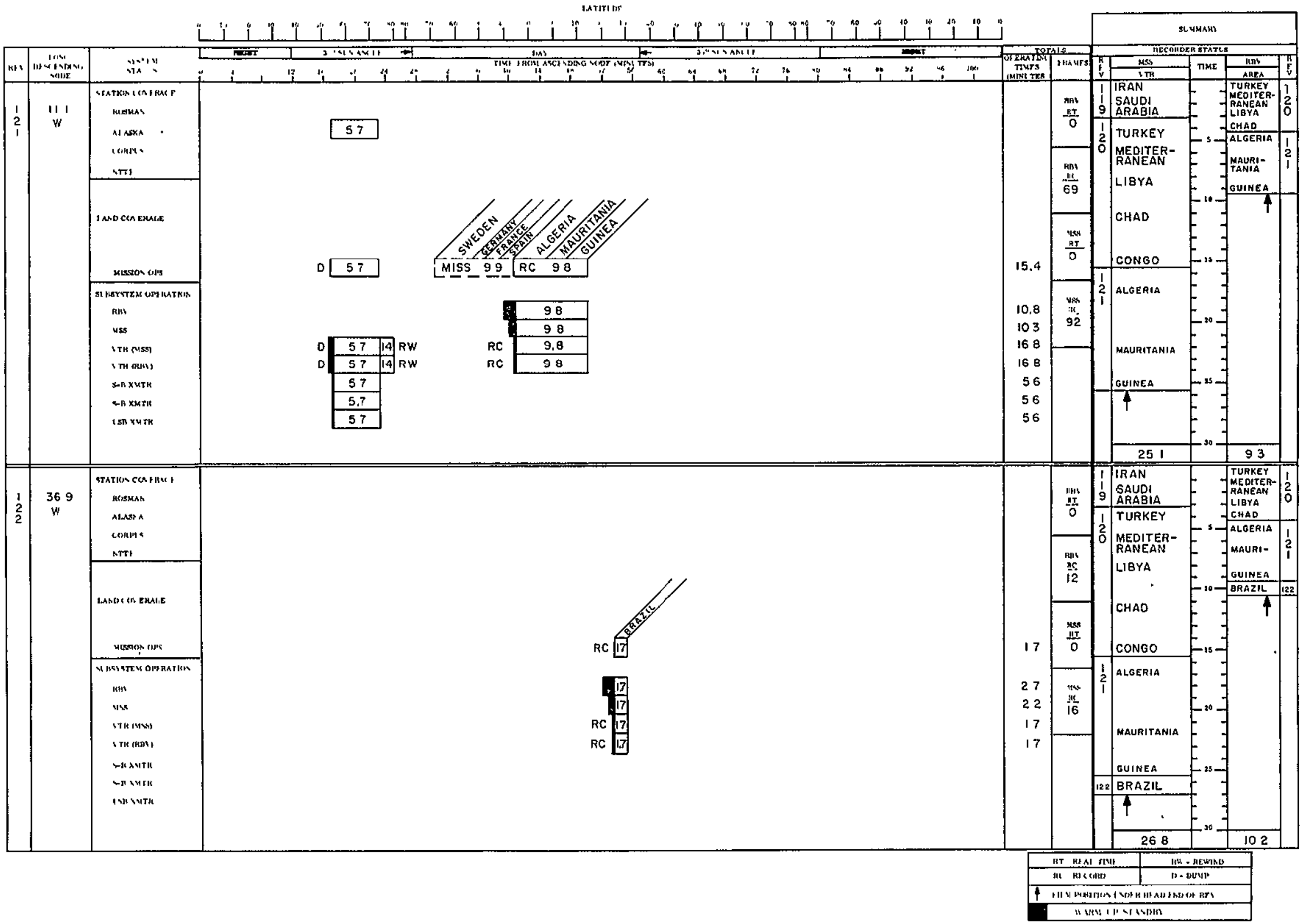


Figure 8.2-3. Typical Flight Operations Timelines (Sheet 5)

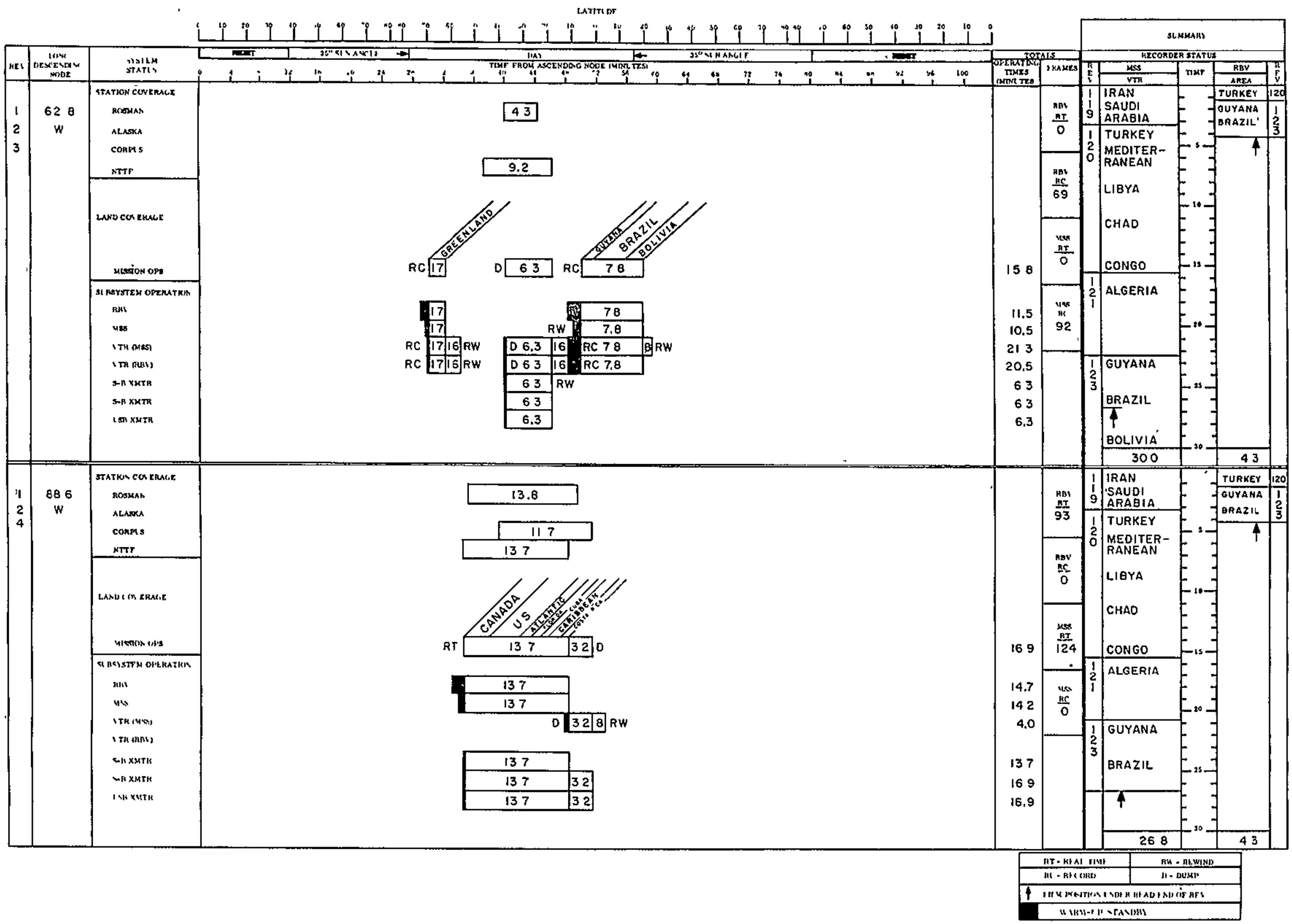


Figure 8.2-3. Typical Flight Operations Timelines (Sheet 6)

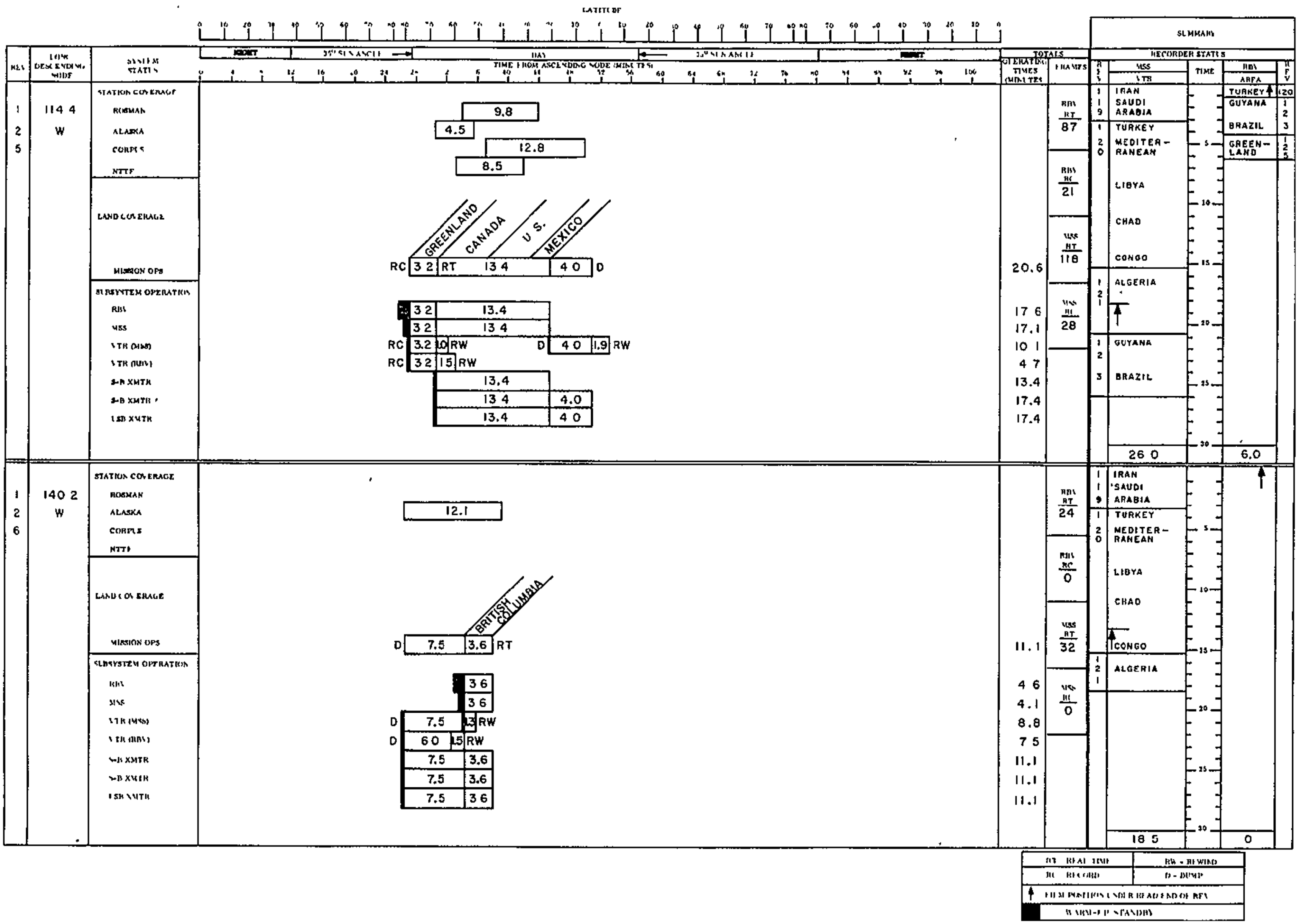


Figure 8.2-3. Typical Flight Operations Timelines (Sheet 7)

Table 8.2-1. Typical Station Pass Activity Categories

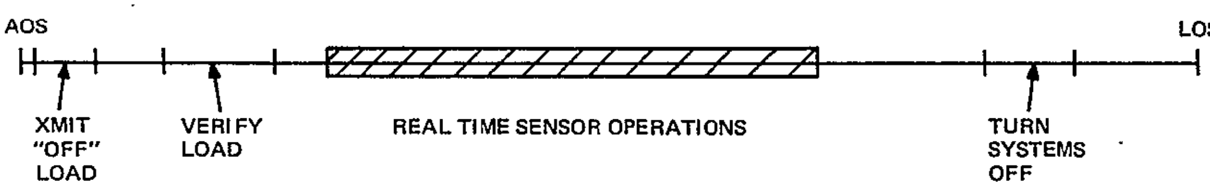
Rev	Site	R/T Sensor Ops	WBVTR Dump	NBTR Dump	SPC Load	R/T Command	R/T TLM	DCS Acq	Orbit Adjust
113	Alaska	x	x	x	x	x	x	x	
114	Alaska		x	x	x	x	x	x	
115	Alaska	x		x	x	x	x	x	
116	Alaska			x	x	x	x	x	
	Rosman					x			
	NTTF		x				x	x	
117	Alaska		x	x	x	x	x	x	
	Rosman					x			
	NTTF		x				x	x	
	Corpus		x			x	x	x	x
118	Alaska		x	x	x	x	x	x	
	Rosman								
	Corpus		x			x	x	x	x
119	Alaska		x	x	x	x	x	x	
120	Alaska		x	x	x	x	x	x	
121	Alaska		x	x	x	x	x	x	
122	—								
123	Rosman				x	x			
	NTTF		x	x			x	x	
124	Rosman				x	x			
	NTTF	x		x			x	x	
	Corpus	x				x	x	x	
125	Alaska	x			x	x	x	x	
	Rosman					x			
	NTTF	x		x			x	x	
	Corpus	x	x			x	x	x	
126	Alaska	x	x	x	x	x	x	x	

8.2.4.1.2 Real Time Sensor Operation

Real time sensor operations will occur while the spacecraft is in contact with one of the three ground stations capable of receiving the wideband video data. These sensor operations will be scheduled in advance of the pass by the system scheduling function of the OCC. The Command Engineer will generate and identify the commands to be sent in order to implement the operations. Since the placement of these operations is dictated by coverage requirement, it must be assumed that the required real time commands could occur anywhere within the pass.

The support of real time sensor operations, as well as WBVTR dump, will require that the ground site scheduled to receive the data by configured accordingly prior to the pass.

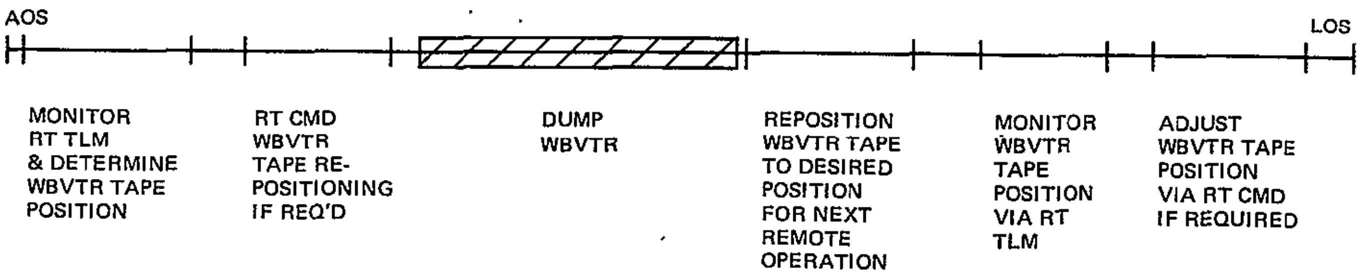
These real time operations require that spacecraft equipments be used that are constrained regards maximum allowable continuous operation times. Due to this, it is planned that, prior to turning on any of these subsystems, turn-off sequence of commands, scheduled to occur near the end of the pass will be transmitted and stored and verified. This concept is illustrated below:



8.2.4.1.3 WBVTR Dump

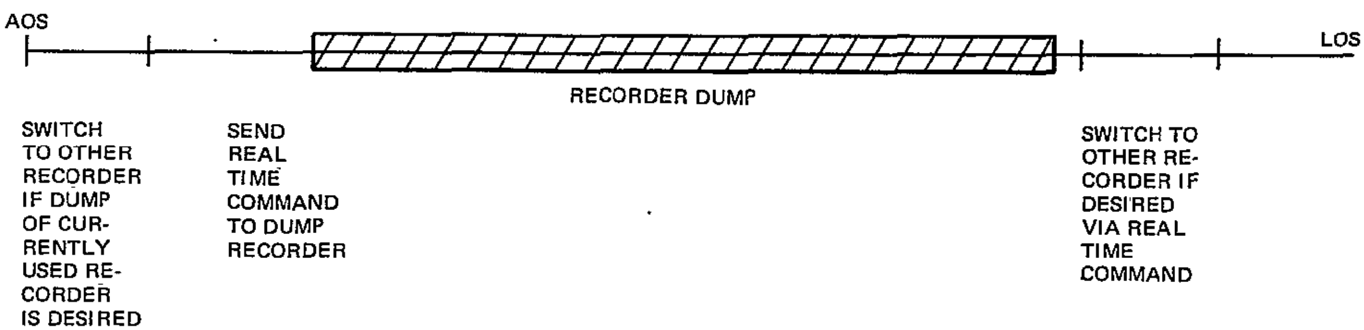
The WBVTR usage management requires that careful positioning of the tape be effected in order to ensure that proper data is received at the ground station. This is shown in the following illustration. The inclusion of the tape positioning information in the PCM telemetry will allow for quick assessment of current tape position via real time telemetry early in the pass. The OCC WBVTR usage management function will have computed the desired position for the planned dump. In the event that the current position is not proper and can be corrected by slight readjustment, a tape repositioning will be effected via real time command. It is conceivable that a gross positioning error could exist such that the time to accomplish the required repositioning would exceed the remaining pass time. In this case, the options will be to accept a partial dump or to dump an alternate data segment, if available and compatible with the current conditions. In event that none of these conditions exist, then the scheduled dump will have to be eliminated and rescheduled at some future pass.

Once the desired data has been dumped, and if time still exists in the pass, the recorder tape will be repositioned, if necessary, to prepare for the next remote operation. If time does not exist to perform this action in real time, then the appropriate stored program command must be included in the command load.



8.2.4.1.4 Narrowband Tape Recorder Dump

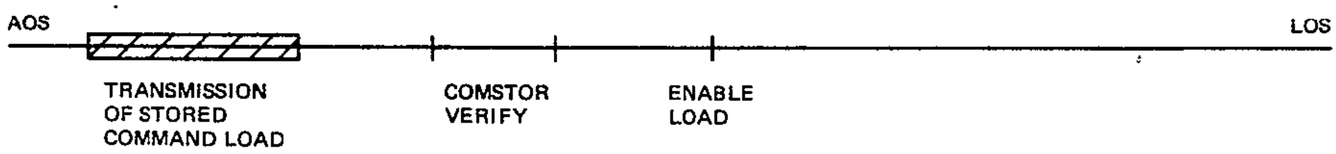
The management of the narrowband PCM tape recorder requires that one of the two recorders be dumped during specific passes where the recorder being used up to the pass is the one scheduled to be dumped, it will be necessary to switch the telemetry to the other recorder at the beginning of the pass if the recorder scheduled to be dumped is then commanded via real time command to the dump mode. In the situation where the recorder being used prior to the pass is not the recorder scheduled to be dumped, then the real time command to dump the recorder can be sent any time early in the pass. It is expected under these conditions that, prior to loss of signal, but after the dump operation, the telemetry will be switched to the recorder that has just been dumped. This is depicted below.



8.2.4.1.5 Stored Command Loads

A stored command load is transmitted to the spacecraft to provide a capability to effect desired spacecraft events when not in contact with a ground station. The load is prepared by the OCC in advance of AOS for the pass and is transmitted to the vehicle during the pass.

After transmission to the vehicle, the command message is verified to be correct by dumping the content of the COMSTOR (command memory unit) via telemetry and comparing it with the desired message at the OCC. Once the load has been verified, it is enabled and will then effect the desired activities throughout the orbit(s) as dictated by the Commands. This is depicted below.



8.2.4.1.6 Real Time Commands
Real time commands will be defined and transmitted by the OCC and can be transmitted at any time during the pass.

8.2.4.1.7 Real Time Telemetry
Real time telemetry will be received by the ground station throughout the pass and relayed in real time to the OCC for processing and display.

8.2.4.1.8 DCS Data Acquisition
The DCS receiver on the spacecraft will be turned on via command at the beginning of the pass and the spacecraft will relay the platform data as received throughout the pass. Prior to LOS, a real time command will be transmitted to turn off the receiver.

8.2.4.1.9 Orbit Adjust Maneuver
Orbit adjust maneuvers will be scheduled to occur when in contact with Corpus Christi during an ascending pass. It is proposed that the command sequence required to effect the maneuver be transmitted as a stored command load scheduled to occur while still in contact with the site. Although it is possible to implement the adjust via real time commands, it is desirable to perform it via stored commands in order to guarantee accurate engine cutoff times.

8.2.4.1.10 Summary
The major items concerning station pass activities may then be summarized as follows. The activity in the OCC is paced by the contact schedule with the satellite. Examination of mission simulations has provided information to determine the types of activity that will occur during specific station passes. A matrix of station pass versus type of activity was generated for a typical day's activities. Some conclusions and design approach comments resulting from this analysis are as follows:

1. The narrowband PCM recorders will be dumped nominally only during Alaska and NTTF passes.

2. Orbit Adjust maneuvers will be scheduled to occur during a night time pass over Corpus Christi.

3. WBVTR dump will be scheduled with tape position adjustment capability prior to dump.

4. Full support of all anticipated ERTS activities can be accomplished via the four prime sites. Other backup sites will only be required in an emergency situation.

5. All OCC operations will be scheduled as a function of the station pass schedule.

The following section develops the time-lines for scheduling and implementing the internal OCC operations required to support the station pass activities.

8.2.4.2 OCC Timelines

Effective operational support of the satellite requires that the OCC perform certain functions prior to, during, and after each station pass. As was indicated in the preceding section, mission simulations have provided a basis for allocating specific support activities as a function of station pass.

8.2.4.2.1 Daily Timeline

Figure 8.2-4 presents a typical daily station contact profile with allocated pass support activities. Since the OCC support activities are primarily computer-oriented processes, an allocation of the OCC computer resource is also shown in the figure. The computer is configured in three basic modes of operation:

1. Dedicated on-line - this mode is employed during final preparation for and support during the pass. It is the real time operating mode while the OCC is in contact with the spacecraft.

2. Time shared mode - this mode is employed prior to final pass preparation when a number of functions must be performed simultaneously.

3. Batch mode - this mode is employed post-pass where large quantities of data must be processed and necessary reports generated.

In the first two modes, the OCC personnel will interact heavily with the computer via console keyboard and display systems. The third mode will require little interaction.

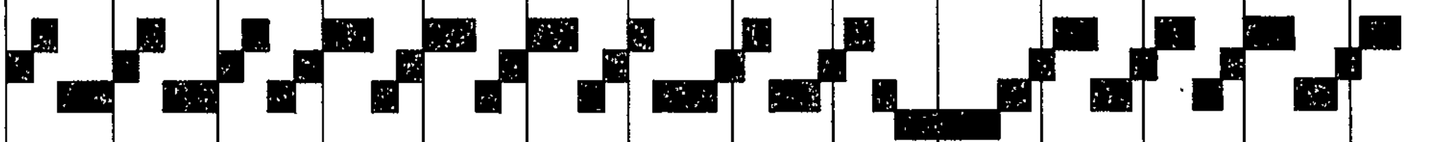
The nature of the station contact profile is such that no-station contacts occur (with prime ERTS sites) on 1 or 2 revs per day. During these dead rev times, approximately two hours will be allocated for preventive maintenance to be performed on the computer.

REV

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
STATION CONTACT SCHEDULE														
(1) ALASKA	13.9	13.5	11.6	10.5	11.4	13.2	13.9	12.4	5.9				4.5	12.1
(2) CORPUS					11.7	12.9						11.7	12.8	
(3) NTTF				11.8	13.5						9.2	13.7	8.5	
(4) ROSMAN				9.0	13.8	6.4					9.3	13.8	9.8	
PASS SUPPORT ACTIVITY SCHEDULE														
NARROWBAND DUMP	1	1	1	1	1	1	1	1	1		3	3	1	1
WIDEBAND DUMP	1	1		1	1,2,3	1,2	1	1	1		3	2,3	2,3	1
REAL TIME OPS	1											2,3	2,3	1
STORED COMMANDS	1	1	1	1	1	1	1	1	1		4	4	2	1
RT TLM	1	1	1	1,3	1,2,3	1,2	1	1	1		3	2,3	1,2,3	1
RT COMMAND	1	1	1	1,4	1,2,4	1,2	1	1	1		4	2,4	1,2,4	1
DCS	1	1	1	1,3	1,2,3	1,2	1	1	1		3	2,3	1,2,3	1
* ORBIT ADJUST					2									

OCC COMPUTER SCHEDULE

DEDICATED ON-LINE
TIME-SHARE MODE
BATCH MODE
PREVENTATIVE MAINTENANCE



*ONLY WHEN REQUIRED

**INDICATES SITE 1 - ALASKA
2 - CORPUS CHRISTI
3 - NTTF
4 - ROSMAN

***APPROXIMATE DURATION OF STATION PASS IN MINUTES

Figure 8.2-4. Typical Daily Timeline

As can be seen from the typical daily profile, a pattern of station contacts as a function of rev exists. Typically half of the 14 revs per day contain a single station pass; one or two contain no station passes, and the rest contain multiple passes. The multiple station passes occur such that they are generally close together, and for all practical purposes, can be thought of as a single long continuous contact with the spacecraft. For internal OCC support scheduling, a multiple station pass will be treated as a pseudo station pass of a duration from acquisition of signal of the first site through loss of signal of the last site (see Figure 8.2-5).

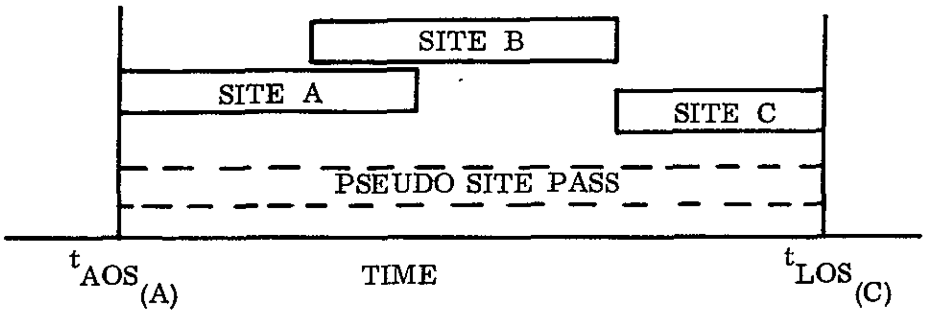


Figure 8.2-5. Pseudo Station Pass

This approach allows for a standardization of OCC operations. The pseudo site pass is only considered in the planning and scheduling of OCC operations. In actual pass support, each site will be considered individually. For multiple passes, a prime site will be designated and displayed to all personnel. Handover from one site to the next will be a procedural matter under the direction of the Operations Supervisor.

8.2.4.2.2 Rev Timelines

The basic support activities required for each rev containing station passes are similar. The differences are primarily in the area of payload operations and orbit adjust. Because of this similarity, the OCC operations and timelines have been constructed as a function of a station pass. Figure 8.2-6 presents the flow and timing of OCC operations for two typical revs each containing a station pass (station pass can be considered to have more than one site involved, pseudo pass).

The OCC operational timeline is shown in terms of computer mode, OCC software, and external inputs. The overall design of the system is such that a complete cycle of mission planning, command generation, and spacecraft telemetry evaluation can be accomplished each rev. This allows for a new activity plan to be generated and a command load prepared for loading on each rev. With this approach, latest weather information and spacecraft status can be factored in for maximization of accomplishment of mission objectives.

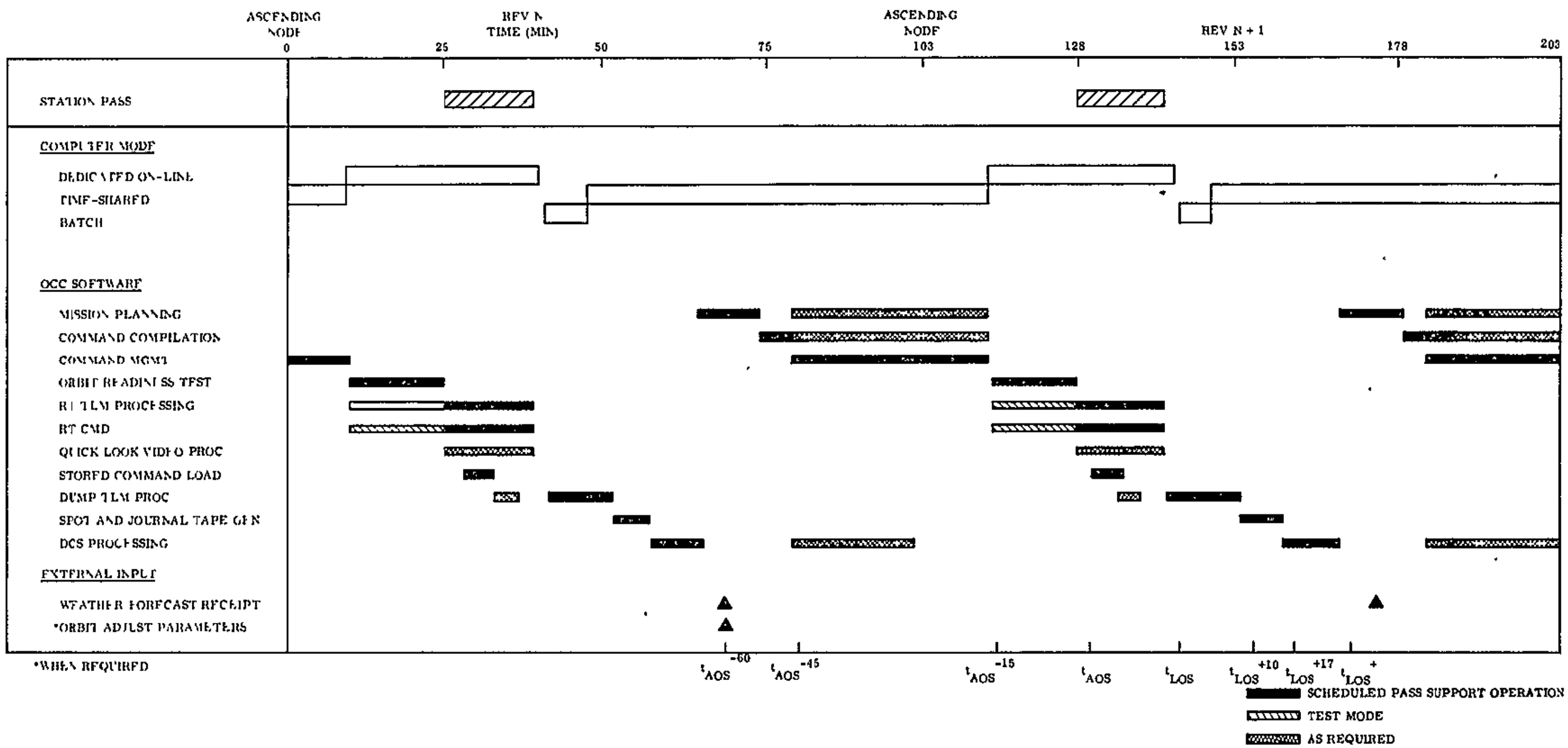


Figure 8.2-6. Typical OCC Timelines for Pass Support

Although this turnaround capability exists, it is not necessary that it always be employed. Since a typical command load will contain operations for a series of revs, loading on each rev may not be necessary especially on ERTS A where sophisticated use of detailed weather forcast data is not seen as required. However, as experience is gained in use of weather data, more frequent command loadings may be desirable to ensure sensor operations responsive to weather forecast information, if faster response is proven to give more effective results.

8.2.5 OCC SUBSYSTEM OPERATION

The preceding sections have defined the OCC in terms of its functions, interfaces, performance requirements and the time constraints imposed on that performance. This section carries the operation concept to the next level of subsystem and operating personnel functions. It lays the basis for the training and operational documentation requirements in the sections that follow. In all these sections, the equipments and operating concepts fit in exactly with existing and/or planned NASA facilities and procedures. Thus, the OCC, although optimized for ERTS, presents a standard network interface. It thus allows NASCOM, NETCON, OPSCON, MSFNOC and Remote Site personnel to easily prepare for and support ERTS operations.

8.2.5.1 System Scheduling

The System Scheduling Subsystem involves determination of sensor operations that will effectively utilize the data collection capability of the spaceborne observatory and the scheduling of necessary system operations such as tracking, orbit maintenance, and ground station contacts.

The System Scheduling Subsystem of the OCC generates an overall system activity plan based upon coverage requirements, spacecraft and payload status, network availability, and environmental constraints. The activity plan produced must be a time-ordered list of spacecraft, payload and network events that do not violate any operational constraint imposed on the ERTS system.

The System Scheduling Subsystem is primarily a nonreal time, data-base oriented, software system.

The System Scheduling Subsystem accepts the various coverage and scheduling requests and other data interfaces and proceeds through the development of the payload and orbit adjust activity plans. These are integrated, approved, and passed to Command Generation via the Data Base. The design makes use of cloud cover mission planning models which can be readily integrated into the operational on-line planning sequence when sufficient confidence in them is gained.

The operation of the System Scheduling Subsystem is done in two basic modes:

1. An off-line pre-processing mode

2. Scheduled pass support mode

Figure 8.2-7 depicts the System Scheduling Operational Flow.

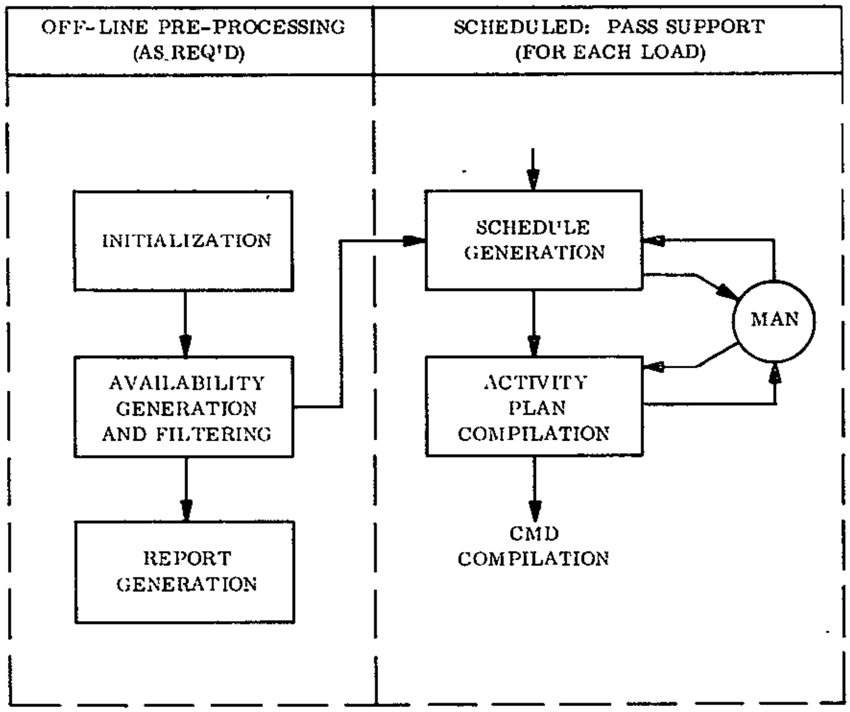


Figure 8.2-7. System Scheduling Operational Flow

8.2.5.1.1 Off-Line

The off-line pre-processing mode primarily involves the initialization of the software system. This is required to update data base files, to reflect spacecraft status, current coverage requirements, orbit updates, and current operations philosophy. Once the system has been initialized, the coverage requirement availability is generated and filtered for such things as sun angle, etc. Since the orbit is stable and coverage requirements remain relatively static over reasonable periods of time (day(s)), it is necessary to generate the availability list only periodically (once per day at a maximum). As part of this off-line process, a series of reports will be generated containing maps, plots, and potential sensor operating regions. By use of these reports, the System Scheduler can prepare preliminary plans and assess overall projected coverage opportunities.

The actual selection of sensor operating schedules and ultimate completion of the comprehensive activity plan is normally scheduled prior to each station pass sequence. The implementation of this function at this time affords the opportunity to integrate latest weather forecast into the schedule.

During the off-line use of the system, the System Scheduler can and will generate an overall activity plan using either long range weather forecast information or no weather information in order to generate projected operational trends and gross plans for overall OCC scheduling.

8.2.5.1.2 Scheduled Pass Support Mode

Prior to each station pass where sensor operations are planned and/or a stored command load is scheduled, the System Scheduling System is employed to generate an activity plan. The starting point is the coverage availability profile that has already been generated off-line. At this point, the Command Generator factors in the weather forecast data and using the on-line sensor scheduling routines generates the sensor operating schedules. Once an acceptable schedule has been generated, the comprehensive activity plan is compiled.

The on-line process is a highly interactive process. The Command Generator is interacting with the computer via the keyboard and CRT display subsystem. This is necessary since the fine adjustments usually required to refine a final operating schedule and activity plan are better done by the man than by the machine. The machine performs the more mundane tasks and performs all the necessary calculations, but the man retains the final decision power.

Although the Command Generator will normally interact heavily during the process, the software is configured to produce a feasible plan without controller interaction. It is, therefore, possible to automatically generate an operating sequence and activity plan.

8.2.5.2 Command Operations (Figure 8.2-8)

This section presents the command philosophies and the operational procedures involved in commanding the ERTS spacecraft through the MSFN and STADAN sites. For normal operation, complete command control and verification is accomplished in the Operations Control Center. There are also provisions for backup commanding in the event of a failure in the prime command loops. Command hardware and software descriptions are included with operational considerations being emphasized. Real time commands, real time command sequences and stored command functions are presented in this section.

8.2.5.2.1 Command Function Hardware and Software

A. Spacecraft. The command/clock system selected for the ERTS is that used on the Nimbus D vehicle. The on-board STADAN VHF command receiver is redundant and conforms to STADAN standards. The 128 bps Frequency Shift Keyed (FSK) uplink consisting of 50 bits per command is fed to the Command Integrator Unit (CIU). This unit serves as an isolation device for the MSFN/STADAN commands and feeds the ERTS command clock. The MSFN will command on the USB uplink by sub-bit encoding data on a 70 kHz SCO. These sub-bits are in the form of 1 and 2 kHz phase-shift keyed (PSK) audio signals. The uplink sub-bit rate is 1000 bps and, since five sub-bits per data bit encoding is chosen, the uplink data rate from MSFN is 200 bits/sec. Both VHF and MSFN redundant systems can operate with only one prime system activated. In the event of a prime command system failure, the operating command system can select the redundant command system.

B. Operations Control Center

1. Consoles. Two consoles in the operations control room will include a command panel for entry of real time commands and sequences of real time or stored program commands. The command console will be the prime commanding location. The Operations Supervisor

console, containing the other command panel, is also capable of sending commands once properly selected as the commanding source. All commands will be entered from the selected command panel. No commands will be entered via the keyboard associated with these and other consoles. Provision for entry of a limited number of discrete commands via push buttons exists at the command panel.

2. Command Generation Software. The Command Generation Software Subsystem compiles the spacecraft command list based upon the activity plan generated by the System Scheduling Subsystem. It then blocks and formats these commands and outputs them to the NASCOM for transmission to the spacecraft. This subsystem consists of two applications software packages, the Command Compiler and Command Management Programs, which operate in the OCC computer.

Command Compilation. The function of the Command Compiler Program (CCP) is to translate desired spacecraft events, defined in the activities plan, into the appropriate spacecraft command sequences which will cause those events to occur.

The CCP will function in the nonreal time environment only as it provides no functions required in the on-line data acquisition phase.

The input to the Command Compiler is the Activity Plan generated by the System Scheduling Subsystem. This activity plan resides in the OCC data base and will be accessed by orbit at program execution time.

For each event listed in the Activity Plan, the CCP will generate the required command or sequence of commands to perform that event. The output of the CCP Command Compiler will be a report which combines the spacecraft events and their associated commands. For each requested activity, the desired time of occurrence will be compared with the predicted RT acquisition window of this orbit. If the event is to occur within this window, real time commands (RTC's) will be generated. If the activity is to be performed outside the RT acquisition window, stored commands will be provided.

Optimization of command lists is designed to exclude transmission of commands which would put the spacecraft into a configuration which should already exist. This will be done by predicting the status at the next acquisition based upon the last known status and the commands transmitted during the past acquisition. Further optimization will be done to ensure that two or more stored commands would not be transmitted to perform a function which could be accomplished using one stored command with a repeat time.

The command list resulting from the processing is stored in the data base for use by the Command Management Program. A report summarizing the activity plan events and the commands compiled to execute those events will be generated for review and approval.

Command Management. The Command Management Program (CMP) will provide for the creation, storage, retrieval and transmission of all prestored command sequences. The module will be run in the on-line real time mode of the system. When requested by the command console operator, the CMP will retrieve a specified command sequence from the data base for transmission. Before actually transmitting the selected sequence, the CMP will examine the commands in the sequence to determine if the sequence contains any of the "critical" commands. If a critical command does exist, the operator will be informed via an alarm display and the operator will have the option of continuing or aborting that transmission before the critical command is sent. A critical command is defined as one which is an irreversible function or a command which affects the existence of the spacecraft. The CMP will then compute the delta times required for any stored program commands in this sequence. Then the real-time commands and stored program commands, the command numbers, execution deltas, with their delta time tags, mode bits and status indicators are polynominally encoded for the NASCOM 494 computer. Polynomial encoding is performed by algorithm to provide a means of transmission quality testing in the 494 computer. The encoded command sequence will then be segmented into 600 bit data blocks with NASCOM routing headers.

Unencoded copies of all commands transmitted will be made available in real-time to the PCM processing subsystems programs, which are co-resident in the computer system, for verification of command execution.

3. NASCOM. The 600-bit command block(s) is transferred to the NASCOM 494 communications processor via the 303 MODEM interface at a 50-kbps rate. The 494 communications processor will inform the OCC as to the transfer status of the command block(s) via the same 303 MODEM interface. The NASCOM header information will determine the routing of the command block to the selected site. The data transfer for all sites is accomplished using 203 MODEMS at a 4.8 kbps rate. Remote site handovers will occur during prime site mutual acquisitions which will be predictable and will be handled in a routine fashion.

The anticipated handover time will be determined well in advance of the upcoming first station contact by the Operations Supervisor. Normally, this decision would be made during the real time Command Sequence and Stored Command load generation pre-pass. The OC would inform the M&O to perform the handover function at a definite time during mutual station contact. Prior to the actual handover, the M&O will inform all OCC personnel (on a closed circuit loop (CCL)) of the upcoming station handover. This action is accomplished via the M&O console.

4. MSFN. The MSFN sites will receive the command data at the compatible MODEM and will route the data to the data transmission unit (DTU) which interfaces with the 1299 switchboard. Upon receipt of command data at the 642B computer, certain checks are made for address, format, polynomial bits, etc. If the command data is correct, the 642B will stip off the site address, polynomial bits, and the filler bits which were inserted at the OCC to make up a 600-word block.

The actual command bits containing sync, vehicle address key, mode, command and other bits are sub-bit encoded by the 642B computer for transmission to the updata buffer. The command is then routed through the remaining command equipment for transmission on the USB uplink. Sub-bit encoded (five sub-bits per data bit) command is transmitted to the ERTS on the 70 kHz subcarrier oscillator (SCO) at a sub-bit rate of 1 kbps.

STADAN. The selected STADAN site receives the command data in much the same fashion as the MSFN site. The 600-bit block arriving at the 4.8 kbps MODEM is routed to the Data Transmission System (DTS). The DTS acts as a bit stripper, removes the header information and polynomial bits, as well as the filler bits, and sends the command bits to the "new" STADAN encoder.

The output of the STADAN encoder is sent to the VHF command equipment for data transmission at 128 bits per second.

Command Verification Echo Check. Both the MSFN and STADAN will have "echo" check capability, thereby comparing bit for bit the command as it is being transmitted. If an error is detected, the command is stopped and retransmission of the command must be accomplished from the OCC by retransmitting the command(s).

Command verification of real time commands is accomplished at the OCC by monitoring the appropriate TLM parameter associated with the command. Stored commands are normally verified by employing the COMSTOR verify function. The contents of COMSTOR are compared with the uplink and, if a correct load has been received, the selected COMSTOR is activated permitting the stored commands to be executed at the appropriate time. The actual execution of stored commands is verified by the playback of the narrowband tape recorder which has recorded these executions.

In summary, all command data is originated, stored, and transmitted from the OCC. The remote sites "relay" in real time all types of commands received from the OCC through the NASCOM interfaces. Echo checks are performed at the remote stations and a fault ceases transmission of commands. All command verification is accomplished at the OCC.

8.2.5.2.2 ERTS Command Operations

A. Real Time Commands. Real time commands will be those selected to be transmitted and acted upon immediately by the ERTS spacecraft. All real time commands are stored in the OCC CPU for transmission to selected remote sites upon request from the command controller. Single real time commands are requested for transmission by performing a specific "enter" action at the command panel. A display is provided of the selected real time command on a CRT display showing the command number and the English translation of the command function. If the command is not categorized as a critical "inhibited" command, the command transmission is activated by depressing the transmit button on the command panel. The 600-bit command block containing NASCOM header information, i.e., sync, selected site ID and polynomial protection bits, command and filler bits, is transferred to the OCC communications processor.

The OCC communications processor acts as the OCC interface unit to the NASCOM 303 MODEM in the OCC. A 50 kbps transfer takes place as a function of the 303 MODEM 50 kbps clock. The command block is checked for proper header and polynomial protection by the polynomial buffer terminal and is routed to the GSFC 494 communications processor. The GSFC communications processor will provide the OCC status as to the incoming 600-bit block command data and will route the command to the selected MSFN or STADAN site. This command data is transferred to the remote site via 203 MODEMS at a 4.8 kbps rate in 600 bit blocks. A minimal delay is expected (i.e., 200 ms delay) through the 494 and the receiving 203 MODEM at the remote site.

1. Real Time Commands via MSFN. The real time command received at the selected MSFN site at the 203 MODEM is transferred to the data terminal unit associated with the 642B command computer. The 642B command computer will function somewhat unlike the mainline Apollo command request since the incoming data contains actual command information rather than computer execute functions. Superfluous command bits such as the NASCOM header information, polynomial protection, and filler bits will be stripped off as a function of the 642B command computer software assuming that the polynomial protection is correct. If the polynomial protection is not deemed acceptable by the 642B computer, the command is rejected and not processed and the status information is forwarded to the OCC via the 203 MODEM interface. However, if the command block is accepted by the 642B computer, the 50 bit command is relayed to the updata buffer sub-bit encoded to five bits for each command data bit preceded by a minimum of 13 zeros and a "one" bit for the required sync pattern. The sync and command data is then input to the 70 kHz SCO for uplink to the spacecraft at 1000 sub-bits per second, which is 200 data bits per second. The 70 kHz SCO is uplinked on the unified S-band at 2106.4 MHz.

2. Real Time Commands via STADAN. Selected STADAN sites will receive the 600-bit command block via a 203 MODEM in the same fashion as the MSFN sites. The 4.8 kbps command data burst is routed to the data transmission system which acts as an interface to the "new" STADAN encoder. The encoder will check for proper format and polynomial protection of the command block. Assuming the command data is correct, the 50-bit real time command is transmitted on the ERTS assigned VHF frequency (154.2 MHz). All single RTC's are preceded by at least 13 zeros and a "one" to establish synchronization with the ERTS command clock. Command status information from the STADAN encoder is fed to the DTS for transmission to the OCC via the NASCOM interfaces. The STADAN command transmission rate is 128 bits per second using Frequency Shift Keyed (FSK) type of modulation. Real time command sequences are covered in stored command operations.

B. Real Time Command Verification. All real time commands will be verified at the OCC either by RT telemetry or by functional verification of an execute, i.e., TLM transmitter ON/OFF, RBV ON/OFF, MSS ON/OFF. Certain selected command functions will be verified on brush and event recorders. However, all command verifications instrumented in the TLM downlink will be displayed on the CRT's. Although real time telemetry processing will be discussed later in the spacecraft evaluation segment of this section, it should be noted that TLM verifications of real time command will be delayed dependent on three factors: (1) when the TLM parameter is sampled in the versatile information processor (which by itself could be a maximum of 16 seconds after the fact); (2) delays encountered in the two-way RF transmission (uplink/downlink); and (3) delays encountered in the command and telemetry processing ground systems at the remote stations, NASCOM interfaces and the OCC. Nominally, the time delay between the time the command leaves the OCC until the last command bit is radiated (including command sync preceding the command) is less than one second. Anticipated command and command verification delays are presented in Table 8.2-2.

Table 8.2-2. *Anticipated Command & Command Verification Time Delays*

		Real Time Command								Stored Commands							
		MSFN				STADAN				MSFN				STADAN			
		Delay		Cumulative		Delay		Cumulative		Delay		Cumulative		Delay		Cumulative	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Command Transmission Request (OCC)	N/A																
CPU	N/A			< 0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec	
CP	< 0.01																
303 MODEM Transfer		0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
491 CP Delay		0.015	0.750	0.027	0.762	0.015	0.750	0.027	0.762	0.015	0.750	0.027	0.762	0.015	0.750	0.027	0.762
203 MODEM Transfer		0.125	0.125	0.152	0.887	0.125	0.125	0.152	0.887	0.125	0.125	0.152	0.887	0.125	0.125	0.152	0.887
Remote Site Command Equipment	< 0.01																
RF Transmission Time		*0.320*	*0.320*	*0.472*	*1 207*	*0.500*	*0.500*	*0.652*	*1.387*	*4.320*	*4.320*	*4.472*	*5.207*	*6.750*	*6.750*	*6.902*	*7.637*
RF Propagation		0.003	0.008	0.475	1.215	0.003	0.008	0.655	1.395	0.003	0.008	4.475	5.215	0.003	0.008	6.905	7.645
Spacecraft Execution		0.010	0.050	0.485	1.265	0.010	0.050	0.665	1.445	0.010	0.050	4.485	5.265	0.010	0.050	6.915	7.695
VIP		0.010	16.000	0.495	17 265	0.010	16.000	0.675	17.445	0.010	16.000	4.495	21.265	0.010	16.000	6.925	23.695
RF Propagation		0.003	0.008	0.498	17.273	0.003	0.008	0.678	17.453	0.004	0.008	4.499	21.273	0.003	0.008	5.928	23.703
Remote Site TLM Equipment		0.500	0.500	0.998	17 773	0.500	0.500	1.178	17.953	0.500	0.500	4.999	21.773	0.500	0.500	7.428	24.203
203 MODEM Transfer		0.125	0.125	1.123	17.898	0.125	0.125	1.303	18.078	0.125	0.125	5.124	21.898	0.125	0.125	7.553	24.328
494 CP Delay		0.015	0.750	1.138	18.648	0.015	0.750	1.318	18.828	0.015	0.750	5 139	22.648	0.015	0.750	7.568	25.078
303 MODEM Transfer		0.012	0.012	1.150	18.660	0.012	0.012	1.330	18.840	0.012	0.012	5 151	22.660	0.012	0.012	7.580	25.090
CP		0.010	0.010	1.160	18.670	0.010	0.010	1.340	18.850	0.010	0.010	5.161	22.670	0.010	0.010	7.590	25.100
CPU		*0.100*	*0.100*	1.260	*18.770*	*0.100*	0.100	1.440	18.950	0.100	0.100	5.261	22.770	0.100	0.100	7.690	25.200
Display (Verification)		0.050	0.050	1.310	18.820	0.050	0.050	1.490	19.000	0.050	0.050	5.311	22.820	0.050	0.050	7.740	25.250
TOTALS (SECONDS)		1 310	18 820	1.310	18.820	1.490	19.000	1.490	19.000	5.311	22.820	5.311	22.820	7.740	25.250	7.740	25.250

NOTES:

1. Stored command transmission time is for 17 commands to one COMSTOR, 2 RTC's and 15 stored commands. If both COMSTORs are filled uninterrupted, add 4.320 and 6.750 seconds for MSFN and STADAN, respectively.

2. Display represents TLM verification of commands.

3. 203 MODEM transfer does not include high speed data transfer through relay satellites as would be encountered by some backup MSFN sites.

C. Stored Commands and RTC Sequences. Detailed explanations of the OCC command software are contained in Books 4, 5 and 6. This section, however, will place emphasis on the operational aspects of formulating and transmitting stored commands to the ERTS spacecraft.

1. OCC Command Generation. Stored commands may only be originated from the OCC Central Processing Unit (CPU). Loads are made up in the OCC computer in a somewhat automated fashion. The system scheduling software will provide the activity plan (or selected portions thereof, based on the Revolution Span of interest) to the command software (command compiler). A command list is generated for CRT display and hard copy may be obtained via high speed printer if required. The command operator and the operations supervisor may edit or modify the stored command or RT sequences. Stored commands will be displayed showing anticipated GMT of executions and the English translation of the command functions. RT command sequences will be displayed with English translations of each command. Those RTC's categorized as critical (inhibited) will be flagged for evaluation. The commands are optimized and maximum utilization of the recycle command capability is used, thereby conserving on the number of commands required to perform like functions. The recycle feature of the ERTS command system allows the re-execution of commands an indefinite number of times. A command may begin to recycle anytime from two seconds to somewhat over 9 hours after the initial execution of the stored command. This initial execution time may occur up to 18 hours after load.

Command instructions needed to define stored loads or RTC sequences are normally input via the keyboard although provisions are afforded on the command panel to perform certain command generation functions. Once the command sequences are approved by the operations supervisor and the command operator, these sequences are stored in a "protected" storage area in the OCC computer.

2. OCC RTC Sequence Transmission. The maintenance and operations supervisor (M&O) will select the remote site scheduled for support of the upcoming stations contact via the M&O console. Proper OCC equipment configurations are verified and the OCC computer is informed of the selected remote station. Following acquisition of signal (AOS) of the ERTS telemetry, status checks are performed on the spacecraft to ascertain proper state of health and operation mode. Normally, the command operator will be the person in the OCC initiating commands. An approved RTC command sequence would normally be sent to the spacecraft prior to the initiation of a stored load. The RTC sequence will be initiated by first calling up the sequence from the OCC computer via the command panel. A CRT display will provide a final check of the sequence of RTC's. Depressing the appropriate push button on the command panel, the RTC sequence is transferred to the OCC communications processor in 600 bit blocks. These blocks will contain the appropriate NASCOM header which contains NASCOM sync information, selected site identification, command bits, polynomial protection and filler bits. The command blocks are transferred to the GSFC polynomial buffer terminal at a 50 kbps rate as a function of the 303 MODEM interface. The polynomial buffer terminal and the 494 communications processor will check that the polynomial protection bits are correct (nominally 33 bits) and will provide a status to the OCC computer via the 50 kbps

MODEM interface. The 494 routes the incoming 50 kbps 600 bit command blocks to the 203 MODEM assigned to transmit to a specific remote site. The remote site, whether MSFN or STADAN, would transmit an uninterrupted string of RTC's to the ERTS spacecraft if the command blocks are deemed correct.

3. OCC Stored Command Transmission. A compiled stored program command load which is identified by a sequence number is normally called up by the command operator. This is accomplished from the command panel on the command operator's console. A final review of the command load sequence, which may only be addressed to one of the two COMSTOR's (memory) in the ERTS vehicle, is performed by the operator. The display will show the command numbers, the English translation and the expected GMT of execution. The next action performed is the depression of the stored command execute push button. The OCC computer then performs a time calculation in order to insert the proper delta time tag for each command. The time the transmit button was activated, the selected site which will radiate the command, ground equipment delays encountered in transferring the command data, the remote site transmission rate, uplink RF propagation delay, the number of commands preceding the COMSTOR verify RTC, the anticipated time of COMSTOR verify entry in the command clock, and finally anticipated GMT of execution of each command are all factors considered in inserting the proper delta time into each stored command.

Countdown of a stored command is begun by the COMSTOR verify RTC which decrements the selected COMSTOR in 16-second intervals or by the activate RTC which counts down the selected COMSTOR every 2 seconds. Although each COMSTOR decrements in two-second intervals, 1-second granularity is accomplished using both COMSTORS since each is decremented on even and odd seconds, respectively.

The stored command sequence contains an RTC, which selects the desired COMSTOR to be loaded, up to 15 stored commands, and the COMSTOR verify RTC. The sequence is formatted in 600-bit blocks and transferred to the OCC communications processor. The routing of the command blocks containing the same type of information as the 600-bit blocks used for the RTC's, are treated exactly the same by NASCOM equipments and the remote stations. Since the remote stations perform a buffering function for command blocks containing more than one command (whether RTC's or Stored Commands), a predictable transmission time of each command is possible due to remote site uplink data bit rate. MSFN will transmit commands faster than STADAN (i.e., 200 data bits per second versus 128 data bits per second). Status and verification of stored commands is the same as real time commands uplink through MSFN and STADAN sites.

D. Backup Commanding. In the event of a failure in the OCC computer preventing normal commanding from this computer, a backup mode can be employed. Special commanding software package is loaded in the OCC communications processor allowing transmission of real time commands. In this backup mode, stored commands cannot be transmitted. Display on the CRT will be primarily used for command approval, status, and verification.

It is planned that the NDPF computer will be software compatible with the OCC. Therefore, if the OCC is expected to be down for an extended period of time (i.e., greater than 1 hour) the NDPF computer may be cross-strapped to the OCC communications processor. In this configuration, all normal OCC functions may be accomplished including stored command generation and transmission.

1. Backup Command (Remote). Real time command capability will exist at MSFN and STADAN sites in the event commands cannot be transmitted to these sites. The MSFN sites will be directed by the OCC to select the local command mode. This is accomplished via the M&O (Remote) Computer Address Matrix (CAM). The M&O will send only those specific commands directed by the OCC. Display of command status will be accomplished on the M&O high speed printer at the remote site. TLM verification of command executions will also be available at the MSFN sites. STADAN sites may send real time commands locally using the "new" STADAN encoder. Display of command status is also available on this encoder command panel. STADAN also has the capability of displaying TLM verification parameters when requested.

E. Command History

1. OCC. The OCC will normally maintain the ERTS command history for all commanding. Display of command history is provided by the CRT's and hard copy is available.

2. Remote Sites. Both MSFN and STADAN will record all transmissions to the ERTS spacecraft. Normally these records of command transmissions will not be required by the OCC. When requested, remote site command history information will be forwarded to the OCC either by voice or by teletype circuits.

8.2.5.3 Spacecraft Evaluation

Figure 8.2-8 (see Section 8.2.5.2) shows the flow of real time and playback narrowband PCM telemetry. All MSFN/STADAN sites supporting ERTS will have the capability of relaying in real time ERTS RT PCM data. All remote sites except for the NTTF will send the RT data over NASCOM circuits interfacing with the GSFC 494. Alaska and NTTF will be capable of sending the 24 kbps dump in real time to the OCC for processing. Backup MSFN/STADAN sites will transfer dumped data to the OCC post-pass by playing back the recorded data at a slower rate compatible with the NASCOM 4.8 kbps interfaces.

The following describes the PCM data flow from the spacecraft to the OCC displays. Table 8.2-2 showed anticipated delays in the PCM downlink commencing with the VIP through to the displays.

8.2.5.3.1 Spacecraft

Real time and dumped PCM can be downlinked via the VHF transmitter and by the USB. The VHF transmitter will normally downlink RT PCM split phase at 1 kbps. All assigned backup STADAN sites are capable of receiving this downlink. The VHF transmitter is also capable of transmitting the 24 kbps dumped PCM data during emergency situations. The VHF transmitter power is increased in order to maintain a reasonable S/N ratio for the increased bit rate. Little usage of this mode is expected since the normal method of dumping will be over the USB downlink. The normal configuration of the USB downlink, as pertains to PCM data, will be to place the RT PCM split phase on the channel 13 IRIG VCO which is mixed on the 1.250 SCO. The dumped 24 kbps data is placed on a 576 kHz SCO. These data are combined for simultaneous transmission over the USB 2287.5 MHz downlink carrier. The USB system is completely redundant and affords several modes of operation. All sites, with the exception of the backup STADAN sites, are capable of receiving and displaying the PCM data received in the USB downlink. The on-board PCM processor is the Versatile Information Processor (VIP) used for Nimbus. The VIP will be programmed for the ERTS needs and will contain 20 columns and 80 rows, 10-bit words downlinked at 1 kbps. The first two columns will contain a unique sync pattern for each row and a third column will contain the incrementing minor frame ID (1 to 80). A major frame period is 16 seconds, while the minor frame cycle is 5 minor frames per second for RT PCM. The dumped PCM is downlinked in reverse, i.e., newest recorded data is dumped first by running the tape backwards.

8.2.5.3.2 Remote Stations

A. Alaska. Real time PCM can be received on both the VHF and USB downlinks at Alaska. The noncoherent USB downlink will contain both the real time and dump PCM. The RT PCM contained on the IRIG channel 13 and mixed on the 1.250 MHz SCO will be demodulated, discriminated, and filtered. This 1 kbps split-phase RT PCM signal will go to two interfaces: (1) to the DHE which will allow local display; and (2) to the DTS for transmission to the GSFC. The 1 kbps PCM will be routed to the GSFC 494 CP. (See STADAN RT PCM for further details). RT PCM will then be routed to the OCC Communications Processor via the Communications and Data Distribution Subsystem. It should be noted that all data arriving at the GSFC X144 data terminal is recorded.

Dumped data normally received on the USB downlink at Alaska is transferred to the GSFC via the X144 data terminal. Once the 24 kbps data is extracted from the 576 kHz SCO, the dumped data is routed to the X144 data terminal for real time transmission to the GSFC X144 terminal. The dump data is recorded on the OCC recorder for post-pass playback into the OCC communications processor. The dumped data will be analyzed in near RT which allows assessing of the previous orbit's data. Events which should have occurred while not over a receiving station are verified and decisions of a go/no-go nature are made for future events planned.

B. Corpus. Corpus will receive the RT PCM on the USB downlink. The 1 kbps PCM is extracted from the USB by demodulating the 1.250 MHz SCO and discriminating the data out of the IRIG channel 13. The output of this subcarrier discriminator is fed to one of the three PCM ground stations through the data switching and distribution unit (DSDU). The selected ground station (EMR or Dynatronics) will decommutate the RT PCM and will provide local display. These local displays are in the form of PCM count readout display on the Decom itself, as well as brush event recorder displays, meters, lights, etc., which are fed by the PCM ground station. The PCM Decom will also feed the 642 BTLM computer with RT PCM data, sync, and frame information. The 642B TLM computer will have the capability of outputting selected PCM parameters to the Maintenance and Operations (M&O) high speed printer. These TLM points may be displayed in percent full scale (PFS), PCM count, or in engineering units (EU). Special computations may be performed (if required) to display alarm conditions, reports by event, trend data, etc. The major function of the 642B TLM computer, however, is to format the 1 kbps PCM data into a NASCOM format.

It is presently envisioned that the 642B computer will output 600 bit blocks of data to a 4.8 kbps MODEM. The 600-bit blocks will be transmitted to the GSFC via 4.8 kbps MODEMS (probably 203 MODEMS). The 4.8 kbps RT PCM data will arrive at GSFC through a compatible MODEM which feeds the GSFC 494 CP through a communication line terminal (CLT) and multiplexer. The 494 CP will buffer the incoming 600 bits and will transfer this data to a 303 type of MODEM at 50 kbps. The output from the GSFC 303 MODEM will feed an OCC 303 compatible (Duplex) MODEM. The 50 kbps output of the OCC MODEM feeds the OCC Communications Processor via the OCC patch panel and OCC switch.

The 50 kbps data containing NASCOM header information and RT PCM data is received by the OCC Communications Processor. The Communications Processor acts as an interface unit between the 494 and the OCC computer. The serialized input is then decommutated for display on the 50 kbps data containing NASCOM header information and RT PCM data is received by the OCC Communications Processor. The Communications Processor acts as an interface unit between the 494 and the OCC computer. The serialized input is then decommutated for display on brush and event recorders. The CP also provides the OCC computer with the necessary data to perform further computations on the real time PCM data. OCC driven displays, such as cathode ray tubes and high speed printers, provide evaluation personnel with the data required. Several advantages of interfacing the 494 CP with the OCC CP exist. An operational advantage is that certain data may be displayed on brush event recorders driven by this unit, even if the OCC computer is not functioning. Another advantage is that the OCC computer is not required to decommutate incoming data, thereby better utilizing core space (or permitting the use of a smaller OCC computer). Also, the OCC computer sees the same "type" of RT PCM data whether the data arrives over NASCOM interfaces, hardline outputs, or data terminal outputs. This simplifies RT data processing in the OCC computer.

Dumped PCM is not expected to occur frequently at the CORPUS site since Alaska and the NTTF will be normally receiving all narrowband tape recorder dumps. However, the 642B TLM computer is capable of formatting dumped parameters for post-pass transmission to the OCC. The recorded dumped PCM data is played back at a reduced rate to the OCC NASCOM circuits. The routing would be the same as the RT PCM.

C. NTTF. The USB downlink containing the RT dump PCM is received at the NTTF USB Receiving System. The RT and dump data is demodulated and discriminated at the NTTF. This RT-dump raw PCM is then fed to the hardline interface patch panel at the NTTF. The OCC hardline patch panel routes the RT PCM data to the OCC Communications Processor preceding the OCC computer via the OCC switch. The outputs of the processor feeds hardware display devices and also feeds the OCC computer for extended processing and display. NTTF then acts as the "front end" to the OCC, and provides back-up USB recording of the data.

D. Backup MSFN. Since RT dump PCM is downlinked via the MSFN, compatible USB and the back-up MSFN sites are configured similarly to Corpus; the method of recording, displaying, and transferring RT PCM data is accomplished in exactly the same manner for all MSFN sites. It is assumed that the back-up MSFN sites will have available the 642B TLM computer software.

No modifications are required or assumed for these back-up MSFN sites. Therefore, like Corpus, the back-up MSFN sites will have the capability of relaying RT-dump DCM over 4.8 kbps interfaces to the GSFC and to the OCC.

E. Back-up STADAN RT. The selected back-up STADAN sites will receive RT PCM only on the VHF downlink. The VHF receiver output will be 1 kbps RT PCM filtered in a split phase PCM format. This RT data will be fed to data handling equipment for local display. Also, RT PCM will be fed directly to the DTS. The DTS will format the 1 kbps RT PCM in a similar manner as the 642B computer for the MSFN sites. The output of the DTS will be 600 blocks containing NASCOM headers, and PCM data (1000 bits). These blocks will be transmitted to the GSFC 494 via 203 type MODEMS at 4.8 kbps. The same functions will be performed by the 494, 303 MODEMS, OCC Communications Processor, display and OCC computer as were performed for the incoming MSFN RT PCM data.

Dumped PCM data will not normally be received at back-up STADAN sites since the data is transmitted on the USB downlink. However, the VHF transmitter is capable of transmitting dumped data by increasing the VHF transmitter power to accommodate the 24 kbps PCM dumped data. If this emergency method were employed, the STADAN sites would record the dumped data and would play it back to GSFC over the 4.8 kbps interface by reducing the playback ratio to output a data rate compatible with the interface. This "slowed" dump data would interface with the DTS which would necessitate routing through the GSFC 494.

F. Console Operations. The five consoles located in the OCC Control Room contain many like functions. The OS and command consoles each contain a command panel capable of sending real time commands, real time command sequences, and stored command loads. Command panel selection is accomplished by the Operations Supervisor. There are two mobile strip chart recorders in the OCC Control Room which will display analog and event parameters. The CRT display at each console is capable of providing all CRT formats stored in the OCC format library. Each console will also have event lights which display specific indications of interest to each operational position. Off-line printouts and records are available to the Spacecraft Evaluator as required.

8.2.5.3.3 Spacecraft Evaluation Operational Considerations

A constant check of specific RT TLM parameters will be performed by the OCC computer and the Spacecraft Evaluators. Table 8.2-3 shows anticipated delays in command executions and TLM processing at the various elements between the VIP in the spacecraft and the display viewed of the OCC. The VIP, having a 16-second major frame and the OCC CPU outputting only the results of a major frame every 16 seconds, results in maximum delays as noted. The brush recorders driven by the OCC CP, however, will be updated in a quicker time frame since a major frame is not required for output.

A. Dump PCM. Normally all incoming Dump PCM is recorded on the OCC recorder for subsequent analysis. The same basic displays will be used for dump data as real time data. However, since dump data normally contains an entire revolution's worth of data, certain trend analysis and profiles will be generated. Analysis of this data will be in near-real time and the results will be maintained for long term analysis.

Table 8.2-3. Anticipated Command & Command Verification Time Delays

		Real Time Command								Stored Commands							
		MSFN				STADAN				MSFN				STADAN			
		Delay		Cumulative		Delay		Cumulative		Delay		Cumulative		Delay		Cumulative	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Command Transmission Request (OCC)	N/A																
CPU	N/A			< 0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec		0.01 Sec	
CP	< 0.01																
303 MODEM Transfer		0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0 012	0.012	0 012	0.012	0.012	0.012	0.012	0.012
494 CP Delay		0.015	0.750	0.027	0.762	0.015	0.750	0 027	0.762	0.015	0.750	0.027	0.762	0.015	0.750	0.027	0.762
203 MODEM Transfer		0.125	0.125	0.152	0.887	0.125	0.125	0.152	0.887	0.125	0.125	0.152	0.887	0.125	0.125	0.152	0.887
Remote Site Command Equipment	< 0 01																
RF Transmission Time		0.320	0.320	0.472	1.207	0.500	0.500	0.652	1.387	4.320	4.320	4.472	5.207	6.750	6.750	6.902	7.637
RF Propagation		0.003	0.008	0.475	1.215	0.003	0.008	0.655	1.395	0.003	0.008	4.475	5.215	0.003	0.008	6.905	7.645
Spacecraft Execution		0.010	0.050	0.485	1.265	0.010	0.050	0 665	1.445	0.010	0.050	4.485	5.265	0.010	0.050	6.915	7.695
VIP		0.010	16.000	0.495	17.265	0.010	16.000	0.675	17.445	0.010	16.000	4.495	21.265	0.010	16.000	6.925	23.695
RF Propagation		0.003	0.008	0.498	17.273	0.003	0.008	0.678	17.453	0.004	0.008	4.499	21.273	0.003	0.008	5.928	23.703
Remote Site TLM Equipment		0.500	0.500	0.998	17 773	0.500	0.500	1.178	17.953	0.500	0.500	4.999	21.773	0.500	0.500	7.428	24.203
203 MODEM Transfer		0.125	0.125	1.123	17 898	0.125	0.125	1.303	18.078	0.125	0.125	5.121	21.898	0.125	0.125	7.553	24.328
494 CP Delay		0.015	0.750	1.138	18.648	0.015	0.750	1.318	18.828	0.015	0.750	5.139	22.648	0.015	0.750	7.568	25.078
303 MODEM Transfer		0.012	0.012	1.150	18.660	0.012	0.012	1.330	18.840	0.012	0.012	5.151	22.660	0.012	0.012	7.580	25.090
CP		0.010	0.010	1.160	18.670	0.010	0.010	1.340	18.850	0.010	0.010	5.161	22.670	0.010	0.010	7.590	25.100
CPU		0.100	0.100	1.260	18.770	0.100	0.100	1.440	18.950	0.100	0.100	5.261	22.770	0.100	0.100	7.690	25.200
Display (Verification)		0.050	0.050	1.310	18.820	0.050	0.050	1.490	19.000	0.050	0.050	5.311	22.820	0.050	0.050	7.740	25.250
TOTALS (SECONDS)		1 310	18 820	1.310	18.820	1.490	19.000	1.490	19.000	5.311	22.820	5.311	22.820	7.740	25.250	7.740	25.250

NOTES.

1. Stored command transmission time is for 17 commands to one COMSTOR, 2 RTC's and 15 stored commands. If both COMSTORs are filled uninterrupted, add 4.320 and 6.750 seconds for MSFN and STADAN, respectively.

2. Display represents TLM verification of commands.

3. 203 MODEM transfer does not include high speed data transfer through relay satellites as would be encountered by some backup MSFN sites.

B. OCC. All incoming PCM data interfaces with the OCC Patch Panel. The Patch Panel is the electronic interface with the "outside world". The OCC switch receives PCM data and normally directs this data to the OCC Communications Processor and to the OCC recorder. The recorder has an obvious role in that a record is kept of all data which may then be played back to various subsystems within the OCC for subsequent analysis of data. Normally, incoming playback data received in real time from the NTTF and Alaska is recorded and played back for future processing. All real time PCM data is normally routed directly to the OCC Communications Processor for immediate processing.

C. OCC Communications Processor. The stand alone OCC Communications Processor acts as a PCM documentator, GSFC 494/OCC computer interface unit and the driver for Event Recorders and the Cathode Ray Tube displays. The Communications Processor also acts as a real time command source when the OCC computer is down.

D. OCC Computer. The majority of spacecraft parameters displayed in engineering units will be presented on the CRT displays located in the consoles in the Operations Control Room. Hard copy displays are available from the High Speed Printers in the OCC. The above functions are performed by the OCC computer. The OCC computer will also drive event lights on the OCC consoles which will display specific functions to each console operator. Parameter limits and threshold settings for CRT display are normally controlled by the Spacecraft Evaluators using the CRT keyboard. The Operations Supervisor approves changes to the CPU data base and normally these changes would be the result of recommendations forwarded by the Spacecraft Evaluator Supervisor.

8.2.5.4 Operations Control

8.2.5.4.1 OCC Equipment Configuration

All equipments in the OCC which are capable of being interfaced with other equipments are controlled by the Maintenance and Operations (M&O) Supervisor. This control is primarily accomplished by the M&O console located in the OCC. Several equipment configurations can be controlled as a normal function and as a result of a failure in one of the equipments.

Stations handovers are also handled by the M&O as directed by the Operations Supervisor. A description of the M&O console and its functions is contained in Section 6.4. The major equipment switching and control functions are as follows:

1. Alphanumeric terminal control
2. Timing signals
3. OCC recorder control
4. Signal conditioning equipment control
5. Strip chart recorder control
6. 303 MODEM control

The M&O will ultimately control all equipment configurations in the OCC either directly from the M&O console functions or by directing other M&O's to perform certain switching functions. Normally, direction to change equipment configurations will come from the Operations Supervisor.

The M&O upon direction from the OS would configure the OCC Communications Processor to interface with the NDPF computer if the OCC were to fault. In summary, cross-strapping and using redundant equipments in the OCC is accomplished by the M&O.

The console operators will select CRT and strip chart display formats independently from the M&O. CRT displays are selected via the Console Keyboard and the strip chart recorders' format. Selection will be accomplished locally at the recorders by selecting one of several available groups of parameters.

8.2.5.4.2 Operational Readiness Testing

Each subsystem is required to pass an operational readiness procedure (ORP) as part of the pre-pass readiness tests. All such tests are coordinated with the M&O prior to start of pass, and he will be notified of the successful completion and/or any malfunctions at the end of the test. These tests are to establish correct signal levels and verify satisfactory performance of equipment to be used during the pass.

Specific tests will be performed on each subsystem and operational interface within the OCC. Pre-pass readiness will establish confidence in data flows and data handling on all ground equipments, local and remote. Detailed testing requirements will be established during phase D for Command, Telemetry, DCS, Payload and Voice.

8.2.5.5 Payload Operations

8.2.5.5.1 Image Data Processing and Display

The Image Data Processing and Display Subsystem in the OCC provides the ability to monitor sensor operation during real-time NTTF station contact. This capability will allow real-time evaluation of payload operation and response to command. Because of the unique nature of the equipment, it will be provided as GFE. The location of this equipment in the OCC has a direct effect on many of the studies; i.e., facilities, operation, etc. The presently planned configuration is as shown in Figure 8.2-9.

The RBVC will image a 100 by 100 nm scene in three spectral bands on a storage-type photoconductor. This image content, with a maximum theoretical resolution of 4200 TV lines, will be readout in 3.5 seconds. Because the RBVC imaging is done by utilizing an exposure shutter, the individual picture-frames will be spaced 25 seconds apart to ensure between frame overlaps of about 10 percent. Although the three RBV cameras make a simultaneous exposure, the readouts are time multiplexed to increase the system readout efficiency. This results in a stream of data 11.5 seconds long, with the beginning of each frame spaced 25 seconds apart.

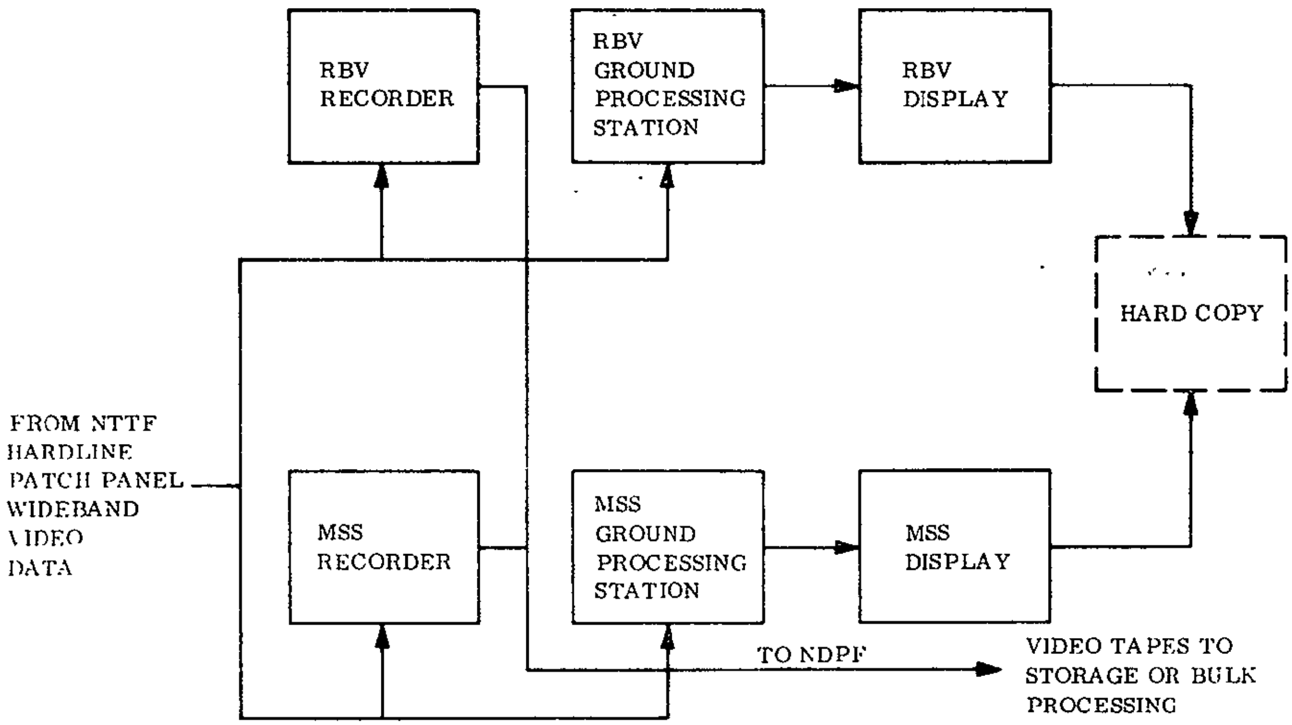


Figure 8.2-9. Image Data Processing and Display Subsystem (GFE)

The MSS images the same scene as the RBVC, but in four spectral bands (five for ERTS B). In turn, each spectral band utilizes six detectors and the scanning is done continuously at a sweep rate of 15.2 Hz, thus covering the 100 nm of sub-set track in about 28.6 seconds.

Because of continuous scanning, the imagery will not be interrupted as in the case of RBVC, but will be in a form of a continuous strip, without interrogation from the system turn-on to the turn-off.

The forming of the four spectral images, in contrast to that of RBVC where the three pictures were sequential, must be done simultaneously.

From the aforementioned, it can be clearly seen that the RBVC and MSS methods of picture display will be different.

8.2.5.5.2 RBVC Imagery Display
Considering the slowness of RBVC video signal, i.e., about 1250 lines/second, a coherent display of images is very difficult if high resolution pictures are desired.

From a supervisory applications point of view, the imagery does not have to be a very high resolution, as long as the condition of cameras focus will not be assessed or adjusted in orbit. This assumption does appear to be valid since the command listing does not include such functions for the RBVC. Based on the above assumptions, two methods of RBVC imagery display can be indicated, namely:

1. Cathode Ray Tube and Polaroid Camera

2. Cathode Ray Tube, Storage Type

A. Cathode Ray Tube with Polaroid Camera. The simplest and probably least costly method of RBVC image display is to use a high resolution CRT and an optically coupled large size film pack Polaroid camera. The elementrary block diagram of such a system is shown in Figure 8.2-10.

Basically, this system would require a high resolution CRT, such as Fairchild KC2619 or equivalent. This type CRT can maintain a very high resolution because of a 7.5 micrometer spot size in conjunction with a well regulated power supply and focus current regulator.

The round faceplate of the CRT is flat and is 5.25 inches (134 mm) in diameter. These features can accommodate a 1:1 aspect ratio image to a size of 3.5 inches without undue corner distortions. Considering the spot size, corner defocusing effects, aging, etc., it can be seen that average resolution compatible with that of RBVC can be assumed for this display. On the other hand, the flat CRT faceplate enables good quality Polaroid camera pictures to be taken.

The RBVC composite video signal is applied to the input buffer amplifier with a level adjustment capability subsequently amplified to the necessary level and applied to the cathode of the CRT with the dc component preserved. A portion of the composite video signal is applied to the sync separator circuitry to generate the necessary horizontal and vertical sync waveforms, as well as providing the drive to the regulated high voltage power supply and generator.

The dc power supply is regulated to minimize drifts and also supplies the precision focus current regulator required to maintain the focus and prevent spot size variations.

Coupled to the CRT is a large size film pack Polaroid camera mounted on a light-tight band with a viewing port for simultaneous monitoring purposes.

After performance optimization/check with a convenient test pattern generator before a satellite pass, the display device will be ready for acceptance of the RBVC signal. Since the CRT screen in absence of video is blanked (i.e., dark), the Polaroid camera shutter release can be depressed thus enabling the picture to be taken.

The incoming signal with its vertical sync interval will enable the drive and deflection circuitry, thus starting a picture on the CRT face. Simultaneously, the incoming video can be monitored for quality, etc., in an A-scope mode on an associated wideband oscilloscope, which can also have a Polaroid camera attachment for visual record purposes.

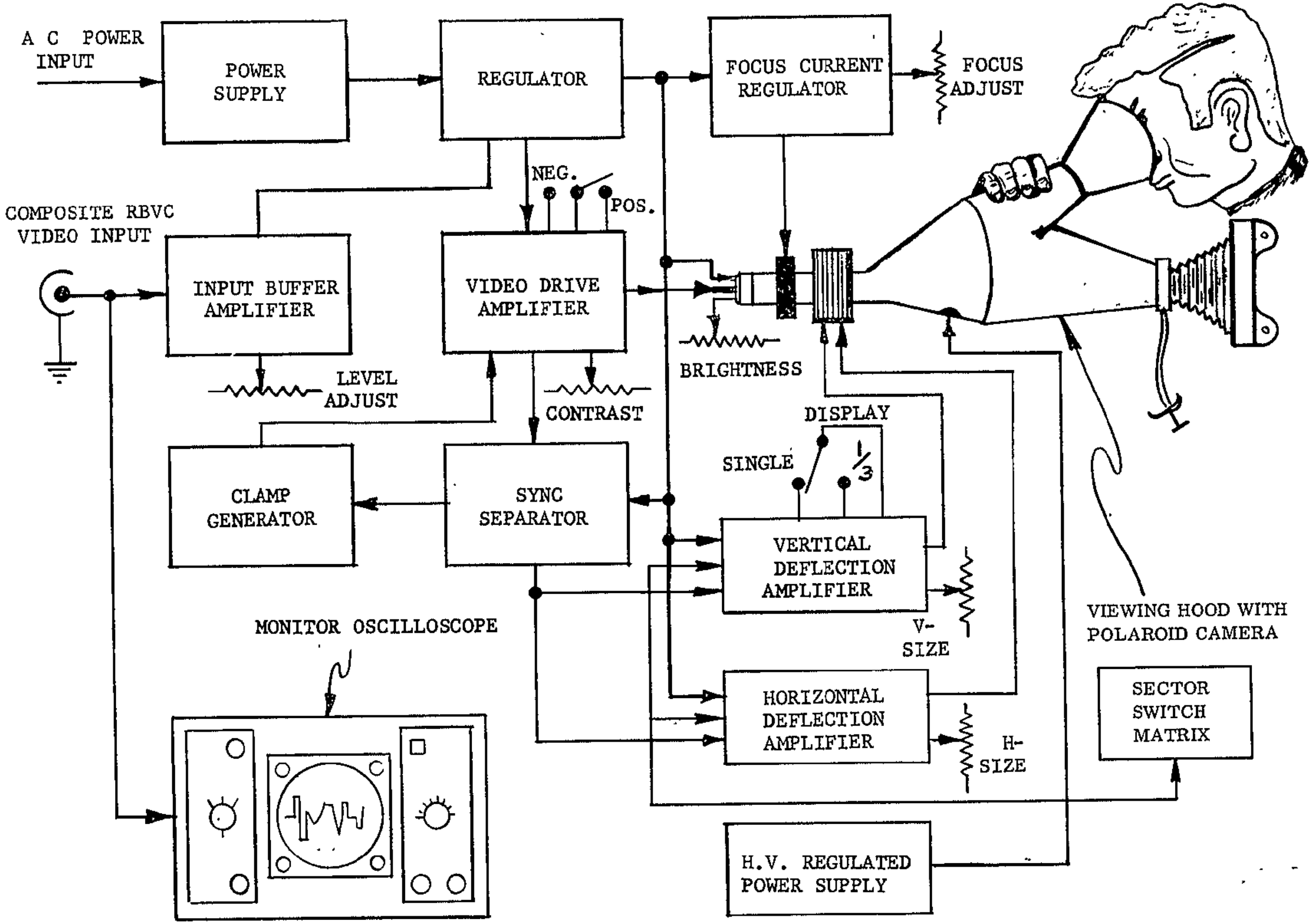


Figure 8.2-10. RBVC Video Display CRT and Polaroid Camera

At the end of each RBVC picture frame, the shutter is closed and one frame of RBVC video is obtained for a quick-look evaluation.

The three RBVC frames are separated by the 0.2-second-wide vertical interval signal pocket, too short to enable an operator to watch the next frame.

To overcome this difficulty, it is proposed to adjust the vertical sweep to 1/3 speed, or 11.5 seconds. This method will enable obtaining all three camera images on one Polaroid positive hard copy. Because this method will produce geometrically distorted images, a switch must also be provided to set vertical deflection to normal, single sweep, in order to be able to assess other vital imagery properties in a normal aspect ratio presentation.

Another variant of CRT display should incorporate an expanded mode, to examine in detail the individual sectors as delineated by the RBVC reticle pattern. This approach involves a selective display which operates by means of sweep expansion and a step-adjusted centering bias. Because of the needed x and y selective shifts, both the vertical and horizontal deflections must be involved.

Operationally, the most convenient method would be to utilize a pushbutton switch matrix. Depressing one switch within the whole "frame" would recall only that sector of the whole display. This approach is illustrated in Figure 8.2-11. The numbering of switches follows what is perhaps the most convenient method, i.e., that of a matrix numbering convention (rows 1 to 8, columns 1 to 8). The remainder of the area is not intended to be displayed, but this could be done in the same manner, by adding the appropriate number of switches. The resultant new matrix would similarly be renumbered.

The activation of the display should be interlocked to the vertical sync occurrence. This will prevent destruction of an "already" being displayed frame, but will preset the circuitry for the correct display in the following frame.

The usefulness of the A-scope presentation, as earlier indicated, will be configured for the inspection of signal qualities, such as:

1. Vertical sync interval contents (200 msec)

    a. Horizontal sync with 1.6 MHz (40 msec)

    b. Horizontal sync with Black Level (40 msec)

    c. Horizontal sync with 50 kHz (40 msec)

    d. Horizontal synch with Time Code (80 msec).

11	12	13	14	15	16	17	18
21	22	23	24	25	26	27	28
31	32	33	34	35	36	37	38
41	42	43	44	45	46	47	48
51	52	53	54	55	56	57	58
61	62	63	64	65	66	67	68
71	72	73	74	75	76	77	78
81	82	83	84	85	86	87	88

Figure 8.2-11. RBVC Display Sector Switch

2. Individual video lines (800 micro sec)

   a. Dc-level stability

   b. Block clipping

   c. Peak white clipping

3. Signal to noise assessments

4. Proper synch-signal characteristics checks.

The checks of calibration can also be made on the basis of Polaroid prints in a normal 1:1 aspect mode. This will be possible since all signals in the video input period will be visible on the print.

Knowing the prevalent Polaroid paper resolution characteristics, the following checks will be possible:

1. Time Code

2. 1.6 MHz waveform

3. 50 kHz waveform

4. Gray levels in "Calibrate" mode

5. Field flatness in "Calibrate" mode.

Should transparencies be desired, the Polaroid camera could be reloaded with this type of film and transparencies produced.

B. Cathode Ray Tube, Storage Type. This type display method is more convenient than the previous one, but it offers low resolution capability. On the other hand, its property to retain the image for over a period of RBVC frame duration is very attractive.

At present, the best resolution capability of this type of CRT is in the order of 4 lp/mm. The diameters are in the order of 10.5 inches (larger tubes are in existence but resolutions are poorer, thus no net gain is realized in this approach). To accommodate the 1:1 aspect ratio image, a 7.5 inch screen is available, which at best will produce a total resolution of only 1400 TVL.

In addition the dynamic range of storage of CRT's is shallow. At best, it will accommodate only six to seven 0.16 density steps. The block diagram is very similar to that previously described and is shown in Figure 8.2-12.

The descriptions and functions of individual blocks are very similar in nature to those described in the previous approach, and therefore are omitted.

As in the previous case, an A-line oscilloscope will be hooked-up for supervisory checks and will serve the same purposes.

Although at a first glance this type display appears to be very attractive, its use will be limited to a very coarse go/no-go type subsystem performance evaluation. Therefore, it is far less desirable.

To overcome the difficulty of low resolution performance, the video may be displayed in a "sector" form as to obtain and display only 1400 elements, or simply a portion of the frame at full resolution. This approach is fully explained in the section on the RBVC and would perform in exactly the same manner.

For data recording purposes, a viewing hood with a Polaroid camera will be of benefit.

At this point, it should be noted that this type of display is not an off-the-shelf item, and as far as it could be determined, other similar equipment does not exist in a readily adaptable system configuration.

8.2.5.5.3 MSS Imagery Display

Referring to the scan characteristics of MSS as indicated in Section 6.2, one can see that the MSS Imagery will arrive at a much slower rate than that of the RBVC. In addition, the

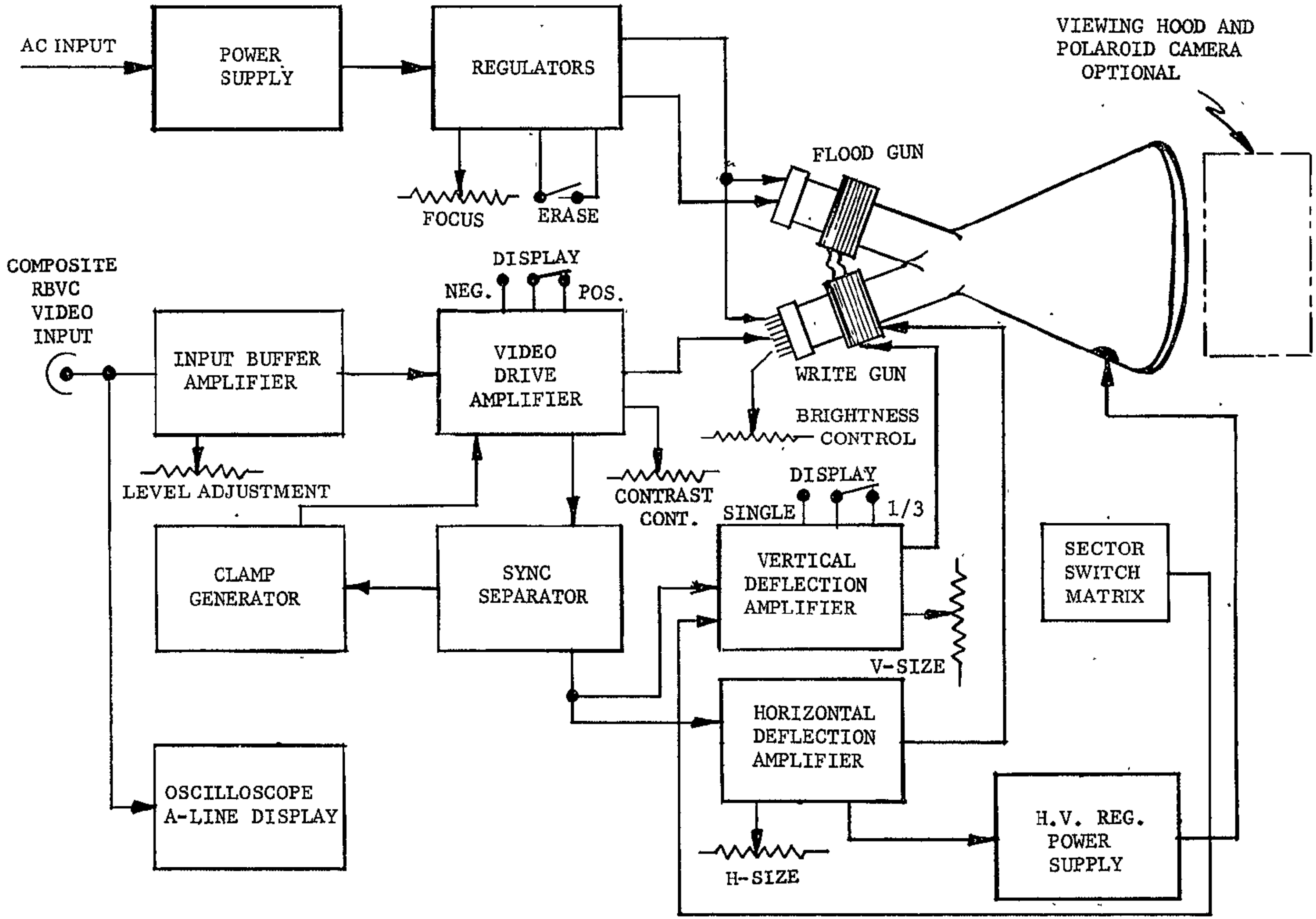


Figure 8.2-12. RBC Video Display, Storage Type CRT

total requirements on horizontal resolution element display are also lower, usually only 2640 cells. On the other hand, the vertical raster is continuous and is certainly of a small inconvenience in view of the OCC functions. As a result, the MSS display technique must be appropriately chosen to be able to maximize its utility. The possible methods of MSS imagery display can be as follows:

1. Facsimile strip

2. CRT partial display with Polaroid Camera.

A. Facsimile Strip Display. In essence, there are two basic facsimile display methods. The first method uses an electrochemical process on paper with an electromechanical video write and paper advance of one continuous paper strip. The length of a paper strip is limited only by the roll size, and therefore it is regarded as unlimited, which simply means a full recording of about 30 minutes in duration can be made quite easily.

One deficiency of this process is its limited dynamic range of density. But, in view of its use only as a supervisory type activity, it can be regarded as adequate. This display method, although feasible, requires modifications, mainly to make it compatible with the required data flow and to convert the parallel inputs from the six detectors to a single serial video.

This approach would involve a multi-track tape recorder (Ampex FR-1900, modified or equivalent) with a slow-down/playback capability and a suitable memory unit.

Should a simultaneous display of all four MSS spectral bands be desired, it can be accomplished by a partial display of each band or by providing four individual facsimile printers, parallel to serial converters.

The facsimile equipment is of the type manufactured by Muirhead Instruments, Inc., under the name of "Pagefax."

The second type of facsimile equipment uses a crater lamp light source to write on regular photographic paper in sizes up to 22 by 16 inches.

One significant feature of this equipment is its high resolution capability (about 70 elements/nm). Another feature, caused by the first, is the ability to accommodate up to four spectral band images in parallel on one sheet of paper. A special digital memory and associated electronics is required to accomplish this. The equipment has a capability of 15 gray scales of 0.16 density increments, but it is limited by the photographic paper to only 9 to 10 steps.

A significant advantage of this equipment is the photographic process that can produce either positives or negatives. The image must be developed externally to the instrument before it becomes stable and visible. Similarly, it cannot record the full pass of MSS imagery. This fact is not significant in view of OCC's supervisory function, thus not resulting in a continuous image display requirement.

One limitation of this equipment is the requirement that it be located in a darkroom, since the rotating drum, with attached photosensitive material, is unprotected except for a dust cover. In addition, loading and unloading must be performed in total darkness, because the rotating drum is not removable, but is an integral part of the facsimile. As a result, an adequately equipped dark room (film storage, water, drainage, air conditioned and inter-comm are required) will have to be provided and this will certainly decrease the efficiency of an overall payload supervisory function.

As in the case of the RBVC display, an on-line switchable A-scope is strongly recommended.

A representative example of facsimile equipment is the one manufactured by Litten Industries, Litcon Division, under the name of "Pressfac."

B. CRT Partial Display with Polaroid Camera. The method is similar to that described under RBVC displays, except that the scan speeds must be compatible with the MSS and vertical deflection, which should be proportionate to the 15.2 Hz rate of MSS scan.

The compressed frame feature is considered undesirable. Instead, it requires a vertical scan recycle in order to print out the continuous MSS video in the form of frames. This will introduce losses of data due to camera paper pulldown time and shutter triggering requirements. However, this is not regarded as a serious drawback.

Of a more troublesome nature is the fact that the four (or eventually five) spectral bands cannot be simultaneously accommodated on the same CRT screen. A solution to this problem would be to switch through the spectral bands during the satellite pass, always completing one full "frame" of image.

The system will also require a parallel to serial video data converter, as do the facsimile machines described earlier.

Signal quality evaluation can be performed by A-line oscilloscope display, in a similar manner as that described for the RBVC.

The storage CRT type display is of extremely low value for MSS image display, therefore, it has been dropped entirely from the MSS applicability considerations.

8.2.5.5.4 Sensor Payload Performance Evaluation

Evaluation of the performance of the RBV and MSS spaceborne payloads will be based on the utilization of three data sources.

1. Quick-look video display from the OCC Image Data Processing and Display Subsystem.

2. Narrowband PCM Telemetry Data from Payload Telemetry Points processed by the OCC PCM Processing Subsystem

3. High Quality Imagery generated by the NDPF Image Processing Subsystem.

The following paragraphs describe how each of the data sources will be utilized to provide maximum confidence in payload status, health and performance.

A. Evaluation Using Quick-Look Display. One of the most effective supervisory tools for assessing sensor performance is the formed image from the sensor itself. Unfortunately, the types of sensors used feature a low line rate video and do not lend themselves to a real-time display. Expedients, such as open lens camera attachments must be used to circumvent the inability of the human eye to integrate the slow scan signal and permit evaluation of the quality of the image and, therefore, sensor performance.

A camera, most conveniently a Polaroid system camera, coupled to a CRT display, can provide the integration of the data into picture information for evaluation by the human eye. Unfortunately, the time elapsed from the initial signal arrival to that of a completed picture is significant, but it is nearest to real-time evaluation of a full coherent frame.

Since a picture frame is composed of individual "lines" of electrical signals assembled on a basis of synchronizing signals, a correctly appearing picture will assure the supervisory personnel of proper operation of the camera. Any other displeasing effect in the obtained pictures is indicative of difficulties. A number of operational problems can be detected to some extent:

1. Geometric distortion (large percentages only)

2. Sync failures

3. Line dropouts

4. Interference of various kinds

5. Calibration signal status

6. Gray scale calibration (if provided in the sensor)

Others more or less obvious, but quite evident, to an experienced sensor performance evaluator can also be detected.

The second supervisory tool is certainly an on-line oscilloscope display, set up to show on its CRT screen the individual incoming signals. Based on familiarity with "good" signals, the anomalous signals can be easily spotted. Nevertheless, once the oscilloscope display shows defective signals, the hard copy picture will also be improper.

B. Evaluation Using PCM Telemetry Data. The second source of performance evaluation data is the processed sensor telemetry.

Telemetry evaluation, in general, is simple once the past history of given equipment is known and familiarity with it exists.

During the integration tests, strip chart recordings of sensor telemetry are made on a routine basis. Telemetry and calibration compendiums are compiled and contain waveforms that appear under all possible modes of operation. Similarly, during the real orbital playbacks, the strip chart recording is performed for both real-time and off-line directing and inspecting for signs of abnormal conditions.

More comprehensive data describing the overall operation of the payloads is generated by the PCM processing software described in Section 6.1. This software processes the payload telemetry in both real-time and from playback and produces a report of sensor performance which defines the operational profile of all sensor activities. In addition, the playback data is used to compute statistical and trend data required for long term performance evaluation.

C. Evaluation Using NDPF Imagery. The evaluation described in the preceding paragraphs was concerned primarily with the identification of anomalies in sensor performance which could endanger the spacecraft or could permanently impair the performance characteristics of the payload if timely corrective action was not taken. More detailed evaluation techniques are required to determine the correctness of the exposure time, or to examine jitter caused by degraded WBVTR performance. These factors cannot be detected at the quick-look level of evaluation, but must be done from a precise examination of high quality image.

The guidelines for evaluation will be firmly established once the real imagery from the respective sensors becomes available and in-test and integration experience is gained.

Similar tasks were performed on Nimbus A. The sensors, the Advanced Vidon Camera Subsystem, Automatic Picture Taking Subsystem, and High Resolution Infra-Red Subsystem, were all considered the "state-of-the-art" sensors and their image performance parameters were just as big unknowns as those of the ERTS payload today.

In spite of these unknowns, a comprehensive data evaluation manual was assembled and used for data evaluation personnel training. This manual was subsequently expanded and updated to include additional sensor equipments for Nimbus C. (Nimbus C Sensory Data Evaluation Guide, Contract NAS 5-9589, General Electric Spacecraft Department, Document No. 65SD4290, 15 April 1966).

A detailed sensor payload evaluation handbook will be prepared for the ERTS Program. Both the RBVC and MSS sensors and their operation will be described, as well as the functional meaning of miscellaneous defects that can occur in their images. The detailed description of how to identify these will be given and possible corrective measures will be provided. In addition, the correlation of these anomalies with telemetry printouts and waveforms will be described.

8.3 OCC ORGANIZATION, STAFFING, TRAINING AND MANUALS

8.3.1 ORGANIZATION AND STAFFING

The study results defining the OCC staffing required to implement the activities described in the preceding sections are presented below. Those positions recommended for staffing by Maintenance and Operations (M&O) personnel are designated (M&O) in Table 8.3-1. The organization of this staff is shown in Figure 8.3-1.

8.3.1.1 Administration

A. OCC Manager. The manager has the overall responsibility for the operation of the OCC and for the management of the assigned personnel. The manager will lead and direct OCC operations in a manner that is responsive to the requirements of the ERTS program.

B. Secretary. Office personnel will perform all routine office assignments and will provide clerical coverage during the day shift.

8.3.1.2 Off-line Organization

The off-line organization consists of the support personnel who are not engaged with the on-pass and inter-orbit spacecraft command and evaluation. Normal coverage will be on a one shift, five days per week basis.

A. System Scheduler. The System Scheduler is responsible for the scheduling of requirements, the generation of the spacecraft interrogation plan, and the command lists to meet the requirements of the program and users.

B. Ground Equipment Engineer. The ground equipment engineer will be responsible for the proper installation and integration of the OCC hardware. He will participate in the initial checkout and data flow tests involving the OCC and assure proper interfaces.

C. Computer Operations Supervisor. The computer operations supervisor has overall responsibility for the OCC computer(s) and assures that routine preventive maintenance is performed. He will also supervise the formulation and validation of the OCC computer programs.

D. OCC Systems Engineer. The systems engineer will address any problems which may arise between OCC and the computer operation and the NASA data processing facility. He will assist the computer operation regarding the various GDHS interfaces when required.

The systems engineer will also assist in the formulation of computer requirements and in the validation of programs.

Table 8.3-1. OCC Manpower Requirements (Case A and B)

Position Titles	Number of People	Number of Shifts (Case A & Case B)	Totals
Manager	1	1	1
Secretary	1	1	1
System scheduler	1	1	1
Ground equipment engineer	1	1	1
Computer operations supervisor	1	1	1
OCC systems engineer	1	1	1
Operations supervisor	1	4	4
M&O supervisor (M&O)	1	4	4
Computer operator (M&O)	1	4	4
Spacecraft evaluation supervisor	1	4	4
Spacecraft evaluators	2	4	8
Command operator	1	4	4
Data Technician (M&O)	2	4	8
Totals	15		42
		4 Shifts to cover 7 day per week, 24-hr per day operations	

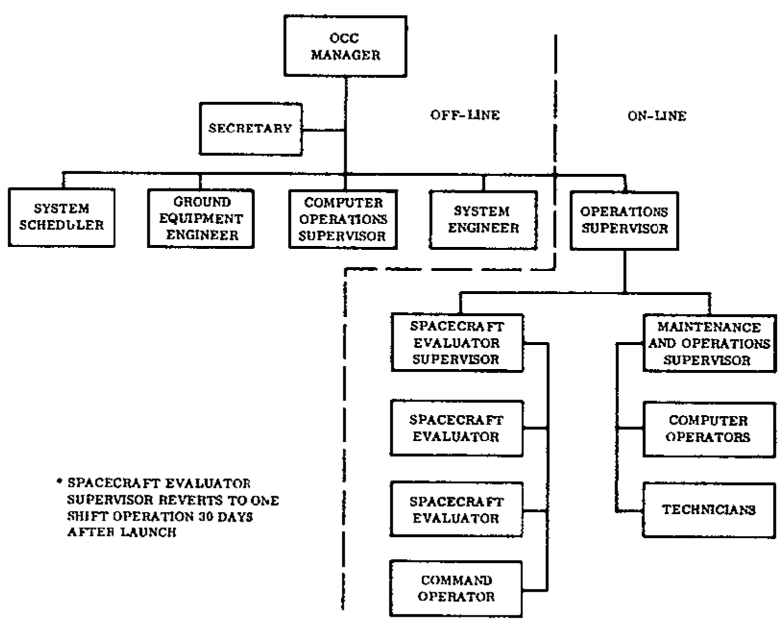


Figure 8.3-1. OCC Organization

8.3.1.3 On-Line Organization

The on-line personnel perform the on-pass and inter-orbit operations and maintenance functions. They work on a 24 hours per day, 7 days per week basis in 4 shifts.

A. Operations Supervisor (OS). The operations supervisor, as shift supervisor, is in charge of all the OCC operational activities for that particular shift. He has overall responsibility for the operation of the spacecraft and ground stations. He approves all spacecraft commands and establishes requirements for spacecraft data acquisition and processing by the ground stations. He directs and participates in evaluation of spacecraft performance. He also approves all emergency maintenance activity performed by the ground stations during ERTS support periods.

The OCC operations supervisor is familiar with spacecraft and ground station failure modes and procedures for corrective action. He is familiar with the operational requirements of the ERTS system.

The operations supervisor is responsible for all normal operational activities for that particular shift. The OS directs and coordinates the activities of the ground stations and is the OCC interface for OPSCON, NETCON, MSFNOC and NASCOM.

Specific tasks of the OS are:

1. Notify the ground stations as to what data will be acquired, what the sequence of data acquisition will be, and what data processing will be required for the upcoming spacecraft station pass.

2. Monitor the pre-acquisition, station pass, and post-station pass activities of the ground stations.

3. Receive and evaluate inputs from the spacecraft evaluations area and the M&O supervisor.

4. Provide recommendations for modification of system operating procedures, as necessary, and keep operating personnel informed of any procedure changes.

B. Maintenance and Operations (M&O) Supervisor. The maintenance and operations supervisor will be responsible for the operation and maintenance of the ground equipment in the OCC during a shift. He is responsible to the OS for the smooth flow of data, starting with the operational pass readiness procedures and ending with all on-pass and post-pass telemetry data and quick-look video processing. He also evaluates inputs from the computer operators and maintenance technicians, and provides recommendations to the AOS. The M&O supervisor controls all OCC equipment switching functions in the OCC either by M&O console control or by direction to other M&O personnel.

C. Computer Operators. The OCC computer operators will normally report to the M&O supervisor during operational periods for routine functions. The spacecraft evaluators will also interface with the computer operators for status and verification functions regarding computer operation.

D. Data Technicians. The data technicians will be responsible for logging data in, separating computer outputs, updating displays, and maintaining the data storage area. The technicians will also perform routine preventive maintenance on the OCC equipments and should be able to repair equipment to the replaceable plug in element level. The technicians will operate assigned ground equipment and cross training will be implemented so that ultimately each operator should be qualified on general ground station equipments.

E. Spacecraft Evaluator Supervisor. The spacecraft evaluator supervisor is responsible for the overall evaluation of the ERTS spacecraft systems, including the payload. He will receive inputs from other spacecraft evaluators and will provide reports of a go/no go nature to the AOS. The spacecraft evaluator supervisor is also responsible for shift manning of evaluation personnel. It is anticipated that the spacecraft evaluator supervisor position will be required only on a one shift basis, 30 days after launch.

F. Spacecraft Evaluators. The spacecraft evaluators will report to the spacecraft evaluator supervisor and will be responsible for analyzing all the data assigned to their respective operational positions. Observations and recommendations will be included in the periodic flight engineering reports. Off-line analysis of spacecraft data will also be performed as required.

G. Command Operator. The command operator is responsible for all command transmissions from the OCC as directed by the operations supervisor. Command formatting based on the activity plan will be accomplished by the command operator and submitted to OS for approval. All commands will be transmitted either by direction of the OS or as directed by approved command procedures.

The command operator is also responsible for updating command lists on an orbit-to-orbit basis, based on the latest information available. He will provide the on-line interface to receive updated coverage requests, update cloud cover inputs and maintain necessary logs of data retrieved. He will also be knowledgeable in operation of the spacecraft and provide on-line evaluation and command confirmation.

The OCC manpower requirements for Case b operation are summarized in Table 8.3-1.

8.3.2 TRAINING PROGRAMS

To develop the staffing and organization just described, a three-phased training program is required. These phases -- an OCC indoctrination, selected O&M courses, and mission operations training -- are described below. The schedule for this training program appears in Figure 8.3-2.

8.3.2.1 OCC Indoctrination Briefing

A 1-day orientation for spacecraft technical support and management personnel will be held four times prior to launch. These sessions will occur in 7/71, 9/71, 2/72 and 3/72. The latter two will immediately precede the mission simulation held 30 and 14 days before launch.

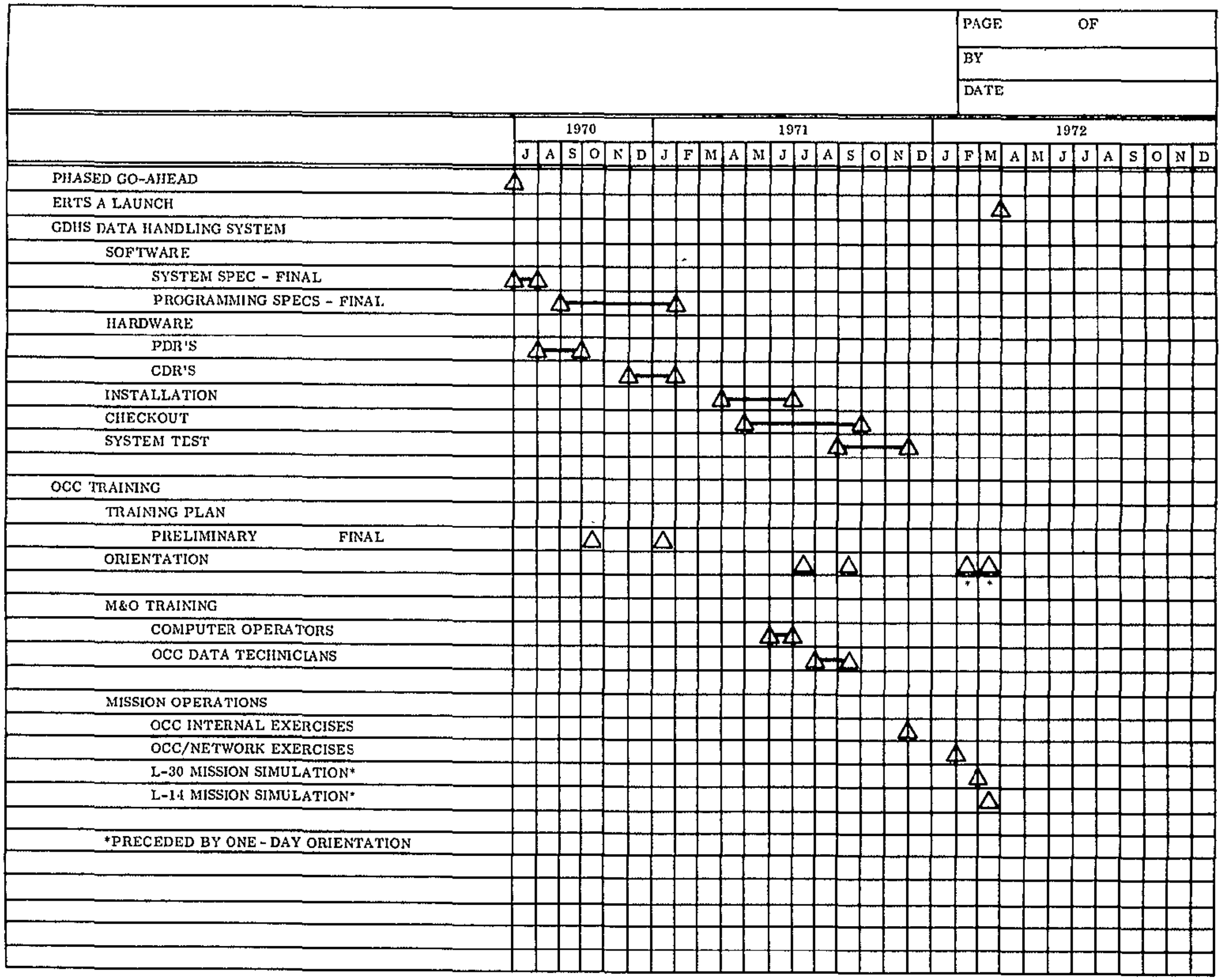


Figure 8.3-2. Training Program Schedule

The orientation will be organized into four sessions as follows:

1. General briefing
2. Working group meetings
    a. On-line operations
    b. Spacecraft support
    c. Payload support
    d. Mission planning
3. Operation demonstration
4. Critique

8.3.2.1.1 General Briefing

The general session will be attended by all personnel. Material to be presented will be of general interest to everyone participating in OCC operations and will include the following:

1. Introduction. Summarizes the agenda for the orientation and outlines the functions of the OCC, interfaces with launch, MD network, responsibilities of various participating organizations and identification of key personnel.

2. Payload Requirements. Discussion of requirements for payload data collection and physical data transfer from Alaska and Corpus.

3. Network Configuration and Operations. Identification of prime and back-up stations supporting ERTS and their data acquisition and handling capabilities. Description of the format and content of RT and dump data and the philosophy concerning the employment of the various data transmission modes. Description of the communications available between OCC and other locations. Summary of the procedures used by the stations for the transmission of commands to the spacecraft.

4. OCC Documentation, Displays and Data Formats. Brief description of the purpose and scope of the key documents used to support OCC operations such as:
    a. OCC Operations and Procedures Material
    b. Detailed On-Orbit Operating Plan
    c. Contingency Analysis
    d. Contingency Procedures

e. Technical Reference Manual

f. Technical Reference Library

g. STADAN/MSFN Operations Plan

h. OCC Displays and Printouts

8.3.2.1.2 Working Group Meetings

The four working group meetings will be held concurrently and each will be attended by personnel having a specific interest in that particular function. Although many of the same topics will be discussed in more than one meeting, the subject matter will be tailored to the needs of each meeting. Some of the material presented in the general session will also be discussed in more detail. The working group meetings will emphasize two-way discussion rather than formal presentation. The basic working groups and their areas of discussion are as follows:

1. On-Line Operations Working Group Meeting

   a. Meeting place: OCC control room

   b. Attendees

      (1) Flight operations directors

      (2) Network operations coordinators

      (3) GE flight operations team members

      (4) Payload representatives

   c. Topics to be covered

      (1) Task descriptions

      (2) Facility

      (3) Communications

      (4) Data displays

      (5) Status displays

      (6) Computer program outputs

      (7) Computer program control parameters

(8) Message and log formats

(9) Pre-pass activities

(10) On-pass activities

(11) Post-pass activities (including logkeeping)

2. <u>Spacecraft Support Working Group Meeting</u>

a. Meeting Place: TBD

b. Attendees

(1) Spacecraft flight controllers

(2) Senior engineering representatives

(3) Subsystem engineers and consultants

(4) Off-line evaluation team

c. Topics to be covered

(1) Task descriptions

(2) Spacecraft annex facility and communications

(3) Data displays

(4) Computer output formats

(5) Status displays

(6) Available logs

(7) Pass assignment and pass summary messages

(8) Anomaly flow

(9) Mission planning and off-line evaluation interfaces

(10) Manning schedules and personnel availability requirements

3. Payload Support Working Group Meeting

a. Meeting Place: TBD

b. Attendees

(1) Flight controllers

(2) Payload support team

(3) Data processing engineer

c. Topics to be covered

(1) Task descriptions

(2) TSR payload ground equipment

(3) NDPF

(4) OCC data displays

(5) NDPF data displays

(6) Computer output formats

(7) Pass assignment and pass summary messages

(8) Expendables record keeping

4. Mission Planning Working Group

a. Meeting Place: TBD

b. Attendees

(1) Orbit computation engineer

(2) GE mission planning staff

c. Topics to be covered

(1) Orbit data formats

(2) NASCOM interfaces

(3) Ground rules for PCM data acquisition

(4) Station scheduling procedures and constraints

8.3.2.1.3 Operational Demonstration

Two typical station passes will be demonstrated using stimulation data played back from the Alaska and Corpus stations. Pass assignment messages will be constructed in the OCC and sent to the supporting stations. Command transmission will be simulated by the OCC; and the Alaska and Corpus sites will transmit TM data to the OCC in real time. Stimulation data will consist of station contacts derived from the thermal vacuum tests at Valley Forge and the OCC operational software PCM simulation capability.

8.3.2.1.4 Critique

All personnel will attend the critique session. At this time, any questions that could not be resolved in the individual working groups will be discussed and final arrangements for the mission simulation will be covered.

8.3.2.2 M&O Training

The training of the OCC computer operators will be performed by the computer vendor. It is recommended that the OCC computer software-related positions be filled by the contractor personnel who design and develop the OCC applications programs; thus, no special training is required in these areas.

The remainder of this section discusses the training required for the OCC data technicians who will operate and maintain the other OCC equipments. This course would cover the following OCC equipments in the communications and data distribution and status data control and display subsystems:

1. Signal conditioning and switching unit
2. Timing equipment
3. Computer complex switching
4. A/N CRT and keyboard
5. Maintenance and operations console
6. Operations supervisor console
7. Spacecraft evaluator consoles
8. Command console
9. Strip chart and display data decoder

In addition, M&O courses will be provided on the analog magnetic tape recorders and repair of strip chart recorders, if present service contracts at Goddard Space Flight Center are not available on these equipments.

This course will be developed and conducted to teach the M&O technicians the principles and theory of operations at the data flow and logic analysis levels to provide assigned M&O personnel with a thorough system understanding of the operational control center equipment.

This training will prepare the OCC technicians for isolating and repairing malfunctions down to a replaceable plug-in unit and applicable card level where required.

In addition, on-the-job training will be provided by assigned contractor personnel during the installation and checkout phase.

8.3.2.3 Mission Operations Training

The mission operations training plan is designed to train the OCC on-line and off-line personnel in the knowledge, skills and procedures required for the successful implementations of on-orbit operations. This plan consists of four discrete steps. The first, intermal OCC exercises is concerned with OCC system readiness and involves the processing, handling display, and logging of data within the OCC. This activity is expected to commence at L-120 days. The second step, OCC/network exercises is intended to exercise NASCOM interface procedures, the handling of data between the remote stations and the OCC, and the familiarization of station personnel with ERTS unique procedures. This phase will begin at L-60 days. At L-30 days, the third step in the mission operations plan is to begin. This mission simulation will provide a demonstration of network OCC readiness by simulating on-orbit time lines and remote station activities. The final step is planned to begin at L-14 days. A complete mission simulation including prelaunch, launch, and orbit operations will be undertaken using the launch facility, simulated data and the remote site data flows.

The plan assumes that the operational hardware and computer software employed in each exercise is fully checked out prior to the exercise. This plan places primary emphasis on the verification of manual operating procedures and the training of operational personnel.

The plan also assumes that simulation data for on-orbit exercises will consist of magnetic tapes of spacecraft telemetry data recorded during vehicle system tests and simulation tapes developed using the OCC software's capability to generate simulated PCM data.

8.3.2.3.1 OCC Internal Exercises

The OCC internal exercises are designed to simulate the data processing and handling activity within the actual control center facilities. Telemetry data input will be provided by a magnetic tape of selected data recorded via either of the two sources listed above. The data tapes will be supplied by GE. During the exercises, the magnetic tape will be played back on a tape recorder at GSFC, the data will be processed by the OCC equipment, delivered to the OCC control room, and analyzed in accordance with the spacecraft on-orbit operating procedures.

The GE on-line analysis personnel will formulate pass assignment messages and teletype message tapes will be generated via OCC computer software but not transmitted to the stations. On-pass command verification performed by the remote stations will be simulated by a member of the GE flight operations team stationed at the OCC pen recorders.

The objectives of the OCC internal exercise are to:

1. Verify calibration and limit data used by the OCC computer programs

2. Familiarize GE flight operations personnel with on-orbit data output formats

3. Evaluate adequacy, CRT, pen recorder channel assignments, and event light displays

4. Provide training for OCC operations personnel in internal OCC data handling procedures

5. Evaluate procedures for internal OCC data handling

6. Provide training for GE flight operations personnel in on-pass and between passes spacecraft analysis activities

8.3.2.3.2 OCC-Network Exercises

The OCC-network joint exercises are designed to evaluate the interface procedures of the OCC and remote stations and to provide training for station personnel in ERTS unique procedures. Telemetry data input will be provided by the GE furnished exercise tapes. Copies of the tapes will be generated by GSFC and mailed to the supporting stations prior to the start of the exercises.

During the exercises, telemetry data will be played back on tape recorders located at the remote stations, processed in the normal manner by the stations, transmitted to the OCC, further processed by the OCC and analyzed by the GE flight operations team. Command and data display instructions will be generated by the OCC and transmitted to the remote stations. During this exercise, the OCC will transmit commands to the remote sites. The remote site M&O group will provide on-pass reports to the OCC by voice and post-pass data reports by teletype.

The objectives of the OCC/network joint exercises are to:

1. Evaluate procedures for the generation and handling of commands

2. Familiarize remote station personnel with ERTS command procedures

3. Evaluate procedures for on-pass command verification.

4. Familiarize OCC personnel with procedures for on-pass command verification

5. Familiarize OCC personnel with NASCOM procedures.

8.3.2.3.3 L-30 Mission Simulation
The initial mission simulations will exercise all of the functions performed during on-orbit operations. The nominal sequence of spacecraft station passes will be simulated on a mission profile time basis.

Stimulation data, consisting of telemetry data tapes, either recorded during ERTS thermal vacuum tests or generated by the OCC PCM data simulation capability, will be played back at the remote stations, transmitted to GSFC, and analyzed by project personnel in the control center. The GSFC computing facility will generate station contact based on a nominal mission profile as part of the exercise. Copies of the data tapes will be sent to the remote stations prior to the start of the L-30 day exercise. The playback of data from each station pass will be timed so as to simulate the station pass schedule of a real spacecraft in orbit.

The objective of the L-30 mission simulations are to:

1. Identify any sequence or timing conflicts in the operational procedures
2. Provide operations familiarization to the spacecraft
3. Evaluate the adequacy of the facilities
4. Evaluate the communications and data handling arrangements between the OCC control room and other related areas

8.3.2.3.4 L-14 Mission Simulations
This simulation will exercise all of the functions performed during on-orbit operations, including the interfaces between the OCC and the launch area. The complete mission simulation is much like the L-30 mission simulation except for the inclusion of launch operations. The objectives and simulation data are the same as the L-30 mission simulations.

It should be noted that the designation L-30 and L-14 denote start dates for the mission simulation. The duration and number of exercises will be defined in Phase D. Past experience indicates these activities and their related support will be almost continuous from L-30 on. It should also be noted that these activities complement the skills developed by the OCC personnel through their support of vehicle system integration testing at Valley Forge. The off-line personnel become involved in test planning and conduct well before thermal-vacuum testing. The on-line personnel are involved primarily in the thermal vacuum test phase.

8.3.3 OCC MANUALS
The O&M manuals required to support OCC operations will be provided by the equipment vendor for off-the-shelf items and by the equipment designer for development items. The basic manual requirements are identified in this section.

It should be noted that the time phasing of this report precludes listing specific manuals to be provided by the ADP equipment suppliers. The standard operator, equipment, and software manuals will be provided, however, as part of the ADP procurement.

It should also be noted that these manuals will form the backbone of the OCC training program described in the previous section. This approach offers the personnel operating and maintaining the OCC an opportunity to become thoroughly familiar with the contents of these document and to become efficient in their use. Moreover, during the course of instruction, the instructor-designer can make certain that concepts requiring particular emphasis are highlighted, and the personnel in attendance can obtain interpretations of the document pertinent to his particular area of concern.

8.3.3.1 OCC Equipment O&M Manuals

The Operation and Maintenance Manual for the Communications and Data Processing (CDP) subsystem and the control and display subsystem portion of the operations control center will be packaged into several volumes to facilitate maximum usefulness.

This manual will be comprised of five sections as listed below:

1. Section 1, General Information
2. Section 2, Operation
3. Section 3, Theory of Operation
4. Section 4, Maintenance
5. Section 5, Diagrams

A. Section 1, General Information. Will contain a brief physical and functional description of the operations control center calling out the CDP, and the control and display subsystems and their interface with the remainder of the ERTS system. The text will be supported by photographs, block diagrams, and tables to assist the reader in acquiring a basic understanding as to the purpose and physical packaging of the equipment.

B. Section 2, Operation. Will contain an illustration of each operator panel in the equipment. Maintenance related panels will be covered in the Maintenance section of the manual. Each panel illustration will be keyed to a corresponding table that defines the function of panel-mounted controls and indicators. Procedures for equipment turn-on, and preoperational adjustments will also be included.

C. Section 3, Theory of Operation. Will provide the maintenance technician with a functional description of the CDP and control and display subsystems portion of the operations control center equipment; followed by functional descriptions of each equipment such as timing, PCM data, computer complex switching, etc. The text will be supported by block diagrams, timing data, and any other information considered essential to a clear understanding of both equipment operation and physical location of the related functional circuit elements. Detailed circuit descriptions will be provided for those circuits considered to be too complex to be fully understood from the functional level description. Detailed circuit descriptions will reference logic or schematic diagrams contained in Section 5.

D. Section 4, Maintenance. Will provide data to assist the maintenance technician in identifying and isolating malfunctions within the two subsystems. Maintenance information will be provided in the form of performance test procedures and adjustment and alignment procedures. A trouble-shooting concept discussion will be included to assist the maintenance technician in utilizing all portions of the manual (theory of operation, diagrams, tests, module location data, etc.) to maximum advantage.

E. Section 5, Diagrams. Will include electrical drawings such as interconnection, block diagram, schematic, logic, etc. Drawings for vendor equipment (normally included in the appropriate vendor manual) will not be included in this section.

F. Vendor/GFE Equipment, Technical Manual Coverage. In instances where a unit/assembly employed within the subsystems is provided by either a vendor or the Government (GFE), coverage for the equipment within the General Electric-prepared technical manual will be on the functional block diagram level only. Detailed maintenance and operation instructions will be referenced to the available manuals for the equipment. Two copies of all vendor equipment manuals will be provided as a supplement to the General Electric prepared manual.

8.3.3.2 OCC Applications Software Documentation

Personnel supporting the OCC software operations will be supported by the standard documentation generated during the software design development cycle. The content and function of the major documents falling in this area are described in Table 8.3-2.

Table 8.3-2. Standard OCC Software Documentation

Document	System Definition Specification	Subsystem/Element Design Specifications	Programming Specifications (Preliminary and Final)
Contents	1. System overview 2. Analysis and amplifies functional requirements 3. Documents constraints 4. Reflects operational philosophy 5. Annotates quantitative data (capacities, rates, timelines, etc.) 6. Declares and allocates functions to, subsystem elements (hardware data base, or programs) 7. Data base definition specification (form and cases of contents) 8. Interface specifications (external and internal)	1. Cites and amplifies element functions and constraints from system definition specifications 2. Identifies and rationalizes implementation concept/approach (i.e., algorithms core loading analyses, etc.) 3. Declares and allocates functions to software, element, or data file. 4. Defines specific data base contents 5. Provides test case, expected values/results	1. Cites and amplifies functions and constraints from design specifications 2. Defines error statements 3. Declares operational setups and cautions 4. Flow diagram 5. Logical description
Function	1. Provide system definition baseline for customer review and approval 2. Defines task environments and constraints to subsystem or element engineer 3. Provides basis for configuration control during design and utilization phase	1. Provide design baseline for review integration and approval by system engineering and customer 2. Defines tasks, environment, and constraints to programmers and data base development engineers 3. Serves as data base assembly specification	1. Provide information and training inputs to operators (preliminary) 2. Provides for review, integration, approval, by system engineering (preliminary) 3. Defines coding tasks (preliminary) 4. Provides as-built definition of program contents and capabilities (final) 5. Serves as a basis for diagnosis and change (final)

8.3.3.3 OCC Operational Documentation

In addition to the documentation discussed in the previous sections, there is a need for a category of documentation, best described as operational documentation. This is the documentation required to define, design, implement, and report the results of a mission of an operational spacecraft. For the ERTS missions, the documentation can be categorized as follows:

1. Requirements, plans and specifications which, when approved by NASA, are used to guide the development of the operational system

2. Operating procedures, technical references and adaptation data that are used directly by the operational system personnel and/or computer software during mission operations

3. Evaluation reports providing an assessment of mission performance with recommendations for system improvements

Table 8.3-3 summarizes this operational documentation requirement, and indicates the approximate time, in weeks before launch, that they should be available.

The development of this documentation is an integral part of the design of an operational system. The operational system is that unique configuration of hardware, software, and personnel required to perform an operational mission. For the ERTS purposes, the operational mission consists of: (1) pre-launch OCC checkout and test, (2) countdown and launch, and (3) orbital flight.

The implementation phases for the operational system are similar to the usual system implementation phases of: (1) definition, (2) design, (3) development, (4) test, (5) operations, and (6) evaluation. The operational system activities performed during each of the phases are summarized in Figure 8.3-3.

8.3.3.3.1 Operational System Definition

The definition phase includes those activities concerned with: (1) the development of operational concepts, the preparation of general flow plans and profiles, (2) the definition of spacecraft-ground system compatibility requirements, and (3) the planning and scheduling of the operational system implementation tasks.

8.3.3.3.2 Operational System Design

The design phase results in the detailed specification of the operational system configuration. Included in this phase are: (1) specifications for long lead time ground support hardware, computer software, and facility requirements, (2) the development of detailed flow plans, (3) the definition of operational support team staffing requirements, and (4) general planning for exercises and rehearsals.

Table 8.3-3. Operational Documentation

Title	Description	Date From Launch (Weeks)
Mission Profile	Part of the system specification which defines the nominal mission and, particularly, the orbit parameters, launch profile, station passes, and command/event sequences for operational planning. It also serves as a flight events model for system test.	T-49
OCC Computer Program Requirements	Defines the computerized digital tape, paper tape, and printed output formats required during on-orbit operations for immediate control; includes a description of the OCC equipment, the data input requirements, and a TM List.	T-46 T-38
OCC Facilities Specification	Defines the mutually acceptable facility requirements and usage in the OCC, including the space, computer controlled digital displays, CRT, and communications and control requirements within the OCC.	T-42
Track and Data Systems Integration	Defines spacecraft ground station compatibility requirements, particularly command and measurement data, frequency and power of beacons and remote stations, noise/range calculations, and equipment lists for all telemetry and tracking stations involved in on-orbit and recovery activities.	T-48 T-44
Data Management Plan	Defines the data acquisition, processing and output requirements for field acceptance, countdown, on-orbit, recovery and post-flight analysis and evaluation; specifies the interfaces with GSFC computer facilities and the programs available or needed.	T-46 T-32
Contingency Analysis	Provides results of an analysis of probable spacecraft malfunctions and lists the telemetry indications of the malfunction, the alternatives available for responding to the malfunction, and the impact of the malfunction on mission performance.	T-22 T-14
Calibration Data Book	Relates engineering units to digital and proportional values of each TM channel, and the meanings of "event" indications; as a source document must reflect current sensor status.	T-36 T-28
OCC Operations and Procedures Manual	Reference guide for controllers, giving the mission objectives ground system configuration, the quick-look computer programs, the organization, displays, and a typical operation sequence.	T-21 T-12
Spacecraft On-Orbit Operating Procedures	Supplements the OCC Operations and Procedures Manual with orbit-by-orbit procedures for command and control, including the command lists and status assessment of the spacecraft and the status summary checklists made out in advance for the nominal mission.	T-21 T-12
On-Orbit Contingency Procedures	These are decision logic diagrams providing a definition of command constraints (improper modes) and command procedures for predefined contingency situations requiring immediate command responses.	T-6
Technical Reference Manual	Provides the OCC operators with a functional description of each spacecraft subsystem and reference information for deriving the status of consumables and interpreting TM measurements with the calibration curves included.	T-4
On-Orbit Exercise Plan	Defines the exercises and the schedule for training the OCC personnel, specifying briefing aids, simulation tapes, logs and personnel organization/task assignments for each scheduled exercise.	T-16 T-6

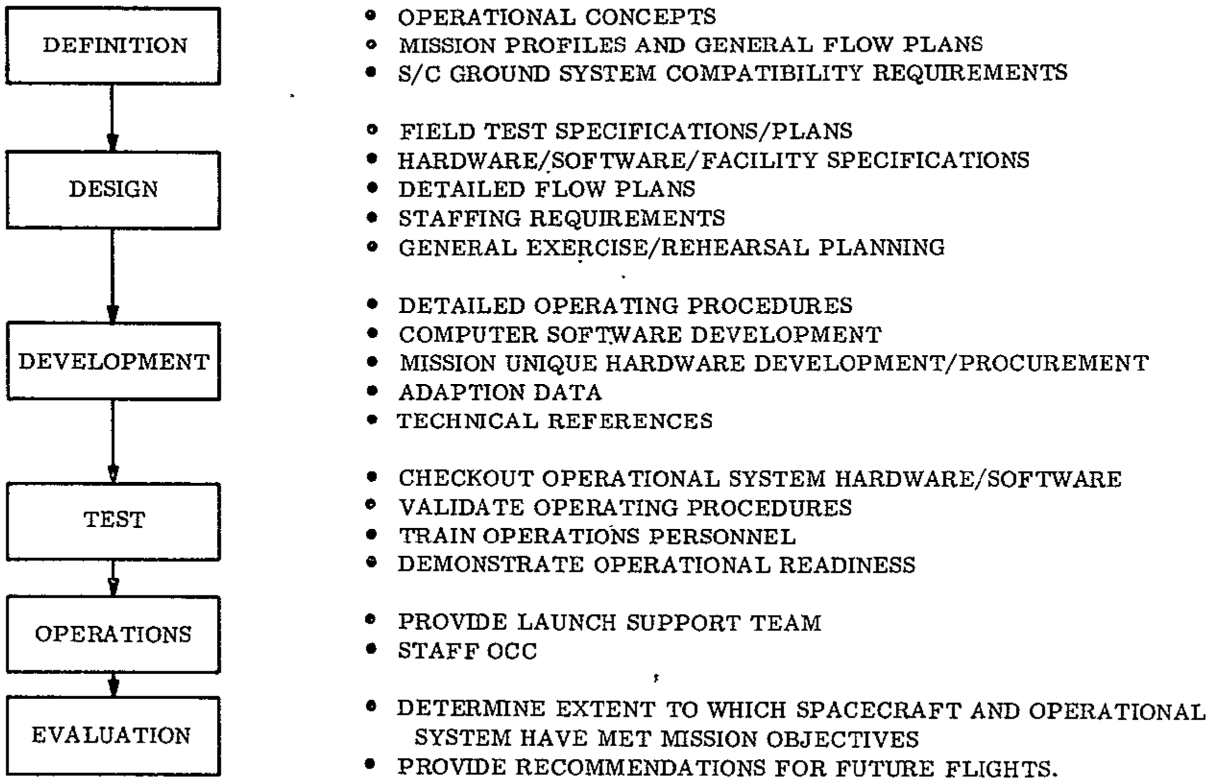


Figure 8.3-3. Operational System Implementation Phases

8.3.3.3.3 Operational System Development

The development phase includes those activities concerned with the preparation of operating instructions, the compilation of technical reference/adaptation data, and the detailed preparation for exercises and rehearsals. The documentation produced during the development phase should be regarded as operational system end item software, since these documents will be used directly by operations personnel during mission operations. The time phasing corresponds approximately to design, development, or procurement and installation of any required mission-unique hardware and the design and development of computer software.

8.3.3.3.4 Operational System Test

The operational system test phase includes the pre-launch walk-throughs, the OCC/STADAN/MSFN exercises, and any related orientations and briefings. The exercise/rehearsal phase begins by testing various portions of the system individually and then gradually combining the portions in order to terminate in a full system simulation including a combined pre-launch walk-through, OCC/STADAN/MSFN mission simulation, and recovery exercise. The OCC/STADAN/MSFN exercise design must also consider the requirement to train the STADAN and MSFN remote station crews to perform ERTS unique operating procedures.

8.3.3.3.5 Mission Operations

The mission operations phase includes those activities concerned with actual performance of the mission. General Electric, as spacecraft contractor, is required to provide a launch support team at VAFB and a OCC support team at GSFC. All of the necessary operating instructions, references, AGE, and other job aids required by these personnel to perform their required tasks should be defined, developed, and checked out during the preceding phases. All of the personnel directly involved in mission activities are required to participate in preflight rehearsals.

8.3.3.3.6 Evaluation (Long-Term Analysis)

Long-term analysis includes all of the activities concerned with determining the extent to which the spacecraft and the total operational system have met mission objectives. The analysis should be directed toward recommending design improvements for future flights. The long-term analysis effort is distinct from the quick-look evaluation activity that will be performed during the operations phase for the purpose of mission control; however, the two activities are related and should complement each other wherever possible.

The need to implement this operational system design/development effort will be discussed in the Phase D technical proposal.

8.4 OCC MAINTENANCE AND LOGISTICS

The basic ADP maintenance recommendations made in the General Electric ERTS ADP Application Study, 2 February 1970, modified with respect to on-site coverage requirements, continue to represent the preferred maintenance approach for the OCC ADP equipment. The main points of this approach are:

1. Use of a standard maintenance and service contract for ADP maintenance.
2. Vendor maintenance personnel available on a 24-hour-a-day basis (on-site, 8 hours per day for prime shifts, 5 days per week; on call 24 hours per day, 7 days per week).
3. Preventive maintenance scheduled on a nominal basis of 2 hours per day.
4. Backup maintenance available via field engineers within 8 hours and specialized headquarters technical support personnel available within 24 hours.
5. On-site, sub-depot, and depot level spare parts support, including emergency service.

Further information on OCC maintenance and logistics, including the OCC consoles, is given in the following sections.

8.4.1 OCC MAINTENANCE AND SPARE PARTS

It is recommended that maintenance of OCC communications and data distribution equipment be performed primarily by GDHS O&M personnel. However, if NASA/GSFC has arranged on-site service contracts for similar equipments (tape units, strip chart recorders, etc.), an extension of these services to OCC equipments could be established.

One of the key elements in this system, the OCC operating consoles, is being designed with a modular, multi-function approach which will provide an excellent console backup capability during maintenance downtime. Also, since the modular approach standardizes internal construction of the consoles, maintenance procedures will be more easily learned and applied by M&O personnel.

A preliminary list of spare parts for the OCC consoles is shown in Table 8.4-1. Spare quantity requirements for identical or similar equipment will need to be examined further and adjusted later to appropriate GDHS inventory levels.

8.4.2 OCC EXPENDABLES

The current estimates of expendable materials required for OCC activation (pre-launch) and post-launch on a monthly basis are shown in Table 8.4-2.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

FOLDOUT FRAME

Table 8.4-1. OCC Console Spare Parts Estimate

Equipment Name	Item No.	Spare Part Name	Quantity
Operations Supervisor Console	1	Fuse	10
	2	Power Supply (±15V)	1
	4	Over Voltage Protection	1
	4	Power Supply (28V)	1
	5	Over Voltage Protection	1
	6	Shunt	1
	7	Test Jack	4
	8	Meter	1
	9	Connector	1
	10	Connector	1
	11	Resistor	10
	12	Connector	1
	13	Circuit Breaker	1
	14	Socket	2
	15	Ferrule	2
	16	Connector	2
	17	Indicator	1
	18	Switch	1
	19	Filter	1
	20	Lamp	5
	21	Switch	1
	22	Plug	1
	23	Receptacle	1
	24	Plug	1
	25	Receptacle	1
	26	Readout	2
	27	Readout	1
	28	Readout	1
	29	Light Switch	3
	30	Connector	1
	31	Connector	1
	32	Connector	1
	33	Pin	30
	34	IC	2
	35	IC	2
	36	IC	2
	37	IC	1
	38	IC	1
	39	IC	2
	40	IC	1
	41	IC	1
	42	IC	2
	43	IC	2
	44	Switch	1
	45	Indicator Light	1
	46	Indicator Light	1
	47	Indicator Light	1
	48	Indicator Light	2
	49	Fan	1
	50	Terminal Board	1
	51	Indicator Light	2
	52	Switch	1
Command Console	1	Test Jack	4
	2	Meter	1
	3	Resistor	10
	4	Circuit Breaker	1
	5	Indicator	1
	6	Lamp	5
	7	Readout	2
	8	Readout	1
	9	Readout	1
	10	Light Switch	3
	11	IC	2
	12	IC	2
	13	IC	2
	14	IC	1
	15	IC	1
	16	IC	2
	17	IC	2
	18	IC	1
	19	IC	2
	20	IC	2
	21	Indicator Light	1
	22	Switch	1
S/C Evaluator Console No. 1	1	Meter	1
	2	Connector	1
	3	Socket	1
	4	Ferrule	1
	5	Indicator	1
	6	Readout	1
	7	Readout	1
	8	Readout	1
	9	Light Switch	1
	10	Indicator Light	1
S/C Evaluator Console No. 2	1	Meter	1
	2	Connector	1
	3	Socket	1
	4	Ferrule	1
	5	Indicator	1
	6	Readout	1
	7	Readout	1
	8	Readout	1
	9	Light Switch	2
	10	Indicator Light	1
S/C Evaluator Console No. 3	1	Meter	1
	2	Connector	1
	3	Socket	1
	4	Ferrule	1
	5	Indicator	1
	6	Readout	1
	7	Readout	1
	8	Readout	1
	9	Light Switch	2
	10	Indicator Light	1
Strip Chart Recorder and Data Display Decoder No. 1 and No. 2	1	Connector	1
	2	Socket	1
	3	Socket	1
	4	Plug	1
	5	Receptacle	1
Strip Chart Recorder and Data Display Decoder No. 1 and No. 2 (Cont'd)	6	Pin	10
	7	IC	1
	8	IC	1
	9	IC	1
	10	IC	1
	11	IC	1
	12	Relay	1
	13	Diode	2
	14	Terminal Board	1
	15	IC	1
	16	IC	2
	17	Power Supply (5V)	1
	18	Power Supply (15V)	1
	19	8-Channel Analog/Event Recorder Spares	TBD
	20	Receiver/Decoder No. 2 Spares	TBD
Control Room Cables		No Spares Required	
M&O Console	1	Meter	1
	2	Connector	1
	3	Connector	1
	4	Socket	4
	5	Ferrule	4
	6	Plug	1
	7	Receptacle	1
	8	Readout	2
	9	Readout	1
	10	Readout	1
	11	Light Switch	1
	12	Indicator	1
	13	Indicator	1
	14	Indicator	1
	15	Indicator	1
	16	Toggle Switch	1
	17	Terminal Board	1
	18	Switch	1
	19	Connector	1
	20	Relay (Dow-Key)	2
	21	Monitor Scope (Display)	TBD
Timing Unit	1	Connector	1
	2	Connector	1
	3	Connector	1
	4	Circuit Breaker	1
	5	Socket	2
	6	Ferrule	2
	7	Indicator	1
	8	Connector	2
	9	Pin	100
	10	IC	10
	11	IC	2
	12	IC	1
	13	IC	2
	14	Rotron Fan	1
	15	Terminal Board	1
	16	Connector	3
	17	Filter	1
	18	IC	2
	19	IC	2
	20	IC	2
	21	IC	2
	22	IC	2
	23	PC Board	1
	24	PC Board	1
	25	Power Supply	1
	26	Time Code Translator	TBD
	27	Pass Time Generator	TBD
Strip Chart Recorder and Display	1	IC	5
	2	IC	1
	3	IC	1
	4	IC	1
	5	IC	3
	6	Relay	2
	7	Diode	4
	8	IC	1
	9	IC	2
	10	8-Channel/Analog Event Recorder	TBD
Signal Conditioner and Switch Unit	1	Fan Rotron	1
	2	IC	5
	3	Connector	1
	4	Connector	5
	5	Resistor	10
	6	Circuit Breaker	1
	7	Socket	5
	8	Ferrule	5
	9	Connector	1
	10	Indicator	1
	11	Filter	1
	12	Lamp	5
	13	IC	4
	14	IC	2
	15	IC	4
	16	IC	5
	17	Patch Cord	10
	18	Patch Cord	5
	19	Diode	15
	20	Connector	2
	21	Connector	2
Analog Magnetic Tape Recorder No. 1 and No. 2	1	Record/Reproduction Heads	8 sets
	2	Other Parts	TBD
Special Test Equipment	1	Lamp Holder	2
	2	Lamp	10
	3	Board	1
	4	IC	2
	5	Connector	1
	6	Connector	1
	7	IC	1

Table 8.4-2. OCC Expendables Estimate

Equipment/Process	Expendable	Pre-Launch	Post-Launch (90 days)
Analog Tape Recording	Magnetic Tape, reel	20 reels	540 reels
Strip Chart and Event Recording	Recorder Paper, roll	10 rolls	210 rolls
Computer	Computer Magnetic Tape, reel	160 reels	1200 reels
Program Development Maintenance	Punch Cards, box	120 boxes	4 boxes
Printer	Printer Paper, box	200 boxes	50 boxes

SECTION 9

OMITTED

OMITTED

NASA
FORMAL
REPORT

FFNo 665 Aug 65

GENERAL ELECTRIC

SPACE DIVISION

SPACE SYSTEMS ORGANIZATION