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LANDSAT D

OPERATIONS CONTROL CENTER STUDY

FINAL REPORT

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GENERAL  ELECTRIC

LANDSAT D
OPERATIONS CONTROL CENTER STUDY

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FINAL REPORT

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PREFACE

The original intent of this study was to provide a workable design, and corresponding cost estimate for an OCC that would meet the requirements of the Landsat-D system. This design, as an initial premise, was to make maximum utilization of the existing Landsat 1 and 2 OCC design concepts.

After the study was underway, a contract modification was made to include the investigation of the compatibility of the Landsat-D OCC with the Payload Operations Control Center Network (POCCNET) concept. This study does not address the detailed design of a POCCNET based OCC for Landsat D, nor does it include cost estimates for such a design. Further, several aspects of the MMS based Landsat D were not included due to study scope limitations. Although these omissions are important for completeness, their impact on the basic study conclusions is felt to be negligible.

In the interests of continuity to the reader these efforts are presented as two relatively complete reports. The initial study objectives (without consideration of POCCNET) are reported in Section 2 and the revised objectives (with consideration of POCCNET) are reported in Section 3. Each section (Section 2 or 3) has been developed as a complete stand-alone section without extensive cross referencing in order to provide the reader with start-to-finish continuity within a section. However, this does imply that some material in Section 3 has been replicated from Section 2; the replicated material is identified for the reader who reads the whole report by an asterisk following the section title.

SECTION 1

INTRODUCTION AND SUMMARY

1.1 BACKGROUND

The pressing need to better survey and manage the earth's resources and environment has prompted man to explore the possibilities of remote sensing from space. Early efforts began with space photographs from the Gemini and Apollo programs and continued with multispectral data from Landsat 1 and 2 spacecraft. Landsat D is currently planned as the next major step for the Earth Resources Program.

Landsat 1, launched in 1972, marked the start of NASA's Earth Resources satellite program. This successful spacecraft was followed two and a half years later with Landsat 2, an identical spacecraft. The overwhelming success of these two Landsats, demonstrated through hundreds of experimental programs, has motivated NASA to continue to improve the Earth Resources satellite program. The third satellite, Landsat C, has been procured and is scheduled for launch in late 1977. This third satellite will carry a modified Multispectral Scanner and will utilize an improved digital ground system. NASA is now planning for the next step, Landsat D, which will provide several major advances. Landsat D will incorporate the Thematic Mapper (TM) as a new sensor, it will utilize the Multi-mission Modular Spacecraft (MMS), it will make use of the Tracking and Data Relay Satellite System (TDRSS) and it will employ a new more advanced ground system. Each of these represent significant improvements in the state-of-the-art. This study is one of several which address various aspects of the planned Landsat D system.

As the Earth Resources Program has matured through the Landsat spacecraft it has begun the transition from an experimental research activity to a sound demonstration of proven utility. This important transition will be completed with the Landsat D system which incorporates several key improvements over the current system. These improvements, based on experience with the existing Landsats, will provide new capabilities in the spacecraft, the sensor, the ground system, and the overall system design. These system

capabilities - which emphasize improved vegetation analysis, prompt availability of data, frequent coverage, and precise data registration and overlay for better change detection will permit the Landsat D to capture already proven economic benefits in such diverse applications as:

- Monitoring world-wide food productivity
- Mapping agricultural land use
- Monitoring rangelands
- Surveying forest resources
- Managing critical watersheds
- Detecting land use changes
- Oil/mineral exploration

An artist's concept of the Landsat D system is shown in Figure 1-1. The spacecraft will be based on NASA's new Multi-mission Modular Spacecraft (MMS) and will operate two remote sensing instruments: a Thematic Mapper (TM), with 30 meter ground resolution, and a Multispectral Scanner (MSS), with 80 meter resolution. The system provides two data communication paths to the Earth; one is a direct readout link for ground stations (both



Figure 1-1. Landsat D System

domestic and foreign) within range of the spacecraft, and the other is a relay link via the Tracking and Data Relay Satellite System (TDRSS) for nearly full global coverage. The spacecraft will be in a sun-synchronous orbit with a descending node time of 9:30 AM (similar to current Landsats). The orbital altitude and inclination will provide near global coverage of the land and near coastal regions with a repeat cycle every 16 to 18 days.

The use of the new MMS spacecraft as the basic bus will provide both improved sensor pointing accuracy (± 0.01 degree) and stability (10^{-6} degrees/second). These improvements will manifest themselves in more accurate and more straightforward geometric corrections of the image data; both relative (image to image) and absolute (with respect to the Earth's surface). The MMS incorporates modular subsystems in the key areas of power, attitude control, and command and data handling. This modularity together with the compatibility for both conventional and Space Shuttle launches will enable in-orbit repair and refurbishment of the spacecraft.

The Thematic Mapper, TM, is an evolutionary improvement of the MSS and provides several significant capabilities. The spatial resolution on the ground has been reduced to 30 meters (compared to 80 for the MSS) which will allow radiances to be measured for areas (pixels) less than one sixth the size as for the MSS. The TM will incorporate six spectral bands (and have the capability for a seventh) which have been located primarily on the basis of their ability to discriminate vegetation (a fundamental application of remote sensing). In addition the radiometric sensitivity of the TM has been improved by reducing the signal-to-noise characteristic and increasing the levels of digital quantization. These sensor changes combine to cause the TM to have a data rate of 120 Mbps, (an order of magnitude increase over the 15 Mbps of the MSS).

For remotely sensed multispectral data to be truly practical for many potential operational users (agricultural analysts, hydrologists, etc.) it must be received by them in usable form within 48 to 96 hours after imaging. Promptness in receiving data products is one of the most critical aspects of the Landsat System.

The Landsat D System will be thoroughly integrated with the needs of operational users. It will include improved preprocessing of all data, central data processing, archiving and retrieval,

low-cost receiving and data centers for large volume users (such as the U.S. Department of Agriculture) and provide maximum efficiency and economy in utilization by state, regional, and foreign users. Featuring the rapid electronic transmission of all data, the Landsat D system will reduce the time between satellite imaging and user reception of data to the required 48 to 96 hours.

As illustrated in the artist's concept the system provides two data links to the ground. The first link, for both MSS and Thematic Mapper data, is directly from the satellite to domestic and foreign ground stations as the satellite passes through their reception areas. The second link is via the Tracking and Data Relay Satellite System (TDRSS). As shown, the data is transmitted to a TDRSS satellite, in stationary orbit, and relayed to the TDRSS receiving station. The TDRSS receiving station transmits the data via a domestic communications satellite to a central data processing facility that, in turn, relays the data to any local data distribution center equipped to receive it. This link, via TDRSS and the communication satellite, will thus have global acquisition and relay capabilities, providing rapid access to Thematic Mapper data for users throughout the world. Both data links have a planned maximum data capability of 135 Mb/second at a 10^{-5} bit error rate.

The Landsat D system described is currently in the planning stages by NASA. As part of the planning for this future system, NASA has undertaken a series of studies, with General Electric and others, to investigate various system options. This particular study (the 5th in the list) is one of seven conducted by General Electric to explore different aspects of the total ground system that will be required by Landsat D in order to meet the overall mission objectives.

The seven ground system studies are:

1. Local User Terminal Study - an investigation into the requirements and options available for direct readout (primarily foreign ground stations) of Landsat D data.
2. User Data Processing Study - an effort to estimate the scope, size, and cost of the major user data processing system requirements.

3. Data Processing Facility Study - a requirement and sizing study to provide preliminary estimates of the scope and cost of NASA's central Landsat D data processing center.
4. GSFC Research & Development Study - a survey and analysis of the functions and facility required of NASA to continue the basic research on spaceborne remote sensing and its applications.
5. Operations Control Study - an analysis of the modifications necessary to upgrade or modify the NASA Operations Control Center (OCC) for Landsat D.
6. Data Transmission and Dissemination Study - an investigation into the options and limitations of various data communication alternatives including centralization versus decentralization.
7. Position Determination and Correction Study - an analysis of the impact and alternatives afforded by the MMS spacecraft of Landsat D on image geometric correction.

1.2 THE LANDSAT D GROUND SYSTEM

A top-level functional diagram of the Landsat D ground system is presented in Figure 1-2. The six major subsystems included are the Data Input Subsystem (DIS), the Central Data Processing Facility (CDPF), the Product Generation and Dissemination Facility (PGDF), the Data Management Subsystem (DMS), the Agriculture Utilization Subsystem (AUS), and the Applications Development Laboratory (ADL). Each of these subsystems is briefly described below.

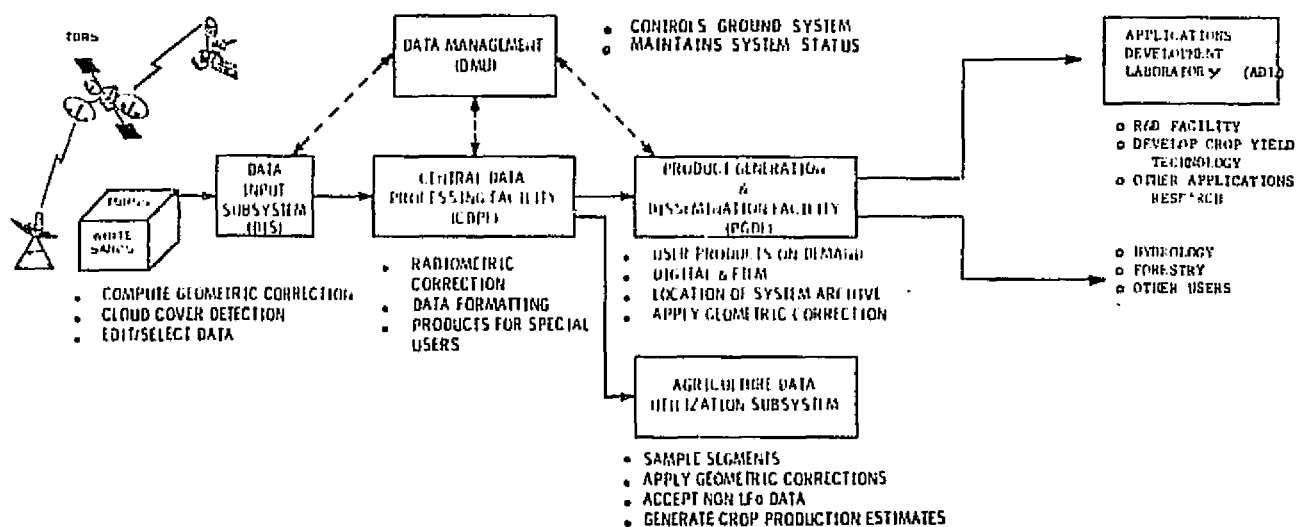


Figure 1-2. Ground System Concept

The Data Input Subsystem (DIS) receives 120-135 Mbps data from the TDRSS via dedicated cable interconnection. The prime functions of the DIS are to record the raw input data, to perform cloud cover detection and scene editing, and to compute geometric correction matrices on a per swath basis.

The Central Data Processing Facility (CDPF) receives edited data from the DIS and performs standard operations to all data. These operations include radiometric correction and data reformatting to a band-interleaved-by-line (BIL) format.

The Product Generation and Dissemination Facility (PGDF) is the main interface between the Landsat D ground system and general users. This facility provides Landsat D data, in either digital tape or film format, to users on demand. The data, which may be geometrically corrected to various map projection systems or enhanced as requested by the user, is available in a variety of sizes, formats and media. The PDGF also houses and manages the system archive.

The Data Management Subsystem (DMS) provides the central point of control and data base management for the Landsat D ground system. Its prime functions include management of user demand, the system archive, system communications and system redundancy. The DMS also maintains system status, production statistics, operations logs and administrative services.

The Agriculture Utilization Subsystem (AUS) receives data directly from the CDPF and performs those operations necessary to produce world crop production forecasts on a periodic basis. The operations to be performed include geometric correction, sample segment extraction, multispectral analysis and areal and statistical analyses. It is included here as part of the ground system because it represents the first major user of Landsat D data.

The Applications Development Laboratory is the main R&D facility dedicated to the applications of TM data. The facility is equipped to receive, store and handle TM and supportive data and conduct analyses in pursuit of quasi-operational applications technology development. A primary goal will be the development of crop yield technology that models TM and supportive data to produce crop yield forecasts.

1.3 OPERATIONS CONTROL CENTER (OCC)

The Operations Control Center (OCC) performs the functions required to operate and evaluate the spacecraft as well as to manage payload data operations. The OCC provides the command and control feedback to the spacecraft for accomplishing specific payload data collection requirements.

The original intent of this study was to provide a workable design and cost estimate for an OCC that would meet the requirements of the Landsat-D system. Since this design was based on maximum utilization of available hardware and software, the applicable design elements of the present Landsat 1 and 2 OCC were employed whenever feasible. The results of this study are contained in Section 2 of this Final Report.

A modification was made to the original study contract (reported in Section 2) to investigate the compatibility of the Landsat-D OCC with the Payload Operations Control Center Network (POCCNET) concept. A specific goal of this portion of the study was to identify any adverse mission unique requirements that the Landsat-D system placed on POCCNET. The conclusions of this area of the study are:

1. All Landsat-D OCC requirements are met by the POCCNET concept.
2. POCCNET features enhance the Landsat-DOCC operation.
3. The Landsat-D OCC is not dependent upon POCCNET implementation.

The results of this Final Report associated with this investigation are reported in Section 3.

It must be noted that this study should not be considered a Multi-Mission Modular Spacecraft (MMS) OCC design. The detailed requirements for operation, software modification, command management, etc., for the MMS have not been included in the

considerations outlined below. Further, the interface and equipment requirements were enumerated, but largely not specified or characterized in detail.

Thus, this OCC Final Report covers two OCC efforts:

1. Design and cost a baseline OCC system based heavily on the current Landsat 1 and 2, (See Section 2).
2. Assess the compatibility of that OCC with the POCCNET concept (see Section 3).

This report does not address the detailed design of a POCCNET based OCC for Landsat-D nor does it provide cost estimates for such a design. Further, several aspects of the MMS based Landsat-D are not included due to study scope limitations; although these omissions are important for completeness. Their impact on the basic conclusions is felt to be negligible.

SECTION 2

BASIC OCC STUDY (WITHOUT POCCNET)

As discussed in the Preface, this OCC Final Report has been divided into two relatively "stand-alone" sections. This Section 2 discusses the original study effort which was aimed at producing a baseline OCC design and cost estimate for Landsat-D. The results of a study contract modification which included the investigation of POCCNET are reported in Section 3 of this report.

Because of the "stand-alone" nature of Sections 2 and 3 there is some redundancy of material between the two sections. Those sections which are redundant have been marked with an asterisk (*) following the title.

2.1 OCC REQUIREMENTS

The OCC has three major areas of responsibility in the performance of its functions.

These are:

1. Data Management
2. Flight Operations Command
3. Spacecraft and payload performance evaluation

Figure 2-1 illustrates the Landsat -D functional interfaces required to perform these functions.

2.1.1 DATA MANAGEMENT GROUP (DMG)*

Planning and scheduling functions which define the spacecraft and ground activities necessary to effectively satisfy the mission and flight operation requirements are performed by the Data Management Group (DMG). The plans and schedules must be based upon sensor coverage requirements, spacecraft and payload configuration, network availability, and environmental constraints. The resultant activity plan is a time-ordered list of spacecraft, payload, and network events.

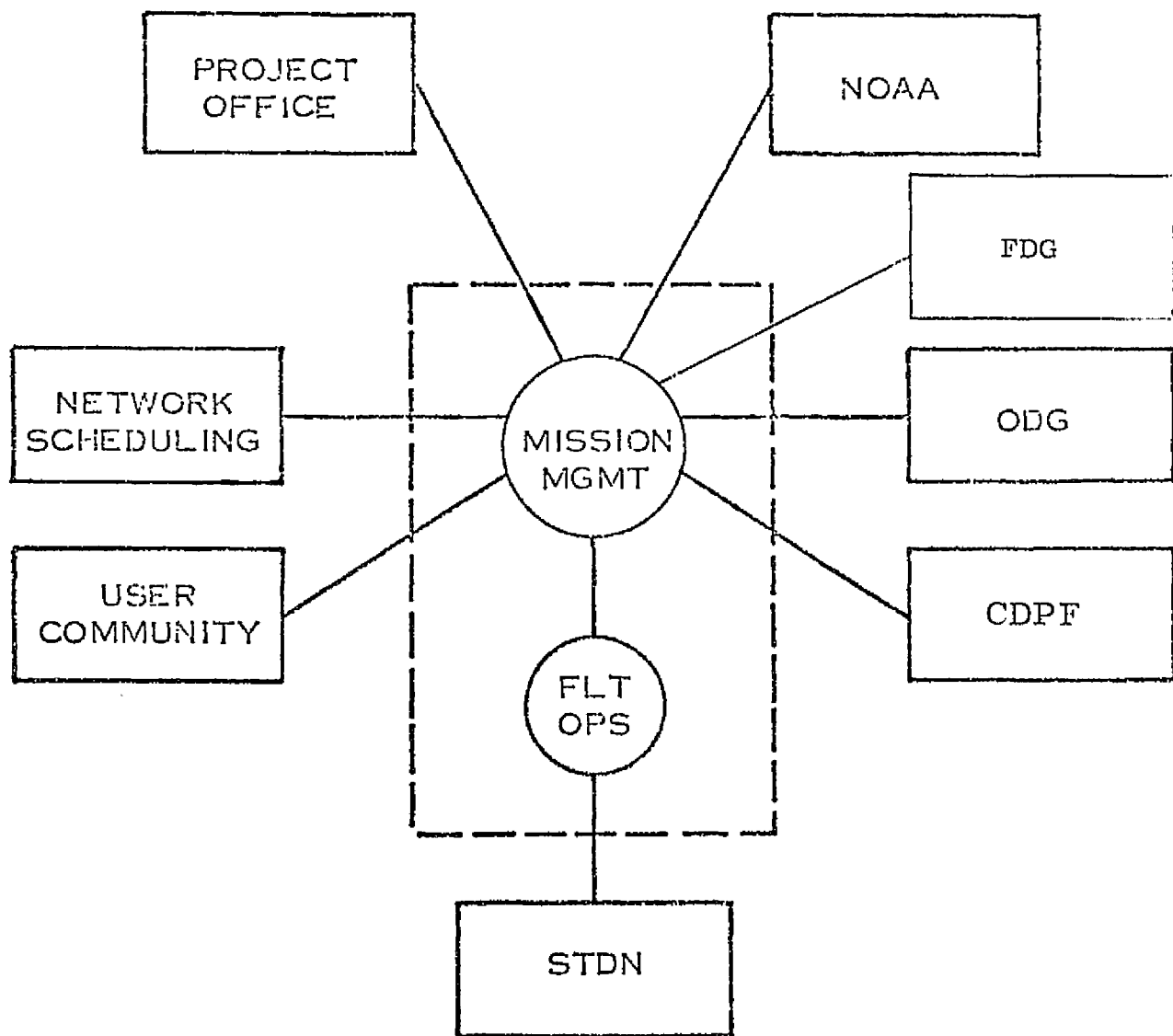


Figure 2-1. Landsat-D Functional Interfaces "

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

2.1.1.1 Sensor Coverage Requirements*

The Data Management Group has the responsibility of receiving requests for Payload Data from the NASA Data Utilization Office, the Landsat Project Office, and some special users and integrating them into the scheduling data base. This data base is used to schedule the on-board payload as well as provide management reports containing, but not restricted to the following information.

- a. All outstanding requests for Landsat images.
- b. All satisfied requests for Landsat images and the assessment of each image.
- c. All in-process requests and their state of completion.

The maintenance of this data base requires feedback from the CDPF on the status of all in-process payload data.

2.1.1.2 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 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 spacecraft health and safety.

2.1.1.3 Network Availability*

Network availability must be determined for emergency contact operations as well as tracking. Tracking requirements will be input to DMG 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 be determined by the Flight Dynamics Group (FDG) and input to the DMG. The DMG must factor these requirements into the activity plan. The DMG must coordinate all network support requirements with STDN and be capable of iterating the activity plan as a result of network schedule conflicts.

In addition, the DMG must maintain a constant availability status with the Tracking and Data Relay Satellite System (TDRSS). All data collection (other than Direct Readout) and tracking will normally be performed through the TDRSS system

2.1.1.4 Environmental Constraints*

Environmental constraints include those factors which affect or restrict payload operations such as sun angle and weather.

2.1.1.5 Spacecraft Location and Attitude Data Processing*

The CDPF requires spacecraft location and attitude data to correctly process the payload sensor data. The spacecraft attitude data is extracted from the spacecraft telemetry data by the OCC and is condensed with location data supplied by the Orbit Determination Group. This data is then transferred to the CDPF for use in payload data processing.

2.1.2 FLIGHT OPERATIONS CONTROL*

The OCC is the focal point for Landsat-D in-orbit operations. The OCC operations control function must, therefore, be capable of integrating and directing both the internal OCC activities and the external network support activities to ensure execution of the activity plan provided by the OCC scheduling function. The operations control function must also be capable of rapid and effective response to contingencies in both the spacecraft and ground support systems.

The internal OCC activities associated with the OCC operations control functions include spacecraft command generation, transmission, and verification; real-time spacecraft and payload performance evaluation; payload data reception and recording; and coordination of the associated OCC computing support.

These internal activities must also be coordinated with the scheduled network support activities in order to maximize the effectiveness of the OCC operations.

2.1.2.1 Spacecraft Command Generation, Transmission and Verification*

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

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.

2.1.2.2 Real-Time Monitoring of Spacecraft and Payload Performance*

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. Real-time processing and analysis are required to permit on-line command and control over the spacecraft. Implicit within this requirement is the fact that the OCC must be capable of receiving, processing, displaying, distributing, and storing the spacecraft data necessary to fulfill these responsibilities.

2.1.2.3 Payload Data Reception*

The CDPF/DIS is the focal point for the reception of the payload data. The data will be transmitted from the TDRSS ground station to GSFC via the DOMSAT relay. The OCC will record incoming payload data for a "Quick Look" display.

2.1.2.4 OCC Computing Support Coordination

The OCC operations control function also coordinates the OCC associated computing support to provide maximum support not only to the on-line flight operations but to the other OCC functions as well.

2.1.3 SPACECRAFT AND PAYLOAD PERFORMANCE EVALUATION*

The OCC is responsible not only for the short-term spacecraft configuration and health, but also for long-term trend analysis, investigation of anomalies, and for the historical reporting of spacecraft and payload performance. The performance evaluation function uses all available sources (telemetry and video data, strip chart records, system scheduler

outputs, etc.) to analyze the spacecraft and payload performance on an in-depth, long-term basis and to investigate anomalies in the spacecraft and payload systems. Periodic reports are generated to disseminate information on the spacecraft and payload performance.

2.2 OCC SYSTEM DESIGN

The three major functional requirements of the OCC are satisfied by the following eight major subsystems:

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

Each of these subsystems is described in the paragraphs below.

2.2.1 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. 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 play-back telemetry data and consists of three software elements.

1. Decommutation Software. Decommutates all spacecraft telemetry data input to the OCC and prepares it for analog and digital displays and further computer processing.
2. On-Line Processing and Analysis Software. Processes all decommuted spacecraft telemetry for real-time display and evaluation and prepares the data for off-line processing.
3. Off-Line Processing and Analysis Software. Processes spacecraft telemetry data for in-depth evaluation of system and subsystem performance.

2.2.1.1 Decommutation Software

The Decommutation Software operates in the OCC communications processor, which is part of the OCC Computing Services Subsystem described in Section 2.2.7. All spacecraft telemetry data received at the OCC is input to the communications processor and is operated on by the Decommutation Software.

The real-time data is input to the Decommutation Software in block format. 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.

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, the go/no-go results of the polynomial decoding and RF echo check, and the time of transmission (minute and second) from the remote station.

2.2.1.2 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 real-time data, and performs the frame-by-frame processing functions. The on-line software also generates a raw data file containing the real-time telemetry data.

The ONPAS system consists of a number of Telemetry Processing Packages, designed to perform the following six functions:

1. Reformatting. Basically a data unpacking and reordering function.
2. Range Check. Fitting analog values into various size "bins".
3. Status Determination. Verification of the necessary indicators of spacecraft status.
4. Calibration. Each telemetry sample is converted to engineering units by means of stored look-up tables.
5. Pseudo-Function Generator. Additional spacecraft performance measures, such as operating efficiencies, power outputs, etc. which are computed from the telemetry data are generated.
6. Smoothing. Transient noise is removed from the telemetry data prior to further processing.

2.2.1.3 Off-Line Processing and Analysis Software

The Off-Line Processing and Analysis Software (OFPAS) accepts telemetry data, via the RDT (Raw Data Tape), and performs the in-depth processing required for detailed evaluation of system and subsystem performance. OFPAS also creates the spacecraft location attitude tape (SLAT) or file for use by the Central Data Processing Facility (CDPF).

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). OLS establishes the processing order, controls the linkages, and brings in the data from data base. Off-Line 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 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 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 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 is transferred to the display software where it is formatted into magnetic tape for output to the plotter.

2.2.2 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.

Evaluation of the performance of the 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 CDPF 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.

2.2.2.1 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 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.

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, 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.

2.2.2.2 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 charts 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 time orbital operations, the strip chart recording is performed for both real-time and off-line detection and analysis of abnormal conditions.

More comprehensive data describing the overall operation of the payloads is generated by the PCM processing software described in Section 2.2.1. This software processes the payload telemetry from the real-time data to produce a report of sensor performance which defines the operational profile of all sensor activities. In addition, this data is used to compute statistical and trend data required for long term performance.

2.2.2.3 Evaluation Using CDPF Imagery *

The evaluation described previously was concerned primarily with the identification of anomalies in sensor performance which could endanger the spacecraft or impair the performance characteristics of the payload. These factors cannot generally be detected at the quick look level of evaluation, but must be done from an examination of high quality images.

The guidelines for evaluation will be firmly established once the real imagery from the respective sensors has become available and test and integration experience has been gained.

2.2.3 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 from the activity plan generated by the System Scheduling software (reference Section 2.2.6). During the real-time acquisition the command messages are formatted, verified, and transmitted under command operator control. All commands generated by the OCC are routed to the remote sites for RF transmission to the spacecraft.

2.2.3.1 Command Compilation Software (CCS) *

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. The CCS functions in the non real-time environment and 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 computer and will be assessed 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 describes the spacecraft commands and their execution times. Commands which are to be executed within a predicted RT acquisition window will be formatted for transmission as real-time commands (RTC's). Commands which are to be executed outside a RT acquisition window will be formatted for transmission as stored commands. Critical commands included in the list will be flagged for the operator.

2.2.3.2 Command Management Software (CMS)*

The CMS performs the processing required to transmit commands to the spacecraft under control of the command operator. This software is normally co-resident with the ONPAS of the PCM processing subsystem (Section 2.2.1) and the Status Data Control and Display Subsystem software (section 2.2.5) and operates in conjunction with this software. 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.

The preliminary command list resulting from the CMS is displayed for the command operator on request. The operator has the capability to edit, delete and insert both single commands and command sequences from the command console.

At the conclusion of this process the complete command list is displayed for review and approval. The command list, with its sequence annotation, is stored within the OCC computer for subsequent call-up by the CMS during the real-time acquisition period.

2.2.4 COMMUNICATIONS AND DATA DISTRIBUTION SUBSYSTEM (C&DD)*

The C&DD Subsystem configuration is shown in Figure 2-2. The C&DD Subsystem consists of the input/output signal conditioning and switching equipment, the OCC/CDPF

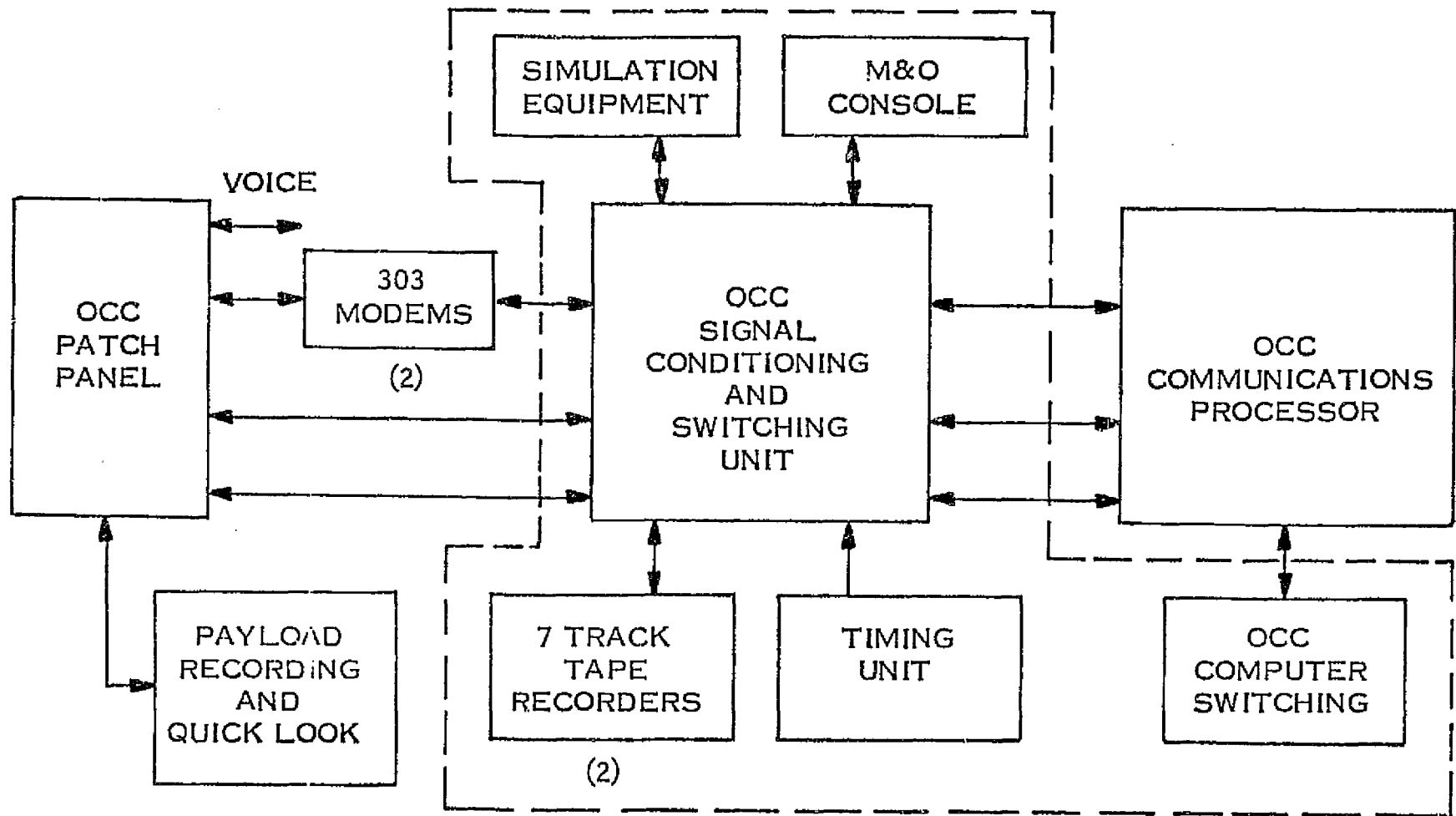


Figure 2-2. OCC Communications and Data Handling Distribution Subsystem*

computer switching equipment, the timing equipment, the maintenance and operational consoles 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 Computer Subsystem and the Control and Display Subsystem. Coordination of OCC operations with the Landsat-D system is provided by use of voice communication equipment.

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. Maintenance and Operational (M&O)
5. Voice Communications

2.2.4.1 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, and command 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.

2.2.4.2 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.

2.2.4.3 Computer Subsystem Switching*

The Computer Subsystem Switching (CSS) equipment switches the OCC input/output signals within the OCC Computer Subsystem. Control of the CSS equipment will be remotod to the M&O console.

2.2.4.4. 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, 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 remotod to the M&O console.

2.2.4.5 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.

2.2.4.6 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.

2.2.5 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 2-3. 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.

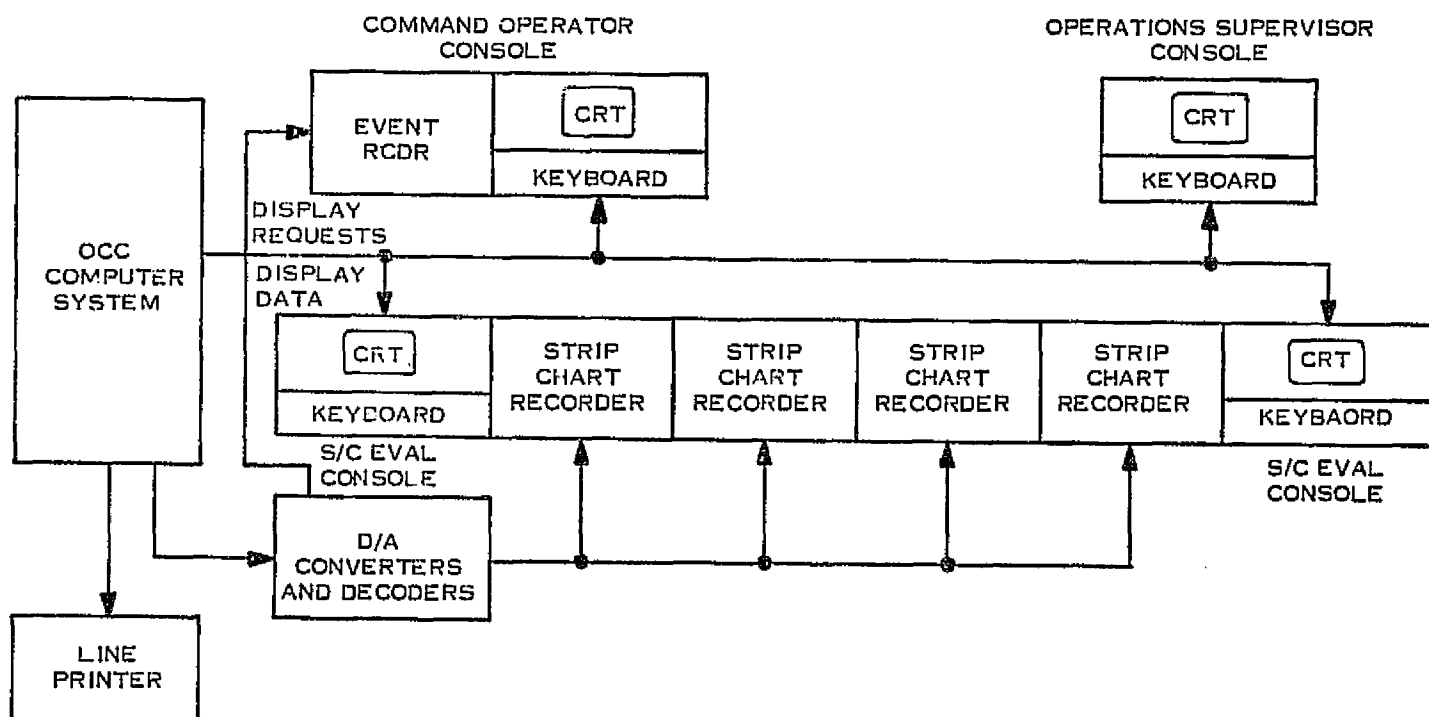


Figure 2-3. Control and Display Subsystem Block Diagram*

2.2.5.1 Operations Consoles*

Four consoles are required within the OCC Operations Control Room. The four consoles have been identified as:

1. Operations Supervisor (OS) consoles
2. Command Console
3. Spacecraft Evaluator Console (2)

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 at any time.

2.2.5.2 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.

Under normal conditions the portable strip chart recorders and the event recorder will be located in the Operations Control 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. This arrangement affords full benefit from the multi-processing 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.

The strip chart and event recorders also serve as a critical backup display capability within the OCC. In the computer system configuration described in Section 2.2.6, 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.

2.2.5.3 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 Generation 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 2.2.7. 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 2-4 defines the information exchange for this 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.

Any CRT 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 RGS. The RGS will then use the new display set table for the requesting console to extract and display the PCM data at that console.

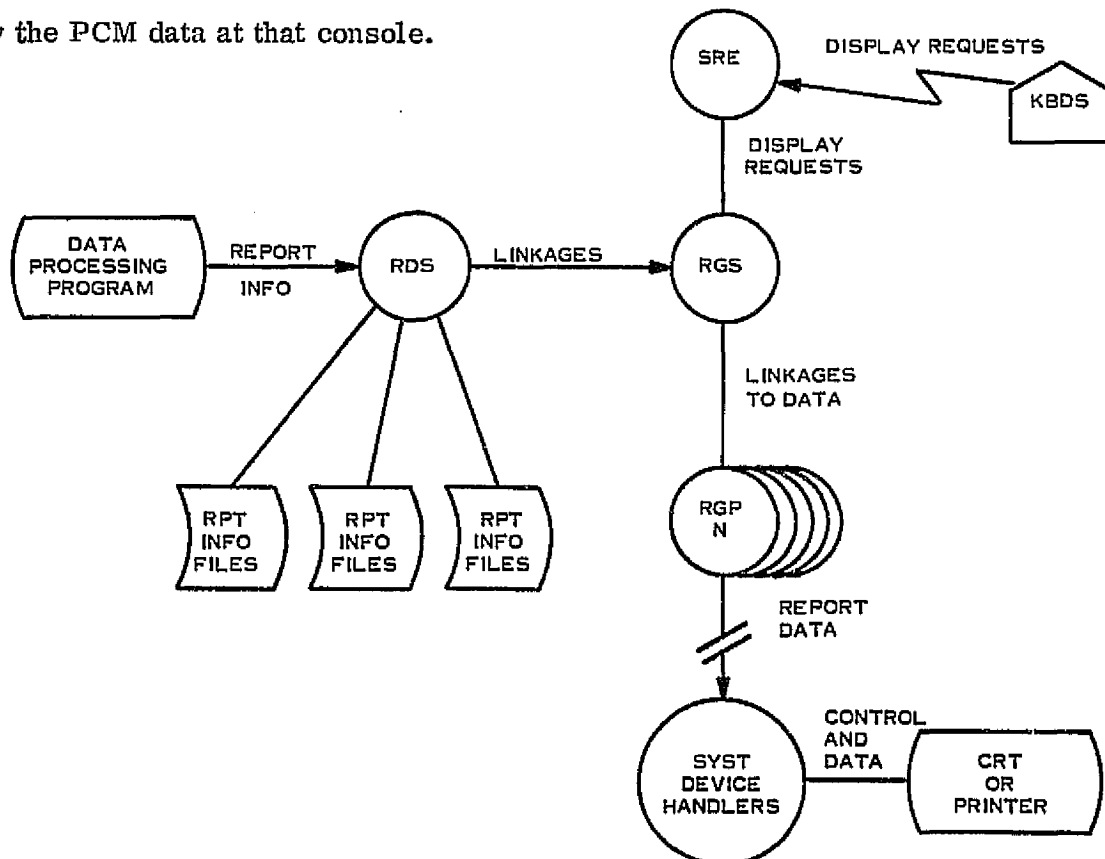


Figure 2-4. Report Generator Packages Processing

Data required for trend analysis will be extracted post-pass from the 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.

2.2.6 SYSTEM SCHEDULING SUBSYSTEM*

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 Landsat system. The subsystem is primarily a non real-time, data-base oriented, software system.

The System Scheduling Subsystem provides the mission planner with a computational and bookkeeping aid to assist him in the selection of a specific mission profile which efficiently uses the data collection capability of the Landsat 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 to report constraint conflicts identified by the computer. In all cases, manual intervention can override computer generated decisions.

2.2.7 COMPUTING SERVICES SUBSYSTEM

The Computing Services Subsystem must provide the data processing hardware and software capabilities to meet the function requirements described in Section 2.2.1 through 2.2.6. In addition, it must provide:

- A backup capability for on-pass commanding.
- Test, diagnostic and simulation capabilities for all interfaces.
- Standard software development and maintenance capabilities.
- A graceful recovery capability for on-pass crashes

2.2.7.1 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 Schedule Module).

2.2.7.2 Computer 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 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, 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 inter program transfers. Tapes provide media for mass memory purging, program storage, archiving of OCC data, CDPF interface, and plotter interface.

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 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-PCU failure in order to maintain analog display output.

2.2.7.3 Communications Processor

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 principal interface considered was that for the telemetry data. This data will arrive at the OCC in NASCOM blocks and data rates of 56 or 112 kbps via the NASCOM 494 communications processor.

2.2.7.4 OCC/CDPF Computer Interface Study

This study was directed at determining the need for, or desirability, of a direct interface between the OCC and CDPF computers. The primary purpose of this interface would be to permit the transfer of telemetry, ephemeris, and payload operations data from the OCC to the CDPF without the need for magnetic tapes, and would also facilitate OCC access to the CDPF image assessment information.

The results of the study concluded the following:

1. Direct interfaces between the OCC and CDPF 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 becomes apparent that such an interface would not appreciably increase the capability of the overall system.
2. The use of a shared disk-pack between the OCC and CDPF computers is available at little or no increase in cost and complexity. A read/write capability on the OCC side and a read-only capability on the CDPF side would provide the necessary interface for the direct transfer of spacecraft location and attitude data from the OCC to the CDPF computer. This would eliminate most of the magnetic tape transfer interface presently used.

2.2.8 OCC SOFTWARE

OCC software required for PCM Data Processing is discussed in Section 2.2.1, for Command Generation in Section 2.2.3, and for Status Control and Display in Section 2.2.5.

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

2.2.8.1 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, be 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 a 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 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.

2.2.8.2 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 day for the input of new ephemeris and image assessment information for the System Scheduling Subsystem.

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 System Scheduling software, for example, generates an activity plan for events required during a particular future orbit, and places that plan in bulk storage for retrieval later by the Command Generation software. Spacecraft evaluation software generates performance reports after each orbit and outputs these reports to the data base for subsequent retrieval for trend analysis purposes.

2.2.8.3 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.

2.3 LANDSAT-D OCC DESIGN ALTERNATIONS

This portion of the report examines the OCC design changes that would have to be incorporated for the Landsat system. The results show that the current OCC design/architecture can perform the Landsat-D/OCC mission with several software program additions as listed in Table 2-1.

The current OCC design/architecture can accommodate these additions.

The mix of FORTRAN to assembly language coded programs in the current OCC are shown in Table 2-2. There are five major categories of software programs: The System and real-time categories of programs are coded in assembly language and represent a significantly small number of programs with respect to the total program complement. The remaining on-line, off-line and mission/planning program categories are coded in FORTRAN. The systems programs were coded and supplied by Xerox as executive software. The remainder, results in only approximately 1 or 2 programs out of 64 coded in assembler. FORTRAN coded programs represent about 95% of the software in the current OCC design.

TABLE 2-1.

APPLICABILITY OF CURRENT OCC DESIGN/ARCHITECTURE TO LANDSAT D OCC

2-28	1. Spacecraft Commanding	● Software	Add Antenna Pointing Commands (Acquisition-Re-acquisition) (TDRSS- Landsat-D + Landsat-D Sites) Add Thematic Commands Add Real time Commanding via TDRSS (Assume like STDN Commanding interface-blocked) Current Software package is applicable for STDN backup commanding Delete RBV control No on-board tape recording possible Change to 4800 Bit Block
		● Hardware	No change required (Assume 4800 Bit Block commanding)
	2. Telemetry Processing	● Software	Add monitoring for loss of lock (Ant. Ptg.) Add Thematic Mapper Sensor Status Processing Drop RBV status processing and possibly on-board tape recording Current design - OK; with change in S.W. architecture due to Landsat D S/C H.W. changes. Change to 4800 Bit Block
		● Hardware	No change required
	3. Sensor Scheduling/Planning	● Software	Add Sensor ON scheduling supplied by DME Add Sensor ON information in R/T to DME
		● Hardware	Probably don't need NOAA facsimile with P/L sensor gating done at White Sands Add 4800/9600 baud hardware interface for OCC and CDPF

TABLE 2-1 (CONTINUED)

4. Spacecraft Performance Data	• Software	Modify the SLAT program to provide CDPF S/C performance data.
	• Hardware	No change required
5. Spacecraft Evaluation and Management	• Software	Delete RBV processing, possibly no tape recording on-board Add TM processing Current design - OK; with change in S.W. architecture due to Landsat D S/C H.W. changes
	• Hardware	No change required
6. Status Control & Display Processing	• Software	Delete edit/review of PL scheduling data to CRT Add PL sensor scheduling received from CDPF Modify current displays for Landsat unique parameters
	• Hardware	No change required (See 3 above)
7. NASCOM Scheduling/Interface	• Software	No change required
	• Hardware	No change required

Table 2-2. Current OCC Software

PROGRAM CATEGORY	No. PROGRAMS	DISK STORAGE REQUIRED	% ASSEMBLY	No. OVERLAYS	WORDS CPU MEMORY ALLOC.	COMMENTS
Real Time	4	412 Granules	100 15 3 3	0 11 3 6	11,776 10,240 15,872 23,552	SRE DIS CMD PCM
System	46	1530 Granules	100	Many	19,968	XDS supplied
On-Line	21	619 Granules	0	*	39,492	*Only 1 Prog. Uses Overlays (2), Max Size 30,439 Min Size 4,608
Off-Line	1	420 Granules	1	14	39,492	Max only 37,000 Min only 29,813
Mission Planning	42	1458 Granules	0	0	39,492	Max size 37,659 Min size 4,339

REMARKS:

1 grandule = 512 words

1 word = 4 bytes

1 byte = 8 bits

An issue to consider above and beyond the fact that the current OCC design/architecture is applicable to the Landsat-D OCC, is that the current OCC hardware is approximately six years old. As the Landsat-D OCC time period begins, the current OCC hardware will be approximately ten years old and presumably, will be expected to last another ten years. Together with the fact that the present equipment manufacturer has gone out of business/market and no longer supports his product are considerations for the replacement of the current OCC hardware for the Landsat-D OCC. Therefore, it is recommended that the equipment listed in Table 2-3 Current Hardware be replaced. It is realized that this impacts the software conversion from the Sigma to Brand "X". However, this is softened somewhat by the high percentage use of FORTRAN coded programs (95%). This assumes Brand "X" executive software system can replace the current OCC executive software in capability since there are extensive real-time executive software computer systems available. The conversion of FORTRAN programs in terms of complexity is a function of the peculiarities of going from the Sigma to Brand "X" compilers and the degree of in-line code (assembler) used. This is not, as it appears to be, a major problem.

The conclusion reached is that the current OCC design/architecture is capable of performing the Landsat-D OCC mission with the addition of several new software programs and the use of an additional modem hardware interface (OCC-CDPF). It is recommended that the current OCC hardware replacement take place since the Landsat-D time period dates the current hardware by ten years which presumably must last for yet another ten years. This with the loss of manufacture/support are contributing factors. Software conversion of existing programs from the Sigma to Brand "X" is aided by the fact that approximately 95% of the OCC software is currently coded in FORTRAN.

NOTE: The assumptions made for the purposes of this report consist of:

1. Single spacecraft operations
2. Use of current OCC design/architecture with changes for Landsat-D
3. 1200 bit block upgraded to 4800 bit block and telemetry commanding
4. TDRSS serial data converted to 4800 bit block for OCC processing

TABLE 2-3

CURRENT OCC HARDWARE

- | | |
|--|---|
| <p>1. NASCOM INTERFACE UNITS</p> <p>2. SIGNAL CONDITIONING AND SWITCHING</p> <p style="padding-left: 40px;">- MTU/SCOPE PATCH PANELS (2 EA.)</p> <p style="padding-left: 40px;">- BIT/FRAME/SUB FRAME SYNCHRONIZER</p> <p style="padding-left: 40px;">- PCM SIMULATOR</p> <p>3. WIDE BAND DATA SET COUPLER (2)</p> <p>4. CONSOLES (6)</p> <p style="padding-left: 40px;">- COMMUNICATIONS PANEL</p> <p>5. COMPUTER INTERFACE EQUIPMENT</p> <p style="padding-left: 40px;">SIGMA 5 GROUND STATION TIME DIL (2)</p> <p style="padding-left: 40px;">SIGMA 5 DIO DISTRIBUTOR (2)</p> <p style="padding-left: 40px;">TIMING EQUIPMENT</p> <p style="padding-left: 40px;">SIGMA 3 DIO DISTRIBUTOR (2)</p> <p style="padding-left: 40px;">SIGMA 3 PCM INTERFACE (2)</p> <p style="padding-left: 40px;">SIGMA 3 RECORDER DIL (2)</p> <p style="padding-left: 40px;">SIGMA 3 GMT/VT DIL (2)</p> | <p>6. SIGMA 3 (2)</p> <p style="padding-left: 40px;">- STRIP CHART /ANALOG RECORDERS</p> <p style="padding-left: 40px;">- GMT/VT DISPLAY</p> <p>7. SIGMA 5 (1)</p> <p style="padding-left: 40px;">- PRINTER (2)</p> <p style="padding-left: 40px;">- CARD PUNCH (1)</p> <p style="padding-left: 40px;">- CARD READER (2)</p> <p style="padding-left: 40px;">- MAGNETIC TAPE DRIVES (6)</p> <p style="padding-left: 40px;">- DISKS (3)</p> |
|--|---|

2.4 COST ESTIMATES

One of the major objectives of this study was to provide rough order-of-magnitude (ROM) cost estimates of the Subsystem and maintenance and operation costs of the OCC. Although every effort was made to make these cost estimates as accurate as possible, it must be remembered that these are only ROM estimates to be used for budgetary and planning purposes. The cost estimates are, of course, directly related to the system requirements and resulting design upon which they are based. As the mission becomes better understood, and the requirements more definitive, it is expected that the costs will change from these initial estimates.

2.4.1 COST ESTIMATING GROUND RULES AND ASSUMPTIONS

The following groundrules and assumptions were adopted during this study for purposes of arriving at the cost estimates. They are an integral part of the resulting ROM estimates and should be reviewed closely.

1. An average labor rate of \$48K per year through overhead and G&A (and before fee and contingency) was used for each applied man throughout the design, fabrication, and test phases of the program. This value represents a reasonable mean between the higher paid senior engineers/managers and the lesser paid technicians/shop personnel. This rate and those used in item 2 below are 1976 rates and are used to keep the results of this study compatible with previous Landsat-D studies (see Section 1.1).
2. Field rates were used for estimating the cost of training operators and for the recurring station operations. These rates were supplied by NASA/GSFC and are as follows through overhead and G&A per year.
 - Manager/Engineers/Supervisors - \$36.36K
 - Lead Technicians/Operators - \$23.64K
 - Clerical and Support - \$13.64K
3. Overhead, IR&D, and General and Administrative rates are included as appropriate in each of the above man-year labor rate categories (direct and field support). The inclusion of these makes the labor rates used fully burdened and thus they only require the final addition of a contingency factor and profit (or fee).

4. Costs were included for contract support and similar support activity, in addition to the basic catalog price for all purchased items.
5. All costs provided are in basic 1976 dollars; no forwarding pricing or inflation factors were used in these estimates.
6. Where newly designed items are used in more than one subsystem of the Landsat-D ground system, the engineering design and drafting costs (non-recurring) were only costed once.
7. Published catalog prices were used for estimating purchased hardware and software whenever possible; in a few cases it was necessary to rely on engineering estimates and past experience for estimates of these purchased items.
8. The cost estimates presume the use of a private (for profit) contractor for all items and include provision for fee or profit at the rate of 10% on total cost.
9. No provision in the cost estimates is made for the physical facilities, land, security, nor operational utilities (light, power, heat, etc.); all of these are assumed to be provided by the government at no explicit cost to the project.
10. A contingency factor of 10% is included in the final total cost to account for some flexibility in requirements growth and unanticipated cost items.

2.4.2 COST BREAKDOWN STRUCTURE

The cost estimates for the Operations Control Center were derived from a "bottoms-up" analysis of each cost element. A cost breakdown structure was developed to four levels of depth as shown in Figure 2-5. Included on this figure are the major task elements which constitute the cost elements. The following descriptions summarize the third level of the cost breakdown structure.

1. System Engineering - this element provides for the overall design definition and integration of the various subsystem elements. Design reviews are provided for and the performance requirements are established.

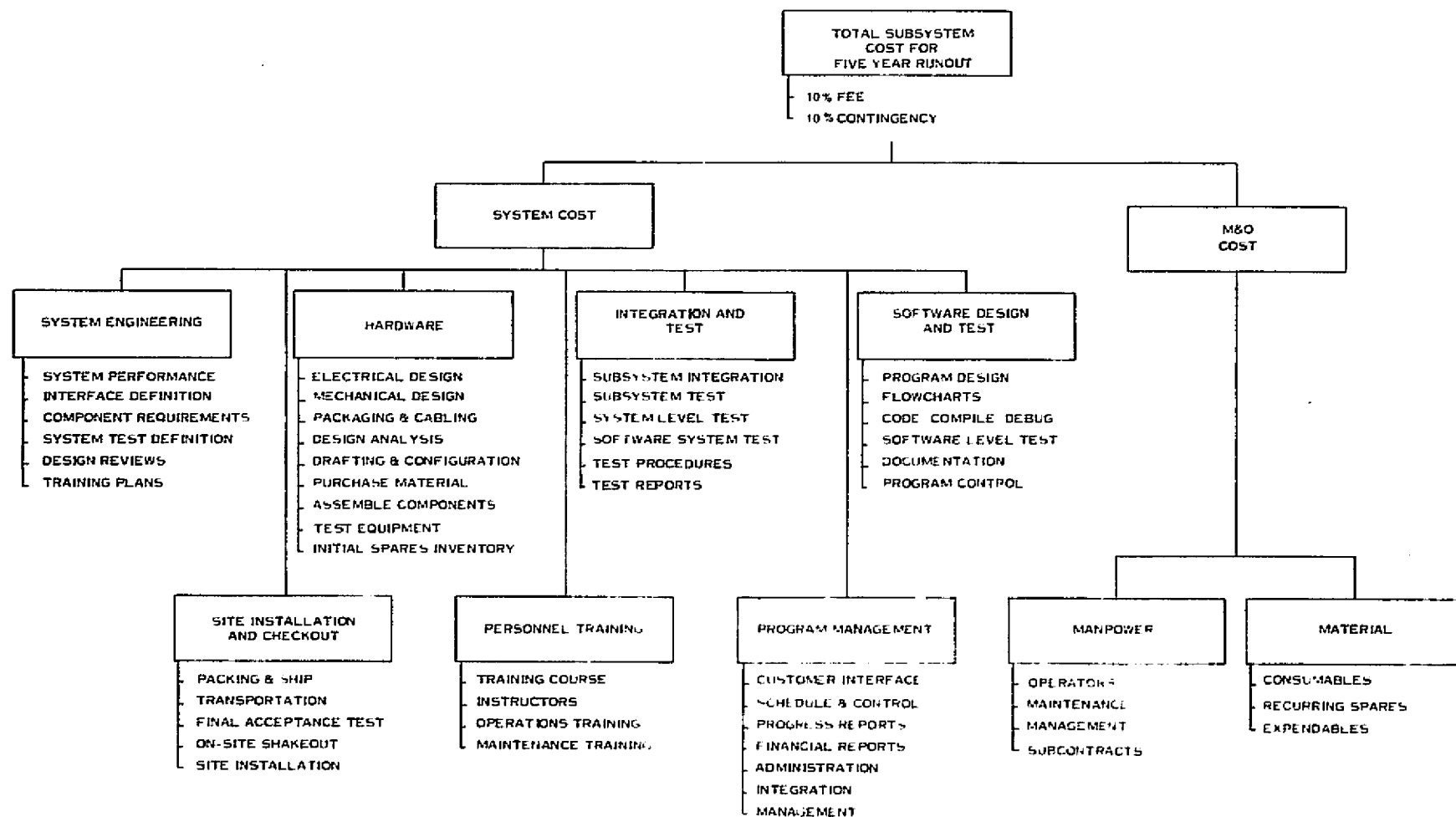


Figure 2-5. Cost Breakdown Structure

2. Equipment Design and Hardware Purchase - this element accumulates the cost of equipment design and manufacture. Purchase of material and bought components; the detailed electrical, mechanical, and packaging design; the necessary drafting and analysis support; and special test equipment design are all included in this cost element.
3. Software Design and Test - because of the importance of software as a key element in digital systems it has been given particular visibility. Included are both the software design and software test activities.
4. System Integration and Test - provides for the subsystem and system level tests of the integrated components. This is representative of the final test at the contractors facility prior to the shipping of equipment to the installation site.
5. Site Installation and Checkout - includes the actual shipment of equipment to the operational site as well as the performance of the final acceptance test on the system.
6. Personnel Training - a training course will be conducted to train the on-site field personnel who will operate and maintain the system.
7. Program Management - provides for the overall management and control of the entire systems development activity. Program management, administrative, and clerical support are included as well as providing for reports and communication with the customer.
8. Maintenance and Operations - this cost element provides for the yearly recurring costs which begin following the final acceptance test. The principal cost here is that of the on-site field personnel responsible for operating and maintaining the system. Costs are also included for expendable and consumable material items as well as for replacement spare parts.

2.4.3 COST ESTIMATING PROCEDURE

A "bottoms-up" cost estimating approach was used to estimate each of the various cost elements in the cost breakdown structure. In all cases the initial engineering and manufacturing cost estimates were reviewed by three levels of management to ensure their accuracy and consistency with recent experience. The following paragraphs are intended to provide some understanding of the rules-of-thumb applied and the procedures followed.

For each of the subsystems, a parts list was developed with each part identified and costed. A percentage was added to the catalog price of purchased items for the contract support required to generate the documentation and provide the necessary controls to purchase all buy items. The cost of the materials required for the newly designed items was estimated based on experience with similar items developed for previous ground stations. The labor effort required to design and manufacture the make items, and to provide the necessary design and manufacturing effort to develop the source control drawings, procurement specifications, and to assemble the buy items, were also estimated based on experience gained with similar equipment.

Catalog prices were used for all purchased items. The labor effort required for the design, drafting, and manufacturing of new items was based on experience with similar equipment, with appropriate complexity factors to adjust the total cost. Material costs were based on the number of electronic circuit boards, the number of parts per board, etc. The systems engineering task was costed based on a level of effort across the 21 month assumed program duration. No discounts were included in any of the hardware or software costing.

Ten (10) percent of the total material dollars were added to account for non-recurring spares. No specific analysis was conducted as to the detailed repair and replacement level nor were particular equipments identified for sparing. Rather, the 10% rule of thumb was applied across the board.

Catalog prices were used for all purchased software packages. The labor required to design the operational and test software, and to perform the debug and verification, was based on experience with similar software systems developed on previous programs and adjusted according to their relative complexities.

The System Integration and Test task was costed by estimating the number of people required to conduct and operate the particular subsystem equipment over the integration and test period.

The cost to pack and ship each subsystem was based on the number of equivalent single bay racks weighing approximately 800 pounds each. Each rack would be supported on a skid (100 pounds each) and the cost for shipping is approximately \$20 per 100 pounds. The installation and acceptance test efforts were costed based on the estimated number of men required over the given installation and test periods.

Training was costed by estimating the number of operators to be trained along with their associated labor category. Field rates were used for all site personnel and the standard contractor rates were used for the instructors. The training time allocated is based on the relative complexity of the subsystem.

Maintenance and operations were costed by estimating the number of man years/labor category required to perform OCC tasks. The NASA supplied field rates were used. An expenditure of 1% of the total material dollars was added for non-replaceable spare parts.

2.4.4 COST ESTIMATES

Five-year runout OCC cost estimates are summarized in Table 2-4 and Table 2-5, for recurring and non-recurring costs respectively.

Table 2-4. Non-Recurring Costs

<u>TASK</u>	
System Engineering	240
Equipment	3116
Software	1420
System Integration	120
Site Installation	50
Training	144
Program Management	<u>214</u>
Total	<u>5304</u>
Thru Fee	6418

1976 Dollars x 1000

Thru Fee = use of 10% fee and 10% contingency

Table 2-5. Recurring Costs

<u>CATEGORY</u>	
Manpower	908
Materials	<u>63</u>
Total	<u>971</u>
Thru Fee	1175

1976 Dollars per year x 1000

Thru Fee = use of 10% fee and 10% contingency

SECTION 3

OCC COMPATIBILITY WITH POCCNET

As was discussed in the Preface, this OCC Final Report has been divided into two relatively "stand-alone" sections. The previous Section 2, discussed the original study effort aimed at producing a baseline OCC design and cost estimate. The study contract was modified to include an investigation of the POCCNET concept as applied to Landsat-D; these results are reported here in Section 3.

Because of "stand-alone" nature of Sections 2 and 3 there is some redundancy of material between the two sections. These sections which are redundant have been marked with an asterisk (*) following the title.

3.1 OCC REQUIREMENTS*

The OCC has three major areas of responsibility in the performance of its functions. These are:

1. Data Management
2. Flight Operations Command
3. Spacecraft and payload performance evaluation

Figure 3-1 illustrates the Landsat-D functional interfaces required to perform these functions.

3.1.1 DATA MANAGEMENT GROUP (DMG)*

Planning and scheduling functions which define the spacecraft and ground activities necessary to effectively satisfy the mission and flight operation requirements are performed by the Data Management Group (DMG). The plans and schedules must be based upon sensor coverage requirements, spacecraft and payload configuration, network availability, and environmental constraints. The resultant activity plan is a time-ordered list of spacecraft, payload, and network events.

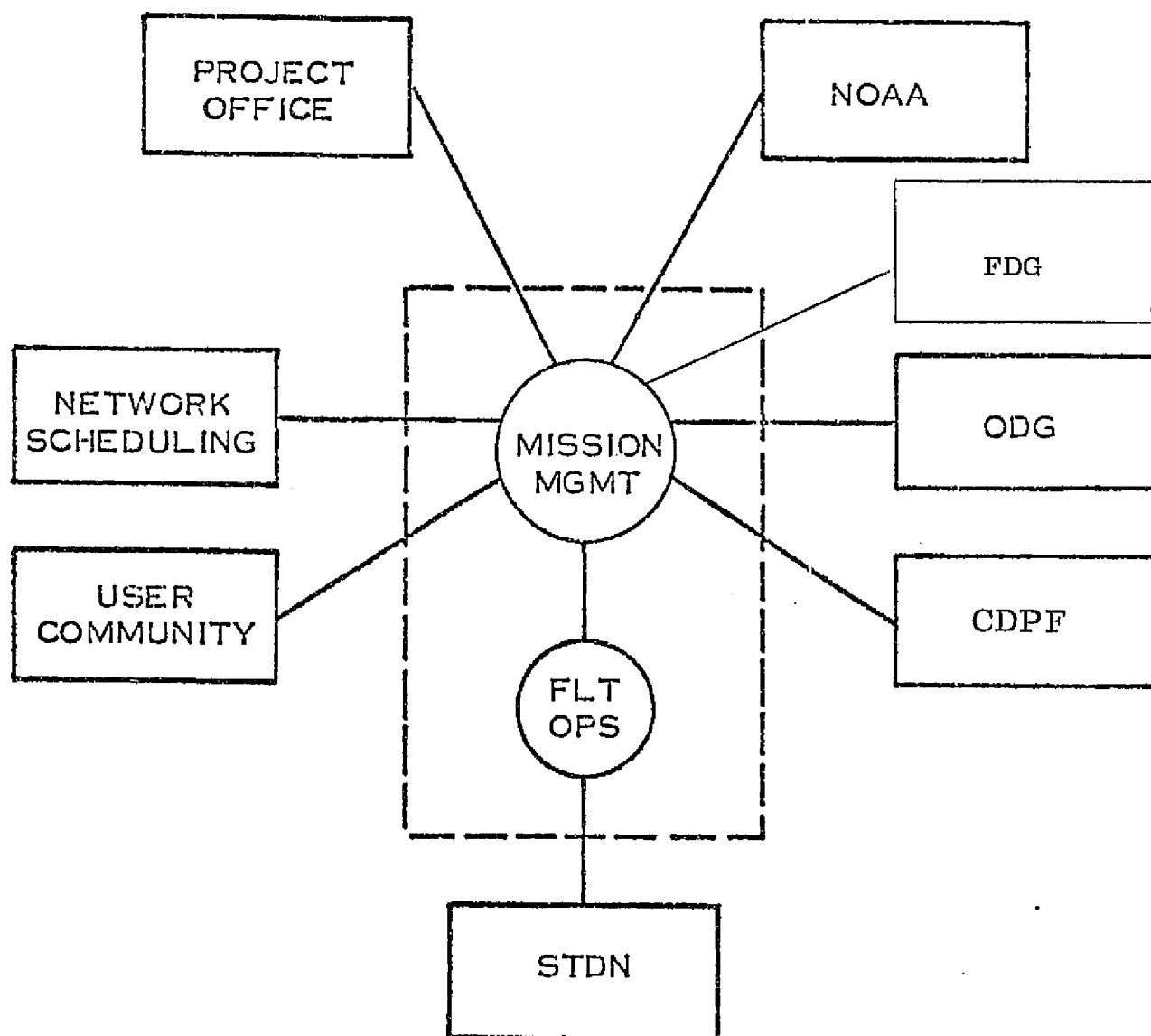


Figure 3-1 . Landsat-D Functional Interfaces *

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

3.1.1.1 Sensor Coverage Requirements *

The Data Management Group has the responsibility of receiving requests for Payload Data from the NASA Data Utilization Office, the Landsat Project Office, and some special users and integrating them into the scheduling data base. This data base is used to schedule the on-board payload as well as provide management reports containing, but not restricted to the following information.

- a. All outstanding requests for Landsat images.
- b. All satisfied requests for Landsat images and the assessment of each image.
- c. All in-process requests and their state of completion.

The maintenance of this data base requires feedback from the CDPF on the status of all in-process payload data.

3.1.1.2 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 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 spacecraft health and safety.

3.1.1.3 Network Availability *

Network availability must be determined for emergency contact operations as well as tracking. Tracking requirements will be input to DMG 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 be determined by the Flight Dynamics Group (FDG) and input to the DMG. The DMG must factor these requirements into the activity plan. The DMG must coordinate all network support requirements with STDN and be capable of iterating the activity plan as a result of network schedule conflicts.

In addition, the DMG must maintain a constant availability status with the Tracking and Data Relay Satellite System (TDRSS). All data collection (other than Direct Readout) and tracking will normally be performed through the TDRSS System.

3.1.1.4 Environmental Constraints*

Environmental constraints include those factors which affect or restrict payload operations such as sun angle and weather.

3.1.1.5 Spacecraft Location and Attitude Data Processing*

The CDPF requires spacecraft location and attitude data to correctly process the payload sensor data. The spacecraft attitude data is extracted from the spacecraft telemetry data by the OCC and is condensed with location data supplied by the Orbit Determination Group. This data is then transferred to the CDPF for use in payload data processing.

3.1.2 FLIGHT OPERATIONS CONTROL*

The OCC is the focal point for Landsat-D in-orbit operations. The OCC operations control function must, therefore, be capable of integrating and directing both the internal OCC activities and the external network support activities to ensure execution of the activity plan provided by the OCC scheduling function. The operations control function must also be capable of rapid and effective response to contingencies in both the spacecraft and ground support systems.

The internal OCC activities associated with the OCC operations control functions include spacecraft command generation, transmission, and verification; real-time spacecraft and payload performance evaluation; payload data reception and recording; and coordination of the associated OCC computing support.

These internal activities must also be coordinated with the scheduled network support activities in order to maximize the effectiveness of the OCC operations.

3.1.2.1 Spacecraft Command Generation, Transmission and Verification*

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

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.

3.1.2.2 Real-Time Monitoring of Spacecraft and Payload Performance *

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. Real-time processing and analysis are required to permit on-line command and control over the spacecraft. Implicit within this requirement is the fact that the OCC must be capable of receiving, processing, displaying, distributing, and storing the spacecraft data necessary to fulfill these responsibilities.

3.1.2.3 Payload Data Reception *

The CDPF/DIS is the focal point for the reception of the payload data. The data will be transmitted from the TDRSS ground station to GSFC via the DOMSAT relay. The OCC will receive incoming payload data for a "quick look" display.

3.1.3 SPACECRAFT AND PAYLOAD PERFORMANCE EVALUATION*

The OCC is responsible not only for the short-term spacecraft configuration and health, but also for long-term trend analysis, investigation of anomalies, and for the historical reporting of spacecraft and payload performance. The performance evaluation function uses all available sources (telemetry and video data, strip chart records, system scheduler outputs, etc.) to analyze the spacecraft and payload performance on an in-depth, long-term basis and to investigate anomalies in the spacecraft and payload systems.

Periodic reports are generated to disseminate information on the spacecraft and payload performance.

3.2 DESIGN OVERVIEW

This section describes an OCC configuration approach that will allow the Control Center to function totally as an independent component or as part of POCCNET. With the configuration as shown in Figure 3-2, the OCC Functional Requirements are satisfied by the following seven major subsystems:

1. PCM Data Processing
2. Video Display and Evaluation
3. Command Generation
4. Communications and Data Distribution
5. Status Data Control and Display
6. System Scheduler
7. Computing Services

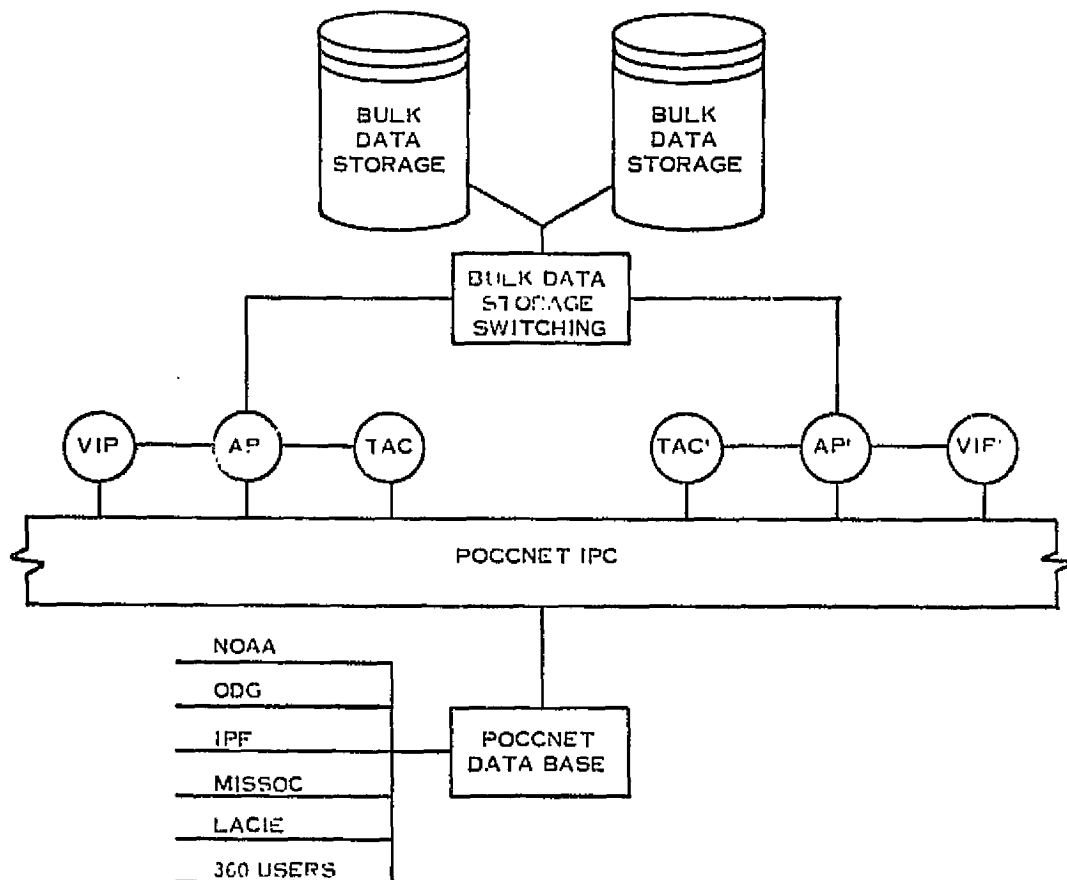


Figure 3-2. Landsat-D OCC Configuration

POCCNET is a set of services that will be used by the Landsat-DOCC. The POCCNET is a network of Operations Control Centers at Goddard. The POCCNET concept views all POCC's as a set of Telemetry and Command (TAC) systems. Applications Processors (AP), displays and other peripherals and external interfaces. The POCCNET will provide the protocols so that all these data processing elements can talk to each other through an Inter-Process Communications (IPC) net. The resource allocation will be, at the request of the POCC's, under control of Data Operations Control Center (DOCC).

The POCCNET concept also includes a Data Base Storage (DBS) service, Gateways and Virtual Interface Processors (VIP). The DBS allows POCC users to use the POCCNET data storage as a mailbox or a scratch area. Gateways are matched interfaces to external communications nets that do not use POCCNET protocols (e.g., to Johnson Space Center). The VIP is a computer that drives the OCC peripherals. It allows the user computer systems (DOCC's, AP's, TAC's) to see a standard interface for its replaceable peripherals. Thus, only the VIP would know the specific device characteristics and idiosyncracies.

The POCCNET is described in detail in "A Concept for a Payload Operations Control Center Network (POCCNET)" by R. des Jardins and J. Hahn, November 1976, Goddard Space Flight Center. (Document #X-510-76-250)

The Landsat-D OCC will be designed to work using the POCCNET concepts but not dependent on the POCCNET itself. Thus, there will be TAC's, VIP's and AP's but, in addition to the POCCNET IPC, DOCC and DBS, there will be a more limited Landsat-D OCC IPC, DOCC and disk storage system.

3.2.1 OCC CONFIGURATION IMPLEMENTATION

The Control Center consists of two Applications Processors, two VIP computers, two TAC Computers, and a Private Storage Disk Pool that can be made available to either application processor.

Following is a brief description of the functions performed by each of these computers.

The on-line Applications Processor (AP) performs on-line PCM, Data Processing OLS, and Command Transmission Functions.

The off-line Applications Processor (AP¹) performs Mission Planning, management Report Generation, Slat Generation, and is a hot backup for the on-line AP.

The on-line Telemetry and Command Computer (TAC) performs the command and telemetry formatting function.

The off-line Telemetry and Command Computer (TAC¹) is available for backup, Software Development or Second Spacecraft Support.

The on-line Virtual Interface Processor (VIP) functions as the Peripheral Interface for all OCC display devices.

The off-line Virtual Interface Processor (VIP¹) is available for backup to VIP, Software Development or a Second Spacecraft Operation.

The Bulk Storage Disc Pool is switchable between either application processor. The pool will normally be selected by the Application Processor that is performing Administrative Functions, Slat, Management Reports, etc.

3.2.2 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. This subsystem consists primarily of telemetry processing applications software operating within the OCC Applications computer. The PCM Data Processing Subsystem operates on real-time telemetry data and consists of three software elements (Figure 3-3).

1. Input Software. Decommutates all spacecraft telemetry data input to the OCC and prepares it for 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 spacecraft telemetry data for in-depth evaluation of system and subsystem performance.

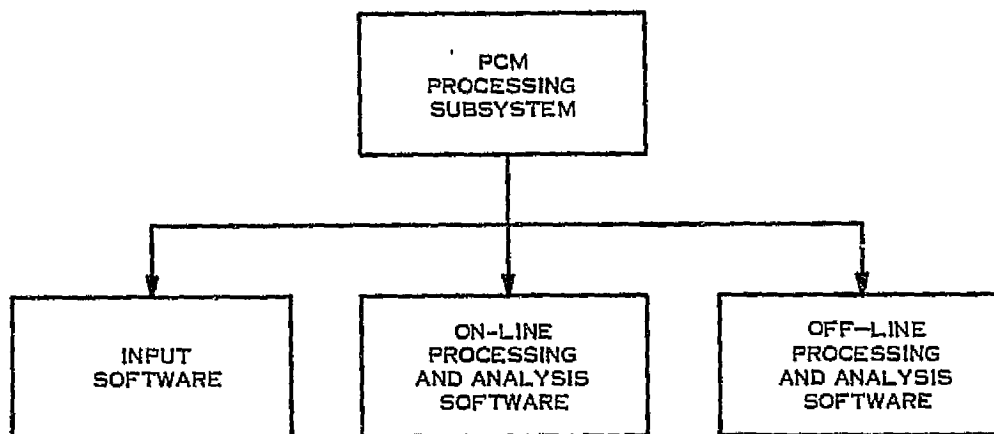


Figure 3-3. PCM Processing Subsystem Elements

3.2.2.1 Input Software

The Input Software operates in the OCC Telemetry and Command processor, which is part of the OCC Computing Services Subsystem described in Section 3.2.8. All spacecraft telemetry data received at the OCC is input to the TAC processor and is operated on by the Input Software.

The real-time data is input to the Input Software in block format. The TAC system 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 Applications computer.

The software first verifies the NASCOM header data to insure that this block contains telemetry data intended for the OCC.

Command status blocks, which also arrive at the TAC processor, are processed as described in Section 3.2.4. Other blocks (e.g. Time code) are stripped and passed unmodified in a standard message, to the OCC Applications computer.

3.2.2.2 On-Line Processing and Analysis Software

The On-Line Processing and Analysis Software (ONPAS) runs in the OCC Applications computer and operates in conjunction with the Input Software. ONPAS accepts and processes real-time data, alerts the Display Report Generators (Section 3.2.6.3) and performs the frame-by-frame processing functions. The On-Line software also generates a raw data tape containing real-time telemetry data, and writes the new telemetry data into the Landsat-D data base both locally and in the POCCNET DBS.

The ONPAS system consists of a number of Telemetry Processing Packages, designed to perform the following seven functions:

1. Reformatting. Basically a data unpacking and reordering function.
2. Range Check. Fitting analog values into various size "bins".
3. Status Determination. Verification of the necessary indicators of spacecraft status.
4. Calibration. Each telemetry sample is converted to engineering units by means of stored look-up tables.
5. Pseudo-Function Generator. Additional spacecraft performance measures, such as operating efficiencies, power outputs, etc., which are computed from the telemetry data are generated.
6. Smoothing. Transient noise is removed from the telemetry data prior to further processing.
7. Data Base Update. Write the new raw telemetry into the Landsat data base, frame by frame.

If the primary AP goes down, the alternate AP will take over. The current status will be derived from the telemetry written into the POCCNET DBS (or, if there is no POCCNET from a data base storage area accessible by both Landsat-D OCC AP's). A requirement on the alternate AP is that it must have a resident copy of the On-Line processing software.

3.2.2.3 Off-Line Processing and Analysis Software

The Off-Line Processing and Analysis Software (OFPAS) accepts telemetry data, via the RDT or the On-Line data base and performs the in-depth processing required for detailed evaluation of system and subsystem performance. (See Figure 3-4).

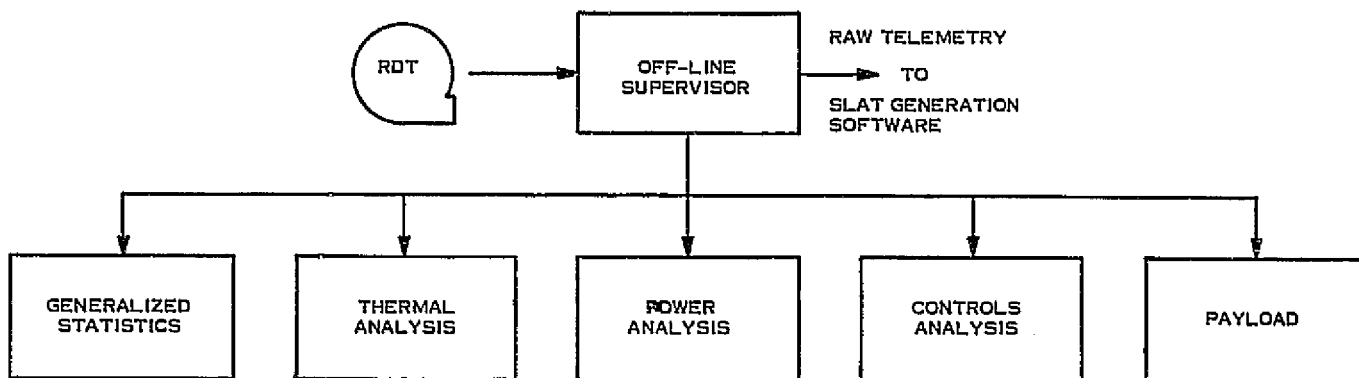


Figure 3-4. Off-Line Processing and Analysis Software

OFPAS consists of individual processing packages operating under the control of the Off-Line Supervisor (OLS). OLS establishes the processing order, controls the linkages, and brings in the data from data base. Off-Line 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 other calculations are made and the results compiled for display by the display software. With the exception of a Generalized Statistics Routine (GSR), the processing packages may be run in any order. The GSR computes the minimum, maximum, mean and standard deviation 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 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 is transferred to the display software where it will be displayed on a graphics terminal.

3.2.3 VIDEO DISPLAY AND EVALUATION SUBSYSTEM*

The Image Data Processing and Display Subsystem in the OCC provides the ability to monitor sensor operations during real-time NTTF station contact. This capability will allow real-time evaluation of payload operation and response to command.

3.2.3.1 Sensor Payload Performance Evaluation *

Evaluation of the performance of the spaceborne payloads will be based on the utilization of three data sources:

1. Quick look video displays from the OCC Image Data Processing and Display Subsystem.
2. Payload Telemetry Points processed by the OCC PCM Processing Subsystem.
3. High quality imagery generated by the CDPF 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.

3.2.3.1.1 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, 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.

3.2.3.1.2 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 shown and familiarity with it exists.

During the integration tests, strip charts 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, from the real time orbital operations, the strip chart recording is performed for both real-time and off-line detection and analysis of abnormal conditions.

More comprehensive data describing the overall operation of the payloads is generated by the PCM processing software described in Section 3.2.2. This software processes the payload housekeeping data from telemetry data to produce a report of sensor performance

which defines the operational profile of all sensor activities. In addition, the data is used to compute statistical and trend data required for long term performance evaluation.

3.2.3.1.3 Evaluation Using CDPF Imagery*

The evaluation described previously was concerned primarily with the identification of anomalies in sensor performance which could endanger the spacecraft or impair the performance characteristics of the payload. These factors cannot generally be detected at the quick look level of image evaluation, but must be done from an examination of high quality images.

The guidelines for evaluation will be firmly established once real imagery from the respective sensors has become available and test and integration experience has been gained.

3.2.4 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 from the activity plan generated by the System Scheduling software (reference Section 3.2.7). During the real-time acquisition the command messages are formatted, verified, and transmitted automatically, but under command operator control. All commands generated by the OCC are routed to the remote sites for RF transmission to the spacecraft.

The Command Generation Subsystem consists of three software packages: the Command Compilation Software (CCS) and Command Management Software (CMS) which operate in the OCC Applications Processor and the Command Blocking software in the TAC computer. The CCS operates off-line and is used by the command operator to compile the command list from the activity plan, and store it in the Landsat data base. The CMS provides the command operator with the full capability to add to, delete from, or change the compiled command list and to transmit both real-time and stored commands to the spacecraft from the command panel at his operations console. The Command Blocker blocks and formats the commands and is responsible for getting them to the uplink command site. Figure 3-5 depicts the Command Generation Subsystem flow.

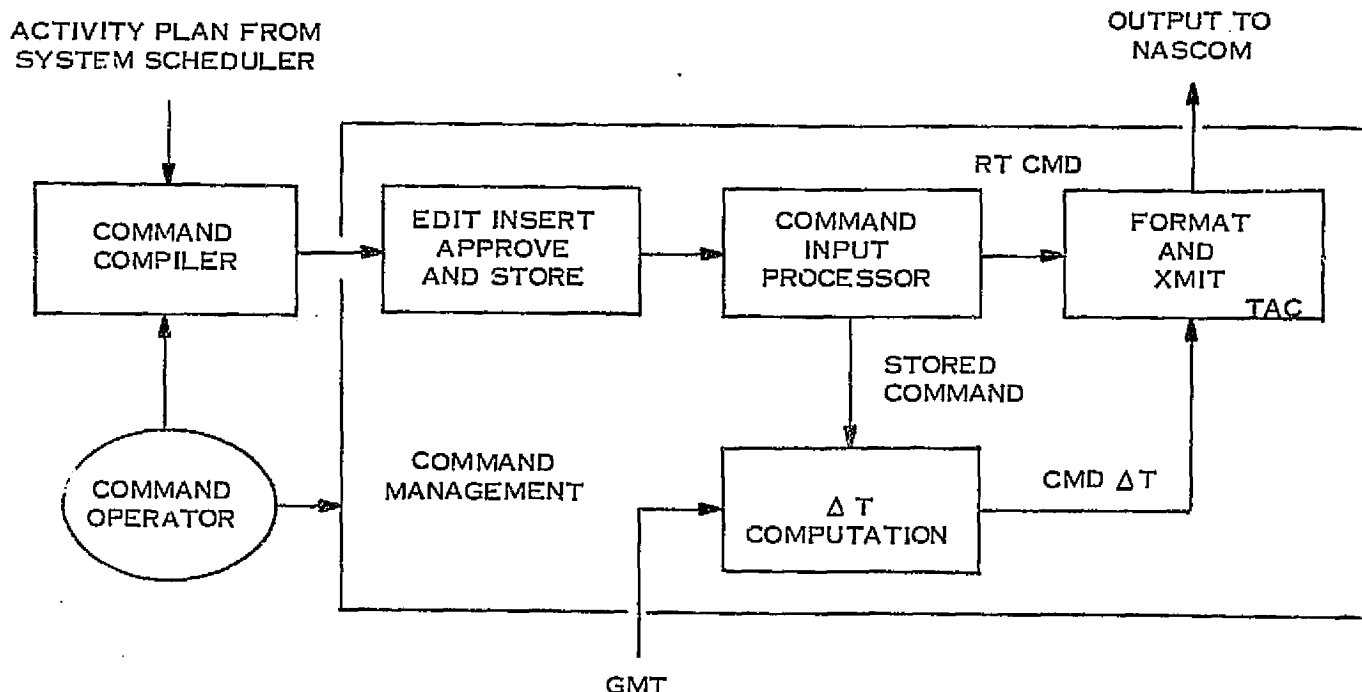


Figure 3-5. Command Generation Subsystem Flow

3.2.4.1 Command Compilation Software (CCS)*

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. The CCS functions in the non real-time environment and 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 computer and will be assessed 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 describes the spacecraft commands and their execution times. Commands which are to be executed within a predicted RT acquisition window will be formatted for transmission as real-time commands (RTC's). Commands which are to be executed outside a RT acquisition window will be formatted for transmission as stored commands. Critical commands included in the list will be flagged for the operator.

3.2.4.2 Command Management Software (CMS)*

The CMS performs the processing required to transmit commands to the spacecraft under control of the command operator. This software is normally co-resident with the ONPAS of the PCM processing subsystem (Section 3.2.2) and the Status Data Control and Display Subsystem software (section 3.2.6) and operates in conjunction with this software. 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 the command operator inputs from his operations console. The commands are sent by the DMS to the TAC computer. The CMS later extracts telemetry elements to decide upon the success of the command and displays these special points on a command display.

The preliminary command list resulting from the CMS is displayed for the command operator on request. The operator has the capability to edit, delete and insert both single commands and command sequences from the command console.

At the conclusion of this process the complete command list is displayed for review and approval. The command list, with its sequence annotation, is stored within the OCC computer for subsequent call-up by the CMS during the real-time acquisition period.

3.2.4.3 Command Block Software

The Command Blocking Software in the TAC processor is responsible for the blocking, reformatting and transmission of command messages from the Landsat Applications Processor.

The Command Block function will gather the messages into a NASCOM block, insert network protocol overhead, do the polynomial encoding and send the command message block to the uplink site. It will handle all command status blocks from the site that deal with command message protocol. Command status messages that are related to message content or command transmission problems are stripped and sent to the Applications Processor.

3.2.4.4 Command System Backup-

The Command System components - the AP, VIP, displays and TAC - each have an available backup in the alternate side of the Landsat-D OCC. If the primary on-line component goes down, the backup can be switched in through the POCCNET IPC or the Landsat-D IPC. (The alternate system will have co-resident inactive copies of the command and telemetry processing software.)

3.2.5 COMMUNICATIONS AND DATA DISTRIBUTION SUBSYSTEM (C&DD)*

The C&DD Subsystem configuration is shown in Figure 3-6. The C&DD Subsystem consists of the input/output signal conditioning and switching equipment, the OCC/CDPF computer switching equipment, the timing equipment, the maintenance and operational consoles 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 Computer Subsystem and the Control and Display Subsystem. Coordination of OCC operations with the Landsat-D system is provided by use of voice communication equipment.

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. Maintenance and Operational (M&O)
5. Voice Communications

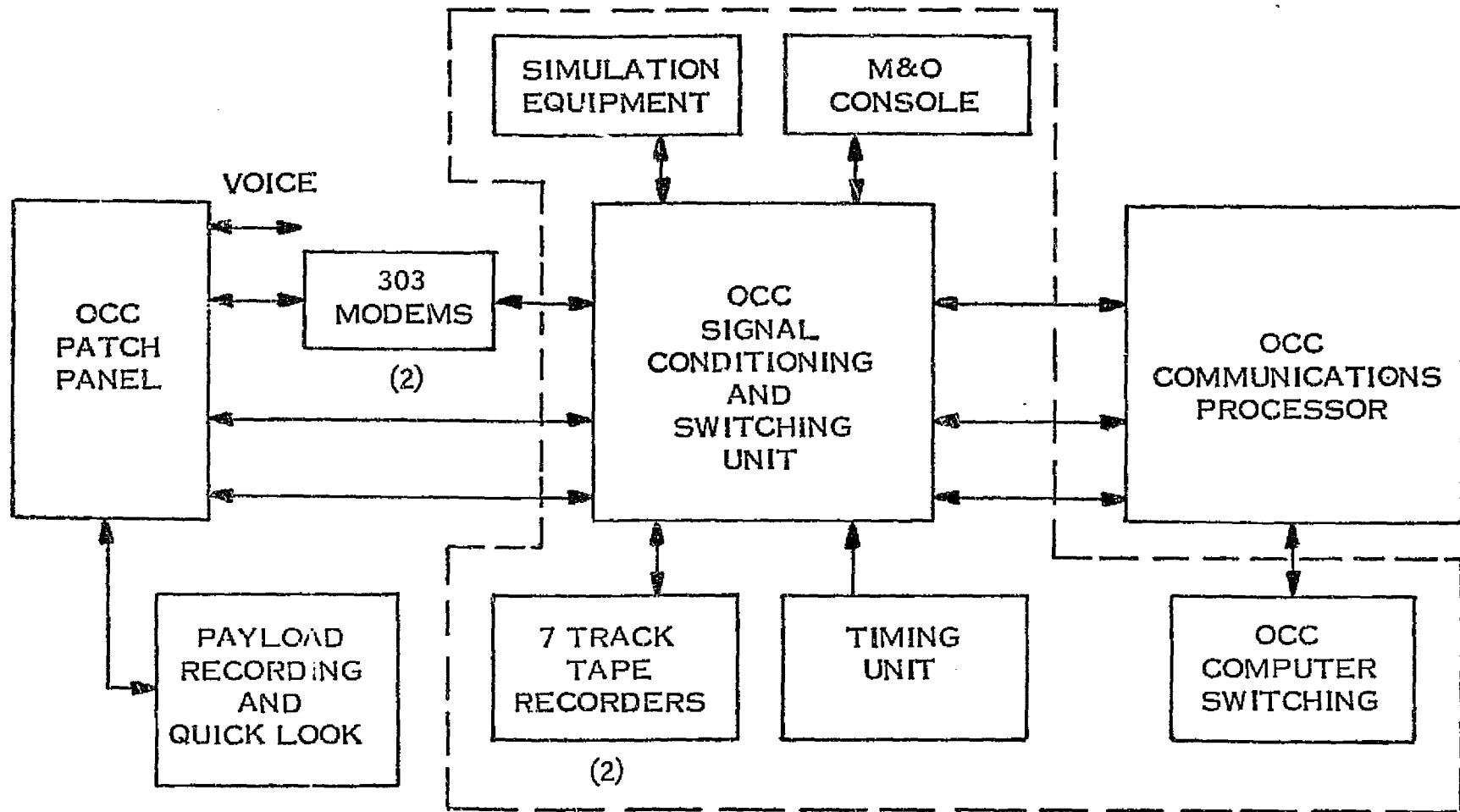


Figure 3-6. OCC Communications and Data Handling Distribution Subsystem

3.2.5.1 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, and command 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.

3.2.5.2 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.

3.2.5.3 Computer Subsystem Switching

The Computer Subsystem Switching (CSS) Equipment is capable of switching the necessary input/output signals for any combination of the TAC, VIP, and AP computers into the on-line configuration. Those computers which are not on-line will be available for off-line use by the DMG for Data Management functions, or alternatively may be placed on a network available status for use by other POCNET control centers. Control of the CSS will be remoted to the M&O console. The computer configuration, including the status of those components controlled by software switching, will be available at all times to the OCC personnel via status panels at the operations and M&O consoles.

3.2.5.4 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, 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.

3.2.5.5 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.

3.2.5.6 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.

3.2.6 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 3-7. 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.

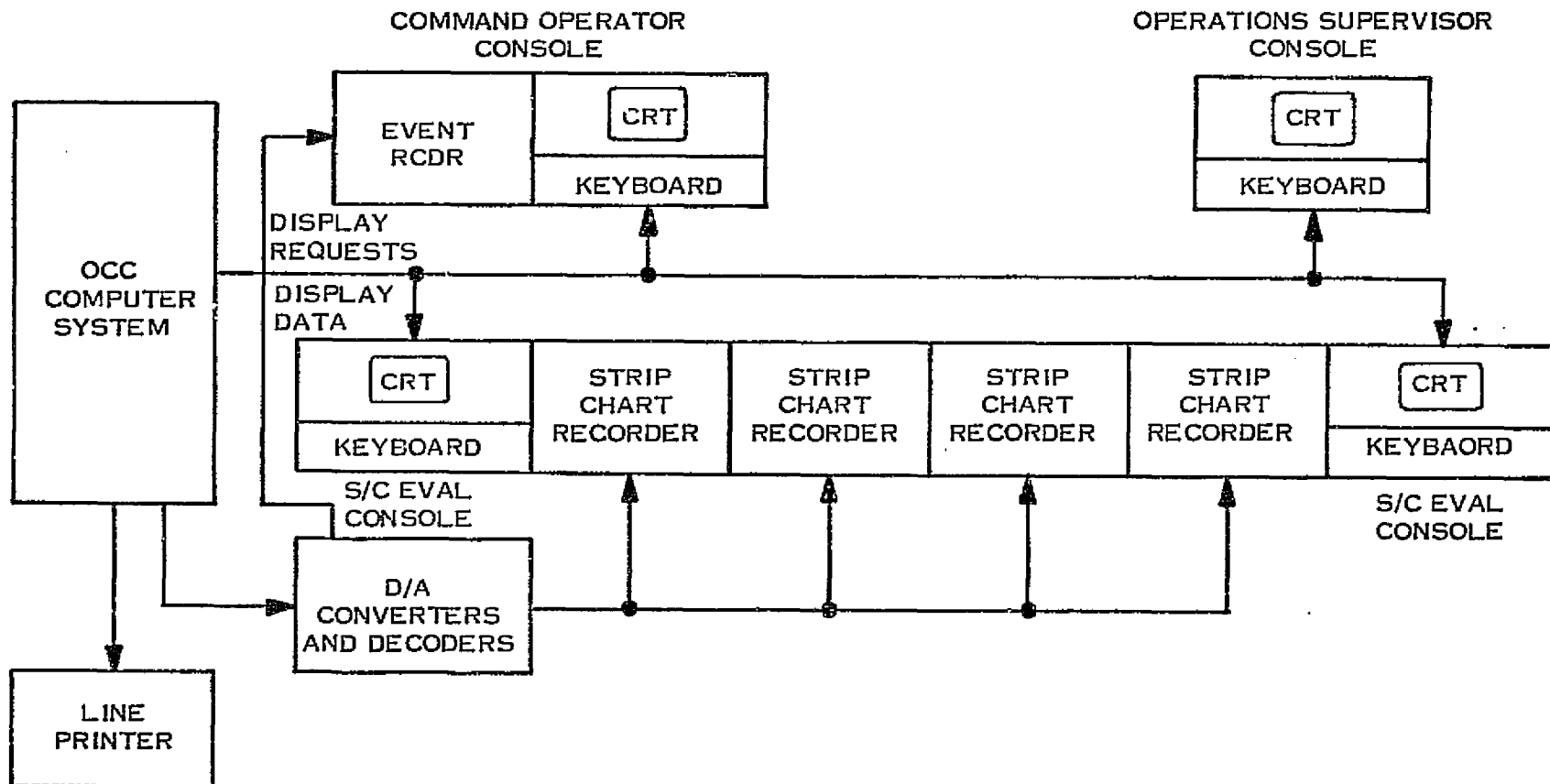


Figure 3-7. Control and Display Subsystem Block Diagram*

3.2.6.1 Operations Consoles*

Four consoles are required within the OCC Operations Control Room. The four consoles have been identified as:

1. Operations Supervisor (OS) consoles
2. Command Console
3. Spacecraft Evaluator Console (2)

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 at any time.

3.2.6.2 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.

Under normal conditions the portable strip chart recorders and the event recorder will be located in the Operations Control 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. This arrangement affords full benefit from the multi-processing 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.

The strip chart and event recorders also serve as a critical backup display capability within the OCC. In the computer system configuration described in Section 3.2.7, 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.

3.2.6.3 Display Control and Report Generation Software

Display generation and control within the Control and Display subsystem is performed primarily by two software packages, the Report Generator Supervisor (RGS) and the Report Generator Packages (RGP).

The purpose of the Report Generator Subsystem (RGS) is to supervise the presentation of requested displays at the operations consoles by supervising the loading of the required Report Generator Packages.

The Report Generators will be loaded at the request of the RGS into partitions known by the Applications Processor operating system. The RGS receives the display requests (through a VIP and the OS) when the operator keys-in the request.

The Report Generators interface with the operating system to request data updates when the new telemetry arrives. Thus, for each new telemetry frame, the operating system will signal each of the requesting Report Generators which will then drive the appropriate virtual devices with updates.

The Report Generator Packages will also contain all of the formatting statements, and tabular and columnar information required to display the report information in a meaningful presentation at any of the operations consoles or printer. They will read this information from files in the Landsat data base.

Analog and digital PCM data, displayed on strip chart and event recorders located at the operations consoles, will be processed in the same manner by special Report Generators that make use of the virtual device interface that allows strip chart recorders to appear as virtual displays.

Data required for trend analysis will be extracted post-pass from the telemetry file for this orbit. This data will be extracted, converted, and formatted in the codes appropriate for input to a graphics display. 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.

3.2.7 SYSTEM SCHEDULING SUBSYSTEM*

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 Landsat system. The subsystem is primarily a non real-time, data-base oriented, software system.

The System Scheduling Subsystem provides the mission planner with a computational and bookkeeping aid to assist him in the selection of a specific mission profile which efficiently uses the data collection capability of the Landsat 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 computed-aided; e.g., the OCC computer is utilized to perform routine arithmetic data processing, and to report constraint conflicts indentified by the computer. In all cases, manual intervention can override computer generated decisions.

3.2.7.1 System Overview

System Scheduling will generate the spacecraft activity plans that will be the input to the Command Compiler Software Package. System Scheduling will determine Station Support Requirements and initiate the scheduling thereof. It will generate video tape directories and determine requirement for Ephemeris. The System Scheduling shall, in meeting its basic responsibilities, be required to directly interface with the following groups:

1. NASA Project Office
2. Network Scheduling (MISSOC/OPSCON)
3. Orbit Determination Group (ODG)
4. Central Data Processing Facility (CDPF)
5. National Oceanographic Atmospheric Administration (NOAA)
6. User Community
7. 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.
8. 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:

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.

3.2.7.2 Spacecraft Activity Plan Generation

3.2.7.2.1 Edit Program

The Edit Program allows additions, deletions, and changes to 360 DATA BASE by creation of a new tape YPRM or Y1050.

3.2.7.2.2 Conversion to Frame World Program

The Conversion to Frame World program converts the latitude and longitude coordinates from the YPRM or Y1050 tape to frame world coordinates and creates the tape merge.

3.2.7.2.3 Frame to Priority Merge Program

The Frame to Priority Merge Program reads the merge tape and using the merge operator adds the effort index from the Priority Card input to generate tape MAPU.

3.2.7.2.4 Area Definition

The Area Definition program takes the requested frame data from MAPU and compares it with the frame taken history data base for the orbits under consideration to find which frames are still desired. It then adds the additional areas from the KITTI file and generates the area definition file (ADTDB).

3.2.7.2.5 Area Availability

The Area Availability program uses sun angle and spacecraft locations from ODG supplied ephemeris data in conjunction with predicted cloud to modify the desired areas from the (ADTDB) and assign start and stop center frame times references to the Equator to each available area after the sun angle and cloud cover predictions have modified the area. This is done via the AADP operator which generates the area availability table (AATBL) and the descending node table (DESNTBL).

INPUTS:

1. The Area Definition Table (ADTDB) contains all the desired areas for the night's scheduling.
2. The Predicted Fit Ephemeris contains the subsatellite trace and sun angles versus time in one-minute increments.
3. The card inputs to Area Availability contain:
 - a. Start orbit - the first orbit of consideration

- b. Time span - last digit of year, day of year, hour, minute, and second of start and stop of the program.
- c. Cloud cover - orbit number, start frame, stop frame and percent of predicted cloud cover.

The Area Availability Program converts the desired areas from frames to times, using the Ground Trace Ephemeris for the calculations. The times are frame center times calculated in twenty-five second increments from the time of Equator crossing. These times are then compared with the sun angle per time, and areas having out of range sun angles are either modified or removed or modified respectively to conform to their acceptable cloud cover. The remaining areas after deletions and modification are written to Available Areas Table (AATBL). The calculated times of descending nodes and the times of maximum sun for each orbit is written to the descending node table (DESNTBL). The operator NODTM transfers the descending node times to a section of the History Data Base.

3.2.7.2.6 Preprocessor

The Preprocessor cards load the Station Capabilities file (SCPTBL) and the Spacecraft Parameters table via the operator ADTX. The card inputs provide:

1. Station Capability data as to whether the station can:
 - a. Provide telemetry support.
 - b. Provide real time support.
 - c. Spacecraft commanding.
2. Spacecraft parameters
 - a. Which payloads may be used and which cannot be used.
 - b. Number of stored commands available.
 - c. Operational AOS & LOS Buffers.

3.2.7.2.7 Station Contact

INPUT

1. The Spacecraft Prediction File (SCP) contains all the stations that are predicted to have visibility of the spacecraft for a 14-day period along with their expected time of acquiring the spacecraft and expected loss of contact with the spacecraft, and the duration of the contact.

2. The station capabilities file provides the information on what service each station can provide.
3. The time span card provides the last digit of the year, the day of the year, hours, minutes and seconds of the start and stop of the data required.
4. The stations desired provide the information as to which stations are to be considered.

The operator takes the information for the desired stations during the time span provided and assigns each stations GO/NO GO capabilities from the station capability file (SCPTBL) and writes the station contact table (STCTBL). The STCTBL is then manually edited to remove any unscheduled stations and/or to add back-up sites that have been scheduled up before the file can be used as an input to the sensor operations program.

3.2.7.2.8 Sensor Operations

The sensor operators program consists of three separate but interrelated programs. These are real time, TDRSS and payload operations summary, which will be discussed separately.

1. Real time program

The real time programs the unified S-band beacon, and payload operations over ground stations having video reception capabilities.

INPUTS:

- a. SCACT - The SCACT file from the previous day provides initial conditions.
- b. STCTBL - The STCTBL file provides the information as to which stations are available, the time they are available and what their individual capabilities are.
- c. AATBL - The AATBL file is a list of the desired available areas containing the times the spacecraft will encounter them and what their priority or effort index is.
- d. SPMTBL - The SPMTBL provides data on the spacecraft indicating which payloads to schedule, and the delay time for command capability (after acquisition of signal and before loss of signal).
- e. ACTDFT - The ACTDFT file defines the acronyms to be used in constructing the SCAT.

- f. DESNTBL - The DESNTBL file provides the times that the spacecraft will cross the Equator going south.

The real time program deltas the command delay time from the station contact times in order to identify when the station can command. It then forms the basic SCACT table after saving the final SCACT from the previous day, adds USB acronyms, then schedules all payload activity that accrues within acquisition of a ground station.

The last SCACT table from the previous night is then merged with the first SCACT table and the complete real time SCACT is written to the SCACT file for use by the stored program.

2. The Stored Program

The stored program schedules payload operations when the spacecraft is not within view of a ground station. The program inputs are:

- a. SCACT - The SCACT file as input to stored is the real time SCACT file output by real time.
- b. STCTBL - The STCTBL file as input to stored is the modified STCTBL as output by real time and number of SCACT tables.
- c. AATBL - The AATBL file is the same as input to real time.
- d. ACTDFT - The ACTDFT file defines the acronyms to be used for scheduling the payload operations. Unlike the real time program the stored program also needs the number of commands and their delta times for each acronym. Since the stored program schedules only payload data when no ground station is in view and stored command capability is limited, commanding now becomes a constraint.
- e. SPMTBL - The SPMTBL file provides the information as to which payloads are to be scheduled. It also provides the number of stored commands available to the program.
- f. DESNTBL - The DESNTBL file provides the time the spacecraft will cross the equator going south on each orbit. The stored program calculates which areas will fit on the TDRSS with priority 1 areas and works toward priority 9 areas. The constraints are time available and the number of stored commands available.

The stored program then merges the stored payload activities with the real time SCACT and writes a combined SCACT to the file.

3. Payload Operations Summary

The POS program reviews the SCACT file for command conflicts. Its inputs are:

- a. STCTBL - The STCTBL provides the number of schedules in the SCACT file.
- b. SCACT - The SCACT file is read in for review and corrections.
- c. ACTDFT - The ACTDFT file provides acronym definitions (command and delta times).
- d. SPMTBL - The SPMTBL file provides spacecraft parameters.

The POS program reviews the SCACT for command conflicts that occur between real time and stored programs. Payload on and off conflicts are corrected by the program. The correct SCACT is then written to the SCACT file in preparation of the final edit.

3.2.7.2.9 Power Management

The Power Management program computes the amount of power that will be utilized by the scheduled spacecraft activities, compensation heater loads on, aux loads on and all other power dissipating items that are energized. The program then computes the solar array output for the duration of day and compares the power to be generated to the power to be consumed and computes the aux loads needed to dissipate excess power during the orbit. The aux load changes are then added to the existing SCACT.

INPUTS:

SCACT - The SCACT file is read to determine the activities that are scheduled in order to compute how much power will be required by the payloads.

PWRMGT - The PWRMGT file is read to determine the status of the spacecraft power subsystem after the last run (i. e., which subsystems were remaining on, which comp loads and aux loads were on and the discharge state) as well as constant and variable rates of power utilization or generation of each item.

STCTBL - The station contact table is read to determine the number of schedules contained in the SCACT file.

DESN TBL - The descending node table is read to determine the time of maximum sun angle for the orbit.

Cards - Modifications to the PWRMGT file are input on cards to the program.

OUTPUT:

SCACT - The SCACT with the aux loads added is sorted in chronological sequence and written back to the SCACT file.

PWRMGT - The PWRMGT table is modified to include the subsystems remaining on and the new discharge is returned to the PWRMGT file.

Printout - The Power Management program provides a print out of its operations and a summary of aux load changes and times.

3.2.7.3 System Scheduler Interfaces

3.2.7.3.1 Landsat Project/System Scheduling

The interface between System Scheduling and the LANDSAT Project was established to provide a means for the project to make its requirements relative to spacecraft operations; i. e. , Payload Operations known to the activity scheduling body. The interface also allows for the passage of data and other information related to spacecraft operations scheduling to the project.

An example of this would be the request for projects resolution of a conflict involving requested sensor operations exceeding the spacecraft's capability.

3.2.7.3.2 ODG/System Scheduling

The System Scheduling Operation will supply to ODG:

1. Orbit Adjust engine burn characteristics (memo)
2. Verification of orbit adjust firings (memo)
3. Payload operations summary (POS)
4. Attitude Gating Summary (AGS) (memo)
5. Orbit adjust system temperatures and pressures (memo)
6. Requests for ground trace ephemeris listings (memo)

7. Requests for special STDN ground Station Contact Summaries (ERTSUMS) (memo)

The ODG shall supply to System Scheduling:

1. Station Contact Summaries (ERTSUMS)
2. Predicted Fit Ephemeris as requested
3. Best Fit Ephemeris as requested
4. Station Contact Prediction Data
5. Ground Trace Ephemeris Listings
6. Recommended O/A Burn Times
7. TDRSS Ephemeris

3.2.7.3.3 Network Scheduling/System Scheduling

System Scheduling will make weekly requests to MISSOC for support by remote sites and TDRSS.

MISSOC will, if possible, schedule as requested and verify to system scheduling the AOS and LOS times of all stations that have been scheduled for LANDSAT support.

3.2.7.3.4 NOAA/System Scheduling

Once a day, NOAA will provide System Scheduling a map (Facsimile) containing predicted cloud coverage data that will encompass the upcoming scheduling period. Areas that have a higher cloud cover than permissible for picture taking will be excluded from Payload scheduling. Scheduling will provide the longitude of the first orbit which will position his overlay for the remaining orbits of the day.

3.2.7.3.5 CDPF/System Scheduling

The OCC/CDPF interface is mainly through SLAT. There are two types of tapes passed to the CDPF from the OCC -- SLAT and WBVT. SLAT shall be the only data transfer media from the OCC to the CDPF that are required for the generation of image annotation data by the CDPF. For each WBVT interval on a SLAT, the SLAT shall provide necessary and sufficient data for the processing of that WBVT interval by the CDPF.

The data that is required for the processing of one WBVT will be grouped in one WBVT file. A 'LACI Indicator' in the name of a WBVT file indicates whether the WBVT file is

generated for the processing of both LACI and Landsat data or just for Landsat data. In the case of WBVT file is generated for the processing of both LACI and Landsat data, a LACI video tape directory record shall be included in the file. The SLAT version file shall be the first file on every SLAT.

3.2.8 COMPUTING SERVICES SUBSYSTEM*

The Computing Services Subsystem must provide the data processing hardware and software capabilities to meet the function requirements described in Section 3.2.2 through 3.2.7. In addition, it must provide:

- o A backup capability for on-pass commanding.
- o Test, diagnostic and simulation capabilities for all interfaces.
- o Standard software development and maintenance capabilities.
- o A graceful recovery capability for on-pass

3.2.8.1 Hardware

The basic hardware configuration as shown in Figure 3-2 meets the Landsat-D OCC requirements. This configuration includes two Application Processor systems, two TAC systems, two Virtual Interface Processor computers and associated peripherals and a local switching system (a local IPC) for switching between the Landsat-D OCC components. In addition, there is local data base storage for each AP and switching to allow one AP to access the storage on the alternate AP (for backup).

The POCNET, if available, provides Data Base/DOCC computers and two VIP's in the DOCC complex, two Gateway processors and whatever computing equipment is necessary to create the IPC net.

This configuration provides processing backup through the redundancy in the local Landsat-D pair, the redundancy in the DOCC complex and the high availability of IPC channels (as described in Section 5 of the Appendix to the Des Jardins, Hahn POCCNET description). The configuration, with appropriate software support, also provides the capability for on pass recovery through a shared scratch data base).

3.2.8.1.1 The Applications Processor

The AP in Landsat-D must have the capability to support medium-scale data manipulations problems (System Scheduling) and real-time data handling (for data from the TAC computer). It must have room for at least six display partitions, a display supervisor, a real-time data input partition, a background partition (for the Off-Line Supervisor, System Scheduling and software development) and a disk-based operating system. Room for a Data Base Management System, may also be required. (The Landsat 1/2/C System has 128K 32 bit words. This should be a minimum).

In addition, the AP must have floating point hardware and memory management hardware is recommended. The AP must be accompanied by sufficient peripherals (card reader, disk storage, tape drive, operator's terminal) to do software development and maintain system, historical and scratch files. The disk storage should be at least large enough for the operating system, historical files, scratch files and software development files. (Landsat A/B OCC has about 40 MB. This should be sufficient if the new Landsat-C historical files are adopted).

In addition, there may be a requirement for a data base that would include the user data that is now available only in the Landsat NDPT data base. In that case, the AP that is used to backup the on-pass AP will also maintain some of the larger NDPT data base. This disk storage would be roughly 100MB and, while it would be maintained by the alternate AP, it would be switchable to the primary.

3.2.8.1.2 The TAC System

The TAC computer for Landsat-D must be able to read data streams, reformat them into AP messages, perform error coding/decoding, and ship the messages into the AP in real-time. It must also be able to read and block commands for the spacecraft and handle site

and NASCOM message protocols. The extent of the problem is difficult to assess now because of the uncertainty in Landsat-D data rates, in the protocols in the TDRSS hookup and in the encoding requirements of the multi-mission spacecraft telemetry.

If the Landsat-D telemetry and command requirements are similar to those of Landsat .1/2/C, a 64KB minicomputer with hardware frame and bit syncs, about 25MB of disk storage and a terminal will be sufficient. It should be noted, however, that if the TAC computer is to handle some of the problems of the TDRSS "bent-pipe" (including free floating frame syncs within the blocks) one or more microprocessors will be required to do some of the syncing. The Mission Operations Division is preparing an RFP for a standard TAC solution for the MMS and TDRSS front ends. This will be POCCNET compatible and available within the next two years.

3.2.8.1.3 The Virtual Interface Processors

The VIP is discussed in Section 7.4 of the Appendix to the POCCNET concept paper. Based on Landsat A and B, the Landsat VIP's will need to support about six standard block displays, two line printers, one or two card readers, a graphics terminal, and four strip chart recorders. The specific size and capabilities of the computer would be best estimated by the Poccnnet project. An initial estimate was a 64KB mini: A PDP 11/34 or equivalent.

3.2.8.1.4 Interfaces and switching

The Landsat-D OCC presented herein has interfaces among the OCC elements, between the two autonomous OCC groups in the pair and between the Landsat-D OCC computers and the Poccnnet IPC. The POCCNET standard interface will call for a serial channel with bit-oriented communications protocol. It is recommended that this standard be used throughout the Landsat-D OCC. The adoption of the standard will allow the OCC computers to talk to one another or to the POCCNET with no additions for changes in protocol. Also, it will allow switching to be done on serial channels rather than parallel ones.

The path of communication between the primary Landsat-D OCC computers and the alternates depends on the existence of the POCCNET. If POCCNET is up and available, the switching will be accomplished by the Landsat-D M40 operator via POCCNET IPC software channels. In addition the standard POCC configurations will be manually patchable via serial patchband (VIP-AP-TAC configuration).

3.2.8.2 Software

3.2.8.2.1 Operating Systems

The Applications Processor must have a disk-based, multi-tasking operating system. It should include memory protection features, a file management system, inter-task communications, prioritized task management and hooks for user interrupt handling. It should also have clear operating procedures, proven system utilities, a batch capability and readable user documentation. It must have demonstrated support by the vendor. (This should be true of all the vendor software).

The TAC and VIP computers should have an operating system that is compatible with the AP operating system. (Compatibility is not required, however, if these systems are provided by the POCCNET project).

3.2.8.2.2 Real-Time Executives

The executive software provides the coordination between the applications functions, the operating system, and the users. It is inextricably married to the operating system. The Landsat 1/2/C System Real-Time Executive for the applications computer is written to interface with the Sigma 5 BPM operating system. If the Landsat-D OCC Sigma 5 is replaced, BPM would also be replaced. The Executive (and most of the real-time applications programs as it turns out) would then have to be redesigned.

The current front end processor (the TAC) for Landsat is a Sigma 3. It uses an in-house executive and operating system. New devices drivers and new requirements cannot easily be accommodated. If the Landsat OCC is to handle 4800 bit blocks or TDRSS or if it is to fit into POCCNET, it would have to be replaced.

3.2.8.2.3 Software Development

The Landsat-D OCC should have the capability for full software development (independent of POCCNET). Each computer should come with a macro assembly language (hopefully the same one) and a re-entrant Fortran compiler. (Hopefully, a new standardized FORTRAN will be available).

All microprocessors must be supported by cross assemblers that can run on a computer within the Landsat OCC.

All software maintenance and development will be controlled under a configuration control plan similar to the one on the current Landsat NDPF.

3.2.8.2.4 Tests and Diagnostics

All vendor equipment should be accompanied by diagnostics. For the computers, these diagnostics should be able to run under the operating system. For all other equipment, a memory partition should be reserved such that the diagnostics may be able to run on-line (where this does not interfere with normal system performance) from the M&O console.

In addition, the M&O console operator will be able to reconfigure the OCC system and run interface tests between any two computers or between the VIP and any peripheral. The M&O console will, therefore, know the status (on-line, off-line or test) of all data processing equipment.

3.2.8.2.5 Data Base Management

The Landsat-D OCC Applications Processor will have an operating system that supports indexed and random files. The application programs will, with the aid of library file access programs, be able to access any record in the data base. Further study must be done to decide whether a vendor supplied Data Base Management System that would allow data base element access is required. (The DBMS would make files transparent to the user.) This study will have to take into account Landsat-A/B/C experience and Landsat-D expansion requirements.

3.2.8.2.6 POCCNET Interface

All computers that interface with the POCCNET will have POCCNET device drivers and protocol modules that adhere to the POCCNET protocol standards. Computers that talk to one another within the Landsat OCC should also follow these protocols in their conversations. This would allow the location of one computer to be transparent to the software of the other computer.

In addition, if the POCCNET Data Base System is to be used (as for picking up ephemeris data), the Landsat Applications processor will require knowledge of Data Base protocols (e. g. , how to access a file).

It may also be necessary for the OCC to know how to send requests to the DOCC for POCCNET equipment reconfigurations

The extent of the POCCNET interface software will depend on how elaborate all the message and communication protocols are. The POCCNET protocol standards document is due to be published within the next three months.

3.2.8.2.7 Standard Test and Operations Language

The purpose of the STOL is to allow the required operations of the OCC to be sent to the computers through a standardized source language. The language macros would be developed and documented by the Landsat-D OCC operations personnel and programmers. It would be interpreted by a program in the Applications computer. Macros would be developed according to the need to automate the OCC functions. STOL and its interpreter, Autopilot, are described in Section 2.8 of the Appendix to the Poccnnet concept paper.

3.2.8.2.8 Switching Software

The Landsat-D OCC data processing components need to communicate and the communication channels must be allocated and controlled. The POCCNET IPC channels configured by the POCCNET DOCC. The Landsat-D OCC will require a limited version of the POCCNET DOCC for internal redundancy. One of the possible methods of implementation of this small network is through a micro-processor and a user CRT. The micro-processor would be programmed to accept user configuration commands (in STOL) and to set up the computer-to-computer channels accordingly. Network topologies will have

to be investigated, however, a starting point should be a duplicate of the POCCNET topology. Another approach support in POCCNET is to allow the Landsat-D DOC limited autonomy in reconfiguring his assigned resources within the POCCNET TPC without requiring the approval intervention of the POCCNET DCCC. These alternative approaches should be investigated further to make a final decision.

APPENDIX A
LIST OF ACRONYMS

AP	Applications Processors
CCL	Closed Circuit Loop
CRT	Cathode Ray Tube
CCS	Command Compilation Software
C&DD	Communications and Data Distribution
CDPF	Central Data Processing Facility
CMS	Command Management Software
CSS	Computer Subsystem Switching
DBS	Data Base Storage
DCS	Data Collection Subsystem
DIS	Data Input Subsystem
DOCC	Data Operations Control Center
DOMSAT	Domestic Communications Satellite
DMG	Data Management Group
FDG	Flight Dynamic Group
GMT	Greenwich Mean Time
GSR	Generalized Statistics Routine
IPC	Inter-Processing Communications
M&O	Maintenance and Operational
MMS	Multi-Mission Modular Spacecraft
MTR	Magnetic Tape Recording
NASCOM	NASA Communications
NTTF	Network Test and Training Facility
OCC	Operations Control Center
ODG	Orbit Determination Group
OLS	Off-Line Supervisor
OFPAS	Off-Line Processing and Analysis Software
ONPAS	On-Line Processing and Analysis Software
OS	Operations Supervisor

PBX	Private Branch Exchange
PAS	PCM Acquisition Supervisor
PCM	Pulse Code Modulation
PDF	Plot Data Formatter
POCC	Payload Operations Control Center
POCCNET	Payload Operations Control Center Network
RDS	Report Data Supervisor
RDT	Raw Data Tape
RGP	Report Generator Packages
RGS	Report Generator Supervisor
RT	Real-Time
RTC	Real-time Command
SCAMA	Switching Conference and Monitoring Arrangement
SCS	Signal Conditioning and Switching
SLAT	Spacecraft Location Attitude Tape
SRE	System Request Executive
STDN	Space Tracking and Data Network
TAC	Telemetry and Command
VIP	Virtual Interface Processor

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