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From: GSFC Code 540/Chief, NASA Communications Division

Subject: Nascom System Development Plan (NSDP)

Enclosed is your copy of the FY95 NSDP. This edition supersedes any other editions that you may have.

As we all very intimately know, NASA is faced with significant challenges in preparing to implement many changes in the way our business is done and, in some instances, even in the locations from which we do it. Nascom is not exempt from this restructuring process. The FY95 NSDP only hints at some of the major changes facing us; more specific detail could not be provided because final approvals for certain actions may not yet have been in hand as the document was completed. Let me highlight some of the more imminent changes. Each action that we have undertaken or are about to undertake was made, or will be made, with one guiding principal in mind: we shall continue to be responsive to our customers' needs while providing the most cost effective network possible.

Currently, the Nascom Division is being reorganized. This reorganization impacts upon both our civil service employees and our contractors. Just this year alone we have lost about 20% of our civil service personnel to retirement or transfer. Of course we have not been able to replace any of these persons. After thorough analysis, we have come up with a relatively flat organizational structure that enables us to do our work with the resources that are left after this current round of reductions. The Division office will basically remain as it is. However, it is planned to be reorganized to accommodate the following functions: (1) the Center Network Environment (CNE) Project which will transfer from Code 520 to Code 540, Nascom; and (2) certain administrative activities (budget, travel, and training) which will be managed and directed at the Division level. Instead of three branches, there will now be two: Nascom Engineering, and Customer Engineering. Within and between these branches, personnel will be matrixed into various teams. Though occasionally there may be different names than some of you are accustomed to, I have every confidence that your requirements will continue to be met in an entirely professional manner. One other significant organizational change has occurred: the NMOS contractor, providing operations and maintenance of Nascom facilities, is now completely responsible for operation of the network. No longer will Nascom civil servants guide and direct the contractor's day-to-day activities. No longer will civil servants be present on console, managing network activities round the clock during manned space missions. There may well be a civil servant on the scene during "critical" coverage periods; the civil servant's role will be that of advisor - he or she will not be there to direct. In a similar fashion, users of Nascom services - our valued customers - may find themselves dealing more frequently and more directly with our NMOS contractor when planning their specific support requirements. Our contractor has stepped up to this challenge and is fulfilling these additional responsibilities. I have every confidence that Nascom will continue to provide those services that are truly needed.

Another point needs to be brought to your attention most clearly and emphatically. Nascom can no longer afford to operate and support its legacy systems. Conversion to standards based network systems (those that are available through use of COTS products) is required now. Our need is most urgent. Many of our users have already expressed an eagerness to convert their Nascom interfaces to TCP/IP or X.25. It is our goal to discourage and eventually discontinue support of the 4800-bit Nascom block no later than FY 1997, and I have challenged my staff to make this happen sooner if possible. Please rest assured that we will work closely with you for the conversion of your existing interfaces and for the meeting of new requirements using accepted standards that are implemented in COTS products. A Nascom IP Transition Team has been formed and is currently available to work with users in accomplishing our goals. Messrs. Brad Torain and Curt Suprock are the persons to whom you should be addressing your questions and/or concerns. Mr. Torain may be reached by telephone at (301) 286-6990, or by electronic mail at "bradford.torain.1@gsfc.nasa.gov." Mr. Suprock may be reached by telephone at (301) 286-6196, or by electronic mail at "curt.a.suprock@gsfc.nasa.gov." Cost tradeoffs will have to be considered for current 4800-bit Nascom block users, and there could be instances where the Nascom 4800-bit block will have to be retained, even though the transport will be IP. In these instances, Nascom will work with the projects to provide the required conversion interfaces. Section 16 of the NSDP provides a view of our vision as Nascom migrates to an ATM backbone. It also depicts other major changes that we are working to put in place now.

In the front matter of the NSDP is a Distribution Confirmation Form. If you use this document and wish to receive the next update, due out in the Spring of 1996, please complete the form and return it. Comments, suggestions, or questions concerning this document are welcomed. Please address them to:

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MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE

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FY95 Nascom System Development Plan

**System Description,
Capabilities, and Plans**

June 1995



National Aeronautics and
Space Administration

**Goddard Space Flight Center
Greenbelt, Maryland**

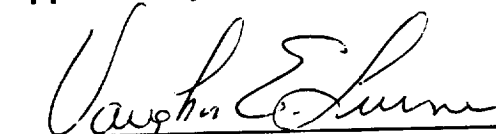


**NASCOM SYSTEM DEVELOPMENT PLAN
FOR
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
COMMUNICATIONS NETWORK**

**SYSTEM DESCRIPTION,
CAPABILITIES, AND PLANS**

FY 95

Approved By:



Vaughn E. Turner
Chief, NASA Communications Division

6/30/95
(Date)

The information in this document is intended for orientation and planning purposes only. It is not suitable for engineering design without effective coordination with appropriate Nascom personnel.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland



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Preface

The Nascom System Development Plan (NSDP) provides information on the charter, organization, capabilities and future plans concerning the NASA Communications (Nascom) Network. The NASA Communications Division, Code 540 (GSFC), is responsible for the planning, engineering, and operation of the Nascom Network.

As implemented by GSFC management, the NSDP method of documentation serves several purposes. As a continuing document, revised and reissued annually, it is intended to serve as a communications medium for disseminating Nascom Network capabilities and development planning information. It is intended to promote organized, coordinated program planning and implementation. In addition, the NSDP facilitates management direction and control, and also provides a logical means for obtaining necessary approval of major Network changes from NASA Headquarters through interaction between updates. This document is intended to fulfill requirements of NASA Management Instruction 2520.1D and other NASA Headquarters instructions.

The NSDP consists of 16 sections. Sections 1 through 13 comprise the basic document and contain a description of the present Nascom System's operational capabilities. Section 14 describes the support configurations provided to the various networks served by Nascom. Sections 15 and 16 summarize information concerning mission-unique support planning and 5-year Network development planning, respectively.

Detailed Network information on current circuit status, individual project support and various other NSDP backup data are maintained by the NASA Communications Division for internal use.

All Nascom Network users, mission and program planners, and managers are encouraged to provide comments relative to this document and mission support requirements to the NASA Communications Division, Code 540, Goddard Space Flight Center, Greenbelt, Maryland 20771. This organization will receive its formal requirements information through official documentation sources. Notification of program changes may be made at any time to the NASA Communications Division in accordance with prescribed procedures in order that these may be reflected in the NSDP and, where necessary, in Network implementation.



Abstract

The Nascom System Development Plan (NSDP), reissued annually, describes the organization of Nascom, how it obtains communication services, its current systems, its relationship with other NASA centers and International Partner Agencies, some major spaceflight projects which generate significant operational communication support requirements, and major Nascom projects in various stages of development or implementation. The NSDP is prepared by GSFC Code 542.1 for the NASA Communications Division. The prescribing authority for the document is NASA Management Instruction 2520.1D.

Keywords: Baseline Data System, BDS, Charter and Management, Control and Status System, CSS, Data Distribution and Command System, DDCS, Digital Matrix Switch, DMS, EOS Communications, Ecom, High Data Rate System, HDRS, High-Speed Data System, HSDS, Interbuilding Communication Link Upgrade, ICLU, Low-Speed Network, LSN, Message Switching System, MODNET, MSS, Multiplexer/Demultiplexer Data System, MDM, Nascom, Nascom 2000, Nascom Interface Facility, NIF, Nascom Overseas Communication System, NOCS, Nascom procurement policy, Nascom System Development Plan, NOLAN, NSDP, primary switching center, Point-of-Presence, Video System, Voice Distribution System, VDS, Voice Switching System, VSS, West Coast Switching Center, Wideband Data System, WDS.



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Appendix A. History and Justification

Appendix B. Block Format Definitions

Appendix C. Nascom Performance Objectives and Standards

Appendix D. Circuit Ordering Process

Appendix E. X.25 and IP Protocols

Abbreviations and Acronyms



Section 1. Nascom Charter and Management

1.1 Nascom Origin, Precept, and Objective

1.1.1 Nascom Origin and Precept

NASA Communications (Nascom) was originally established in 1964, under authority of NASA Headquarters Office of Tracking and Data Acquisition (OTDA) Code T to unify the operational management and implementation of all of NASA's emerging long-haul ground communications networks. Until that time, individually implemented and operated networks had developed for each major NASA program. (Refer to Appendix A.) Presently, the Office of Space Communications (OSC) Code O, the successor to Code T, generally provides NASA's space tracking data networks operational ground communications and data transport networks; NASA program and administrative support communications networks; and certain mission control and data processing facilities.

1.1.2 Nascom Objective

The objective of NASA in establishing Nascom is to provide operational telecommunications in support of all NASA projects and mission activities at minimum cost, consistent with their individual unique requirements for capacity, effectiveness, efficiency, reliability, and security. This is accomplished by managing and operating the system as a multimission commonly shared resource, to the extent feasible.

1.2 NASA Communications Charter

1.2.1 Basis Document

NASA Management Instruction (NMI) 2520.1D, dated November 18, 1991, is the charter document formally specifying the establishment of the NASA Operational communications system: Nascom. This Instruction sets forth the policies, responsibilities, and procedures for acquisition, control and management of the "NASA Telecommunication System." The Instruction defines two distinct responsibilities for NASA ground communications facilities and services. One is strictly for operational use (Nascom), the other for nonoperational use and the administrative networks.

1.2.2 Nascom Definitions

In NMI 2520.1D, the term "NASA Operational Communications Network (Nascom)" is defined as follows: NASA's mission operational telecommunications network provides communications services used in the operational conduct of flight missions, programs, and projects. They are largely spaceflight oriented, but also include the systems, networks, communication circuits, and facilities. Nascom interconnects NASA's foreign and domestic tracking and telemetry acquisition-sites, launch areas, mission and project operations control

centers, science data capture facilities, and network control centers. Loss or degradation of Nascom entities (i.e., systems, networks, communications lines, and facilities) could directly affect mission success or safety of life or property. Colloquially, Nascom refers either to a network or a system, depending on context and semantics. "Nascom" is also used to refer to the organization of the NASA Communications Division.

1.3 Scope of Nascom Responsibility

The primary responsibility of Nascom is to interconnect overseas and domestic tracking and telemetry stations and sites, all launch areas, the mission and project/payload operations control centers, science data capture facilities, and network control centers. The loss or degradation of Nascom entities (i.e., systems, networks, communications lines, and facilities) could directly affect mission success or safety of life or property. Nascom bears this responsibility as the NASA operating component in the National Communications System (NCS).

1.3.1 Nascom Functions

The functions of Nascom are to provide the communications network facilities and services:

- a. To transport spacecraft telemetered data, air/space-to-ground voice, video and data for command, control, tracking and orbit determination.
- b. To transport user data and user products in support of NASA missions and projects.
- c. For spacecraft prelaunch compatibility and simulated mission readiness testing.
- d. To contractor locations where spacecraft and spacecraft components are undergoing tests for integration, network compatibility, and mission control center operational readiness.
- e. For scheduling, maintenance, control and coordination for all NASA Office of Space Communications space and ground tracking network elements.
- f. For the real-time interaction and control of spaceborne sensors, instruments, and attached payloads by the mission control centers and payload operations control centers.
- g. For all mission operational secure communications (COMSEC) requirements of NASA.
- h. For NASA approved mission operational international cooperative missions.

1.4 Responsibility for Nascom

This section describes the responsibilities of the NASA hierarchy from NASA Headquarters down to the NASA Communications Division. The overall responsibility for the technical management of the Nascom Network has been assigned to Goddard Space Flight Center (GSFC). Figure 1-1 locates Nascom in the GSFC organization chart.

1.4.1 NASA Headquarters

The Associate Administrator for Space Communications, Code O, NASA Headquarters, is charged with overall management responsibility for all NASA operational long-line commu-

nications, facilities, systems, and services. This responsibility includes providing proper management direction and budgetary programming guidelines to the NASA Communications Division at GSFC, and approving major project requirements prior to beginning system modifications or work implementation. Responsibilities of the other NASA elements relative to Nascom are described in the following paragraphs.

1.4.1.1 NASA Headquarters Program Offices

NASA Headquarters Program Directors are responsible for ensuring that the operational long-line communication requirements for support of their respective programs and projects are documented through accepted methods in sufficient time to allow GSFC to plan and implement Nascom support. To ensure early coordination and planning, representatives of the Director, GSFC, may participate in the preparation of these requirements.

1.4.1.2 NASA Field Center Installations

The Directors of NASA field installations are responsible for current and long-range planning, budgeting, design, implementation, operation, and maintenance of on-site operational communications required for field installation projects. On-site communications that will be interconnected with the Nascom Network must have the concurrence and technical approval of the NASA Communications Division, GSFC, concerning the technical characteristics of the interface. NASA Field Installation Directors are also responsible for ensuring that access to Nascom data lines is restricted to interfaces controlled by Nascom and that access to Nascom data lines is restricted to automated information systems that preclude unauthorized access and secondary connection to external networks. Changes to on-site operational communications, which are interconnected, must have similar technical approval.

1.4.2 Goddard Space Flight Center

GSFC is assigned the overall responsibility for the technical management of the Nascom Network. At GSFC this responsibility is assigned to the NASA Communications Division, Code 540 within the Mission Operations and Data Systems Directorate, Code 500. Responsibilities include current and long-range planning, budgeting, design, implementation, operation, and maintenance to meet the operational communications requirements of the NASA programs and projects. In a few instances, for reasons of economy, workload, and responsiveness, GSFC has delegated these responsibilities to other NASA field installations for certain operational point-to-point systems within the continental U.S.A. When extending its operational communications overseas to foreign locations, Nascom may provide its own services or enter into an arrangement for shared use of other NASA or International Partner (IP) agency backbone systems. In those cases where Nascom shares the backbone system of another NASA network or IP agency, appropriate agreements (recognizing Nascom's standards for operational communication) are in place.

1.4.3 NASA Communications Division

This paragraph describes the practices and procedures observed by Nascom in integrating the various communications requirements of the spaceflight missions during the planning and

implementation phases. The functional responsibilities of this division and its authority constraints are detailed in paragraphs 1.4.3.1 and 1.4.3.2.

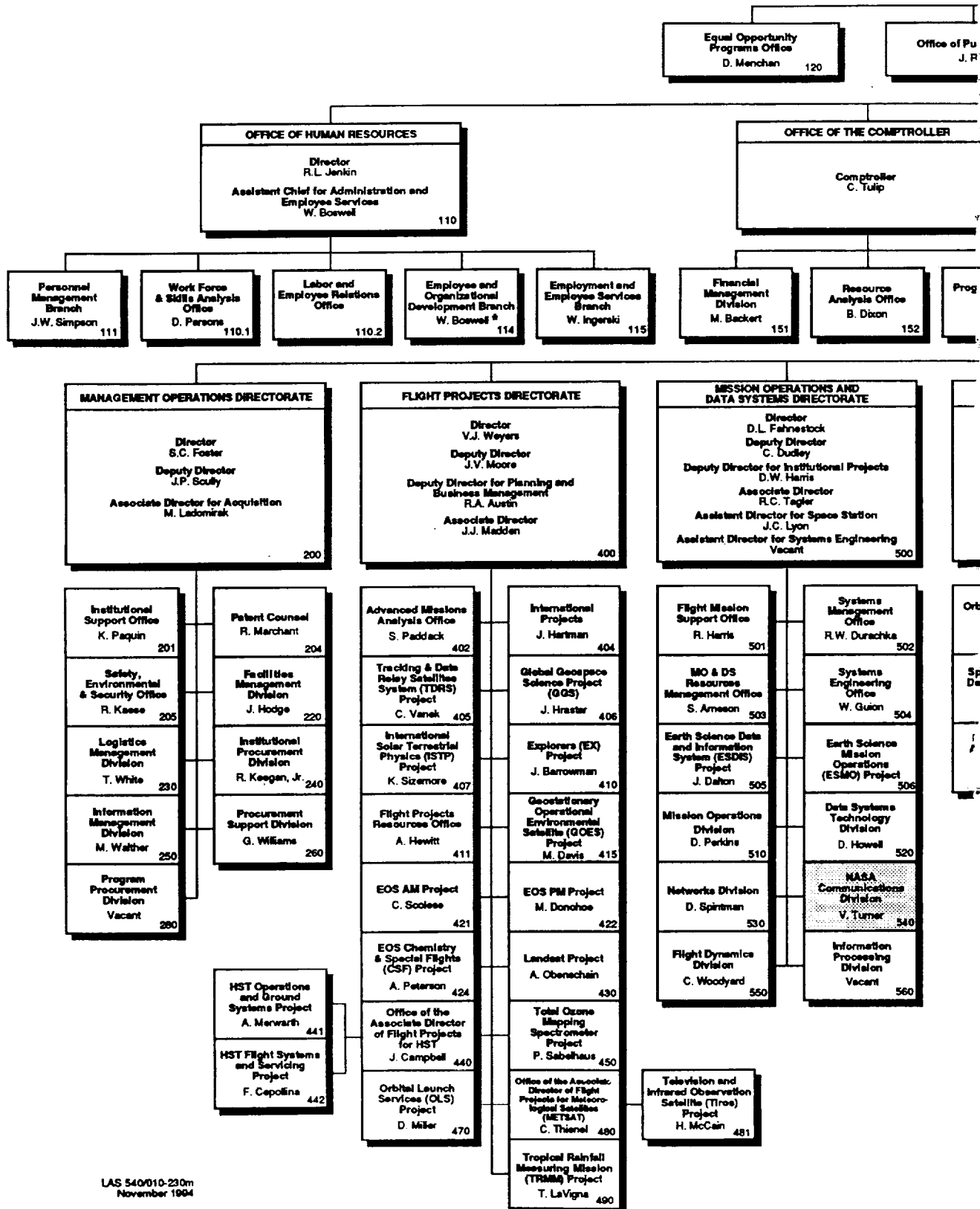
1.4.3.1 Functional Responsibilities

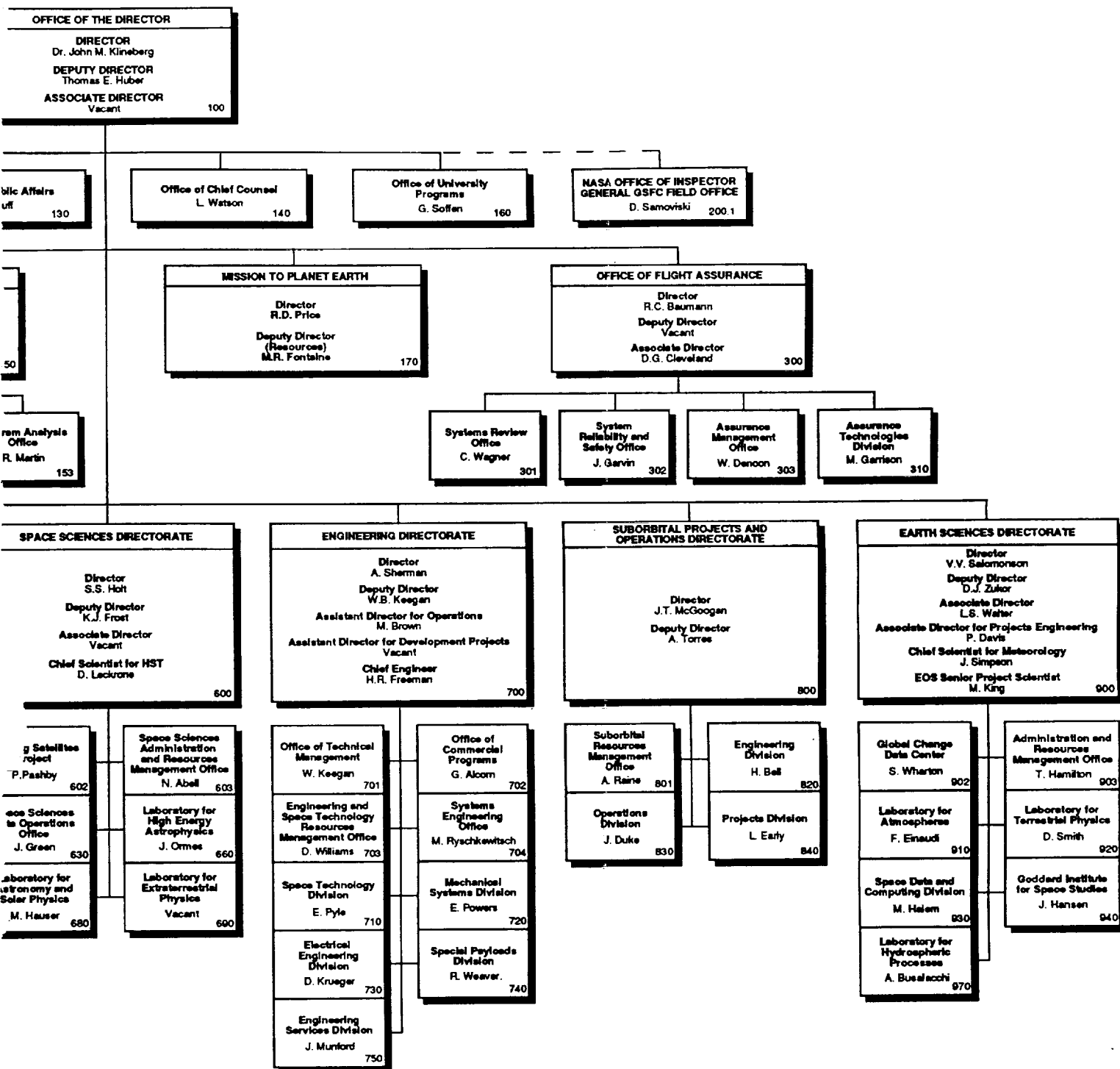
The NASA Communications Division is responsible for the following:

- a. Review of requirements and development of interim and long-range plans for modification and/or expansion of the network.
- b. Preparation and submission of the Nascom System Development Plan (NSDP), including a Nascom Five-year Development Plan.
- c. Preparation, review, analysis, and submittal of all Nascom budgetary and financial plans.
- d. Provision of technical assistance to NASA field installations and NASA program directors in developing requirements for operational long-line communications in support of space missions.
- e. Engineering and design of communication systems, circuitry, and equipment as required in the Network.
- f. Implementation of circuits and systems through lease, procurement, installation, and testing, as required.
- g. Operational management of the Network, including traffic operations, circuit ordering, circuit scheduling, and circuit restoration in direct support of mission activities.
- h. Recurring review and analysis of Network performance, requirements, and reliability, with continuing modification and improvement.
- i. Continuing examination of state-of-the-art advancements in communications, where related to Network application.
- j. Ensuring that the provisions of OSC's Nascom Access Control Policy dated 4 August 1988 are carried out.

1.4.3.2 Demarcation Interfaces

Responsibility of the NASA Communications Division extends to the main distribution frame or to designated commercial carrier Points-of-Presence (POP) at other NASA centers and field installations, except under special arrangement with the respective NASA centers. By such special arrangements, Nascom Network responsibilities have been extended into NASA Tracking and Data Acquisition (T&DA) sites with varying interface arrangements among the Spaceflight Tracking and Data Network (STDN) and Deep Space Network (DSN). These arrangements are dependent upon the specific operational requirements, resources, and capabilities of the organization involved. All NASA centers, field installations, and tracking sites having on-site communications that have interconnection to, or that will be interconnected with the Nascom Network, are required to have the concurrence and technical approval of the NASA Communications Division concerning the technical characteristics of the interface.





LEGEND:

* Acting

Figure 1-1. GSFC Organization Chart

1.4.3.3 Nascom Manager

The Chief, NASA Communications Division, GSFC, has been designated manager for the Nascom Network. In this capacity, he is the overall Nascom manager who represents the Director, GSFC, in all matters pertaining to Nascom. He is responsible for the performance of the Network and has full authority, subject to limitations established by the Director, GSFC, to carry out all foregoing functions necessary for management of the Network. In particular, he is responsible for Network-wide planning and evaluation, system integration, systems engineering, scheduling, budgetary and financial planning and management, contract management, and project reporting.

1.5 NASA Communications Division Organization

This paragraph describes the organization of the NASA Communications Division and its affiliated functions and responsibilities. The placement of this division in the NASA hierarchy comprising and supporting the Nascom Network is shown in Figure 1-2. The dash-line enclosing the Telecommunications Branch indicates that its managed elements are not considered a part of the Nascom Network as defined.

1.5.1 NASA Communications Division Office

The NASA Communications Division Office (Code 540) provides operational communications network facilities and services for the transport of spacecraft telemetered data for command, control, tracking and orbit determination. Its services include communications associated with spacecraft testing, mission operation control center interfaces, and scheduling of Nascom Network facilities to meet the requirements of NASA supported organizations and facilities for their flowing of real-time information by electronic means. Configuration management and project review activities are managed by the Division office. Additionally, management of major projects may be provided from the Division office when a significant shift in the technologies used by Nascom to provide its services is involved.

1.5.2 Systems Engineering Branch

The Systems Engineering Branch (Code 541) performs long range planning, design, and development of communications systems to meet the future telecommunications requirements of NASA's spaceflight programs. To accomplish this work, the Branch is organized in three sections: Communications Engineering Section, Computer Systems Section, and Advanced Development Section.

1.5.2.1 Communications Engineering Section

The Communications Engineering Section (Code 541.1) designs, engineers, procures, tests, and modifies specialized communication systems that provide voice and message traffic, analog and digital services, multiplexing/demultiplexing, video, and video teleconferencing services.

1.5.2.2 Computer Systems Section

The Computer Systems Section (Code 541.2) performs the design, engineering, implementation, integration, testing and sustaining engineering of computer systems developed to

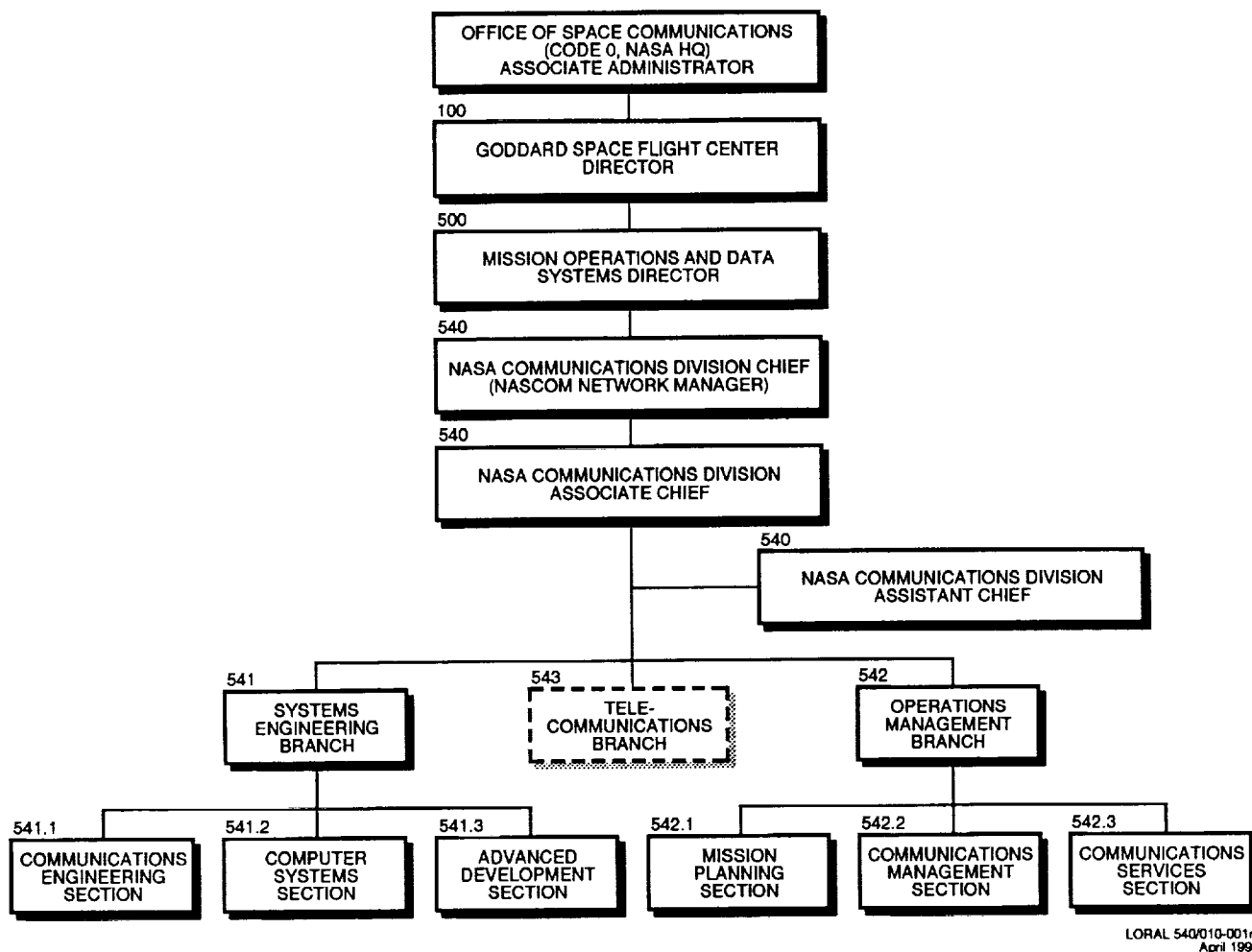


Figure 1-2. Nascom Network Management Organization Chart

command, control, and status the network's (1) data transport subsystems; (2) switching systems developed to route real-time command, telemetry, and science; (3) performance monitoring systems; and (4) switching systems using commercial packetizing techniques and protocols.

1.5.2.3 Advanced Development Section

The Advanced Development Section (Code 541.3) develops detailed, long range plans for the orderly evolution of the Nascom operational communication network. It studies advanced communication and data transport technologies to determine their applicability to future flight projects and to position Nascom to take advantage of both proven and emerging technologies to provide the most cost-effective information transport services to meet the continuously evolving requirements of NASA's spaceflight projects. This section also implements advanced networks to support major NASA projects such as the Earth Observing System (EOS).

1.5.3 Operations Management Branch

The Operations Management Branch (Code 542) is responsible for the overall technical and operational management of the NASA Communications Network. To execute these responsibilities, the Branch is comprised of three sections: Mission Planning, Communications Management, and Communications Services.

1.5.3.1 Mission Planning Section

The Mission Planning Section (Code 542.1), is tasked with reviewing all flight projects communications requirements to ensure that the telecommunications needs of the projects are met. It initiates actions to provide new communications services, if required, with due consideration given to the availability (or non-availability) of existing network resources. The section provides liaison between the technical implementation organizations and the flight projects while the service is being planned, engineered, and implemented. This section is also responsible for developing and publishing the Nascom System Development Plan (NSDP) for the Nascom Division.

1.5.3.2 Communications Management Section

The Communications Management Section (Code 542.2) provides operational management of the Nascom Network on a 24-hour-per-day schedule, ensuring that all supporting elements are available to meet project requirements. It provides liaison between Nascom and the commercial carriers supplying its circuits, thus ensuring the provision of reliable telecommunications services. It furnishes the technical control functions required to maintain the network in a constant state of readiness to meet all telemetry, command, and other operational data and voice signal transport requirements. This section also has the responsibility for managing the GSFC Communications Security (COMSEC) Account.

1.5.3.3 Communications Services Section

The Communications Services Section (Code 542.3) provides technical contract management functions for leased telecommunications services and equipment, equipment purchases, and support service contracts. It provides guidance for the development of telecommunications performance standards and measurement techniques for Nascom Network circuitry. The section analyzes network performance and develops circuit performance data for use in the circuit procurement and rebate process.

1.5.4 Telecommunications Branch

The Telecommunications Branch, Code 543, manages the requirements, system planning, design, maintenance and operation of the "GSFC Telecommunications Network." This network includes voice/data systems, local area communications networks, video systems, electronic mail facilities, office automation systems and cable plant facilities located at GSFC, NASA Headquarters, and the Wallops Flight Facility (WFF).

The Telecommunications Branch is organized functionally as indicated in the following paragraphs.

1.5.4.1 Closed Circuit Television (CCTV)/Datacom

The Closed Circuit Television (CCTV)/Datacom function provides continuous support for the GSFC control centers including the distribution of video, timing, and data. It maintains and operates TV Central and the centerwide GSFC RF video distribution network. Additionally, it provides TV engineering, transmission, and production support for GSFC and NASA Headquarters.

1.5.4.2 NASA Select TV Network

The NASA Select TV Network function provides a maintenance and operation service for the NASA Select TV system. This service, provided five days per week, includes the production, scheduling and broadcasting of the Space Transportation System (STS) events, internal NASA educational and scientific projects, and other NASA-sponsored video products.

1.5.4.3 Office of Space Communications (Headquarters Code O) Support

This function provides for the installation, maintenance, and operation of the audio/video distribution system at the new NASA Headquarters building.

1.5.4.4 GSFC Local Area Communications Network (LACN)

This function provides for the overall maintenance and operation of the GSFC LACN. Additionally, it is significantly involved in assessing applications of new technology and evaluating systems for operational implementation at GSFC.

1.5.4.5 GSFC Institutional Support

This function provides for GSFCMail service support to Code 500 elements and maintains the extensive data base for the GSFC Interconnect Telecommunication System (ITS) (ROLM) telephone system. It also coordinates, with MSFC, all GSFC and Wallops requirements for PSCN service. It provides the technical support necessary to provide PSCN tail circuit extensions at GSFC and WFF. Related to this is the responsibility for installation and maintenance of cable plant facilities at GSFC, NASA Headquarters, and the WFF for support of institutional and scientific programs.

1.5.4.6 Public Affairs Office (PAO)/Visitor Center

This function provides repair and preventative maintenance for all the audio/visual equipment in the GSFC Visitors Center.

1.6 Nascom System Development Plan

1.6.1 Concept, Philosophy, and Use for NSDP Documentation

The NSDP is a management document containing the approved plan for establishing and maintaining the Nascom Network System. The concept in developing the NSDP is to provide a document concerning the Nascom Network that can be useful to a wide range of readers from NASA management to the various levels of Network users. Aside from serving as a

technical reference, the NSDP can also serve as an introductory paper or tutorial for those who plan to use the Nascom Network. The NSDP reflects Nascom's interpretation of the communications services required to support NASA programs in existing and planned implementation.

1.6.2 Scope

The NSDP covers the system description of Nascom systems, existing capabilities and requirements for these systems, plans and development activities during the fiscal year, plans for the ensuing fiscal year and the following five years, and descriptions of support provided to various NASA projects and missions.

1.6.3 Content

Section 1 provides information on the Nascom charter and management, and Section 2 on procurement and resource planning. Sections 3 through 13 describe the various Nascom systems, circuit configurations, and arrangements. Section 14 provides information on NASA networks (other than the Nascom Network) and the extent of Nascom support. Section 15 describes Nascom planning for individual NASA missions. Section 16 provides information on development of Nascom systems that are planned or in the process of implementation to meet future program requirements.

1.6.4 Responsibility

The Mission Planning Section of the NASA Communications Division is responsible for the publication, maintenance, and issuance of the NSDP. The Chief of the NASA Communications Division is, however, the signature authority for approving the NSDP.

1.6.5 NSDP Preparation

Preparation of the NSDP necessitates that communications requirements from all programs be received and consolidated into an overall Nascom Network plan in a timely manner. Nascom development plans are coordinated with field installations and the NASA centers before implementation. Information is promulgated through publication and distribution of the NSDP.

1.6.6 NSDP Publication Cycle

The NSDP is published annually in the spring, with information that is current as of each April.

1.7 Nascom User Requirements Planning

1.7.1 Source Documentation

The following paragraphs identify the major source documents that are used to establish the requirements for support of spaceflight projects and missions. These documents will include operational ground communications support requirements, many of which may directly or

indirectly specify Nascom systems support for the respective mission. Requirements are documented in two different ways: the Universal Documentation System (UDS) for manned flight missions and the Mission Requirements Request (MRR)/Detailed Mission Requirements (DMR) Document for unmanned space projects and for suborbital and aeronautical flight projects. The operational communication requirements, originally documented, approved, and maintained in the UDS and MRR/DMR, are used by the Mission Planning Section, Code 542.1, for Nascom's mission-unique planning requirements activity.

1.7.1.1 Universal Documentation System

The following paragraphs describe the UDS:

- a. **UDS Basis Document.** NMI 8610.10B, dated December 19, 1991, prescribes use of the UDS. The UDS provides a system for managing operational support requirements for manned flight missions including the requesting of support and the responding to those requests. The UDS is applicable to NASA Headquarters and the NASA field installations (including GSFC/Nascom) and DoD installations in accordance with the NASA/ DoD Memorandum of Understanding (MOU) on Management and Operation of the Space Transportation System and its subagreements.
- b. **UDS Description.** The UDS consists of three levels of documentation in six documents:
 1. **Level 1: Program Introduction Document (PID)/Statement of Capability Document (SCD).** The PID and SCD are the long-lead-time Level I Program requirements and response documents initiated at the start of a new program and signed by the cognizant Program Associate Administrators. These documents are generated and maintained for the Space Shuttle Program (SSP). They are revised as required according to approved Level I and Level II change procedures to reflect changes both in requirements and commitments.
 2. **Level 2: Program Requirements Document (PRD)/Program Support Plan (PSP).** Within the scope of the requirements and responses developed in the PID and the SCD, these program Level II documents define requirements and responses for prelaunch, launch, flight, landing and postlanding operations. These documents are used for direct support requests among NASA and DoD elements. The Space Shuttle requires launch and landing PRDs, prepared and approved by Kennedy Space Center (KSC), and flight PRDs, approved and maintained by Johnson Space Center (JSC) for flights launched from KSC. Each PRD consists of two volumes, Volume 1 containing Shuttle support requirements, and Volume 2 containing cargo/payload requirements, with separate annexes for each payload. The PSP is the support agency response commitment to PRD requirements.

There are also provisions for an Expedited Operations Requirements (EOR) system for unanticipated prelaunch test, launch, flight, and landing requirements to be requested and responded to in an expedited mode when essential to maintain continuing operations. These are known as Launch Support Requirements (LSR) and Flight Support Requirements (FSR) for the respective PRDs.

3. **Level 3: Operations Requirements (OR) and Operations Directives (OD).** Within the scope of the requirements and responses developed in the PRD and PSP, these program Level III documents define requirements and responses in sufficient detail to be used for developing operational documentation for mission support. As the OR presents the detailed requirements of a mission or activity, the OD supplies the supporting agency's response commitment.
 4. **OSC and GSFC Role:** OSC is responsible for overall management and commitment for support of NASA's tracking and data acquisition, and communications and data systems. OSC responds to Level I Program support requirements for manned flight missions through the Associate Administrator for Space Communications. OSC responds to Level II and Level III program support requirements through the Goddard Space Flight Center.
- c. **UDS Requirements Control.** All Space Shuttle requirements are documented in the UDS. Requirements control starts with JSC as the requestor for MO&DSD (Code 500) support services, which includes Nascom. The Flight Mission Support Office (Code 501) is responsible for preparing the UDS system OR document and their Mission Support Manager (MSM) or Mission Operations Manager (MOM), as applicable, coordinates with the Mission Planning Section (Code 542.1) for responses to requirements for Nascom Network services.
 - d. **Automated Support Requirements System.** An Automated Support Requirements System (ASRS) has been implemented for automated processing and electronic mailbox distribution of requirements. ASRS is mandated by NMI 8610.10B except where classified requirements and responses in support of classified DoD payloads are concerned; in the latter case, manual documentation of requirements and responses employing UDS formats is used. Data bases for both launch and landing, and flight operations support requirements reside in host computers at KSC. Compatible interacting terminals are located at various NASA centers and DoD locations.
 - e. **UDS Handbook.** The UDS Handbook, published in three volumes, describes the total UDS structure in Volume 1, Levels 2 and 3 sample formats in Volume 2, and Levels 2 and 3 response data in Volume 3. Handbook Supplement 2 describes the procedures for electronic processing of Levels 1, 2, and 3 documents.

1.7.1.2 Requirements Documentation Process for Unmanned Space, Suborbital, and Aeronautical Missions

The following paragraphs describe the process for obtaining use of OSC capabilities to support unmanned space missions, suborbital missions, and aeronautical missions. The process herein described is that prescribed by NMI 8430.1C; it applies to missions for which planning commenced subsequent to the issuance of this NMI (December 31, 1991).

- a. **General.** This requirements process is both iterative and interactive, providing the mechanism for customers to obtain use of OSC capabilities throughout the mission life-cycle. The objective of the process is two fold: (1) attaining timely determina-

tion of the requirements for OSC support and (2) enabling OSC to develop cost and schedule baselines.

The customer is expected to initiate early coordination with OSC prior to the end of Phase A studies. This early interaction with OSC is intended to (1) provide the customer with knowledge of OSC capabilities, (2) identify requirement trade-offs and alternatives, and (3) provide OSC with information that may influence its long-range planning. This early coordination activity precedes any formal requirements documentation from the customer to OSC.

- b. **Mission Requirements Request.** The MRR is a concise summary document designed to identify the project's top-level requirements. The format to be used will be provided to the customer by OSC during the early coordination process. As its Phase A studies are concluding, a customer requiring OSC capabilities forwards its MRR, signed by the customer's Associate Administrator (or equivalent level if non-NASA) to the Associate Administrator/Space Communications. If new OSC capabilities are required, then the MRR must be submitted in sufficient time to allow for obtaining any budget authority necessary for implementation of the new capabilities. Whenever significant changes to customer requirements become known, the customer must update the MRR by submitting appropriate addenda to OSC.
- c. **MRR Acknowledgement Letter.** In response to the MRR, OSC provides an Acknowledgement Letter in which are contained the following items: (1) confirmation of receipt of the MRR by OSC, (2) designation of the point-of-contact within OSC, (3) designation of OSC's Lead Center and direction to that Center to formally develop plans to meet the customer's requirements, and (4) designation of the Capacity Projection Plan (CPP) as the primary document summarizing how OSC's planned capability and capacity satisfies the customer's mission requirements.
- d. **Capacity Projection Plan.** The CPP is the OSC document which presents to all customers a projection of their demands measured against the available supply of OSC capabilities and capacities. Issued semi-annually consistent with the NASA budget cycle, the CPP lists all projects for which MRRs have been received and indicates the extent to which each project's requirements may be satisfied. The CPP also identifies any capacity and capability shortfalls requiring resolution.
- e. **Detailed Mission Requirements Document.** The DMR documents the customer's detailed requirements and includes the corresponding OSC plans for meeting those requirements. This document is the source of detailed requirements and plans needed by lower levels to guide their implementation activities. Requirements in the DMR are traceable to the MRR; whenever a requirement change impacts a planned OSC capability or capacity, an update is issued by the customer. The DMR is prepared and approved jointly by the customer's project manager and the OSC Lead Center's representative. Issued by the customer at the time of Phase C/D approval, the DMR is then used by OSC to baseline mission requirements and the corresponding cost and schedule for implementing any new capacity and/or capability required by the mission.

Where Goddard Space Flight Center is designated OSC's Lead Center, detailed requirements are processed by Code 501's applicable Mission Operations Manager (MOM) or Mission Support Manager (MSM). The MOM or MSM, in turn, formally coordinates any requirements for Nascom services with Nascom's Mission Planning Section. As a member of the MOM's or MSM's team, Nascom provides capability and capacity information to Code 501 for inclusion in Code 500's "responses" to the mission's requirements.

1.7.1.3 Other Documentation

The other documents that specify the ground operational communication requirements for the Nascom Network to support a NASA project or mission include:

- a. NMI 8410.2(), Use and Reimbursement Policy for Non-NASA U.S. Government Users of TDRSS, and NMI 8410.3(), Tracking and Data Relay Satellite System (TDRSS): Use and Reimbursement Policy for Non-U.S. Government Users.
- b. GSFC-Level I Requirements, Code 500 Systems Management.

1.7.2 Nascom Participation

1.7.2.1 Nascom Inputs

The Mission Planning Section, Code 542.1, provides inputs to planned support for response documentation prepared by GSFC MO&DSD, Codes 501, 502, and 530. It also provides inputs to Jet Propulsion Laboratory's (JPL) managers for the various DSN-supported missions, via the DSN/Ground Communications Facility (GCF) Mission Coordination Group at JPL. The Mission Planning Section has varying degrees of participation in the drafting of the original Level 1 and 2 ground communications requirements section of the PRDs and MRRs, through participation in ad hoc support planning working groups. Nascom may also provide inputs concerning ground communications to the development of ancillary requirements documentation, such as the Payload Integration Plans (PIPs) prepared by JSC, which are preliminary to PRD annex documentation for STS payload mission requirements.

1.7.2.2 NSDP Reportage

The requirements for approved or planned future NASA missions as reflected in GSFC MO&DSD level planning and NASA mission models, as well as future ongoing mission phase support requirements, are summarized in Sections 15 and 16 of this document.

1.7.3 Integration of Requirements

This paragraph describes the practices and procedures observed by Nascom in integrating the various communication requirements of the spaceflight missions during the planning and implementation phases. The manner in which the common-user Nascom Network is configured to meet necessary communication requirements for the various missions supported by the STDN and DSN stations is contained in Sections 3 through 13 of the NSDP. The integration of requirements for the communications channels and facilities is described in the following paragraphs.

1.7.3.1 Communication Channels

The actual number and type of communication channels required for a network station are determined largely through continuing consultation and review with the project and program planners, Ground Network (GN), SN and DSN GCF planners, and the NASA Communications Division, based on the validated, mission-related communication requirements.

1.7.3.2 Facilities

The number and type of facilities provided in the common-user portions of the network are ultimately determined by the NASA Communications Division, based upon the limitations of facilities actually available, budgetary constraints, carefully considered circuit sharing, mission traffic, and scheduling criteria, as provided by the program planners.

1.7.4 Funding

1.7.4.1 Recurring Charges

The major portion of Nascom Network operating costs consists of recurring charges for full-period (24-hour/day) lease of various types of point-to-point telecommunication services from domestic and foreign common carriers. These are carried in the operations budget. Also carried in the operations budget are operator, switching systems software, maintenance, engineering and operational support services.

1.7.4.2 Equipment Budget

An equipment budget provides for government-furnished voice, data, and switching, monitoring, and test facilities required for cost-effective use and operational control of the communication channels that cannot otherwise be provided through lease from the common carriers.

1.7.4.3 Variations

The fiscal year-to-year funding level changes projected in the overall operations budget for leased channels (domestic and overseas carriers) reflect the net effect of numerous anticipated circuit deletions, additions, or replacement actions, tariff revisions, monetary exchange rate variations, state-of-the-art developments, etc. Therefore, these overall budgetary year-to-year variations normally may not be correlated with particular project requirements or system changes.

1.7.4.4 Sources

Funding of the Nascom operational network is provided through the OSC, Code O, NASA Headquarters. In addition, some services are provided, on a reimbursable basis, to NASA projects; experimenter and commercial interests; and foreign governments and interests. This reimbursement is based on the actual cost of the service. Funding responsibility remains with the organization requiring the service on a continuing basis.

Additional information regarding OSC-funded categories for Nascom-obtained resources is contained in Section 2. Detailed Nascom budgetary information is contained in the GSFC

Project Operating Plans (POP) and is supported by the current GSFC MO&DSD Work Authorization Documents (WAD). Information on network development related to the current Nascom portion of the WAD may be found in Section 16 of this document.

Deviation from the approved program as set forth in the Nascom WAD (exceeding \$100,000 annual cost) must have concurrence of NASA Headquarters. All changes involving unique project communications will be coordinated with the cognizant field installation, regardless of size.

1.8 Nascom Policies and Practices

1.8.1 Manpower

This paragraph describes the role of the NASA Communications Division and the contractor in providing manpower for implementing the various activities of the Nascom Network.

1.8.1.1 Government Role

The majority of NASA Communications Division government-employed personnel are located at GSFC engaged in the planning, engineering design, technical management, and operational direction of the Network.

1.8.1.2 Contractor Support

Government manpower is supplemented through contracts generally providing coordinated program support for engineering services, network planning and analysis, switching computer programming support, and communication controllers and operators at GSFC. The prime contracts for providing these services are described as follows:

- a. The Systems, Engineering, and Analysis Support (SEAS) contractor is responsible for providing general systems engineering support services to Code 540 which include system engineering, installation monitoring, engineering, and Acceptance Test (AT) monitoring.
- b. The Network Mission Operations Support (NMOS) contractor is responsible for providing general systems operations support services to Code 540 which include supervisors and operators to man positions on a 24-hour-per-day, 7-day-per-week basis to perform the day-to-day maintenance and operations (M&O) functions.
- c. At overseas Nascom Interface Facilities, operations and maintenance personnel are provided through NASA contract arrangements with respective foreign governments or agencies.
- d. The operationally oriented personnel are provided at the remote Nascom Interface Facilities and in the project control centers by the interfacing user organizations.

1.8.2 Delegation of Authority

The Director, GSFC, for reasons of economy, workload, and responsiveness to project requirements, may request the cognizant field installation to implement the required opera-

tional long-line communications facilities and services. This may include provision for the applicable item in the appropriate program/project budget. It does not alter the requirement for the Director, GSFC, to concur in the technical adequacy of the planned facilities and services.

1.8.3 Configuration Control Management

This paragraph describes the makeup and workings of the Configuration Control Board (CCB).

1.8.3.1 Configuration Control Board

The MO&DSD has delegated the authority for the management of the Nascom Network configuration control to the CCB, which reports to the NASA Communications Division. The CCB is chaired by the Associate Division Chief and is composed of the Branch and Section Heads of the Division. The purpose of the CCB is to ensure that all proposed configuration changes to the Nascom Network satisfy the system performance necessary to meet program support requirements as scheduled, and within resource restraints.

1.8.3.2 Configuration Change

Each proposed configuration change is evaluated in reference to its design, performance, cost, schedule, operational effectiveness, logistics, training, maintenance, and interfaces with associated systems. Where configuration changes affect systems of other organizations, these changes are processed through their CCB for review and concurrence.

1.8.4 Communications Operations Control Management

1.8.4.1 Communications Manager

The Communications Manager, Head, Nascom Operations Management Branch, is responsible for the operation and control of the Nascom Network. He, or his designated representative, is continuously available (24 hours per day) as the centralized point of coordination and source of information for the mission control teams in the various project operations and mission control centers. This arrangement allows the mission control team to concentrate more efficiently on the simulation or mission in progress.

1.8.4.2 Delegation of Communications Manager's (COMMGR) Responsibility

On a routine operational basis, this responsibility is represented continuously in an operating position designated COMMGR, located in the primary Nascom Switching Center. This position is manned continuously, 24 hours per day, 7 days a week.

1.8.4.3 Unmanned Mission Support

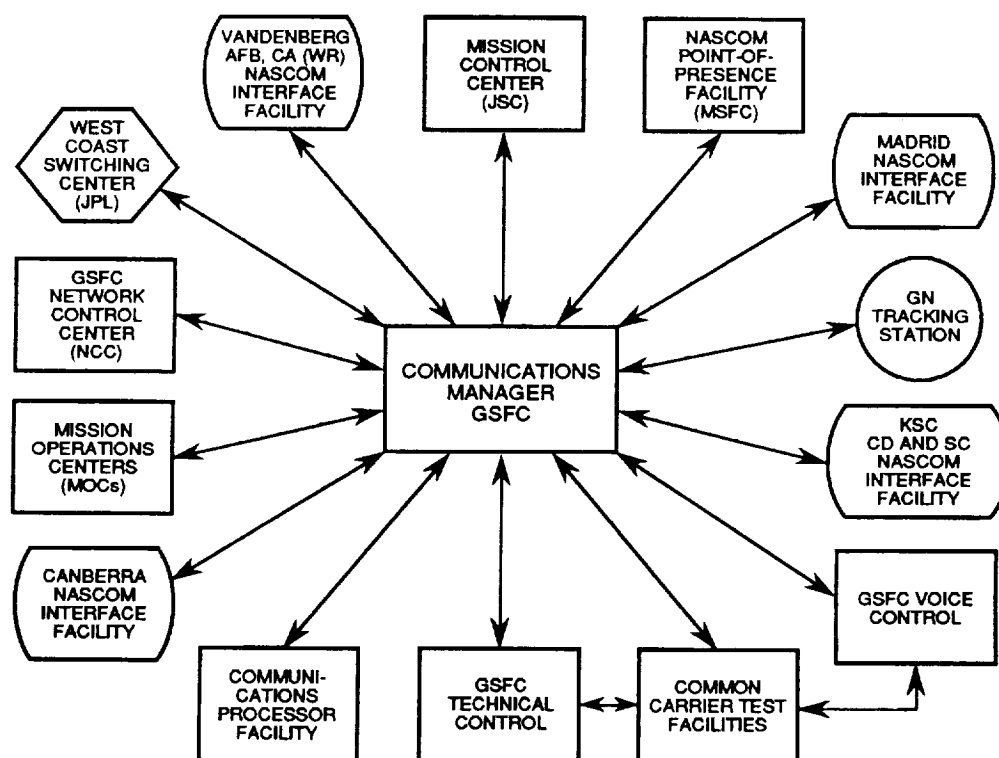
During missions, the COMMGR reports, as required, all information relating to that portion of the Nascom Network which is supporting a particular mission, directly to the Mission Controller or an authorized representative at the Mission Operations Center (MOC). This

gives direct cognizance of communications to that mission control center and places the COMMGR in direct operational coordination with the Mission Controller. Figure 1-3 illustrates this function. Generally, the COMMGR will provide the following types of information to Mission Control:

- a. The overall status of the communications network.
- b. The nature of any existing problem, what action is being taken to correct it, expected time the service will be restored, and notification that the service has been restored.
- c. Potential problems (e.g., severe storm information).

1.8.4.4 Manned Missions

For manned-flight missions, information relating to status normally will be passed over full-period orderwire/service channels between the Shuttle Mission Control Center (SMCC) and the COMMGR. The COMMGR, however, is not directly responsible for technical control of directly routed circuits (circuits not routed through GSFC). This authority is delegated to the appropriate NASA centers involved in the interface.



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Figure 1-3. Flow Diagram, Nascom Coordinated Communications Control

1.8.4.5 COMMGR Responsibilities

The responsibilities of the COMMGR range from vital mission-alert activities to general routine functions. The major responsibilities of the COMMGR are as follows:

a. General:

1. Provide adequate facilities and personnel to perform circuit quality monitoring, testing, analysis of circuit performance, and to establish standards of performance.
2. Provide and maintain sufficient orderwire facilities to remote facility control points, commercial domestic and overseas carrier toll test centers, and primary routing points, and to the mission control center when necessary for circuit and facilities coordination, trouble reporting, and fault location.
3. Establish backup circuits and make-good facilities, and prepare diverse routing plans.
4. Establish working relationships with the various common carriers and develop mutual plans, as applicable.
5. Establish uniform and efficient communication procedures and disciplines.
6. Establish Network operational procedures and circuit discipline.
7. Exercise technical and administrative supervision of technical control centers at the GSFC primary switching center and remote Nascom Interface Facilities.

b. During Missions:

1. Ensure that all mission and mission-related traffic has the necessary priority on communication facilities dedicated to the respective missions. This applies to common carrier as well as NASA facilities and will be accomplished through the operating procedures contained in NASA Communications Operating Procedures (NASCOM), Volumes 1 and 2.
2. Ensure that technical tests and routine maintenance are performed on a noninterference basis with respect to mission simulations and operations.
3. Ensure that no marginal circuit is taken out of service for corrective action (or for any other reason) without the explicit approval of the director of the mission in progress, or his authorized representative.

1.8.4.6 Nascom Network Scheduling Group

The complexity of operational support imposes a continual evaluation of all project and mission requirements. Therefore, a Nascom Network Scheduling Group (NNSG) has been established to perform the following functions:

- a. Accept project and mission operational requirements.
- b. Coordinate inputs and examine for overlap.
- c. Resolve conflicts.
- d. Develop and disseminate schedule information.

The NNSG consists of contractor representatives in support of the Nascom Operations Management Branch of the NASA Communications Division, in coordination with personnel from other operating centers of NASA. The Nascom Operations Management Branch, Head, serves as the permanent chairman of the NNSG. All real-time scheduling requests received during NNSG off-duty time (4:30 p.m. to 8:00 a.m. GSFC time) are handled by the Shift Communications Manager (SCM). This method of operation is required when the circuit-sharing concept is employed. Circuit sharing, which permits more efficient use of facilities, is adopted where wideband data circuits exist from remote sites to GSFC and multiple project support is performed by the sites.

1.8.4.7 Operational Procedures Documentation

- a. NASCOP Volume 1 is prepared and issued by the NASA Communications Division, prescribing procedures to be followed by all persons who may have to communicate over the Nascom Network. It contains sections with guidance to and information for voice network users, message originators, and communications personnel concerning internal message flow and distribution, message format breakdown, message examples, and routing indicator assignments for low-speed, high-speed, and wideband data transmission via the Nascom Network.
- b. NASCOP, Volume 2, contains the operational procedures and policies that govern the operation of the Nascom Multiplexer/ Demultiplexer (MDM), the Statistical Multiplexer (SM) and the Digital Matrix Switch (DMS) systems in support of NASA Space Network (SN) operations. Appendix B to the NASCOP Volume 2 was replaced in 1992 by the Nascom Space Network Ground Segment Support Data Book (542-016); the Data Book defines the various facilities and user configurations required to support the Space Network.
- c. Corrections and/or changes to NASCOP are issued by the NASA Communications Division in "pen-and-ink" form, as necessary, and twice a year by printed pages.

1.8.4.8 Schedules

Information on Nascom status relative to individual mission schedules for programs and projects supported by the Nascom Network are maintained in the Nascom Mission Planning Section, Code 542.1. For current, official schedule information, the individual Project Office should be consulted; however, the NASA Communications Division Office may also be consulted regarding general program scheduling information relating to Nascom-supported projects.



Section 2. Resource Planning and Procurement

2.1 Nascom Resource Planning

2.1.1 Resource Planning Requirements

Nascom Network funding and manpower requirements are updated by POP and WAD submissions by GSFC to NASA Headquarters. The GSFC chart of accounts applicable to the Nascom Network includes two major job categories; communications operations and communication systems.

2.1.2 Operations Funding Considerations

The following paragraphs describe the Nascom Network funding as subcategorized in the Job Order Structure Chart of Accounts in three groups. These groups: Domestic Carriers, Overseas Carriers, and Communication Services, are described in paragraphs 2.1.2.1 through 2.1.2.3.

2.1.2.1 Domestic Carriers

For domestic circuits, NASA is assigned to the General Services Administration (GSA) Federal Telecommunications System (FTS) 2000 contract's Network A provider (AT&T). Where the FTS2000 contract does not offer the services required by Nascom, the required service from other domestic carriers may be obtained by competitive procurement.

2.1.2.2 Overseas Carriers

Primarily U.S. and foreign companies that provide international communications services.

2.1.2.3 Communication Services

This category of Nascom operations provides for nonpersonal services contracts for the following:

- a. Operations of the primary switching center at GSFC.
- b. Engineering and software support service for system design and engineering development, programming, planning and facility implementation.
- c. Requirements planning and network review and analysis support.
- d. Any special studies and services required.

Also under this job order category are other supply and service items required to support the Nascom Network.

2.1.3 Communications Equipment

The following paragraphs describe certain communication facilities and equipment needed in the Nascom Network, which are not available from common carriers and are procured under

the major job order category. These facilities and equipment are established for procurement purposes under the GSFC job order structure, as follows:

2.1.3.1 Switching Systems

This includes automatic message-switching and circuit-switching equipment for both low-speed and high-speed data systems located at GSFC, such as switching computers and related peripherals, and interface, control, and display equipment.

2.1.3.2 Data Terminals and Voice Systems

Includes voice; high-speed and wideband data terminals; modems; encoder/decoder equipment; racks; power supplies and patch facilities, described as line terminating or interface equipment.

2.1.3.3 Network Equipment

Nascom provides network equipment that is both necessary and sufficient for the automated transport of information on a global basis. Some examples include the following:

- a. Transport equipment (routers, hubs, intelligent multiplexers, Asynchronous Transfer Mode (ATM) switches, patch panels, frame encapsulation/decapsulation equipment, and diagnostics equipment).
- b. Network management system equipment and software.
- c. Engineering support system equipment and software sufficient to sustain the current network and test such new technology developments as may be under consideration for integration into the existing network.

2.2 Nascom Procurement Policy and Practices

2.2.1 Nascom General Procurement Policy

The Nascom procurement policy follows the general provisions of NMI 2520.1D, as revised, Federal Acquisition Regulations (FAR) and Federal Information Resources Management Regulations (FIRMR), and other management guideline documents pertinent to the type of procurement involved. There are established practices and procedures for each type of procurement. However, in keeping with NMI 2520.1D, operational communication services or facilities will be obtained through lease from U.S. commercial and/or foreign common carriers, or maximum use shall be made of facilities or other government agency communications, whenever they are available and meet NASA mission reliability criteria. Consequently, Nascom Network equipment and facility purchases and installations do not duplicate common carrier facilities, but are limited to terminal, control, monitoring, and switching devices not available through lease from the common carriers.

2.2.2 Types of Resources Procurement

There are three types of resources procurement involved in establishing and operating the Nascom Network. These are: Communication Services, Communication Equipment, and Nonpersonal Services. These are described in paragraphs 2.2.2.1 through 2.2.2.3.

2.2.2.1 Communication Services

The first procurement area that involves a major Nascom procurement action, is dictated by NASA policy with regard to obtaining operational communication services.

- a. **Lease Versus Purchase Considerations.** As indicated in paragraph 2.2.1, the NASA policy is to obtain such services through lease of common carrier facilities whenever possible and feasible. Lease-vs.-purchase considerations are required when it can be clearly demonstrated that purchase would be in the interest of the government. This policy results from long-standing requirements of the Office of Management and Budget (OMB). Furthermore, it is generally considered that NASA interests can be best served when all parts of a publicly offered communications system are provided by the common carriers offering the service. Unless operated in this manner, it becomes extremely difficult to set responsibility for standards and maintenance, and to effect changes, improvements, and compatibility of parts of the system.
- b. **Communications Carriers and Tariffs.** Requirements may be met with the services available under existing common carrier public lease offerings or special construction tariffs which follow cost, pricing, and service specifications filed with the FCC. However, since deregulation has occurred, not all companies now capable of providing communications services are filing tariffs with the FCC. This is their own option and many choose not to file. Further, not all such companies are specifically known as "communications carriers." Prior to deregulation "common carrier," or "commercial common carrier" were other derivative terms used by the industry and the FCC, to identify the limited number of companies authorized by the FCC to provide communications services to the general public in accordance with their published, FCC-approved tariffs. Now, there are large numbers of such companies that may provide communications services, unregulated, and with no FCC involvement. Therefore, these derivative terms, although still used, no longer apply in the same sense. Use of these terms in this document therefore, will refer to any company, tariffed or nontariffed, that provides a leased communications service in support of Nascom.
- c. **Competitive Procurement.** Within the U.S., competitive procurement procedures are employed by Nascom for services obtainable from U.S. communications carriers. As indicated in paragraph 2.1.2.1, Nascom uses the communication services of the GSA FTS2000 contract's Network A carrier where the contracted services meet Nascom's service and quality requirements. In those instances where a required service is not available through FTS2000, Nascom follows the practices and procedures established by the Circuit Selection Board (CSB) for competitive procurement of required services not available from the FTS2000 contract vendor. CSB action is then reflected as a service order to the communications carrier company in the form of a Communications Service Authorization (CSA) issued under the authority of a Basic Order Agreement (BOA).
- d. **Other Sources.** When adequate common carrier facilities are not available, use may be made of other government agency communications available that meet NASA requirements.

2.2.2.2 Communication Equipment

The second procurement area involves communication equipment not available from the common carriers but required for domestic and overseas installations. These procurements are made through established procurement channels, either by direct purchase or lease from the equipment suppliers. However, some communications line terminating equipment is acquired by CSA under a BOA. Many foreign carriers are unable to provide the unique communication equipment required to support NASA missions.

2.2.2.3 Nonpersonal Services

A third procurement area involves contracting for nonpersonal services for communication operators and controllers at GSFC, and for engineering support services. Other services include a software support, network planning and analysis, and technical studies. These services are obtained using established procurement channels.

2.2.3 Circuit Selection Board

This paragraph describes the CSB as an organization and its awarding criteria for competitive procurement of common carrier services.

2.2.3.1 CSB Organization

A procedure for award of new long-line circuit leases has been established through a CSB (Refer to GMI 1152.30). This board, whose members evaluate proposals received from the carriers, is composed of personnel from the NASA Communications and Procurement Divisions of GSFC. The Chief of the NASA Communications Division is chairman of the CSB.

2.2.3.2 Award Criteria

The CSB operates under criteria applicable to all carriers operating in the geographic area of the new service required. These criteria involve:

- a. Responsiveness to NASA requirements.
- b. Price (total cost to the government).
- c. The ability of the existing carrier to provide the class of service required in the area.
- d. Recent relative performance of the carrier, based on outage records of existing NASA-like services in the same area.
- e. Lowest overall monthly dollar volume of NASA business for the preceding three months.

Upon request, carriers failing to gain an award are debriefed regarding the reason the award was not made to them.

2.2.4 Basic Ordering Agreement

A BOA is established with each qualified company that responds to a synopsis appearing in the Commerce Business Daily (CBD). A Nascom Network synopsis appears in the CBD in

approximate 6 month intervals identifying the types of communications services for which Requests For Proposals (RFP) will be issued. Response to the CBD may result in the issuance of a BOA, but does not necessarily indicate that a service will be obtained. That would be determined by a company's response to a specific RFP, and the decision of the CSB. A CSA is then issued under the BOA for the specific service.

2.2.5 Communications Service Authorization

The following paragraphs describe the CSA as an element in the Nascom procurement process, and the concomitant CSA practices and procedures.

2.2.5.1 CSA Practices

Communication services are specifically requested from communications companies under the authority of a BOA entered into between the company and the government. Requests are issued in the form of a CSA. Each BOA is assigned a Purchase Order (PO) number, and the PO is also used in the paying of bills, the specific cost of which are determined by the CSAs issued against that BOA/PO. This method is universally used for ordering communication services by General Services Administration (GSA), DoD, and most government purchasing activities. CSAs issued to the companies identify those particular services which the company is required to provide. They are usually issued by a Contracting Officer's Representative (COR) in the Nascom Division's Communication Services Section (CSS).

2.2.5.2 Negotiation and Pricing

Specific negotiations between Nascom and a company for leased services are seldom necessary. The competitive process compensates for this as it does with the establishment of the cost and no further cost or pricing information is needed. CSAs may be issued for any company-provided/proposed service without regard to dollar value and in accordance with the BOA.

2.2.5.3 Coordination with NASA Headquarters

Procurements for new circuits must be consistent with the GSFC POP (paragraph 1.7.4.4). Any new service not identified in the Nascom WAD, and that exceeds annual operating costs of 100,000 dollars requires separate NASA Headquarters, OSC, approval.

2.2.5.4 Procurement Funding

The practices and procedures followed in procurement funding are as follows:

- a. **Commitment.** Funds are committed by the Accounting Office for the fiscal year to the communications carriers mentioned above, based upon Procurement Requests (PR) for the respective contracts, from the NASA Communications Division. Funds are apportioned throughout the year and supplemental PRs are issued as funding authority increases.
- b. **Obligation.** The funds are, in turn, obligated monthly, based on estimates provided by the CSS for the total of current monthly bills anticipated under the current CSAs

to allow prompt payment. Existing financial management instructions call for payments to be made after services have been rendered and billed, which is the method generally used by the government in payment for public utilities services (monthly, after services rendered). The CSS validates the carrier's monthly bills, which then go to the Accounting office. Accounting then submits the invoices to the U.S. Treasury for payment.

Section 3. Nascom Network

3.1 Overview of Nascom Network

3.1.1 Network Configuration

Principal locations and functions supported by the Nascom Network are portrayed in Figure 3-1. The network globally interconnects various communications systems by variety of domestic and overseas circuit facilities that are operationally controlled from the GSFC Nascom Switching Center.

3.1.2 Network Elements

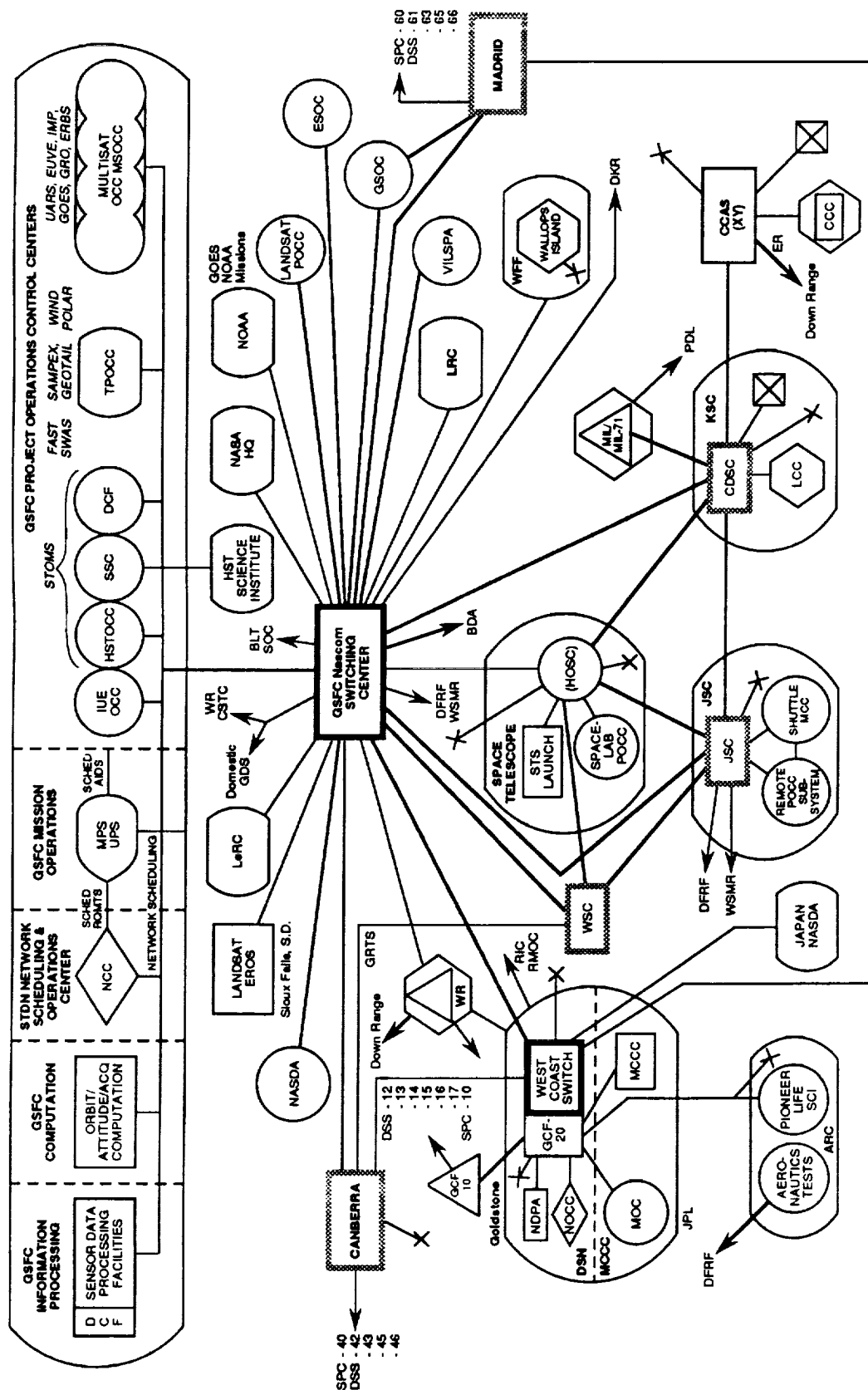
Inclusively, the Nascom Network consists of an array of facilities controlled from the GSFC Nascom Control Center. Included are circuit facilities, an intermediate switching center, Nascom interface facilities, a Point-of-Presence, and control and switching facilities of other agencies with which NASA has support agreements. This array is employed to interconnect the various user control centers and user tracking stations (terminals) with the supporting Nascom systems. The systems that do not interconnect with the GSFC Nascom Switching Center are also considered to be part of the Network when Nascom is responsible for the ground communications system on an end-to-end basis. For a broader perspective, the Nascom Network covers the following elements:

- a. Circuit facilities.
- b. GSFC Nascom Switching Center.
- c. Intermediate Switching Center.
- d. Nascom Point-of-Presence Facility (POP).
- e. Nascom Interface Facilities (NIF).
- f. User terminals.
- g. Nascom Ground Communication Support Systems and Services.

These elements are briefly described in the following paragraphs.

3.1.2.1 Circuit Facilities

Nascom circuits are comprised of diversely routed voice, low-speed data, high-speed data, wideband data, and video communications channels. These are provided to Nascom by communications common carriers employing both satellite and terrestrial based transport services. The circuit facilities are full-period channels leased from various domestic and foreign communications companies on a worldwide basis. The Nascom Network Circuit Directory Document (542-012) which is published quarterly by the Nascom Communications Management Section, Code 542.2 for internal use, contains a current listing of all leased long



LEGEND:

| | | | | | |
|--|--|---|--|--|---|
| | Network Scheduling and Operations Control Center | | Launch Operations Center | | Other Terminal Points, Cooperating Agencies, Test and Checkout Sites, Development Sites, Contractors, Experimenters, Etc. |
| | Primary and Intermediate Nascom Switching Center | | Computation and Data Processing Center | | Remote NASA T&DA Sites (STDN & DSN) |
| | Nascom Interface Facility | — | Main Trunk Routes, Domestic and Overseas | | Internal and Local Distribution |
| | Program Management Center | — | Other Long-Haul Routes | | Payload Checkout Facilities |
| | Project Operations Control Center (Spacecraft Command and Control) | | Remote Nascom Routing & Distribution Point | | |

Figure 3-1. Principal Locations and Functions Supported by the Nascom Network

haul circuits. Many channels are derived through subchannelization by Government-Furnished Equipment (GFE). Use is made of various common carriers via communications satellite relay facilities, terrestrial and submarine cables (including fiber optic) to obtain maximum feasible diversity and reliability. The variety of voice, data circuits (analog and digital), with a wide range of digital data rate(s), and video services are reviewed in paragraph 4.2. The major common carrier circuit routings and arrangements are described in Section 13.

3.1.2.2 GSFC Nascom Switching Center

The GSFC Nascom Switching Center is the primary switching center and control point furnishing, under direct Nascom control, centralized switching capabilities and technical control services. The GSFC Nascom Switching Center is located at Goddard Space Flight Center, Greenbelt, MD. It is described in paragraph 3.2.

3.1.2.3 Intermediate Switching Center

There is one intermediate switching center, the West Coast Switching Center, and it is located at Pasadena, CA. Operated for NASA by the Jet Propulsion Laboratory, this facility provides flexible circuit sharing of costly overseas channels, and to a limited extent alternate routing and circuit restoration capabilities. The intermediate switching center is described in paragraph 3.3.

3.1.2.4 Nascom Point-of-Presence Facility (POP)

A Nascom Point-of-Presence facility is one that is physically located at a NASA center other than GSFC, operated and maintained by Nascom (or its contractor) personnel, and is comprised of significant Nascom communications equipment, patch and test facilities, and commercial carrier interfacing hardware. A POP interfaces to the host NASA center at channel level; the host center is responsible for the on-center distribution of the signals handed off by Nascom at the demarcation point between a POP and the Center. The POP performs functions such as multiplexing, routing, and providing the Nascom demarcation point for the carriers' interfaces to the Center. Currently, there is one Nascom POP and that is located at MSFC. For a description of this POP (occasionally referred to as the Nascom/Huntsville Switching Center), refer to paragraph 3.4.

3.1.2.5 Nascom Interface Facilities

Nascom Interface Facilities are communications facilities located on other NASA and DoD sites where significant numbers of Nascom circuits are interfaced with the systems and networks of the host site. Significant NIFs are located at Canberra, Madrid, Kennedy Space Center (KSC), and Vandenberg Air Force Base [Western Range (WR)]. Nascom Interface Facilities provide not only a demarcation point for Nascom circuits terminating at the host installation but also provide Nascom with first-line capabilities for diverse or alternate routing, testing, circuit restoration, and access to the downrange communications systems of the host installation over which operational data, voice and teletype communications may be transported. These NIFs are described in paragraphs 3.5 through 3.7.

3.1.2.6 Users

As indicated in Figure 3-1, the primary users of Nascom services are:

- a. NASA Space Network (SN) ground station(s) for the Tracking and Data Relay Satellite System (TDRSS) (refer to paragraph 14.4).
- b. NASA tracking and data acquisition stations of the Ground Network (GN) (refer to paragraph 14.5).
- c. NASA/JPL Deep Space Network (DSN) ground tracking and data acquisition stations operated by the JPL for NASA (refer to paragraph 14.2).
- d. NASA project or mission operations control centers. Refer to Section 15 for the various mission supports provided.
- e. NASA computation and data processing centers.
- f. NASA network scheduling and operations control centers.
- g. NASA / DoD launch operations centers.
- h. Ground stations and facilities designated to provide contingency support to projects such as the EOSDIS.
- i. Other remote locations for Nascom users directly or indirectly related to mission and network operations and program operational management, including but not necessarily limited to network and spacecraft simulators, spacecraft contractors, payload experimenters, cooperating agencies, facilities and networks.

3.1.2.7 Nascom Ground Segment Communications Support Systems and Services

These systems provide value-added capabilities to support the user terminals in the functions of switching, multiplexing, transmission, technical control, test, and analysis. The Nascom transport systems and services are reviewed in paragraph 4.2.3, and the major ground segment communications support subsystems are more fully described in Section 5.

3.1.3 Network Capabilities

The Nascom Network offers a variety of transport system capabilities and communication services. Two approaches to requirements satisfaction are available, depending upon the nature of the user requirement: (1) use of Nascom generic (institutional) transport systems currently operated by the Network or (2) by an expansion of the capabilities of the existing network (e.g., by adding to the Nascom-2000 interface servicing a given location), or by (3) in those special cases such as the Earth Observing System Data Information System (EOSDIS) where NASA Code Y is funding its own network [EOSDIS Backbone Network (EBnet)], Nascom may establish a project to manage the implementation of that new network. The second approach is used when existing capacities are exceeded by the requirement. At the present time, the Nascom Network provides the following capabilities:

- a. Provides all NASA mission control centers with real-time communication access to spacecraft via launch sites and remote tracking stations. Such access is required

during various mission phases, including pre-mission spacecraft checkout, mission and network simulations, launch, orbital, and landing (for Shuttle missions). Access is also required for deep space and interplanetary missions during near-Earth, cruise, and planetary encounter phases.

- b. Provides communication support, where needed, to spacecraft development contractor's test facilities for prelaunch spacecraft checkout, network and POCC compatibility testing, and for post-launch monitoring and support.
- c. Provides for the transport and delivery of spacecraft telemetry, housekeeping and experiment data to control centers for command and control of spacecraft, in real-time or near-real-time, and to data capture and processing centers for "quick-look" processing, where required.
- d. Provides for the transport and delivery of science data to data capture facilities for non-real-time preprocessing and for production data processing prior to delivery to experimenters and investigators.
- e. Provides the data transport of experiment and science data to science operations support centers, and to experimenters that interact with mission control for command management support of onboard instruments.
- f. Provides data transport support such as that needed between aircraft test locations and their respective project management and analysis locations.
- g. Provides the communications link for agencies or organizations that participate in, cooperate with, or otherwise support the NASA spaceflight program with the program management and mission control centers, where their activities are closely related to the operational aspects of the missions.
- h. Provides transport of user data and user products in support of NASA missions and projects.

3.2 GSFC Nascom Switching Center

The following paragraphs describe the GSFC Nascom Switching Center.

3.2.1 System Description

3.2.1.1 System Configuration

Comprehensive information on the configuration of the GSFC systems is contained in the Nascom Primary Switching and Control Center Station Handbook, Document No. 542-013, original issue June 1988. The primary Nascom operational control, switching, transmission, technical control, test, and analysis functions are conducted within or directed from the GSFC facility. Nascom provides networking capabilities through systems such as its X.25 based packet switched Data Distribution and Command System (DDCS) (refer to paragraph 5.5) and through its TCP/IP based Nascom Operational Local Area Network (NOLAN), and its HYPERchannel based MO&DSD Operational/Development Network (MODNET) (refer to paragraph 14.5.8).

3.2.1.2 System Elements

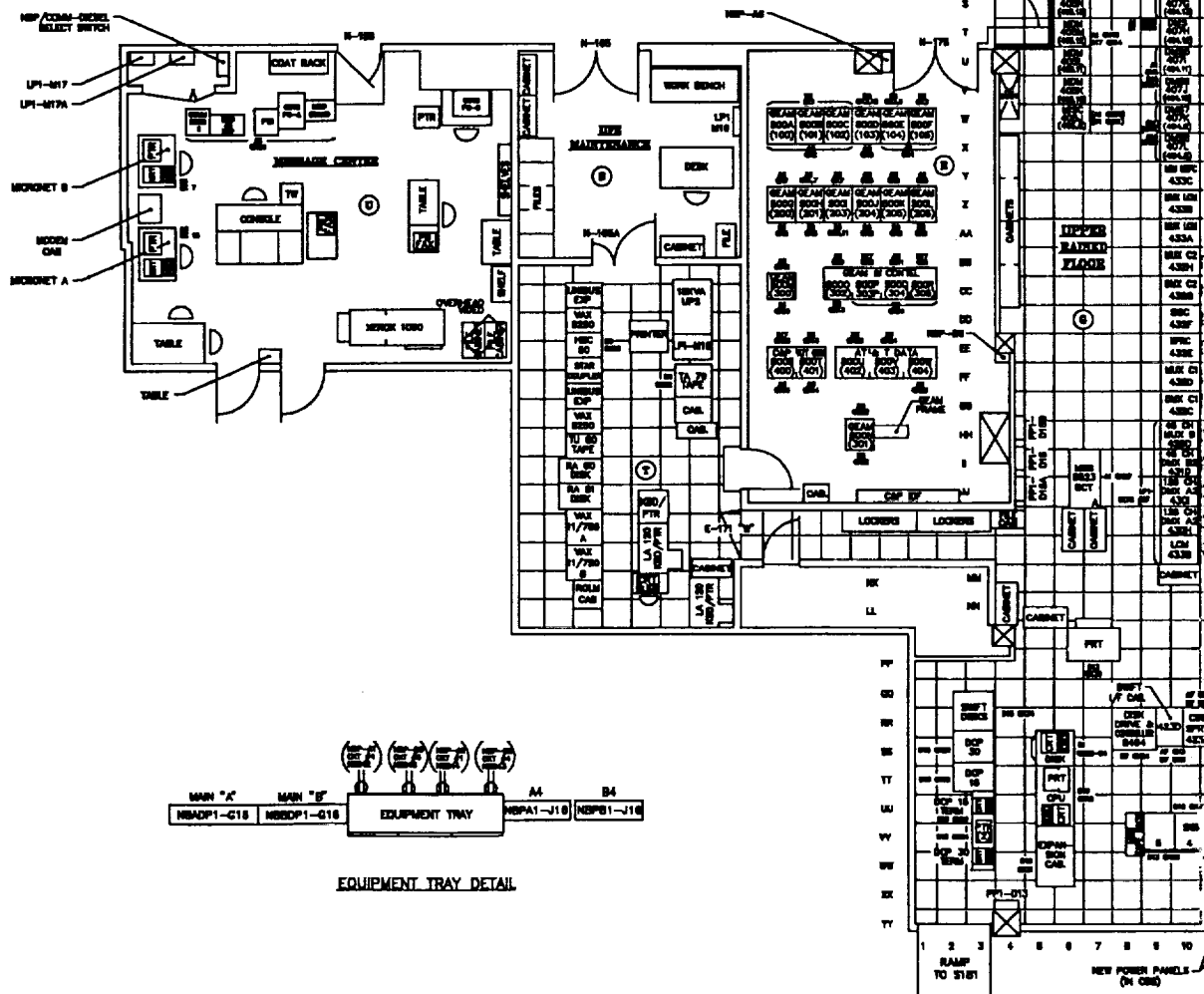
The primary elements are Building 3/14 Nascom facilities, associated common carrier facilities, and environmental support facilities. Components of these elements will be discussed in greater detail in Sections 4 through 12 of this document. Environmental support and technical control facilities are mentioned here only as necessary for the context of this discussion; they are addressed specifically in paragraphs 5.9 and 5.10. A brief description of the primary elements is given in the following paragraphs.

- a. **Building 3/14 Nascom Facilities.** The primary Nascom facilities at GSFC are located in the contiguous Buildings 3/14, which occupy a total of approximately 21,000 square feet on the first floor and in the basement. Nascom switching and technical control facilities are contained in rooms on the first floor of Buildings 3/14. (See Figure 3-2.). The data terminal switching and control facilities and data operator positions are located in Room E-171 (technical control) of Building 14. The voice control facility and voice operations are located in Room E-158 of Building 14. The technical support facility is located in Room W-2 of Building 14. The COMMGR positions are located in Room E-125.
- b. **Associated Building 3-14 Common Carrier Facilities.**
 1. The American Telephone and Telegraph Company (AT&T) provides a digital Central Office (CO) in Room N-37 of Building 3. Interconnections of the CO to the AT&T digital network is accomplished over two diversely routed fiber optic facilities. One enters the GSFC over AT&T routed fiber from its Southwest Washington, D.C. facility 'WASH3'; the other enters over Inter-Center Communications, Inc. (ICC) routed fiber from AT&T's facility office in Silver Spring, MD.
 2. The ICC provides a third fiber optic service into Room N-63. ICC provides various leased circuitry to several other carrier terminals in Room N-63 as well as to AT&T.
 3. Bell Atlantic maintains frame and/or circuit termination responsibility into Room N-63 and Room N-58. Specific leased circuitry is provided to various other carriers by C&P. C&P provides diverse routes to the C&P point-of-presence in Building 1 from their off-site central offices (CO).
 4. The AT&T, General Telephone Electronics, Inc. (GTE), and GE American Communications, Inc. (GEAM) each own and operate a domestic satellite Earth station(s) at the GSFC in the area adjacent to Building 25. AT&T services terminate in the AT&T CO, Room N-37. GTE and GEAM terminate wideband services in Room N-175 and voice grade services in Room E-175.
 5. All local circuit facility extensions from the above described carrier interfaces to Nascom facilities are the responsibility of the government. On-center, Bell Atlantic provided and government controlled cables, other than those identified above in subparagraph (3), are the responsibility of Code 543.

- (A) VOICE CONTROL
- (B) COMMUNICATIONS MANAGER POSITION
- (C) SECURITY AND ACCESS CONTROL (SWO)
- (D) MESSAGE SWITCHING SYSTEM (MSS)
- (E) CONTROL AND STATUS SYSTEM (CSS)
- (F) COMBINED OPERATOR WORKSTATION (COW)
- (G) MDM EQUIPMENT AREA/TECH CONTROL
- (H) DIGITAL MATRIX SWITCH (DMS) EQUIPMENT
- (I) DATA ANALYSIS/MISSION CONSOLE POSITIONS
- (J) MACS COMPUTER
- (K) CSS CONTROL POSITION
- (L) MACS AND DMS CONSOLES
- (M) TDMA TERMINAL EQUIPMENT
- (N) TTY TECH CONTROL AND EQUIPMENT

- (O) TECH CONTROL--WB DIGITAL DATA
- (P) TECH CONTROL--HS DATA
- (Q) TECH CONTROL--WB ANALOG DATA
- (R) COMMON CARRIER MODEM EQUIPMENT AREA
- (S) UNIVIS FIELD ENGINEER AREA
- (T) NASCOM VAX MIS
- (U) TTY MESSAGE CENTER
- (V) BREAK ROOM
- (W) MSS OPERATORS AREA

1. CABINET NUMBER IN PARENTHESES DENOTE OLD CABINET NUMBER DESIGNATION.





- c. **Environmental Support Facilities.** The environmental facilities are the primary power system, uninterruptable power system, emergency lighting, and air conditioning.

3.2.2 Circuit Switching System

Circuit switching is the routine operational connection of one circuit to another performed by Nascom in response to schedules or real-time requests. It may be accomplished in several ways, depending on the circuits involved. It may be done manually, using the analog and digital high-speed and wideband patch panels in Technical Control to accomplish the direct interconnection (hardware) of long-haul point-to-point and/or local GSFC data channels. It may be accomplished semiautomatically via the Digital Matrix Switch (DMS), configurations being entered from local operator console positions. Or circuit switching may be accomplished automatically under the Control and Status System (CSS). This definition distinguishes circuit switching operations from message switching and those switching functions performed for trouble isolation, circuit testing, and restoration.

3.2.3 Message Switching System

The Message Switching System (MSS) is used to perform automatic message switching functions on wideband, high-speed, and low-speed digital data, and on LSN tracking data messages.

3.3 West Coast (Intermediate) Switching Center

The following paragraphs describe the West Coast Switching Center (WCSC) as an intermediate switching facility of the Nascom Network.

3.3.1 WCSC System Description

3.3.1.1 WCSC/Nascom Facility Description

JPL operates both the GCF-20 communications center and the WCSC to support the communications requirements of the DSN as part of the Nascom Network, respectively. These centers, integral parts of the Central Communications Terminal (CCT) located in the Space Flight Operations Facility (SFOF) building at Pasadena, CA, share common equipment. They are separately budgeted and funded by JPL.

3.3.1.2 WCSC System Elements

Nascom uses the JPL-provided audio switch assembly, which has a capacity of 100 external line terminations. The 758A switchboard provides for switching, conferencing, and configuring voice and voice/data circuits. Voice/data technical control and data terminal facilities for high-speed and wideband data are jointly provided by JPL and Nascom at JPL. This equipment is used to through-connect voice and data circuits from sites in the west coast area to GSFC, as well as for local termination, distribution, facility control, test, and restoration operations.

3.3.1.3 JPL/GSOC Interface

In July, 1992 the German Space Operations Center (GSOC) located in Oberpfaffenhofen, Germany established a direct interface with JPL/DSN. To establish this interface, GSOC leased a 64 kilobits per second (kb/s) data circuit and furnished GDC, Inc. MiniMux time division multiplexers for use on each end. Figure 3-3 depicts the multiplexer and circuit configuration.

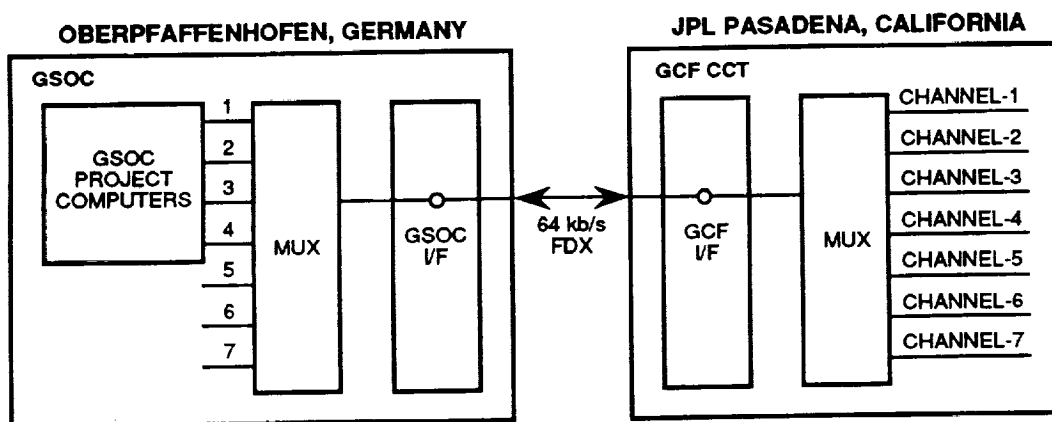
3.3.2 Nascom Operating Arrangements

Both the GCF-20 communications center and the WCSC are operated 24 hours per day, 7 days per week by contractor personnel. The operation of both GCF-20 and the WCSC are subject to Nascom operating policies, procedures, and guidelines.

3.3.3 WCSC Environmental Support Facilities

The environmental support facilities provided for the WCSC system include:

- a. **Power Facility.** Normally, all loads are carried on commercial power. Three 1380 kVA auto-start diesel generators will assume the load within 20 seconds in the event of a commercial power failure. During critical mission periods, the generators are brought up in a standby mode. In the event of failure of both commercial power and



NOMINAL MUX CHANNEL DISTRIBUTION

| CHANNEL | USE |
|---------|--|
| 1 | 9.6 kb/s FDX 4800-BIT BLOCK A1 ROSAT DATA |
| 2 | 9.6 kb/s FDX 4800-BIT BLOCK A7 AT EUTELSAT DATA |
| 3 | 9.6 kb/s FDX 4800-BIT BLOCK D2/51 ICV/ODF/SOE DATA |
| 4 | UNASSIGNED |
| 5 | 16 kb/s ROSAT VOICE |
| 6 | 16 kb/s EUTELSAT VOICE |
| 7 | UNASSIGNED |

LAS 540/010-0222m

Figure 3-3. GSOC-JPL MUX Configuration

diesel generators, an Uninterruptable Power Supply (UPS) will provide up to 30 minutes of power.

- b. Air Conditioning Facility. The air conditioning system provided for the SFOF has a 1500-ton capacity.

3.4 Marshall Space Flight Center Nascom Point-of-Presence

The following paragraphs describe the Nascom POP at MSFC as an extension of the Nascom network.

3.4.1 MSFC Nascom POP Description

3.4.1.1 MSFC Nascom POP Configuration

The Nascom POP facility at MSFC is designed, managed, operated and maintained by Nascom. The Nascom POP is located in room 107, Building 4207, MSFC. This facility provides a Nascom interface and demarcation point at MSFC where individual circuits and signals from user facilities may be interfaced to complex communications systems for transport between MSFC and other NASA Centers.

3.4.1.2 MSFC Nascom POP Elements

The communications systems in the POP consist of Nascom-2000 AT&T Paradyne Model 745 and Model 740 multiplexers transporting voice and data circuits, DDCS nodes A and B, the asymmetrical multiplexer/demultiplexer replacement (MDMR) equipment, MDMR Automated Control System (MACS), carrier equipment for both the Nascom-2000 services and those provided by others, and the patch panels and distribution frames associated with the foregoing circuits and systems. JMRTS and KMRTS, originally installed in the late 1980s to provide redundant transmission services with JSC and KSC respectively, have been deactivated. Their circuits have been cutover to Nascom-2000 for transmission. To interface the nonstandard (to Nascom-2000) data rates that KSC provides to MSFC, the GDC TDM-1258 multiplexers have been retained to submultiplex these signals onto a 1024 kb/s aggregate which then presents a standard interface to the Nascom-2000 AT&T Paradyne 740 multiplexer. Also located in the POP are countdown and elapsed time clocks. An electronic logging system is maintained on one PC, and the station's records on another PC.

NOTE

As yet, there is no project to relocate the high data rate system statistical multiplexer from the HOSC to the POP; should such a project materialize, it is to be expected that the existing hardware would be replaced with new equipment and that the replacement hardware would be installed in the POP. This would complete removal of "Nascom facilities" from the HOSC.

Figure 3-4 depicts the floor plan of the Nascom POP as of February 1995.

540-030

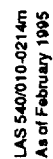


Figure 3-4. Nascom POP Floorplan

3.4.2 Nascom Operating Arrangements

A Memorandum of Understanding (MOU) for Nascom POP at MSFC, developed between Nascom (GSFC/540) and the Information Systems Office (MSFC/AI01), sets forth the following:

- a. The MOU formally codifies accommodations and arrangements previously agreed upon. It defines major areas of responsibility for Nascom and for MSFC.
- b. The Nascom POP is staffed by Nascom and reports operationally to the Communications Manager at Nascom, GSFC. Nascom provides specifications for hardware installation and determines requirements for the facility. Nascom provides operating and maintenance personnel sufficient to staff the facility on a single shift basis five days a week. This staff is also required to provide coverage on an extended basis as operational mission requirements may dictate.
- c. MSFC supplies the POP with facilities space, HVAC, electricity, and administration support. MSFC also supplies local packaging, shipping and transportation services to the POP in support of POP logistics functions. The POP receives maintenance for its test equipment, office space, and other administrative services such as office supplies, telephone and mail services, property accountability and physical security from MSFC in the same manner as MSFC supplies these services to any of its on-site contractors.

3.5 Madrid Nascom Interface Facility (MNIF)

The following paragraphs describe the Madrid Nascom Interface Facility.

3.5.1 MNIF System Description

3.5.1.1 MNIF Configuration

The MNIF has significantly decreased its role as a Nascom interface for circuits extended to other sites, and for messages to be relayed or switched to other locations. Network engineering by both Nascom and the JPL has resulted in cost saving efficiencies to the point where the "Nascom equipment" at the MNIF consists of an intelligent wideband multiplexer in the CTNE building. From this multiplexer, submultiplexed aggregates and individual circuits are extended across the site to the DSN's SPC-60 building where the communication equipment is managed, operated, and maintained by DSN/JPL and not by nor on behalf of Nascom.

The NASA-owned communications building of approximately 4,000 square feet is adjacent to the MDSCC operations building at Robledo (about 36 miles west of Madrid). This building houses all equipment needed for operational wideband, voice/data and TTY channels and also for administrative telephone service to the MDSCC. All communications terminal equipment is NASA-owned except for Telex, carrier, and microwave terminals, which are leased from Compania Telefonica de Espana, S.A.(CTNE); the space segment is leased from Intelsat.

3.5.1.2 MNIF Elements

Presently, Nascom equipment consists of an ascom Timeplex/Link 2 + TM multiplexer terminating a 1.544 Mb/s data link between Madrid and the JPL-operated Nascom West Coast

Switching Center. This multiplexer provides transport services for a DSN-multiplexed 768 kb/s data stream known as the "Big Pipe." Also multiplexed onto the same aggregate are DSN slow-scan television, an Internet interface channel, DSN and Nascom voice loops digitized for transmission at line rates of 32 kb/s, and three high-speed data lines for electronic mail, tracking data, and DSN's network interface management system. The ascom Timeplex/Link 2+™ aggregate is then transported via Intelsat to JPL.

Nascom also terminates and transports a 64 kb/s multiplexed data circuit via the TAT-9 submarine cable. This circuit, known as the "Little Pipe," is between Madrid and GSFC where the circuit is directly transported to JPL by Nascom.

3.5.2 Nascom Operating Arrangements

The INTA operates and maintains MDSCC station communication equipment in the SPC-60 building for JPL. This equipment consists of fiber optic intermediate distribution frames, modems, Avanti and Timeplex multiplexers used to build the "Big Pipe" and "Little Pipe" aggregates, digital data interface panels, voice and data patch panels, and the associated communication terminal equipment. INTA also operates and maintains the voice switching system and the digital switching matrix supporting the station.

3.5.3 MNIF Environmental Support Facilities

Both primary and standby power are provided from diesels at the MDSCC site. As part of an energy reduction effort, MDSCC is operating the Electronics (E) and Utilities (U) busses from the same generator(s). In the event of a total power outage, the Nascom building automatic power transfer switch will provide power for all of the electronics equipment. This transfer switch is fed from a small capacity generator being used at MDSCC for special power requirements. A 48-volt Direct Current (dc) battery supply provides no-break power protection to all telephone company carrier systems and to part of the Nascom terminal equipment. During an MNIF power failure, voice and data can be patched line to line. However, all data regeneration and monitoring capability will be lost during the outage.

3.6 Canberra Nascom Interface Facility (CNIF)

The following paragraphs describe the Canberra Nascom Interface Facility.

3.6.1 CNIF System Description

3.6.1.1 CNIF Configuration

The CNIF is located within and staffed by personnel of the Canberra Deep Space Communications Complex (CDSCC) at Tidbinbilla. This facility concentrates circuits from the CDSCC and offices and support facilities in Canberra. This facilitates the sharing and control of long-haul trunk circuits between Australia and the U.S.

3.6.1.2 CNIF Elements

The following paragraphs describe the CNIF elements:

- a. Nascom-furnished Equipment. This equipment provides the capability of testing, monitoring, and allocating GSFC/JPL/Canberra trunk circuits to the CDSCC and

Department of Industry, Technology and Commerce (DITAC) agencies, depending on mission requirements. An order wire is provided for Nascom coordination. The Nascom-furnished equipment in the CNIF includes:

1. Low-speed data TDM system between Canberra and GSFC.
 2. Data Technical Control Facility with test equipment and data modems for test, termination, and control of high-speed and wideband data circuits extending from GSFC to Australia.
 3. Low-speed data Technical Control Facility.
 4. Site Voice Switching Facility with the capacity for terminating 26 long-lines and local access loops as follows: 12 switchable and 14 patchable.
- b. Facsimile Transceiver. A low-speed facsimile transceiver terminal is provided for communication of logistics and engineering support traffic (page copy) on a voice/data channel. Every effort is made to contact the addressee regarding delivery.

3.6.2 Nascom Operating Arrangements

The CNIF is operated by the CDSCC Contractor under a contract providing operations functions for NASA/JPL. All operations and maintenance functions are performed by site personnel attached to the CDSCC. The CNIF is manned on a continuous basis.

3.6.3 CNIF Environmental Support Facilities

The environmental support facilities provided for the CNIF include:

- a. Power Facility. Normally, all loads are carried on public power. Station diesel generators assume the loads in the event of a public power failure.
- b. Air Conditioning. The building air conditioning system is used to provide cooling for the switching center area.

3.7 Kennedy Space Center Nascom Interface Facility (KSCNIF)

3.7.1 Description

With implementation of Nascom-2000 (for a detailed description of Nascom-2000, refer to Section 5), Nascom interfaces with the Cape launch and supporting facilities were consolidated in the KSC Communication Distribution and Switching Center (CD&SC) facility. Virtually all Nascom circuits (those to GSFC, MSFC, JSC, and JPL) now have their point of demarcation in the CD&SC. From the CD&SC, the KSC Communications Division (Code TE-COM) extends the tail circuits out to the MILA communication and tracking station, to the Launch Control Center, to Payload Communications, and to the Cape Canaveral Air Station's (CCAS) X-Y building and Hanger AE. Nascom interfaces with the Air Force's Eastern Range (ER) are now also through the KSC CD&SC facility.

3.7.2 Nascom Operating Arrangements

Although the NIF function supporting the Cape Canaveral area launch and range operations has been relocated to and consolidated within the CD&SC, the CCAS X-Y facility still

functions as the primary Eastern Range interface and demarcation point for NASA through its interfaces with the CD&SC. Nascom service requirements entailing interfaces with the ER are still processed through the NASA Communications Division at GSFC. The GSFC COMMGR remains in control of the mission configuration of Nascom circuits going into and out of the Cape via the CD&SC.

Section 4. Overview of Nascom Systems and Services

4.1 General

Definition of Terms

The terms defined herein are commonly used in the Nascom lexicon. The presentation of these definitions is intended to provide a distinctive and basic meaning of these terms in the context of this document.

- a. **Nascom Communications Service.** An act that Nascom performs in accomplishing any of the communications functions specified in paragraph 1.3.1 of this document for the Network users in response to a specific request. This term may also refer to the functions of providing any of the transport systems such as voice, data, or video transmission. Very often, it refers to a communications circuit obtained from a common carrier as an end-to-end communications service being provided by Nascom.
- b. **Nascom System.** A reference to a collection of individual communication networks, transmission media, relay stations, tributary stations, and/or interfaces or terminal equipment(s) established and operated by Nascom that is capable of interconnection and interoperation to form an integrally identifiable functioning entity.
- c. **Major Ground Communications Support System.** A reference to a ground-based Nascom system that is considered unexpendable to the user community; i.e., the loss of this system virtually nullifies the Network service. This terminology may also refer to a Nascom system that has a relatively high installed and/or recurring cost. Examples of system elements that qualify under this heading are the MODNET/NOLAN and DDCS X.25 packet switching system.

4.2 Nascom Communications Services

4.2.1 Review of Nascom Communications Services

Based on traditional and new transmission systems, Nascom is able to provide a variety of communication services, primarily in the transport system service area. These transmission systems and transport system services are either the prime or support elements of a given Nascom system. These systems and services all play significant roles in the way Nascom operates. An attempt is made in this paragraph to categorize and define them to provide the reader a better perspective and understanding of Nascom systems and services.

4.2.2 Transmission Systems

4.2.2.1 Categories of Nascom Transmission Systems

In the broadest sense, Nascom Transmission Systems are categorized as follows:

- a. Voice transmission system.
- b. Data transmission system.
- c. Video transmission system.

These transmission systems are defined in paragraphs 4.2.2.2 through 4.2.2.4.

4.2.2.2 Voice Transmission System

This system consists of one or more facilities connected to provide a path for communicating at voice frequency between two or more points. ("Voice frequency" refers only to the signal's form at the input to and output of the end instruments [microphone, headset, handset, speaker, etc.].) The facilities may consist of metallic cable pairs, coaxial cable, microwave radio link, fiber optic, or a satellite circuit. The last connection in the chain is usually the local loop, provided by twisted cable pairs which connect the station equipment to the switch or central office. This system includes voice transmission via both analog and digital means.

4.2.2.3 Data Transmission System

This system consists of one or more facilities connected to provide a path for the transfer of bits, characters, or data blocks per unit of time from a data source to a data sink. The facilities may consist of cables, microwave radio link, fiber optic, satellite circuits, modem, line driver, multiplexer, or even a switch to facilitate the data interconnection or traffic routing. Network systems that are encompassed within this category include the DDCS, MODNET and NOLAN, Nascom Overseas Communications System (NOCS), and the EBnet, currently being designed and implemented for the Earth Sciences Data Information System (ESDIS) Project.

4.2.2.4 Video Transmission System

This system consists of one or more facilities connected to provide a path for the transmission of signals comprised of frequencies and modulation rates (analog or digital) normally required for pictorial information. The facilities may consist of video equipment and the associated cables, microwave radio link, fiber optic, or satellite circuit. The common applications, which Nascom provides, are one-way point-to-point or video broadcast, Video Conferencing (VC), and Closed Circuit TV (CCTV) services.

4.2.3 Transport System Services

4.2.3.1 Nascom Support Service Arrangement

Nascom generally provides the procurement of a common carrier service, and the engineering, procurement, and installation of the GFE facilities, as required for establishing the

above-mentioned services on an end-to-end basis. If necessary, Nascom tailors a system to a primary users' specific requirements and specifications. Nascom has what may best be described as a "mission contract" for the operation and maintenance of its facilities. The NMOS contractor is completely in charge of managing and directing network operations support activities. Nascom civil servants are no longer involved in the day-to-day operational direction and management of the network. To maintain the transport system services, Nascom, in most cases, provides ongoing support services that include preventive maintenance, testing, monitoring, and restoration of the communication lines and equipment associated with the given service on a 24-hour/ 7-day-per-week basis. This includes close coordination with the common carriers involved, spare parts, logistics and repair services for GFE equipment. The service provided depends on the types and characteristics of the transmission channels employed, the termination and configuration of the channels, and the switching and operational flow of information on those channels. Wherever possible, Nascom attempts to gain multiple-user utility of a system implemented to the pacing or driving requirement of a principal user.

4.2.3.2 Types of Nascom Transport System Services

The types of transport system services provided by Nascom are as follows:

- a. Generic voice transport system service.
- b. Generic data transport system service.
- c. Dedicated data transport system service.
- d. Video transport system service.
- e. Integrated communication system service.

4.2.3.3 Generic Voice Transport System Service

This paragraph defines the two types of voice transmission used by Nascom to provide the Voice Transport System Service.

- a. Analog Voice Transmission. This type refers to the transmission of voice information that is represented in analog waveform (i.e., a variable, but continuous waveform), which typically ranges from 300 to 3,400 Hz.
- b. Digital Voice Transmission. This type refers to the transmission of voice information encoded in discrete binary form where the original voice signal, in analog form, is converted into and from digital form before transmission and reception. Adequate sample rates are used to maintain full commercial quality voice fidelity.

4.2.3.4 Generic Data Transport System Service

This paragraph profiles, generically, the Nascom systems used to provide this service. Except for the packet switching service, these systems are considered generic; i.e., they are provided to the users in general. Due to this nature, these systems are given the main section title headers in the document for wider and more detailed coverage.

- a. Low-speed Network Data System. Nascom no longer supports teletype network switching. In its place, Nascom has implemented a Low-Speed Network (LSN). This

network provides transport and switching of low-speed tracking data messages (messages must be ASCII, not Baudot coded), and transports text messages via a separate electronic mail system. Refer to Section 6 for a description of the LSN.

- b. **High-speed Data System.** As used in the Nascom lexicon, this refers to a system that is capable of transmitting synchronous baseband binary digital information at rates in excess of 1200 baud and up through 9.6 kb/s. The High-speed Data System (HSDS) is widely used by STDN, DSN, and the remotely located, circuit-switched terminals. In many applications, the HSDS circuits are derived from the wideband data trunk line through MDM process.
- c. **Wideband Data System.** As used in the Nascom lexicon, this refers to a system that is capable of transmitting digital data signals at rates in excess of 9.6 kb/s. In its wider meaning, the Wideband Data System (WBDS) includes the transmission of digital or analog data that requires greater than normal analog voice bandwidth (4 kHz) channels, or digital data transmission at rates greater than 9.6 kb/s on digital channels. The WBDS is widely used as the data transport workhorse of preference by user systems. Various rates up to 50.0 Mb/s are in use domestically, and rates of 56 kb/s, 224 kb/s, and 512 kb/s up to 2048 kb/s overseas.
- d. **Message Switching System.** Such a system refers to the transmission of data by means of addressed message block or packet that occupy the transmission channel solely for the duration of transmission. The addressed data message block or packet is defined as a collection of encapsulated data containing source and destination address plus control information.
- e. **Packet Switching Systems/Services.** Nascom provides packet switched services for X.25 based users, and increasingly for those users with TCP/IP interfaces. IP is becoming a standard Nascom offering, witness EBnet, and will supplant the legacy Nascom 4800-bit block.

4.2.3.5 Specialized Data Transport System Service

This paragraph profiles several examples of data transport systems that Nascom designed and implemented to provide a specially tailored service primarily (but not exclusively) for support of a specified user.

- a. **Baseline Data System.** The Baseline Data System (BDS) is one of two distinct major multichannel transport systems designed and established by Nascom in response to requirements for the SN. The BDS extends the TDRSS Type I data transmission in the relatively low rate range [10 bits per second (b/s) to 2 Mb/s]. The BDS is described in Section 11.
- b. **High-Data Rate System.** The High-data Rate System (HDRS) is the other major multichannel transport system that Nascom designed and established for the SN. The HDRS provides for the ground system extension of the TDRSS return link Type I and Type II services in the relatively high data rate ranges (2 Mb/s and up), and the Shuttle-unique analog and TV interfaces. The HDRS is described in Section 12.

4.2.3.6 Video Transport System Services

Nascom provides a variety of video system services. The provided service can either be mission-oriented or administrative. Code 543 operates the video system services jointly with the Operations Management Branch, Code 542. This section introduces the four basic video transport system services used in providing these video system services.

- a. **NASA Video Transponder Service.** This service provides one-way satellite broadcast, commercial grade TV services, time-shared by 10 transmitting NASA locations via a GTE SN2 domestic satellite full transponder, under full-period lease, thru GEAM, by Nascom. Uplinking stations are under scheduling control by Nascom operations. Thirteen NASA locations are equipped to receive the broadcast signal. This service is primarily used in connection with STS missions.

Currently, Nascom is leasing two separate 50 Mb/s transponder services on the GTE Space Net 2 satellite for video broadcast services. "NASA TV 1" is provided on Transponder 5, and "NASA TV 2" is provided on Transponder 3. The NASA Administrator has indicated that these services will be used for coverage of Shuttle and other NASA events, however, the first priority for use is to cover operational support of Shuttle and other NASA spacecraft. The scheduling of these two transponders is through the Nascom Scheduling Office in accordance with the following priority system:

1. Shuttle operational support.
 2. Other NASA spacecraft operational support.
 3. Public Affairs Office.
 4. Systems and engineering testing.
- b. **Nascom Video Teleconferencing Service.** This service is provided as a simultaneous two-way transmission of the video signal using compressed digital CODECS operating at 1.544 Mb/s at several sites serviced by Nascom.
 - c. **Occasional Use TV Service.** One-way, point-to-point, temporarily required commercial-grade TV service(s) leased by Nascom from one or more domestic common carriers, usually for STS missions or any other significant NASA launch events, supplementing the NASA video transponder service as needed.
 - d. **CCTV and Video Distribution Service.** Closed circuit video relay and distribution services both locally and off-site GSFC via video transport system services.

4.2.3.7 Integrated Communications Service Systems

This section defines a category of communication systems established by Nascom that integrates or incorporates several types of communication services into a common all-digital transmission system.

Nascom offers and supplies integrated voice, data, and facsimile transmission services between NASA Field Centers, the facilities of other government agencies whose space and aeronautical research activities are conjoined with NASA, NASA contractor facilities such as

Rockwell's Downey, California plant where the shuttle orbiter vehicle is built and supported, and with International Partner Agency facilities in various foreign countries. In the CONUS, these services employ Nascom-2000 circuits and equipment; for overseas services, leased wideband circuits terminating in intelligent multiplexer equipment are becoming the standard. Where requirements cannot be directly supported by Nascom-2000 or Nascom Overseas Communications System services, Nascom will lease the service(s) necessary to satisfy the requirement(s). In some instances, the solution employs a submultiplexer in front of the Nascom-2000 channel multiplexer. This submux has the required capabilities, e.g., interfacing isochronous and rate-shifted signals onto an aggregate data stream which may then be directly interfaced with a Nascom-2000 channel interface card. Where requirements for encrypted classified data and voice remain, the requirements may be satisfied by transmitting the encrypted (Black) aggregate of a classified (Red) submultiplexer over a Nascom-2000 data channel.

4.3 Nascom Systems

This paragraph introduces the major systems established and currently operated by Nascom. These systems are either the prime or supporting elements for a given Nascom user. Brief system profiles are presented to provide the reader information on these systems.

4.3.1 Nascom Major System

A major system, as referred to in this document, is a high-level system that incorporates other systems or subsystems in an integral whole to provide the communication service. The Nascom major systems, because of their significance and high service impact, are the primary section headers for this document. The major systems are the following:

- a. Low-speed network data systems.
- b. Voice systems.
- c. Wideband data systems.
- d. Video systems.
- e. Baseline data system.
- f. High data rate system.

4.3.2 Nascom Major Ground Communication Support Subsystems

The following are considered to be the major supporting subsystems established and currently operated by Nascom. A major subsystem may either stand alone or be an integral part of a NASA system that provides highly significant value-added services to system users. These systems will be described first in Section 5:

- a. Voice Switching System (VSS).
- b. Digital Matrix Switch (DMS).
- c. Message Switching System (MSS).

- d. Data Distribution and Command System (DDCS).
- e. Multiplexer/Demultiplexer (MDM) Data System.
- f. Statistical Multiplexer Data System (SMDS).
- g. Control and Status System (CSS).
- h. Nascom Environmental Support System.
- i. Technical Control Systems (TCS).
- j. Nascom-2000.
- k. MODNET/NOLAN.



Section 5. Major Ground Communication Support Subsystems

5.1 General

This section describes the Nascom systems that are considered vital to the operation of the Nascom Network. These systems are within the scope of a major ground communication support system as defined in paragraph 4.1. They are introduced in the early part of this document to provide the reader an understanding of what they are first, and what they become as part of an integral or whole system.

5.2 Voice Switching System (VSS)

5.2.1 System Description

The VSS is a totally electronic digital switching system. The VSS currently has the capability to switch, conference, and monitor 2048 analog lines/circuits. The VSS is equipped to terminate 10 two-wire dial lines and 2038 four-wire private-line, long-haul or local circuits with manual "ringdown" signaling. The two-wire lines are incorporated into the system to provide emergency dial-up service in the event of four-wire private line failures. Two-wire dial-up services are not a standard offering for Nascom operational voice conferences. Conferencing capability is limited only by the number of circuits configured to the system. The system hardware design is modular thus enabling expansion to support future user requirements.

The VSS provides point-to-point and/or conference voice communications for project and operations support on a network of high-quality local and long-haul voice and voice/data circuits. The circuits radiate to the Nascom users either directly or through a Nascom remote switching center. Figure 7-1 shows the communications environment in which the VSS operates. [Note: Use of the term "SCAMA" is now limited to denote tail (local loop) circuits between the VSS and the POCCs located on Goddard Space Flight Center; any other use of the term is outmoded and discouraged.]

5.2.2 System Interfaces

The VSS is the focal interface for voice and voice/data circuits coming from the following:

- a. Local GSFC facilities.
- b. Domestic NASA switching center.
- c. JSC Mission Control Center.
- d. Overseas Network Stations.
- e. KSC facilities and other U.S. terminals.

5.3 Digital Matrix Switch

This paragraph provides a standalone description of the DMS. Its role as a major support system of the BDS for SN is described in Section 11.

5.3.1 DMS Definition

The DMS, located at GSFC, is a three-stage, solid-state circuit switch composed of a forward matrix and backup, return matrix and backup, and a control subsystem. The function of the DMS in the SN is to route TDRSS/WSC and JSC MDM traffic flows to/from users of the SN via GSFC. The DMS, when used as a generic system, can be defined as a computer-driven system that provides a circuit switching capability for the Nascom Network.

5.3.2 DMS System Description

5.3.2.1 Brief Profile of DMS

The DMS was built by Applied Physics Laboratory (APL) of Johns Hopkins University. In August 1989 the PDP 11-03 was replaced by DEC MicroVAX II computers, which can be controlled by the CSS or an operator. The CSS at GSFC automatically controls and monitors the status of the DMS in accordance with the NCC schedule. Except for the computer terminals and printer, the DMS hardware is housed in nine racks.

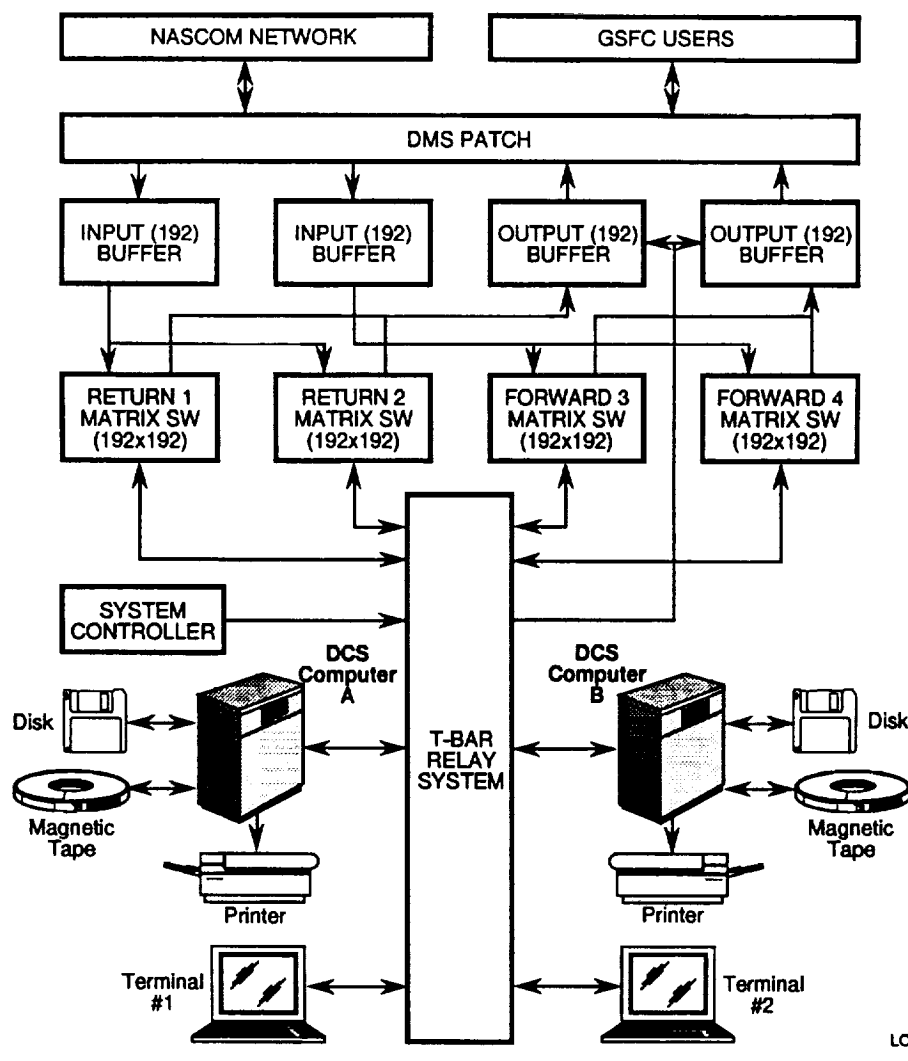
5.3.2.2 DMS Configuration

A block diagram of the DMS is shown in Figure 5-1. The DMS is configured to employ full switching redundancy, where four switching systems (two forward and two reverse) utilize redundant power systems tied to "A" no break and "B" no break power grids.

5.3.2.3 System Elements

The DMS consists of circuit switches and a Digital Matrix Switch Control System (DCS). The DMS system consists of the following elements:

- a. DCS hardware. The operational configuration is comprised of two systems, prime and backup. Each system consists of the following components; 1 DEC MicroVAX II CPU, 1 DEC Winchester disk, 1 DEC terminal, 1 DEC magnetic tape, and an AT&T printer.
- b. DCS software consisting of the DEC VMS Operating System and application software developed by Science Systems and Applications, Inc. (SSAI), and CSC in FORTRAN language.
- c. DMS system controller based on a T-bar relay system panel featuring or using illuminated push-button switches.
- d. Two input and two output buffers, where each buffer features a 192-port capability using an RS-422 interface.
- e. Two forward and two return 3-stage switch matrices, where each switch matrix is capable of handling 192 input and 192 output lines.
- f. A DMS patchfield to physically interface the Nascom Network and GSFC users with the DMS.



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Figure 5-1. System Block Diagram of the Digital Matrix Switch

5.3.2.4 System Interfaces

The DMS was designed to provide the interface between the SN Type 1 forward return link services and local and remote POCCs.

5.3.3 System Operation

5.3.3.1 DMS Data Flow

As indicated in Figure 5-1, all data flow through DMS is referenced to the GSFC users forward link as data-out from the user. The network return link is data-in from the network to the user. The data flow through the matrix switch is described in the following paragraphs:

- a. **DMS System Controller.** This controller provides the mechanism for centralized control and configuration of the DMS. It operates through the T-bar relay system

panel consisting of illuminated pushbutton switches. The online systems can be selected from this controller panel, where the select and control pushbuttons for the forward and return matrix switch arrays, associated output buffers, DEC MicroVAX computers, and the VT-220 terminals are featured. The controllers can also allow reconfiguration in the event of a system component failure or for normal maintenance and testing.

- b. **Matrix Switch Signal Flow.** The matrix switch design employs a 3-stage switch array based on the theory developed by Charles Clos. A non-blocking design, which reduces the number of switch crosspoints from that of an X-Y equivalent array, was implemented. The switching algorithm follows the crosspoint equation: Number of crosspoints = $6(N \exp(3/2)) - 3N$, and with $N = 192$, the number of crosspoints = 15,387. The matrix switch arrays, consisting of the A-array, B-array, and C-array, are controlled via an IEEE-488 General Purpose Interface Board (GPIB). The computer is used to determine the path through the switch for a given input/output connection.
- c. **Ancillary Device Function.** The Baseline Data System uses the DMS as an ancillary device to support the SN. MDM channels are terminated at the DMS. MDM channels that are scheduled to support the SN are configured by commands from the CSS or by technical control personnel using keyboard entries to make DMS Input/Output connections.

5.3.3.2 DMS Circuit Switching and Control

The DMS acts as the heart of the SN/Nascom Network for circuit switching. Network and user channels of the BDS are connected by the DMS. NCC schedule requests to Nascom are satisfied by circuit switching the network and user channels for forwarding and returning data through the DMS. Figure 5-2 depicts the Nascom Digital Matrix Switching System and Controls. Figure 5-3 depicts the DCS hardware configuration.

- a. **Return Link-DMS.** The DMS for the return link has 192 input ports and 192 output ports. The switch is controlled by a MicroVAX II. Any input port from the network channels can be switched to any ten output ports (top user channels) for interfacing return link services to users. The first 100 input ports of the return link DMS represents the SN-Baseline Data Channels. The source channel identification number of the SN-service channel is used to identify the port to be switched. The output ports of the return link DMS are used to terminate users of the SN-BDS service channels and become the destination channel ID for data transferred to them.
- b. **Forward Link-DMS.** The forward link DMS is identical to the return link DMS with 192 input and 192 output ports and a MicroVAX II as the controller. User source channels are connected to the input ports of the DMS. SN destination channels are connected to the output ports. The first 36 ports represent the SN destination channels in the forward link.

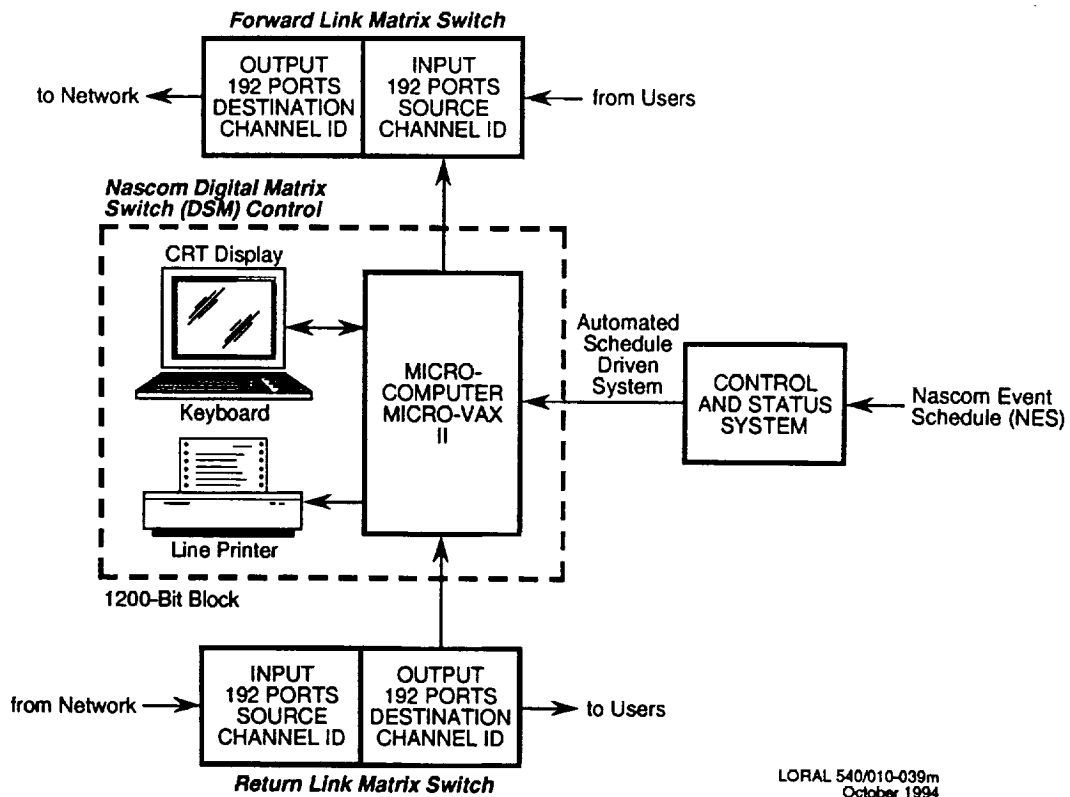


Figure 5-2. Nascom Digital Matrix Switching System and Controls

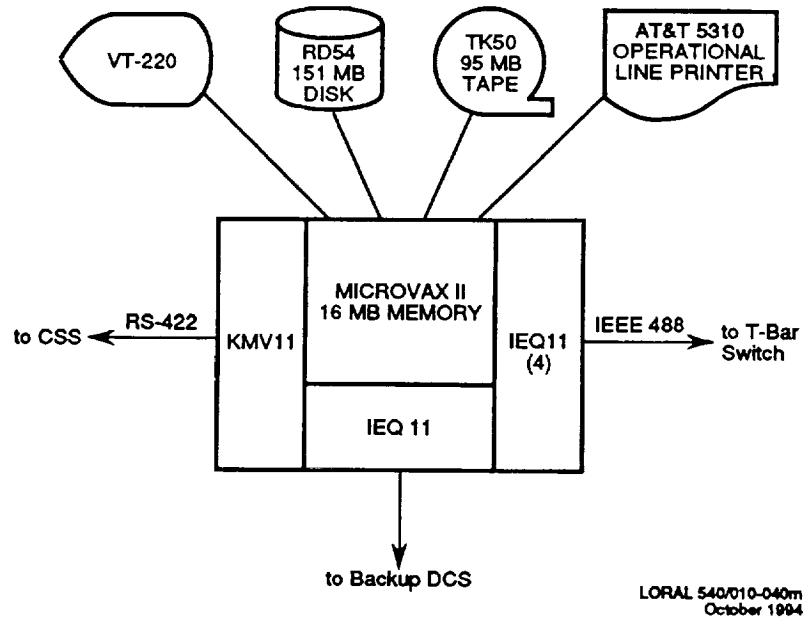


Figure 5-3. DCS Hardware Configuration

5.4 Message Switching System

This paragraph provides a standalone description of the MSS. Its role as a major support system of the other Nascom and NASA Network systems is described in later sections.

5.4.1 System Definition

Message switching is the general classification of a data driven, connectionless oriented switching system in which the destination address(es) of a given message are included as a portion (normally the leading characters or headers) of the message itself. The system handles data and message traffic through a switching center, either from local users or from other switching centers. Message switching operates in one of two ways: either a virtual real-time data path is established between the transmitting and receiving stations, or the message-type traffic is stored and forwarded through the system.

5.4.2 System Description

5.4.2.1 MSS Configuration

Since the MSS is a computer-driven system, the discussion of its configuration will include the hardware and the software elements. The hardware components are grouped into two separate but functionally identical systems. The MSS software is configured from the vendor-supplied system software, and from the in-house or Nascom developed software, commonly referred to as the applications software.

5.4.2.2 MSS Hardware Elements

The cluster of equipment for each group consists of the following elements:

- a. **MSS Switching Computer.** The MSS switching computer hardware is a Concurrent Computer Corporation Series Micro 3200 Expanded System (Micro 5 ES). The system is enhanced by the addition of an integrated, highperformance, intelligent serial input/output (IO) communications control system (ComPlus) supplied by Kardios Systems Corporation. The ComPlus system interfaces with the Concurrent host processor via direct memory access (DMA). The ComPlus supports dynamic port reconfiguration, and is programmed to the communication-line level to identify the 24-bit Nascom block synchronization code. The ComPlus supports the reception of bit-contiguous blocks with no idle time and buffers each Nascom 4800-bit block to the extent necessary to complete the application software processing of the block. Seven ComPlus port cluster units are configured with the Concurrent machine. Each cluster unit supports 32 ports for a total of 224 ports for each MSS Switching Computer. Additional MSS peripheral devices include a line printer, a system console, a mass-storage disk system, two cartridge tape units, and a ninetrack tape unit.
- b. **COW.** The COW hardware is a SUN SPARCstation II that uses reduced instruction set (RISC) technology. The COW peripheral devices include a laser printer, a high-resolution color monitor, a mass-storage disk system, and CD-ROM unit, serial ports, and a cartridge tape unit.

- c. **X Terminals.** The X terminal hardware is a 19-inch color Tektronics XP337 with nine megabytes of memory and a trackball pointing device. The XP337 is capable of displaying 256 colors simultaneously and running both X windows and the Motif window manager locally. There is one X terminal associated with each COW. The X terminal supports some of the COW screen displays.
- d. **Hybrid PC.** The hybrid PC hardware is an IBM PC compatible 80486 running at 33 Mhz. The hybrid PC provides a gateway between the TCP/IP LAN and the Nascom high-speed network. The PC includes 3Com network boards which provide the interface to the TCP/IP LAN. Nascom boards, developed by NASA, provide the interface to the high-speed network. The hybrid PC utilizes the UNIX operating system.
- e. **MSS Command LAN.** An Ethernet LAN provides Institute of Electrical and Electronic Engineers (IEEE) 802.3 physical interface connections between all of the MSS and COW system. The two MSS and COW systems are configured on a single LAN trunk. This LAN trunk is comprised of two parallel LAN rails which are used as primary and backup LANs. By changing the machine plugs into the LAN, the operator can isolate a single machine or machine group on the backup LAN rail.

5.4.2.3 MSS Software Elements

Software for the MSS is best addressed in two categories: MSS software, and COW software. The components for each category are delineated in the following paragraphs:

- a. **MSS Software.**
 - 1. **Vendor Software.**
 - (a) OS/32 – Concurrent Computer Corporation multi-tasking real-time operating system.
 - (b) Utility and support programs.
 - (c) Editor programs.
 - 2. **Application Software.**
 - (a) MBI – MSS backup operator interface task.
 - (b) MCMD – MSS console command task.
 - (c) MCU – MSS/COW common utility modules.
 - (d) MDD – MSS database distribution task.
 - (e) MDS – MSS data simulator task.
 - (f) MHL – MSS high-speed logging task.
 - (g) MHS – MSS high-speed switching task.
 - (h) MHU – MSS high-speed utility task.

- (i) MHY – MSS hybrid data task.
- (j) MIF – MSS/COW interface task.
- (k) MIN – MSS initialization and recovery task.
- (l) MMG – MSS message generator debug tool.
- (m) MSS – MSS tools and utilities.
- (n) MU – MSS common units.
- (o) MUDUMP – MSS task dump utility.

b. COW Software.

1. Vendor Software.

- (a) OS 4.1.3 – SUN SPARCstation operating system.
- (b) Utility and support programs.
 - (1) X-Window
 - (2) Transportable Application Environment Plus (TAE Plus)
 - (3) Motif window manager
 - (4) C Language Integrated Production System (CLIPS)
- (c) Editor programs.

2. Application Software.

- (a) BOOTMSS – warm start of the MSS applications from the COW.
- (b) CAL – COW alert processing task.
- (c) CCM – COW baseline configuration change task.
- (d) CCQ – COW command and query task.
- (e) CDB – COW database manager task.
- (f) CDL – COW delogging task.
- (g) CES – COW expert system task.
- (h) CHC – COW checkpoint configuration change task.
- (i) CIF – COW/MSS interface task.
- (j) CIN – COW initialization and recovery task.
- (k) CLD – COW line indicator display task.
- (l) CLG – COW logging task.
- (m) CMG – COW message generator debug tool.

- (n) COA – COW operator assistance task.
- (o) CONVTXT – converts ASCII text files.
- (p) COS – COW operator stations task.
- (q) CTS – COW troubleshooting task.
- (r) CU – COW common units.
- (s) STARTCOW – warm start of the COW applications.

5.4.2.4 System Interfaces

The MSS interfaces with the high-speed data and wideband network users. The principal user MSS interfaces are for GN-related operations. The users are required to generate compatible high-speed and wideband data message switching format. When the Nascom 4800-bit block format is used, the 48-bit network header is utilized for routing high-speed data.

5.4.3 System Operation

5.4.3.1 Overview of MSS Operations

Two complete MSS hardware systems are configured to provide an online operational system and an offline hot-spare system. The hardware systems are designated as either the A or the B system; thus there is an MSS-A, an MSS-B, a COW-A and a COW-B. The two X terminals are designated as XTERM-A and XTERM-B. The systems communicate with each other across the LAN. Figure 5-4 illustrates the configuration of the MSS. Input from the network is sent to both systems. Output to the network is selected by the transfer switch. The transfer switch allows operations to select the online MSS. The output of the online MSS is sent to the network; the output of the offline MSS is discarded. The MSS switching computer and COW each perform a subset of the MSS functions as described in the following paragraphs.

- a. The MSS switching computer is primarily responsible for switching the 4800-bit Nascom blocks. Other functions of the MSS switching computer include collecting historical archives of high-speed network activity, managing the high speed network configuration, interfacing with the operator workstation, and providing a backup operator interface.
- b. The COW computer is the primary means of access for the MSS operator. It supports operator interfaces to display the network status and to change the network configuration.

The two online MSS computer systems are operated from no-break power. The no-break systems normally take power from the commercial feed, but have the capability to be transferred to local diesel power in case of loss of commercial service. The transfer to battery power is automatic. The diesel transfer can be automatic or manual. Where it is critical that hardware, such as disk memory, be protected from power spikes, peaks, and surges, their electric power circuits are buffered by means of motor-alternators. These motor-alternators

are normally powered from the commercial source with diesel capability existing via the transfer switches.

5.4.3.2 MSS Communication Format

Users are required to generate a compatible high-speed and wideband data message switching format for use with the high-speed MSS. Appendix D describes the 4800-bit block structure which is the basic Nascom high-speed and wideband data message switching format. This format is generated by the GN and by all users of the system.

Based on the current field size for source and destination codes in the Nascom 4800-bit block, all 256 MSS source and destination codes have been exhausted. In order to expand the number of valid source and destination codes from 256 codes to 512 codes, the sequence monitoring field is being eliminated from the Nascom 4800-bit block. The sequence monitoring bits, which currently identify the sequence of block transmission, are bits 41-43 of the Nascom network header. The following changes will be implemented for these bits:

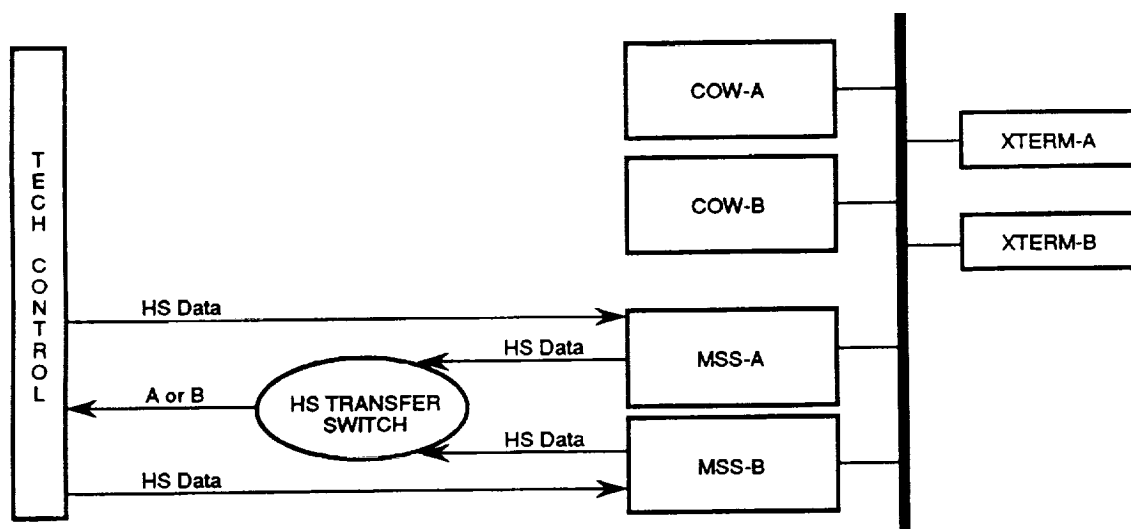
Bit 41 - destination code expansion (this aligns with the current destination code bits 33 to 40)

Bit 42 - source code expansion (currently the source code occupies bits 25 to 32)

Bit 43 - spare

For both source and destination codes, a value of zero (0) in the new bit would use the current routing codes of 0 to 255. A value of one (1) would use routing codes 256 to 511.

The changes are currently scheduled for implementation in March 1995.



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Figure 5-4. MSS System Configuration

5.5 Data Distribution and Command System (DDCS)

The DDCS derives its name from its original implementation role in supporting the packet switching requirements of the GRO project as a dedicated system, which is described in Section 15. The DDCS is intended, however, to be an institutional X.25 packet switching system for operational traffic requirements of Nascom users. The institutional, shared network resource nature of DDCS is demonstrated by its use in support of the EUVE and SAMPEX projects.

5.5.1 System Definition

The DDCS, as defined in Nascom Document No. 541-008, DDCS System and Functional Requirements, is the system which will provide the packet switching communications, via the X.25 protocol, to satisfy the command request, data base exchange requirements, and telemetry distribution for the various projects' principal scientific investigators. The X.25 protocol is an international, standardized data communications protocol which specifies the interface between DTE and DCE for terminals operating in the packet mode.

5.5.2 System Description

5.5.2.1 Brief Profile of DDCS

The DDCS will generally support ground data communications between the scientific experimenters whose instruments are aboard certain spacecraft, the ground support equipment at the experimenters location, and other GSFC systems necessary for operational support of the satellite experimenters operations and data distributions. These other systems and their roles are as follows: the Packet Processor (PACOR)/Code 560, which processes the telemetry data packets that are shipped to the experimenters; and the Command Management System (CMS)/Code 510, which receives and validates instrument command data from the experimenters; and the spacecraft contractors System Test Complex (STC) facility, which simulates the functions of the PACOR and the CMS for prelaunch integration, testing, and support. These are the end systems which presently use the DDCS packet switching network.

5.5.2.2 DDCS X.25 Configuration

The DDCS Packet Switching Network (PSN) consists of two main PSNs, located at GSFC Building 14, which include online and backup support for up to 40 trunks or X.25 subscriber ports, and switches up to 300 packets per second per PSN. Two remote PSNs are trunked to the main PSNs (see Figure 5-5).

5.5.2.3 System Elements

- a. GSFC PSNs. The configuration of the GSFC PSNs consists of two AMNET Nucleus 7400 Network Management Processor (NMP) nodes, each with a hot backup. The AMNET N7400 is a mid-range performance packet switching system based on Line Processor (LP) boards using 80186 microprocessor chips. These LPs exist in an extended chassis with the 80386-based CPU. The N7400 contains a 1.2 MB floppy disk drive with a high density disk controller. The PSN is booted off the Disk

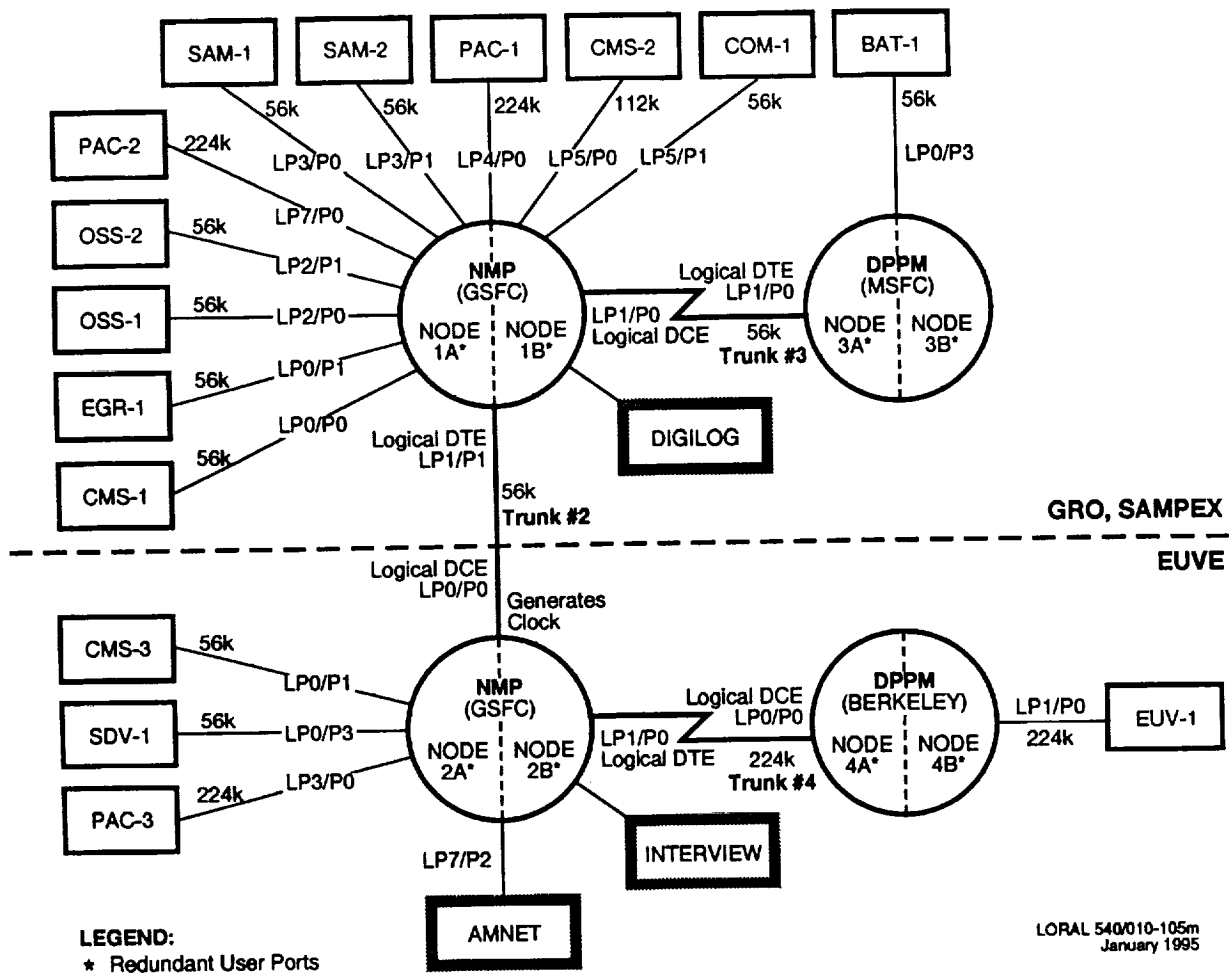


Figure 5-5. DDCS Network Configuration

Operating System (DOS) floppy disk containing AMNET software. Automatic failover switching occurs between node/primary and backup nodes through the HADAX switch/control unit. All user ports are connected through the HADAX. Through patching at the Nascom Technical Control area, an X.25 protocol analyzer can be used for circuit data monitoring. GRO and SAMPEX users are connected to Node 1; EUVE users are connected to Node 2.

- b. NMPs. Two NMPs function as the operator control and status interface, providing a graphics display for troubleshooting, and manage the operational network database. NMP 1 is connected to Node 1, and NMP 2 is connected to Node 2 at the GSFC. The NMP is currently based on 80386 IBM Personal Computer Advanced Technology (PC/AT) hardware with a 100 MB hard disk. The NMP stores system software files for initial program load and selective program load. These software files have been programmed using the high-level "C" language, which is used under the UNIX operating system. The NMP is connected to the respective node through an AMNET custom-designed Primary Interface Adapter (PIA) cable and computer board.

- c. Remote PSNs. The remote PSNs are located at MSFC in Huntsville, Alabama, and the University of California, Berkeley Campus. These remote PSNs are N7400 Packet Processor Modules (PPM) nodes, and do not have local NMPs attached. They communicate with the GSFC NMPs via the trunks. Each site has an N7400 PPM with a redundant backup node. HADAX automated failover units exist at each site. Each N7400 consists of an 80286 PC/AT compatible unit, 640K Random Access Memory (RAM) and a 1.2 MB floppy drive with high density disk controller. The nodes boot off of DOS system formatted floppies, with node boot floppy software downloaded from the GSFC NMPs. Each remote PSN contains two LP boards with 80186 microprocessors. Node 3, which supports GRO, and Node 4, which supports EUVE, are currently operational.

5.5.3 System Operation

The DDCS Network was accepted by Nascom operations on 17 May 1990. DDCS operations are described in the following paragraphs.

5.5.3.1 DDCS System Capabilities

The DDCS provides the following capabilities:

- a. Packet switching communications between the Principal Investigators Instrument Ground Support Equipments (IGSE), CMS, STC, and PACOR.
- b. Monitoring the status of the network, and communication links.
- c. Logging/deloggging all alarms, status, and changes in the system configuration.
- d. Operations from a local interactive terminal.
- e. Printing information on traffic data and usage.

5.5.3.2 Details on Provision for X.25 Packet Switching Capability

The DDCS provides an X.25 packet switching (CCITT 1984 Recommendation) capability to distribute the packetized scientific data for the spacecraft missions and packetized command requests between the IGSEs, CMS, experimenter homesites, STC, and PACOR. The CCITT X.25 specified system supports the first three levels of the International Standard Organization (ISO) Open System Interconnection (OSI) architecture. The DDCS as a DCE was developed to interface the external equipment or DTE at the following levels:

- a. Physical layer (Level 1). The required characteristics are as follows:
 - 1. Interface. The physical, electrical, and functional characteristics to establish, maintain, and disconnect the physical link between the DTE and the DCE shall conform to the Federal Standard 1020, EIA RS-422, and EIA RS-232-C.
 - 2. Transmission rate. The DDCS supports 9.6, 56, 64 and 224 kb/s transmission rates between the DCE and DTE.
- b. Link Layer (Level 2). The DDCS supports the LAPB procedure and all parameters specified by the users of each project.

- c. **Network Layer (Level 3).** The DDCS supports the following communication features:
 - 1. **Services:** Virtual call and permanent virtual circuit.
 - 2. **Packet types:** All basic packets specified in CCITT X.25, 1984 Recommendation.
 - 3. **User data field length:** Maximum of 1024 octets/packet.
 - 4. **Packet sequence numbering:** Modulo 8.
 - 5. **Frame sequence numbering:** Modulo 8 and Modulo 128.
 - 6. **X.25 Diagnostic code:** Standard.

5.6 MDMR Data System

This paragraph provides a standalone description of the MDMR Data System. Its role as a major element of the BDS is described in Section 11.

5.6.1 System Definition

The MDMR Data System, when referred to as an integral part of the BDS, can be defined as a system featuring the following characteristics:

- a. Two online, full duplex terminals at each location: GSFC, JSC and WSC (upon completion of WSC upgrade project).
- b. Functionally consists of separate MDMR data terminal controlled by a collocated Multiplexer/Demultiplexer Automatic Control System Upgrade (MACSU) at each location. (The MACSU was developed as a separated project to upgrade the MACS in support of the MDMR Data System. See paragraph 5.6.5 for more information on the MACSU.)
- c. MDMR line interface channels designed for data rates between 10 b/s and 7 Mb/s.
- d. A composite (common carrier interface) transmission rate capability of up to 20 Mb/s. (This is an upgrade from the original MDM Data System capability.)
- e. Range of data format capabilities and operating features available as options to the users.

5.6.2 System Description

5.6.2.1 Brief Profile of the MDMR Data System

The Nascom Network extends the TDRSS forward link and return link services by providing data transport systems between the NASA Ground Terminal at White Sands, NM; the NCC; and major user spacecraft control centers and data processing facilities. Both the TDRSS and Nascom Network are elements of the SN. Nascom has implemented two distinct multichannel transport systems to extend the TDRSS data transmission. One of these is the BDS which

supports the Type I interfaces (10 b/s to 2 Mb/s). An essential component of BDS is the MDMR Data System. An MDMR terminal is installed at MSFC to serve as the tandem link to GSFC, where WSC forward and return link SN user services are extended to MSFC. The Nascom replacement MDM Data System specification document (541-89-03) was developed in the early 1990's in accordance with the Project Management Plan (541-097). Installation of the MDMR was completed in late 1993.

5.6.2.2 MDMR Data System Configuration

Figure 5-6 illustrates the MDMR data flow block diagrams. The system configuration of the baseline MDMR data subsystem is shown in Figure 5-7. The MDMR data subsystem consists of separate data terminals at GSFC, WSC, and JSC. Operationally, the baseline MDM system had the capability of 100 return link channels from WSC to GSFC, and 36 forward link channels from GSFC to WSC. The JSC station in the baseline MDM system was operationally considered as a drop and insert station. JSC could insert up to 30 channels into the forward link and up to 20 channels into the return link to/from WSC and GSFC. When this occurred, the total number of channels available for scheduling between WSC and GSFC was reduced by an equivalent number. The MUX/DEMUX systems and channel capacities provided by the MDMR Data System at the respective locations are as follows:

- a. GSFC:
 - MUX Broadcast) 48 channels
 - DEMUX (WSC) 128 channels
 - DEMUX (JSC) 48 channels
- b. JSC:
 - MUX (Broadcast) 48 channels
 - DEMUX (GSFC) 48 channels
 - DEMUX (WSC) 48 channels
- c. GSFC/MSFC Trunk:
 - MUX/DEMUX 24 channels
(duplex)

The above channelization represents an upgrade to the original MDM Data System capabilities. All indicated MUX/DEMUX equipment will be provided in redundancy. Connectivity is the same as per the original MDM Data System, except that spare DEMUX equipment lacking in the original MDM Data System has been added for each downlink at each location; also a connectivity change has been implemented at the GSFC location wherein all receive channels from WSGT and JSC have been extended to the DMS in lieu of a channel termination sharing arrangement.

5.6.2.3 System Elements

As indicated in Figure 5-6, the MDMR functional elements are as follows:

- a. Interface equipment that includes patch panels, signal splitters, and channel select switches.
- b. Multiplexer that includes Input Terminal Units (ITU) and Output Controller (OC).

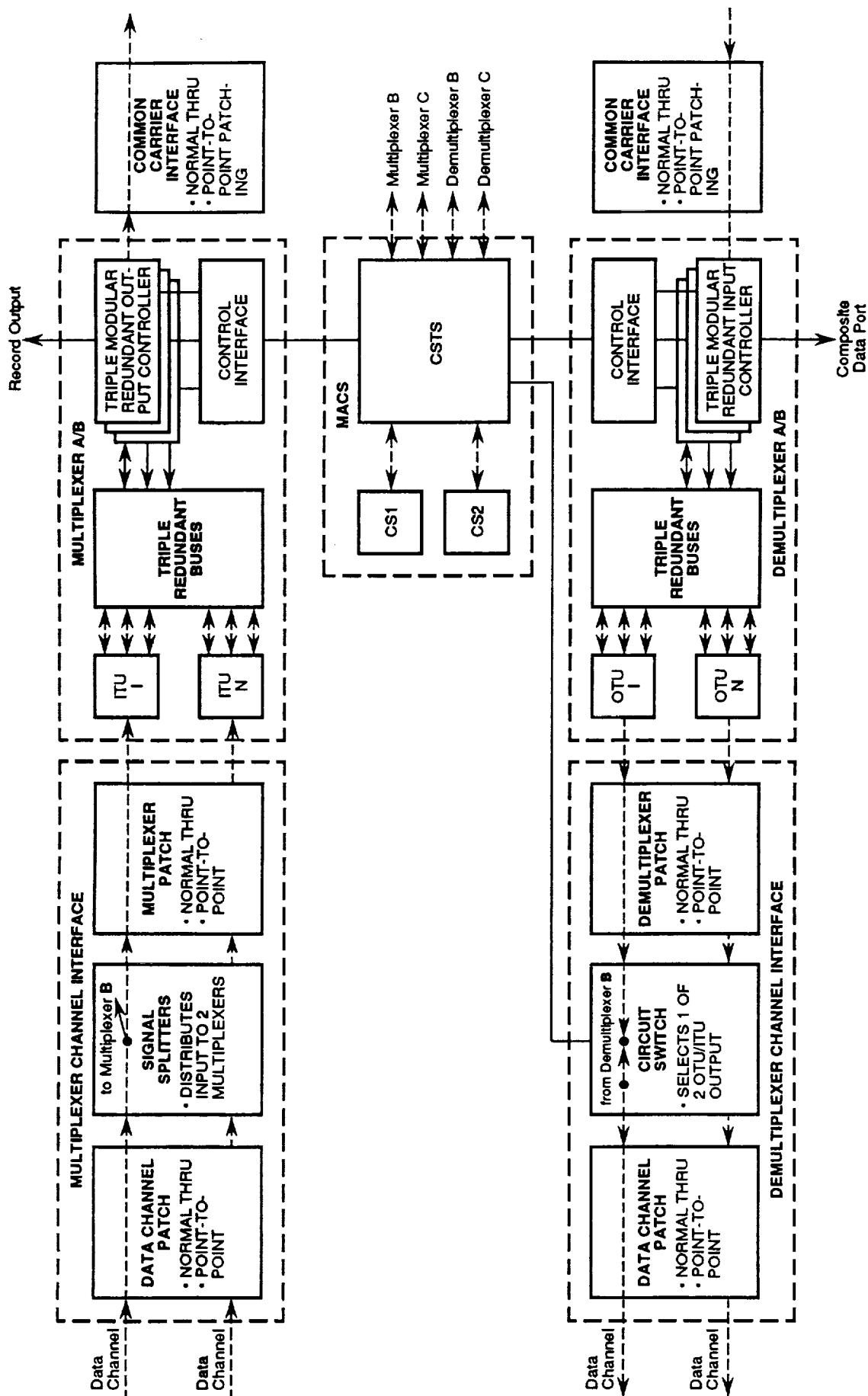
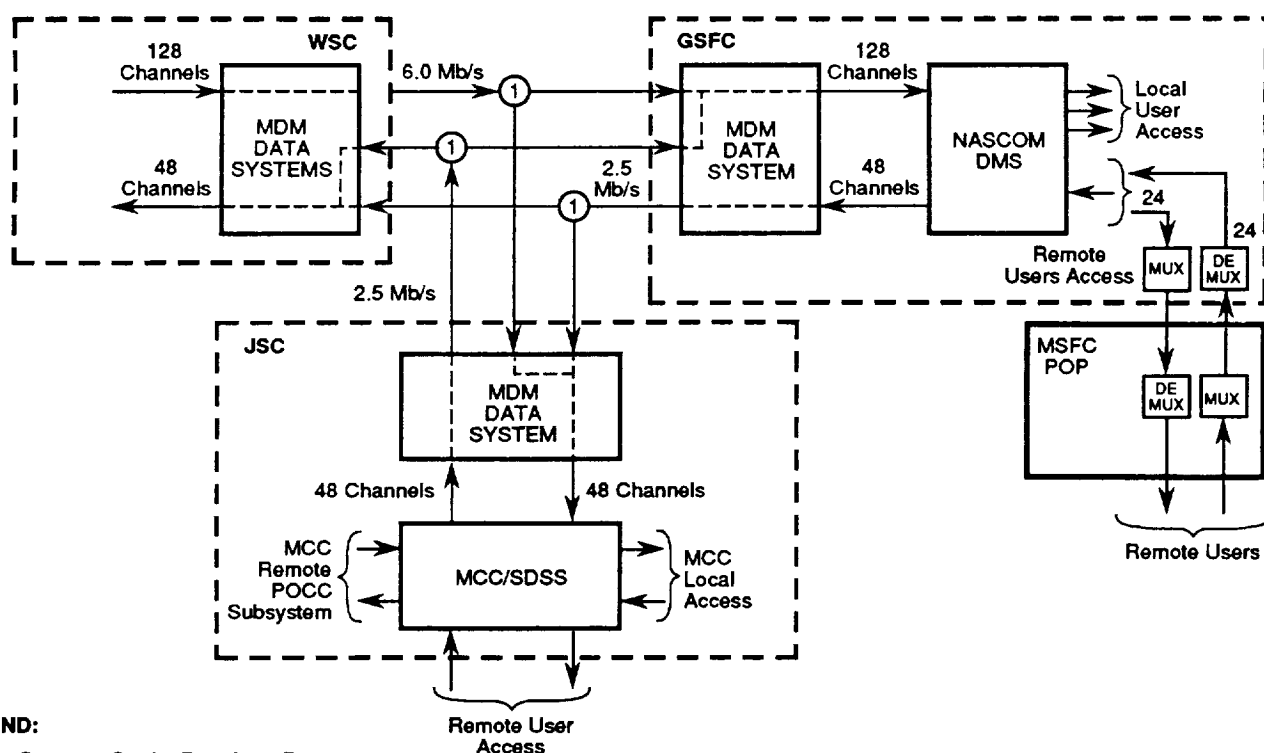


Figure 5-6. MDMR Data Flow Block Diagram

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October 1984

Figure 5-7. Configuration of the MDM Data Subsystem in the Baseline Data System

- c. Demultiplexer that includes Input Controller (IC) and Output Terminal Units (OTU).
- d. MACSU that include Control Subsystem Transfer Switch (CSTS) computer system.
- e. Local operator control console that provides manual configuration capability at individual ITU/OTU control panel.
- f. Effective with the MDMR Data System, MDM control is entirely remoted to consoles (no front panel controls) and channel Port address is now remotely controllable.

5.6.2.4 System Interfaces

The system interfaces of the MDMR Data System are as follows:

- a. At WSC, the MDMR interfaces with the TDRSS forward and return link user services.
- b. At GSFC, the MDMR interfaces with the NCC via the CSS and with the SN users.
- c. At JSC and MSFC, the MDMR interfaces with the SN users.

5.6.3 MDMR Options And Features

MDMR Data Systems users can select data processing options by specifying the options in configuration codes developed during mission planning and by including their options in their scheduling requests to the NCC. The MDMR Control Systems configure the MDMR in accordance with the user's scheduled request to the NCC. The following processing options and operating features are available to the users.

5.6.3.1 Unblocked or Blocked Data

The user chooses to supply/receive data in either unblocked or blocked format. Unblocked data is defined as a serial bit-contiguous data stream with no header or routing information. When unblocked data is supplied, it is inserted in the data field of an MDMR Data System-generated 4800-bit data block, along with appropriate system-generated network header information and a polynomial code per data block. Users who elect to receive unblocked data receive a serial stream of data from the data field of the block, after the system strips out the network header, user header, time block, and the block error control field.

Blocked data is defined as data that is supplied/ received in a 4800-bit block format, and that contains a network header, user header, time tag, and a block error control field. The user may insert the time tag.

If a user is remotely located from the MDMR and requires long-haul circuit facilities, Nascom can be consulted to determine the technical feasibility and cost effectiveness of selecting the unblocked serial data option. At rates above 1800 b/s, special payload block formatting equipment may be available from Nascom on a loan or reimbursable basis.

5.6.3.2 Selectable Data Rate

MDMR Data System users may choose supplying or receiving blocked or unblocked data at rates from 10 b/s to 7 Mb/s. The data rate selected must be approved by Nascom personnel due to the bandwidth limitations of the Common Carrier Broadcast Transmission Service (CCBTS) and the multiple user network channels serviced by the MDMR Data Systems. The exact data rate specified is selected by setting the most significant decimal digits and a single decimal digit exponent of the associated clock. In addition, when receiving blocked data, the option of supplying the clock externally or using the internal MDMR Data Systems clock exists.

5.6.3.3 Unmodified or Modified Network Header

This option is available only to users supplying data in a blocked data format. The MDMR Data System user may choose to have an unmodified or modified network header. If the user

chooses the unmodified network header, the user inserts the network header information into the MDMR Data System, and the system transmits the 4800-bit block exactly as inserted by the user. If the user chooses the modified network header, the MDMR Data System will modify the network header by inserting a selected data stream ID and a sequential port sequence number. The MDMR Data System will also generate a new polynomial code at the end of the 4800-bit block.

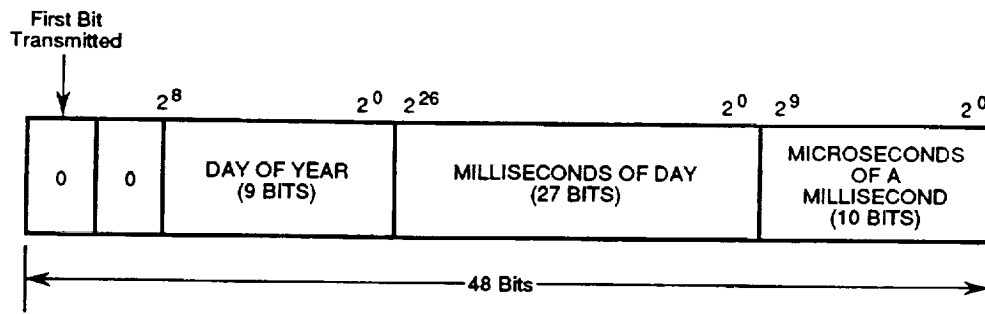
5.6.3.4 Time Tagging

The time-tag option is available only when a user is transmitting blocked data to an MDMR Data System. When requested by a user, the time-tag option enables an MDMR Data System to write the time of year into the time field of the 4800-bit data block. The time of year is provided in the NASA PB-4 time format. (See Figure 5-8.) This time is referenced to the time the MDMR Data System detects the last bit of the network header synchronization pattern. A new polycode is generated and inserted in each data block that is processed under the time-tag option. If the time-tag option is not selected, the MDMR Data System transmits the 4800-bit data block with the time field exactly as received. The GSFC system inserts a static pattern in the time-tag field when the time-tag option is not selected.

5.6.3.5 One-second Timeout

The one-second timeout option is useful to a user supplying unblocked data to an MDMR Data System at a low bit rate. The unblocked data is inserted into the data field of an MDMR Data System generated 4800-bit data block. With the timeout option selected, if the input data rate is such that the full block of 4624 data bits is not received in one second, the MDMR Data System will timeout, complete the data field with fill bits, generate a polynomial code, transmit the data block, and begin building a new data block. The timeout of the data block occurs only at the boundaries of 8bit bytes as measured from the first bit inserted in the data field of the data block.

If the timeout option is not selected, the MDMR Data System continues to accumulate the incoming data and generate circuit assurance blocks at the rate of one per second until a full data field of incoming data is entered in the data block.



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Figure 5-8. NASA PB-4 Time Code Format

5.6.3.6 Circuit Assurance Blocks

This option is available only to users receiving blocked data. If the input data rate is such that the source MDMR Data System does not have a data block ready for transmission within one second, the source MDMR Data System generates and transmits Circuit Assurance Blocks (CAB) to the destination MDMR Data System at a one block-per-second rate. The CABs are generated in the same data format as the Nascom/TDRSS 4800-bit block, but are uniquely identified (by setting the data length field to zero and filling the data field with a 11001001 bit pattern) to distinguish CABs from data blocks.

The CABs are generated for use within the MDMR Data System. When a user specifies the CAB option, the operation of the MDMR is not altered, but merely enables the user to receive the CABs whenever they are generated. The CABs provide the user with a confidence check on circuit operations.

5.6.3.7 Unclamped or Clamped Clock

The destination MDMR/OTU delivering unblocked data has the option to deliver an unclamped clock or clamped clock signal to the user interface. With the unclamped clock option, the destination user interface receives a continuous clock signal at the selected rate. The clock signal is uninterrupted as long as the user's channel is enabled, regardless of whether data is being processed or not. When the user selects the clamped clock option, the destination interface receives data and clock signals at the selected rate. During those periods when no data is being processed (OTU buffers depleted), the clock signal is clamped to a logic 1. When the next data block is available for transmission to the user, the clock signal resumes in synchronization with the data.

5.6.3.8 Clock Tracking

The clock tracking option is available when the destination MDMR Data System is supplying unblocked (serial bit contiguous) data to the user. This option prevents the data overflow/underflow condition that occurs from the inevitable variations between input clock and output clock frequencies, even when operated within specified tolerances. Data overflow occurs when the input clock runs faster than the output clock and an underflow condition occurs when the input clock runs slower than the output clock. The clock tracking option allows the destination MDMR output clock to track the source MDMR input clock. The output clock tracks the input clock for variations of plus or minus .12 percent from the nominal input clock rate.

5.6.3.9 Internal/External Clock

An engineering option is available in the selection of a clock choice for data transfer of blocked data from an OTU to a user. The data transfer is synchronized to either an external clock, if a source is available, or an internally generated clock, at the specified rate.

5.6.3.10 Single Data Block Transfer

The single data block transfer feature of the MDMR Data System is an online operating option available to the user and does not require scheduling configuration of the MDMR.

The feature is controlled by the user's software in real-time operations. It is principally intended to accommodate the POCC's preferred method of real-time throughput commanding of spacecraft through the MDMR/TDRSS. It is only available for user-generated blocked data being transmitted to the MDMR Data System at WSC. The WSC MDMR is normally operated in the unblocked smooth (contiguous) data mode.

The smooth data mode requires that the demultiplexer wait for the receipt of five data blocks, or for a maximum delay of 264 ms from receipt of the first data block (whichever occurs first) before beginning transmission. When the entire data transmission is a single data block, the single data block transfer option allows the user to bypass the smooth data mode delay (i.e., allows immediate uplinking). To single data block transfer, the user must generate blocked data and set the datagram bit to a logic 1. The logic 1 datagram bit flags the data block as a single block transmission and the demultiplexer begins transmission of unblocked data immediately upon receipt of the data block.

5.6.4 System Operation

The 4800-bit block is the standard transmission format used in the MDMR system. Three block formats are described in Appendix D of this document. These are:

- a. The GN block, also called the throughput block, is used to transmit digital data to and from GN sites for support of spacecraft that are TDRSS compatible; the GN block is also used for launch support of TDRSS compatible spacecraft.
- b. The SN block is used to route digital data via the MDMR data system to and from the SN.
- c. The DSN GSFC Interface Block, also called the DGIB, is used for transport of command and telemetry data to and from DSN stations in support of TDRSS compatible spacecraft that use the DSN for contingency or emergency support should TDRSS be unavailable (inoperable) for an extended period of time.

All data transferred between terminals of the MDMR Data System are in a 4880-bit block format. This includes an 80-bit link control header added as a prefix by the MDMR systems. The 4800-bit block format portion is used for transport of user data. The 80-bit link control header is used exclusively by the MDMR data system for routing and message accounting purposes and is transparent to the user (the MDMR inserts and removes this link control header).

5.6.5 MACSU

The Multiplexer/Demultiplexer Automatic Control System Upgrade (MACSU) uses VAX 4000 series computers. The MACSU has enhanced monitoring capabilities that enable notification to the operator in the event of MACSU performance problems. The MACSU also provides the capability to archive operational changes to disk, and of generating alarm and configuration change history reports. MACSU was installed and operational in time to support MDMR project equipment as it was integrated into the network in late 1993.

5.7 Statistical Multiplexer Data System

This paragraph addresses the Statistical Multiplexer Data System (SMDS) in a standalone description. Its role as a major element of the HDRS is described in Section 12.

5.7.1 System Definition

The SMDS can be defined as a Nascom system that has the following capabilities:

- a. Interfacing of return link services from WSC to JSC, JPL, MSFC, and GSFC for digital data.
- b. A time division MDM system that creates four discrete digital channels to timeshare 50 Mb/s digital common carrier bandwidth.
- c. Interfacing capability of up to four individual user data streams.
- d. Individual user data rates range between 125 kb/s to 48 Mb/s.

5.7.2 System Description

5.7.2.1 Brief Profile of SMDS

The HDRS consists of a Statistical Multiplexer (SM) system and a high data rate digital service (up to 50 Mb/s) in a full-period, protected, leased Domsat transponder broadcast configuration. The system provides a return link broadcast transmission capability from WSC to user's ground data capture and processing facilities at JSC, ARC, MSFC, and GSFC. The SM is designed to effectively utilize the leased digital transmission resource on the domestic communication satellite. The SMDS creates discrete channels that time-share the total bandwidth in the digital mode, with alternate analog and video services provided by the common carrier. The system is used to extend high data rate science and image data, Orbiter/Spacelab high rate science, analog, and video data to GSFC, JSC, ARC, and MSFC. The SMDS was procured by Nascom from Aydin Monitor Systems.

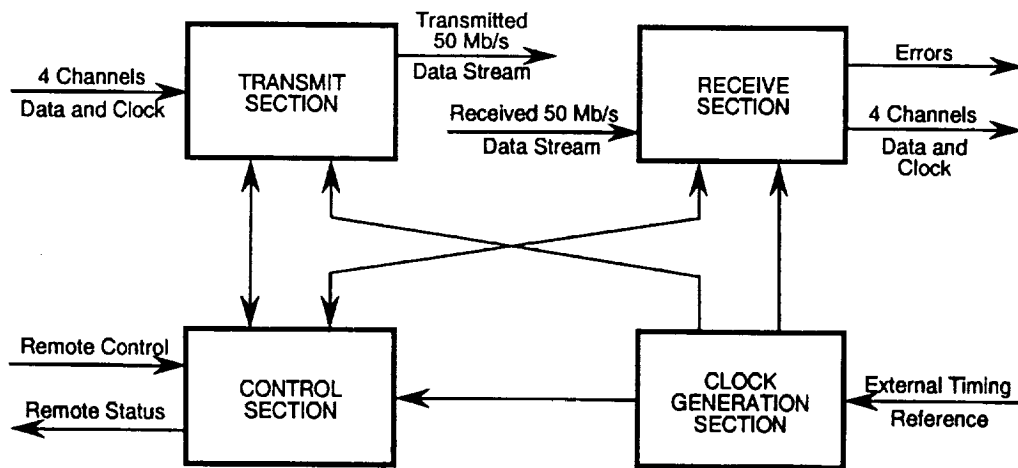
5.7.2.2 SMDS System Configuration

The functional block diagram of the SM is shown in Figure 5-9. The SMDS configuration is based on the Aydin Model 781 Statistical Multiplexer.

5.7.2.3 System Elements

The Statistical Multiplexer principally consists of: transmit section (multiplexer), Receive Section (demultiplexer), control section, and clock generation section. These system elements are described in the following paragraphs:

- a. **Transmit Section.** The transmit section accepts data from up to four input ports at frequencies from 125 kb/s to 48 Mb/s. The unit measures the input clock rate independently on each port, buffers the data at each port into separate storage queues, and formats the data for output based on rate-determined priority. The resultant multiplexed 50 Mb/s data stream is output to a modem. Pseudonoise (PN) is transmitted by a 2047-bit PN generator when no port is ready with buffered data.
- b. **Receive Section.** The receive section accepts a 50-Mb/s data stream from the modem, obtains frame sync using the distributed sync patterns in the data, decodes the port address, and routes the data and frequency information to the addressed



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Figure 5-9. Simplified Functional Block Diagram of the Aydin Model 781 Statistical Multiplexer

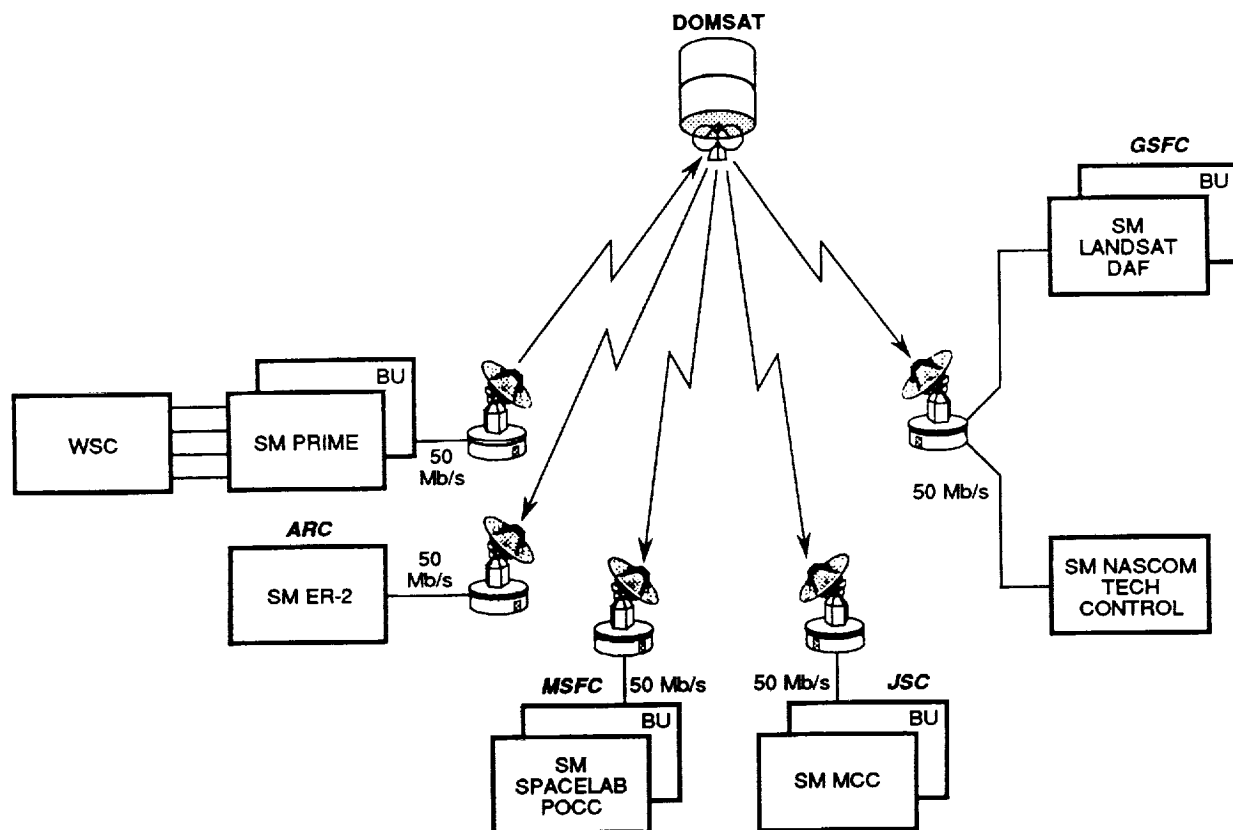
output section. The output sections buffer the data in independent storage queues and then output the data and clock from the ports at the nominal rate of the original data.

- c. **Control Section.** The transmit and receive sections share a control section that is based on a type 6502 microprocessor. The control section performs the following functions:
 1. Provides control and display interface with the operator.
 2. Calculates and displays input frequencies to six significant digits.
 3. Determines port input priority assignments based on rate measurements.
 4. Adjust receiver output rates to guard against output buffer underflow or overflow.
 5. Controls updating of the frequency synthesizer prescale divider so that there is no discontinuous change in output frequency when a synthesizer breakpoint is crossed.
- d. **Clock Generation Section.** The clock generation section uses an external timing reference and two internal voltage-controlled oscillators to generate the clock signals used by the control, transmit, and receive sections.

5.7.2.4 System Interfaces

As illustrated in Figure-5-10, the SMDS interfaces with the systems at WSC, GSFC, JSC, and MSFC are as follows:

- a. At WSC, the SMDS interfaces with the TDRSS KSA Type II return link channels using two SMs.



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Figure 5-10. Location Diagram of the SMDS System Terminals

- b. At GSFC, the SMDS interfaces with the following:
 1. Landsat DAF near Building 25 using two SMs.
 2. Nascom Tech Control at Building 14 using one SM for monitoring of SM transmissions in the DAF near Building 25.
- c. At JSC, the SMDS interfaces with the JSC MCC at Building 30 using two SMs.
- d. At MSFC, the SMDS interfaces with the MSFC Spacelab POCC and Data Processing Facility at Building 4663 using two SMs.
- e. At ARC, the SMDS interfaces with the ER-2 Ground Processor System using one SM.

5.7.3 System Operation

5.7.3.1 SMDS Operation

The SMDS operates in the following manner:

- a. For the high rate (50 Mb/s) synchronous digital data mode of the Common Carrier Domestic Satellite Transponder Service (CCDTS), Nascom provides a special four-

channel SMDS capable of multiplexing individual user data streams (up to four) with individual user data rates between 125 kb/s – 48 Mb/s into a composite data rate of up to 48 Mb/s. The SM reserves 2.0 Mb/s of bandwidth for system overhead. The capacity of the system for user's data is constrained to 48.0 Mb/s. The system is designed to be adaptive to data rate changes and to track data rate variations from nominal rates indicated due to oscillator variation and system Doppler effects within specific tolerances, with the maximum increase above 48 Mb/s not exceeding 48.024 Mb/s.

- b. The SN has provided cabling and a distribution switching system (DSS-II) at WSC to integrate the switching of the 14 KSA Type II return link channel interfaces. NCC-directed WSC operations configure the DSS-II to provide up to four digital signals from the Type IIB interfaces through the DSS-II to four input channels of the SM. The SM multiplexes the input channels and outputs a composite serial data stream for transmission to the 50 Mb/s data service. A service switch interfaces the digital modulator (see Figure 12-2), while the digital modulator interfaces a mode switch before the multiplexed data is uplinked to the domestic satellite.
- c. Demultiplexers of the SM are installed at the Landsat DAF and Nascom Technical Control Facility at GSFC, the Spacelab POCC and Data Processing Facility at MSFC, the ER-2 ground processing system at ARC, and the MCC at JSC. The demultiplexers at these user locations demultiplex the composite data stream and deliver the data to each of its assigned channels. Each stream, at this point, is a synthesized replica of the bit synchronized clock and data stream originated at the input of the SM at the White Sands interface. The SM uses its own data formatting and multiplexing technique (that is germane to Nascom) and is transparent to the users of the system. Redundancy is provided in the system with a patchable backup SM at each location (except ARC). The SM equipment is provided in full duplex for local loop-back test capabilities.

5.7.3.2 SM Frame Format

The SM is designed to accept and deliver user spacecraft raw bitstream data. The frame formatting of the bitstream data, as illustrated in Figure 5-11, is described in the following paragraphs:

- a. At the transmit section, each of the four ports receives an ECL balanced channel of data and clock. The serial data is converted to 31-bit parallel words organized into 248-word frames. These frames are then formatted into 250 32-bit words that include distributed sync, frequency, and port address information. The sync information is attached, one bit per word, to the end of each of the first 248 words. The sync pattern in the last 31 words of the 248 provides end-of-frame information. Words 249 and 250 contain the port frequency and the frame sequence number. The formatted frames are passed to the communications link modem at 50 Mb/s. When no data is available from any of the input ports, PN data pattern 2047 is generated for transmission.
- b. At the receive section, the 50 Mb/s data stream from the communications link modem is received in the rear panel. The frames are synchronized into 32-bit words

5.8.2.2 System Elements

The hardware system elements are the central complex cabinets housing the UNISYS 2200/400 processing systems, system support processors, system consoles, FEPs and assorted peripheral devices. The software system consists of the vendor and application software. The software system elements are briefly described in the following paragraphs:

- a. **Vendor Software.** The vendor software shown in Figure 5-12, consisting of Unisys-supported products such as OS, utility programs, diagnostics, and other system programs required to operate the UNISYS 2200/400 computers and peripheral devices configured for the CSS. Vendor software includes system- or machine-specific programs that support a set of general functions for the CSS. The vendor software follows:
 1. **Transaction Interface Processor (TIP) System.** An extension of the Series 1100 EXEC OS that allows immediate execution of transaction programs.
 2. **Message Control Bank.** A general-purpose message-handling mechanism that provides the capabilities of controlling and recovering input and output messages.
 3. **Data Management System 1100 (DMS1100).** A system that allows users to define the data base and the various user views of the data base.
 4. **Integrated Recovery Utility (IRU).** A program that provides a set of language commands for the recovery and reconstruction of TIP/DMS files.
 5. **Command Management System 1100 (CMS1100).** A system that provides a real-time interface for routing communications data from hardware devices to the 1100 EXEC OS.
 6. **DCP OS.** DCP OS handles information queries from its own application and provides boot capabilities and file services.
 7. **TELCON.** TELCON provides (1) data send and receive capability to the operator terminals, (2) Advance Schedule via the CMS1100, and (3) Nascom line modules to and from the host.
- b. **Application Software.** Application software consisting of function-specific programs that enable the execution of application processes specified for the CSS. This software is developed in-house by a contractor according to Nascom specifications. Application software cannot be executed in the computer by itself; it requires the operating system program provided by the vendor.

5.8.2.3 System Interfaces

The CSS system interface configuration is illustrated in Figure 5-13. All interfaces shown are Nascom internal control and status interfaces, except for the interfaces with the NCC. The CSS Systems interfaces are described as follows:

- a. **NCC Interface.** The CSS interfaces the NCCDS with two 56 kb/s data lines routed via the Nascom MSS and the NCC Restricted Access Processor (RAP). (These 56

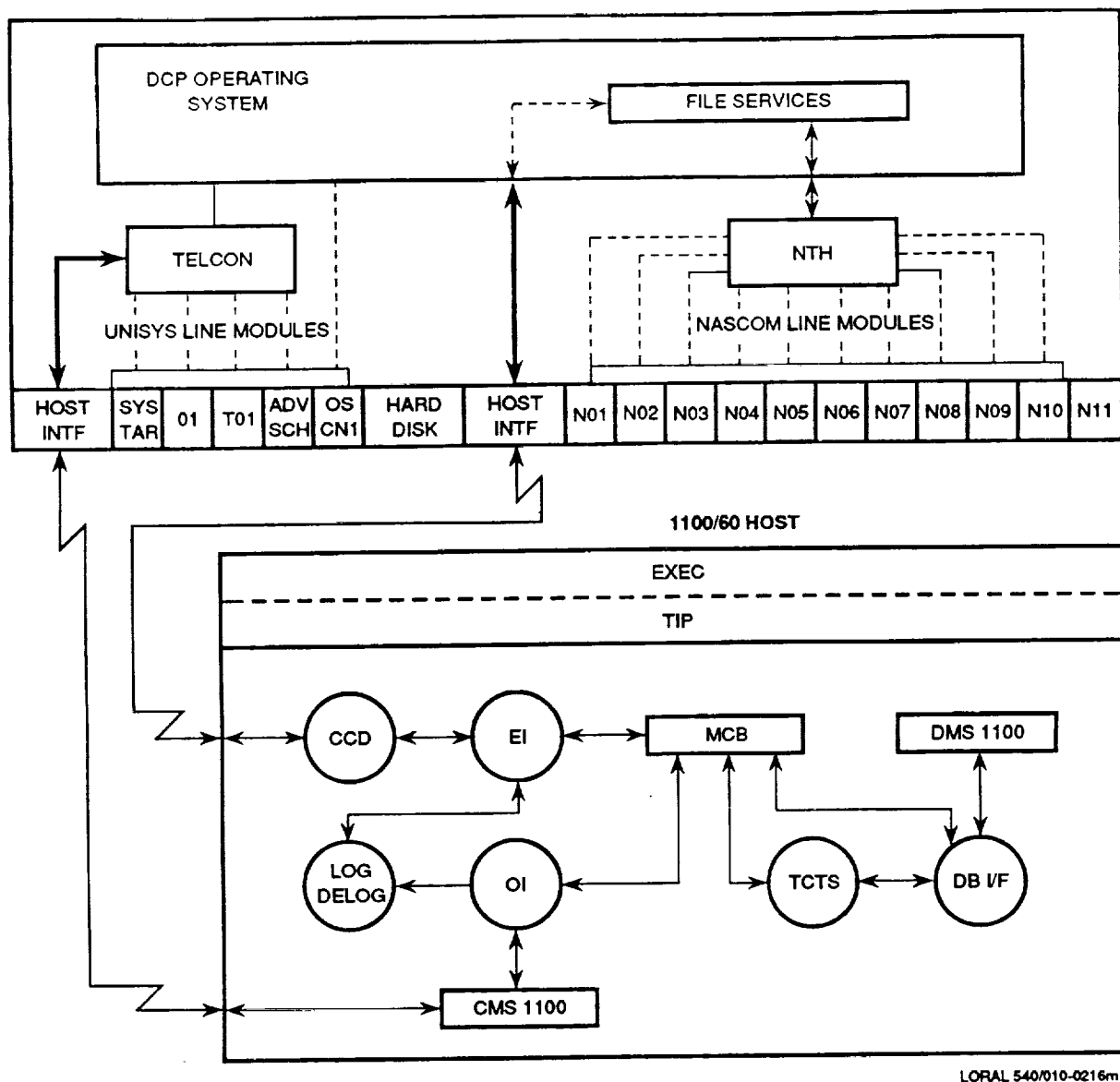


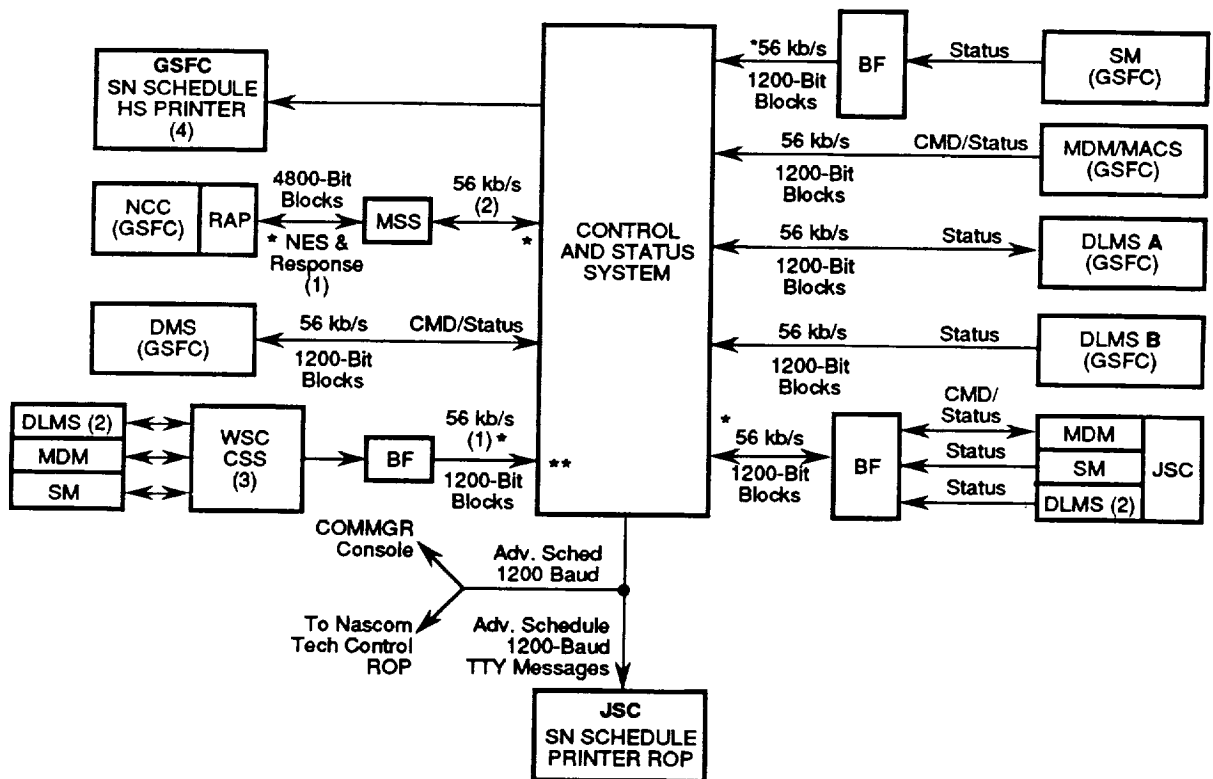
Figure 5-12. CSS Vendor Software Configuration

kb/s data lines are still routed via the PDS installed in the 1980s for support of classified DoD shuttle operations, an activity now discontinued.) Message interchange between the NCC and the CSS are in standard 4800/bit blocks. The NCC is constrained by Interface Control Document (ICD) agreement to a maximum transmission rate of eight blocks per second. NES messages may be multiblock messages. The definition of messages by type, class, content, and protocol for interchange between the NCC and CSS is contained in STDN 220.9 "Interface Control Document between the Network Control Center and the Nascom Control and Status System."

- b. Subsystem Interfaces. On the basis of the NES messages received from the NCC, the CSS performs a resource allocation, produces a Traffic and Configuration Time

Schedule (TCTS), and issues TCTS time-driven command blocks to the subsystem control elements. The CSS also maintains a data base of available Nascom system resources and updates it based on status data received from subsystems.

- c. **NCSS Interface.** Since the WSC CSS controls the WSC equipment, status information is sent to the CSS from the NCSS via the Block Formatter.
- d. **Block Formatter Interface.** The Block Formatter (BF) is a Nascom subsystem element that was developed for each of the four installations (WSC, JSC, and two GSFC SM locations). It multiplexes block status information from the MDM, SM, and DLMS at WSC and JSC for transmission to the CSS, and distributes schedule-driven control messages from the CSS to the MDM. The SMs (and the Mode Switch at WSC) require external block formatting/deblocking capability, which is also furnished by the BF. The BF is capable of block multiplexing/demultiplexing 6 channels, and will handle 1200 bit blocks. The BF is required in conjunction with the CSS for implementation of automated scheduling and control of the Nascom SN elements. In-house fabrication, assembly, and testing were completed as of March



LEGEND:

- (1) Via Protected Wire Distributed System (PWDS)
- (2) Quantity two
- (3) Advanced schedule furnished to WSC by NCC via another 56 kb/s circuit to the NSS
- (4) Delivers advance schedule locally to tech control for all locations

* Indicates Block Error Detector (BED) in series with data flow

** CSS control of MDM and SM at WSC replaced by the WSC Control and Status System (NCSS) capability implemented at WSC. NCSS will continue to return status information to the CSS via the BF.

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Figure 5-13. CSS Functional Interface Block Diagram

1985. Installations were completed in conjunction with CSS Phase I at the end of the second quarter 1987.

1. A total of six BFs plus supporting equipment are installed, two each, at the following locations:
 - (a) Landsat Data Acquisition Facility (DAF) near Building 25 at GSFC.
 - (b) Communications Circuit Technical Control Facility in Building 30 (Mission Operations Wing) at JSC.
 - (c) WSC at White Sands, New Mexico.
2. The BFs are arranged in a hot-standby, redundant configuration. Each BF is capable of interfacing two SMs, one MDM MACS, and three DLMS units to the CSS. The BF select switch, which is part of the installation, provides switching functions of their BF serial, RS-422 interfaces. These functions include a 2 x 2 switch to route two communication links to/from the two BFs, as well as a 2x1 switch to route the MACS and DLMS to/from either of the two BFs. The SM switch switches the interface of two SMs to/from the two BFs.

The CSS communicates with Nascom subsystem control elements in 1200-bit blocks and 56-kb/s interfaces. The MDM, DLMS, SM, and DMS control subsystems are compatible with the 1200-bit block 56-kb/s interfaces. The 4800-bit block is used on the NOC interface. For CSS communications with the WSC and JSC locations, the BF also performs a block multiplexing function for efficient utilization of 56-kb/s circuits to be established between GSFC and remote locations for the CSS function. These 56-kb/s control circuits established external to the MDM systems for a normal operational diversity configuration, but may use channels within the MDM system (serial data mode) as an alternate path.

- e. Statistical Multiplexer Interface. The SM shown at GSFC represents the system controller of SM equipment located at the Landsat DAF and interfacing to the CSS via a BF.
- f. DLMS Interface. Each of the three BDS locations (WSC, JSC, and GSFC) will have two DLMS, one for each alternate downlink (A and B system), which will periodically send link status to the CSS. The DLMS provides status only, and requires no CSS commanding function. At GSFC, the DLMS interfaces directly with the CSS to provide link status. At WSC and JSC, the DLMS interfaces via the BF and at WSC indirectly via the NCSS.
- g. MDM Interface. The MDM system is interfaced directly to the CSS at GSFC, and via the BF at WSC and JSC for control and status functions.
- h. TTY Interface. The CSS also interfaces with a 1200-baud TTY circuit for transmission of the 24-hour advance schedule, which is sent to a Receive-only Printer (ROP) at the local MDM operating positions at JSC and GSFC Nascom Tech Control for manual execution of the schedule (if needed) as a backup to the CSS. A translation

of the 4800-bit block NES messages into identifiable instructions in TTY message form is accomplished in the CSS. The advance schedule for WSC is also transmitted by the NCC directly to the WSC Scheduling System (NSS) via a separate 56-kb/s channel.

- i. **DMS Control System Interface.** The DMS, located at GSFC, is a three-stage, solid-state, circuit switch composed of a forward matrix and backup, return matrix and backup, and a control subsystem. Each of these four matrices is capable of handling 192 input and output lines. The function of the DMS in the SN is to route TDRSS/WSC/JSC MDM traffic flows to/from users and operators of the SN via GSFC. The CSS at GSFC will be used to automatically configure and monitor the status of the DMS, in accordance with the NCC schedule. The current DCS is a DEC MicroVAX II.

5.8.3 System Operation

5.8.3.1 CSS Subsystem Operations

The CSS operation is premised on the functions specified for the system. The functions of CSS, as depicted in Figure 5-14, are grouped into three main subsystems. These are:

- a. **EI Subsystem.** Manages the communications interfaces between the CSS and other network elements. As can be seen in Figure 5-13, the NCC is included as an element, in addition to the various network equipment at each of the sites.
- b. **TCTS Subsystem.** Receives daily Nascom event schedules from the NCC via EI or from the local operator via OI, configures the network equipment in accordance with the schedule, and monitors the network status.
- c. **OI Subsystem.** Provides for operator control of CSS and network activities.

5.8.3.2 Fundamental CSS Processes in Subsystems

There are seven identified fundamental processes operating in the subsystems to perform the functions. The acronym placed after a process indicates the subsystem where the process occurs:

- a. Manage NCC/CSS interface communications (EI).
- b. Manage Network/CSS interface communications (EI).
- c. Manage JSC SN/CSS interface communications (EI).
- d. Schedule Nascom events (TCTS).
- e. Command network configuration (TCTS).
- f. Monitor network status (TCTS).
- g. Interact with operator (OI).

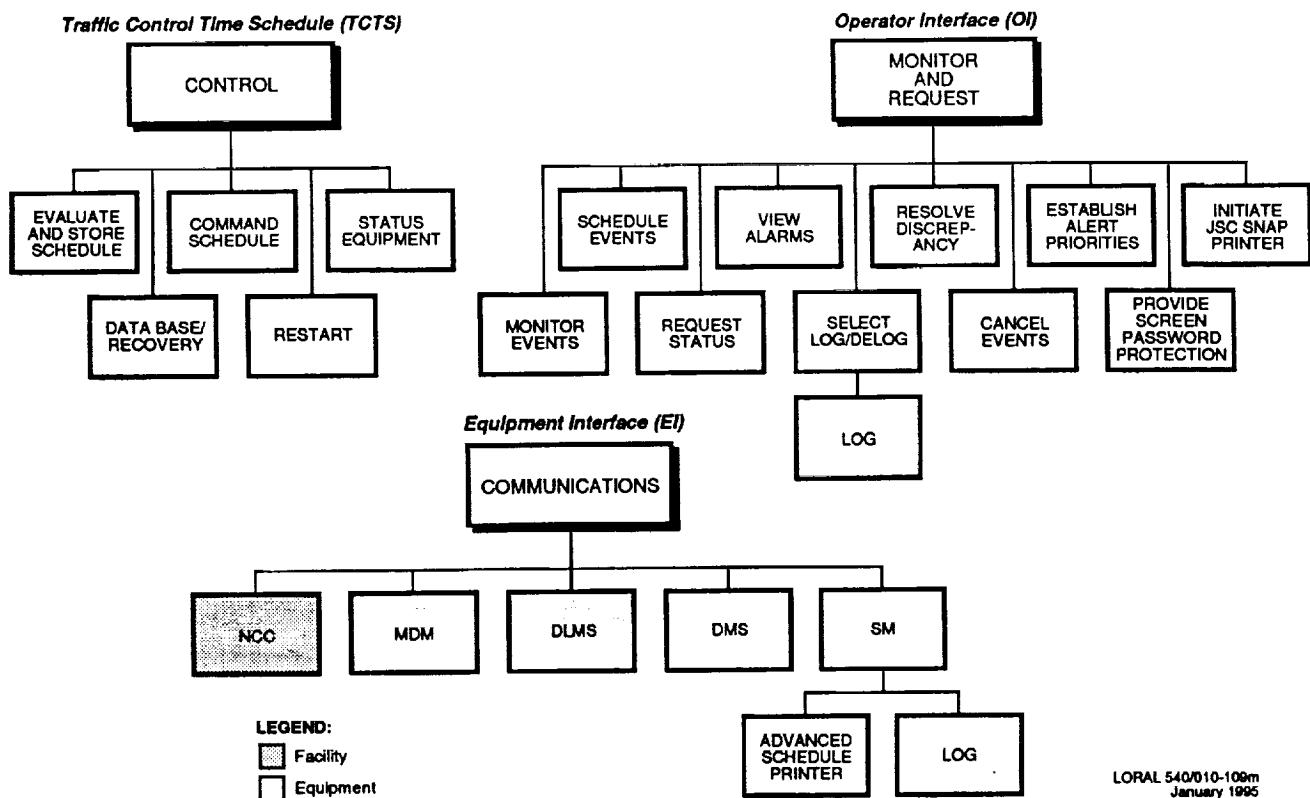


Figure 5-14. Categories of the Main CSS Subsystem

5.9 Nascom Environmental Support System

5.9.1 System Definition

The Nascom Environmental Support System refers to the various systems that support the environmental requirements of the primary switching and technical control facilities at GSFC in the areas of electric power, emergency lighting, and air conditioning.

5.9.2 System Description

5.9.2.1 Primary Power

Primary power to Buildings 3 and 14 is provided by two separate commercial feeders backed up by four 500-kVA diesel generators. During critical mission periods, the diesel generators are kept running continuously. Nascom does not utilize the diesel power source unless commercial power becomes unstable or fails. Special power switching arrangements are provided such that the Voice Switching System (VSS), Control and Status System, and Technical Control areas and their associated UPSs can be automatically supplied from either the commercial or diesel power sources. In the event of failure of either power source, these loads are automatically (or manually) switched to the remaining unfailed source.

5.9.2.2 Uninterruptible Power System

Three separate UPSs provide for a continuous power feed to Nascom's Voice Switching System, the Control and Status System, the Digital Matrix Switch, and the Technical Control area. The UPSs operate on a battery/converter principle with the battery system permanently floating on-line. When commercial power fails, no switching is required: the batteries assume the critical load instantaneously until commercial power is restored or the diesels are brought on-line. In this manner, critical systems and circuits which must be protected from power fluctuations are assured stable, reliable power.

5.9.2.2.1 Voice Switching System UPS

The Voice Switching System UPS consists of two identical battery chargers and four battery banks providing for a minimum of four hours operation without an external Alternating Current (ac) power source.

5.9.2.2.2 Technical Control System UPS

The Technical Control Area systems are supported by three identical UPSs. These UPSs provide an operating period on battery of about 15 minutes. Currently, these UPSs are loaded at about 70 percent of their rated capacity.

5.9.2.3 Emergency Lighting

Emergency lighting is provided by one 30-kVA no-break power systems which provide power to selected fluorescent fixtures in Building 14.

5.9.2.4 Air Conditioning

Air conditioning is provided by the GSFC chilled water supply. Two standby water chillers with 250-ton and 125-ton capacities (located in Building 3) can be arranged to supply air conditioning in the event of failure of the GSFC chilled water supply. Three separate air-handling units, located in Building 14, provide cooling for the equipment and afford approximately 50 percent redundant capacity. With this margin, any two of the three units are capable of handling the anticipated total heat load generated when all equipment is operated simultaneously. all equipment is operated simultaneously.

5.10 Nascom Technical Control System

5.10.1 System Definition

The Nascom Technical Control System refers to arrays of test, patch, monitoring and diagnostic capabilities arranged on a functional subsystem basis for support of Nascom TTY, Data, and Video services.

5.10.2 System Description

5.10.2.1 TTY Tech Control

The TTY Tech Control, located in the Building 14 TTY operational area, consists of rack-housed jackfields and test equipment used for configuring, testing, and monitoring of the TTY circuits, including the restoration and/or replacement of TTY equipment.

5.10.2.2 Data Tech Control

The Data Tech Control, located in the Building 14 communications area, consists of an extensive array of bay racks housing the test and patch subsystems used for test access, reconfiguration and/or restoration, testing, and monitoring of data channels. From the High-speed Data Technical Control area, the capability to test and monitor analog [alternate voice/data (AVD) and TTY] as well as digital data channels, and order wires, is provided. Another area is called the Wideband Data Tech Control, which is used for the test and monitoring of wideband data circuits.

5.10.2.3 Video and Timing Tech Control

The Video and Timing Tech Control, (Tech Support) located in Building 14, consists of an extensive array of bay racks housing the video test and monitoring equipment, and test and patch facilities (including the video consoles for video signal control). Video Tech Control operates jointly with TV Central Control, located at Room N-2, Building 8, which is also operated by Nascom but under Code 543.

5.11 Nascom Datacom-Technical Support Facility and Interbuilding Cable Network

5.11.1 Datacom-Technical Support Facility

Operated by Code 543, the DATACOM-Technical Support Facility is located in Room E-2, Building 14. It consists of the following equipment:

- a. Remote-control POCC video switching and distribution matrix.
- b. Termination frame for the GSFC Interbuilding Cable Network.
- c. Time standards generator and distribution system.
- d. Interface for internal extension of commercial carrier supplied video and audio circuits.
- e. Audio terminal for Mission Operations audio and General audio.
- f. Main-frame for control of all remote-controlled cameras.

5.11.2 GSFC Interbuilding Cable Network

5.11.2.1 General

Managed and operated by Code 543, the GSFC Interbuilding Cable Network is comprised of twisted pair, coaxial and fiber optic cables. Over this cable network are transported television, audio, computer-to-computer data, data to and from interfaces external to GSFC, and spacecraft data for operational and testing support between Goddard control centers and their respective spacecraft. Each building connected to the cable network has cable-appropriate termination frames or racks on which the outside cables serving the building are terminated, including appropriate audio and video outlet boxes. Within each building are

“house cables” that interface to the outside plant cables at these frames/racks used to extend circuit paths to the end user’s facilities.

5.11.2.2 Obtaining Service

To obtain a cable circuit on GSFC, the requiring office submits its requirements in writing to Nascom’s Telecommunications Branch, Code 543. Each request needs to contain the following information:

- a. Types and quantities of circuits.
- b. Data rates to be transported.
- c. Period(s) of support.
- d. Building and room number where service is required.
- e. Name and phone number of person who will be point of contact to work with Code 543 to implement the requested service.

Upon receipt of a service request, Code 543 determines the availability of appropriate cable(s) to the service location and identifies the routing and circuit configuration for the requested service. When the circuit is established, it is tested end-to-end (on-site) to demonstrate compliance with service requirements. If the on-site segment of a circuit is being implemented to meet a Nascom requirement, then Nascom may supply conditioning or line-driver equipment if necessary for the circuit to function properly.

If there is a circuit problem after activation of the on-site circuit, the user opens a trouble report with Nascom. The circuit is then turned over to Nascom for fault isolation and correction by CCTV-DATACOM personnel of Code 543. If the problem cannot be corrected, then the service will be restored on a similar cable, if one is available.

5.11.3 Mission-oriented Fiber Optic Cable Plant

5.11.3.1 General

To support the ever increasing requirement for extending digital circuits between buildings housing operational mission supporting facilities, the Nascom Telecommunications Branch maintains an extensive and growing fiber optic cable plant. This fiber optic cable plant centers on Building 14 (Nascom GSFC Switching Center’s location) and provides connection to and between buildings housing operational, mission-oriented facilities.

5.11.3.2 Description

Nascom’s fiber optic cable plant consists of fiber optic cables possessing the following characteristics:

Type: multimode
Size: 50/125/250 microns
Numerical Aperture: 0.20
Attenuation: 400/1000 MHz @ 2.5/1.5 dB/km

Type: multimode
Size: 62.5/125/250 microns
Numerical Aperture: 0.275
Attenuation: 1.5dB/km/500 MHz@1300nm

Type: single-mode
Size: 8-9 micron
Attenuation: 0.4/1310/1550nm

From the principle node in Building 14, cables fan out across GSFC. Route diversity to selected buildings is achieved through intermediate patch facilities (nodes) in buildings 10, 11, 23, 28 and 29. Figure 5-15 portrays the operational, mission supporting fiber optic cable plant currently installed on GSFC. Cables for support of the ICLU project (paragraph 16.4.7) are shown on this drawing.

5.12 Security of Nascom Systems

5.12.1 ADP System Risk Analysis

5.12.1.1 Background Information

All government organizations are required to assess vulnerabilities and the feasibility of additional safeguards for their Automatic Data Processing (ADP) systems, where appropriate. These analyses, performed by GSFC organizations, are used by NASA/GSFC Automated Information Security Officials (AISO) in compliance with various directives on this general subject. Those directives include the Office of Management and Budget (OMB) Circular No. 130, the NASA Management Instruction (NMI) 2410.7, and the NASA Handbook (NHB) 2410.9.

5.12.1.2 Nascom Activities

Risk analysis is a continuing activity that requires periodic reassessments. Accordingly, Nascom has tasked its Nascom Maintenance and Operations Support (NMOS) contractor to provide support to the Nascom Division AISO. Risk analyses have been performed for all systems/networks, requiring them, and reassessments are conducted on a periodic basis.

5.12.2 Nascom Access Control

5.12.2.1 Background Information

NASA Code T originally established a NASA-wide policy regarding Nascom access control in its Memorandum TS-88-246. Code O has continued the policy through publication of NMI 2520.1D. The purpose of the policy is to prevent unauthorized access and potential damage to Nascom operational systems and user AISs. Initially, Nascom users were required to survey their resources possessing Nascom interfaces and determine the applicability of the policy to their interconnecting resources; at the same time, they would also assess the extent to which their resources were in compliance with the policy. Today, Nascom performs audits of the interconnecting resources for compliance with the policy.

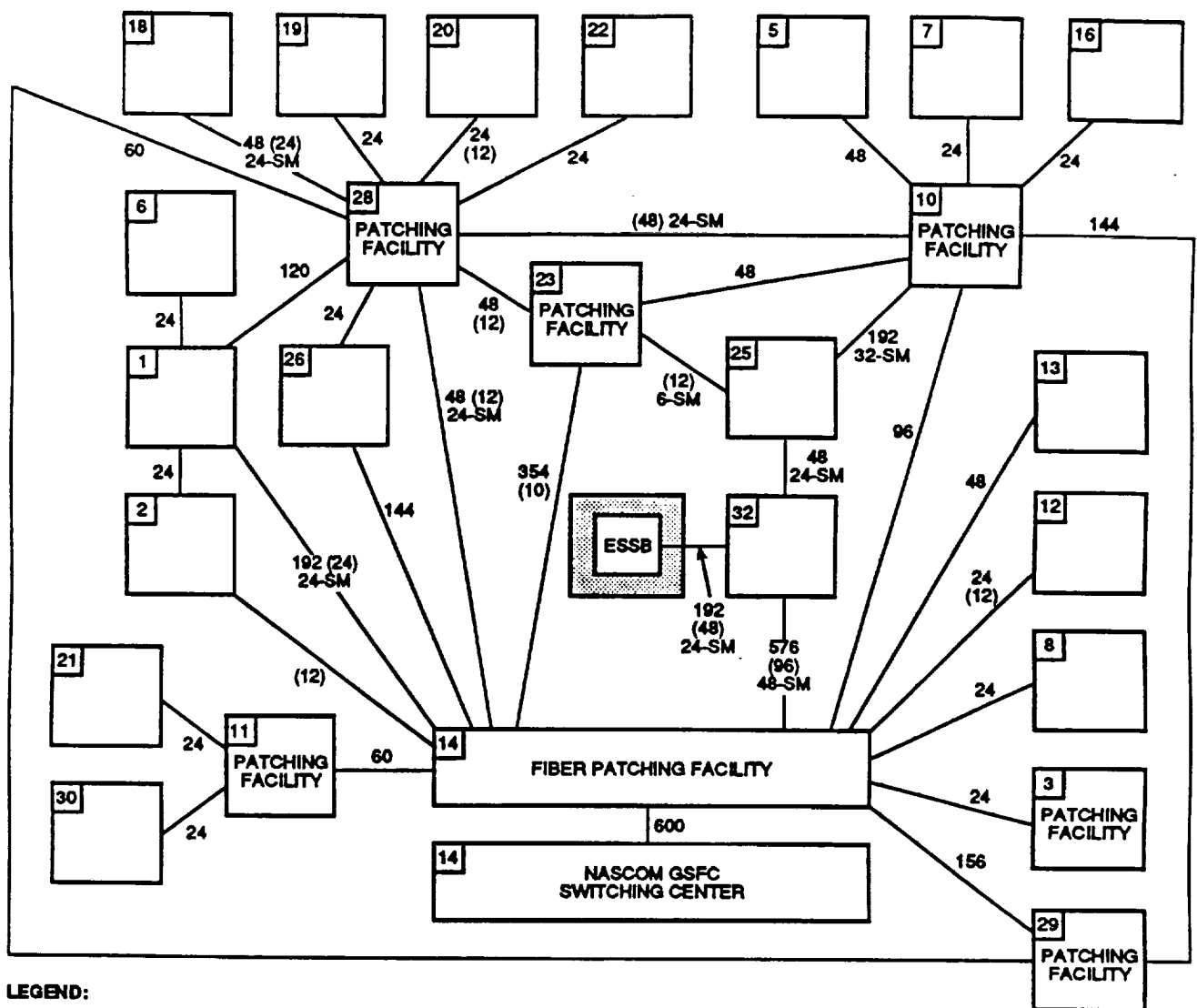


Figure 5-15. Operational, Mission-oriented Nascom Interbuilding Fiber Optic Cable Plant on GSFC

5.12.2.2 Nascom Responsibility

Nascom has been given responsibility to verify compliance through unannounced audits at Network user sites. The SEAS contractor has been tasked to support the Nascom AISO by forming a security audit team to carry out this policy. The schedule and identity of installations are determined by Nascom. The contractor furnishes a detailed written report following each site visit. This is, and will be, an ongoing and continuing activity. Specific details are found in NASA Communications (Nascom) Access Protection Policy and Guidelines (541-107).

5.12.3 Nascom Physical Security Arrangement

The physical security system established for the Nascom Network consists of the following: coded lock access for operational areas, access procedures, and badge systems, earth station fencing, limited access area delineation, closed circuit TV surveillance, and contractor clearances.

5.12.4 Secure Nascom Systems

5.12.4.1 Multiplexed Circuits

The following wideband circuits/systems are encrypted at the aggregate interface of the multiplexer:

- a. NCC/WSC (sole remaining link of the ISC).
- b. CSTC/NCC.

5.12.4.2 Nonmultiplexed Circuits

The 56 kb/s circuit for the WSC communications hardware configuration and status remains encrypted pending completion of the WSC guard processor project.

5.12.4.3 RED Information Transport Practice

For intercenter wideband trunks terminating in Nascom managed time division link multiplexer equipment, it is now the practice to implement the occasional requirement for classified voice and data signal transport with user supplied and installed RED submultiplexers, located in secure user facilities, the encrypted aggregates of which are interfaced as BLACK synchronous data signals to appropriately configured data channel cards of the link TDMs.

5.13 Nascom-2000

5.13.1 Background

Nascom-2000 is the name given to that portion of the total Nascom Network which is provided by AT&T under provisions of the Network Service Assurance Plan (NSAP) contract modifications to the General Services Administration's (GSA) Federal Telecommunications System (FTS) 2000 contract. Use of the term "FTS2000" to denote the carrier or Nascom

circuits and services was causing confusion among the users of Nascom services. The prefix FTS is used throughout the federal government to refer to network services provided to government agencies by AT&T (FTS2000 Network A) and Sprint FTS2000 Network B), the two carriers with which GSA has signed FTS2000 services contracts. To minimize confusion within Nascom and among the users of Nascom circuits and services, use of the term FTS2000 will be avoided. However, some use of the term FTS2000 will be made in this section to provide a fuller understanding of the origins and composition of Nascom-2000.

Public Law 100-440 imposes a requirement that all government agencies use GSA's FTS2000 contract to meet their network telecommunications requirements. In order for the FTS2000 to meet Nascom performance requirements, significant contract modifications needed to be made. In early 1991, the GSA, in conjunction with Nascom and AT&T (NASA is assigned to Network A for FTS2000 services; the vendor for Network A is AT&T), undertook to define the contract modifications that would be needed if FTS2000 were to provide the required services and meet Nascom's performance requirements. Three contract modifications were identified: Network Service Assurance Plan (NSAP), Special Routing (SR), and Alternate Network Connectivity (ANC).

- a. **Network Service Assurance Plan.** The NSAP contract modification was awarded in April 1993. Basically, the NSAP provides for flagging and tagging of FTS2000 Network A assets supporting Nascom, maintains Nascom's position within the National Security Emergency Preparedness program, provides for enhanced maintenance response and special coverage, implements automatic restoration and reconfiguration within Nascom's allocation of Network A resources, and provides for site visits by the vendor.
- b. **Special Routing.** The SR contract modification provides for the establishment of a totally diverse terrestrial route, on an end-to-end basis, between any two points supported by Nascom where such route diversity is a requirement.
- c. **Alternate Network Connectivity.** The ANC contract modification makes provision for use of domestic satellite services between given locations, e.g., by making use of GTE Americom earth stations currently contracted for by Nascom.

5.13.2 Network Site Types

The NSAP contract modification makes provision for five different site types, i.e., node configurations. A center's complement of NSAP-provided equipment may be comprised of multiple site types. Each site type will be briefly described in the following paragraphs.

- a. **Primary Site.** The distinguishing feature of the primary site is the network management capability. Nascom will perform the network management function, remotely from GSFC, of the FTS2000 resources allocated for Nascom support. Network management functions may be extensively automated; however, human interaction with the network via remote terminal or workstation interfaces is standard. As is the case today, network access protection is assured. The primary site is equipped with the network management system, a Digital Cross Connect Device (DCCD) with five ports, a fully equipped enhanced (intelligent) multiplexer, and provisioned with spare circuit cards. (Figure 5-16).

- b. Site A. An "A" site is similar to a Primary site with the exception that it does not have a capability to monitor or control the network. Otherwise, it is equipped the same as a Primary site. (Figure 5-17).
- c. Site B. A "B" site is configured with an intelligent multiplexer terminating an FTS2000 T-1 line. The multiplexer is fully equipped and spared, but there is no DCCD. (Figure 5-18).
- d. Site C. At a "C" site, there is a fully equipped and spared intelligent multiplexer which is interfaced to the FTS2000 network via a DCCD configured with two port cards. (Figure 5-19).
- e. Site D. A "D" site interfaces the FTS2000 network via a DCCD configured for three ports. Each T-1 terminates in customer-provided, enhanced, multiplexer equipment. To be connected to the NSAP T-1, the customer-provided multiplexer must be approved by the FTS2000 vendor. In effect, this means using equipment designated by AT&T. (Figure 5-20).
- f. Site T-1. A "T-1" site is equipped with an NSAP-provided CSU (and spare). On the customer side of the CSU is customer-terminating equipment, for example, the communications front end of a data processing facility, but with no NSAP provided nor NSAP-approved multiplexer. (Figure 5-21).

5.13.3 Architecture and Topology

There are two intelligent multiplexers approved for use under the NSAP contract modification: the ACCULINK 740 and ACCULINK 745 ("ACCULINK" is a registered trademark of AT&T). The 740 is a programmable, time division, point-to-point, T-1 multiplexer capable of combining analog, voice, and digital data (both synchronous and asynchronous) into a single composite data stream with T-1 framing. The 745 is a T-1 switching multiplexer which, along with the 740, is installed on the customer's premises by the FTS2000 vendor. The 745 supports the following network configurations: multipoint, drop and insert, and channel group bypass.

Nascom-2000 provides transport and transmission services between locations that are within the 48 contiguous continental states and to the state of Alaska. Nascom-2000 services are not

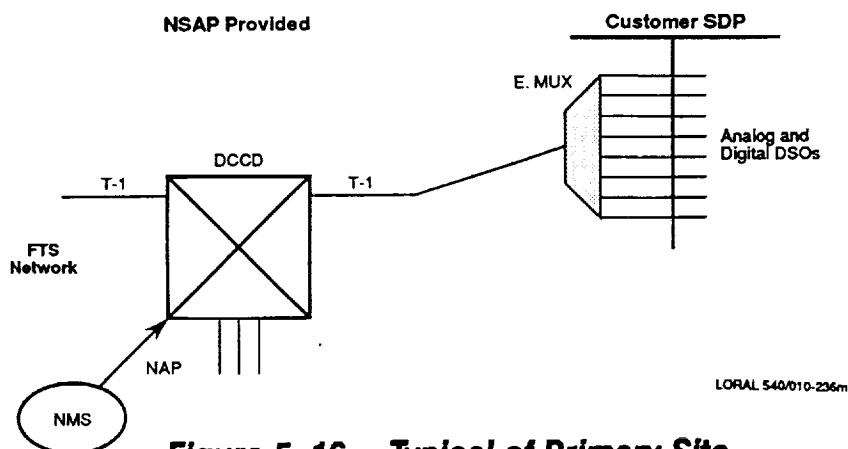
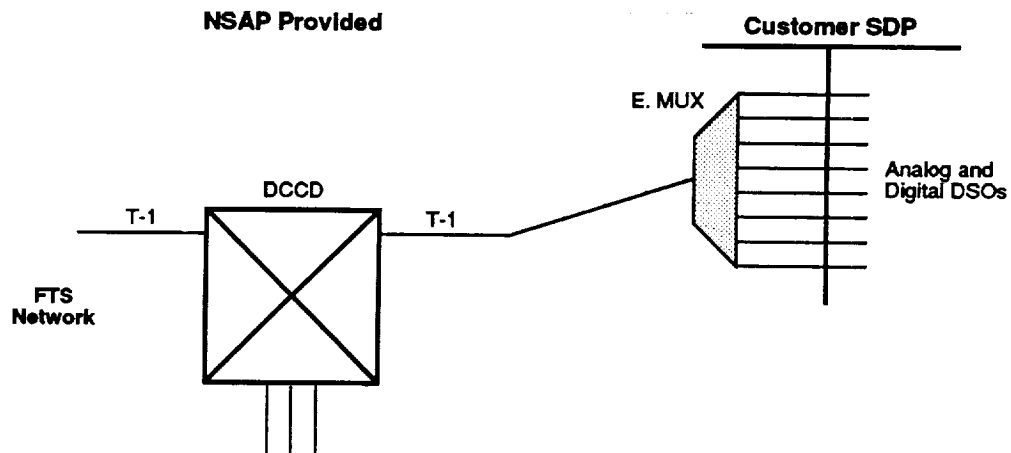
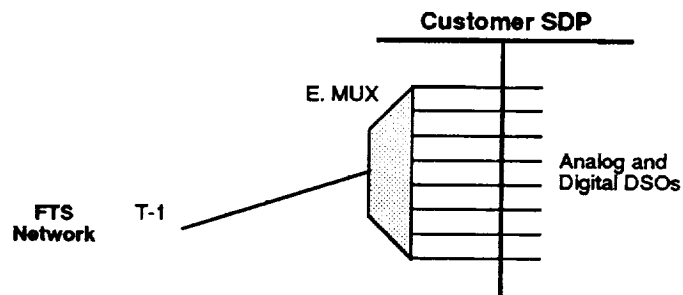


Figure 5-16. Typical of Primary Site



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Figure 5-17. Typical of Site A



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Figure 5-18. Typical of Site B

available for Nascom's overseas international links. Figure 5-22 depicts the Nascom-2000 topology, the number of interconnecting T-1 spans between any two sites, and annotations of the interface type: 745 switching multiplexer, 740 T-1 multiplexer, or one of the optional interfaces offered by Nascom-2000. Figure 5-23 shows the architecture of the Nascom-2000 network.

5.13.4 Supported Data Rates

The following paragraphs describe technical capabilities of the ACCULINK 740 multiplexer. It should not be inferred from this list that Nascom will necessarily implement each of the rates for which the equipment is technically capable.

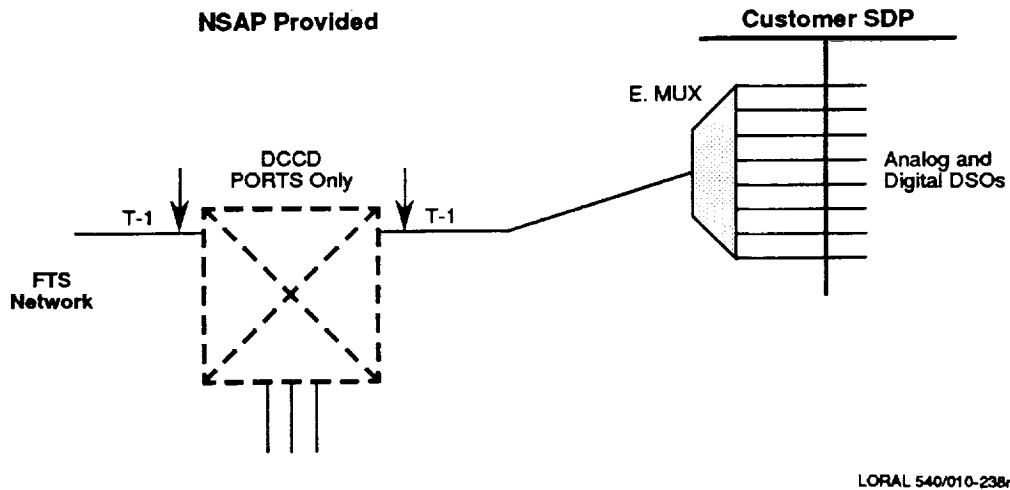


Figure 5-19. Typical of Site C

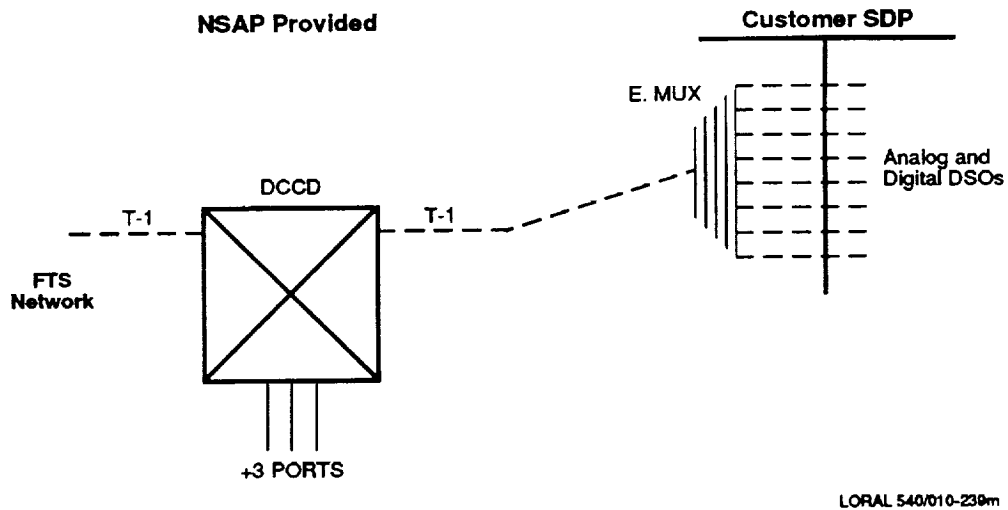


Figure 5-20. Typical of Site D

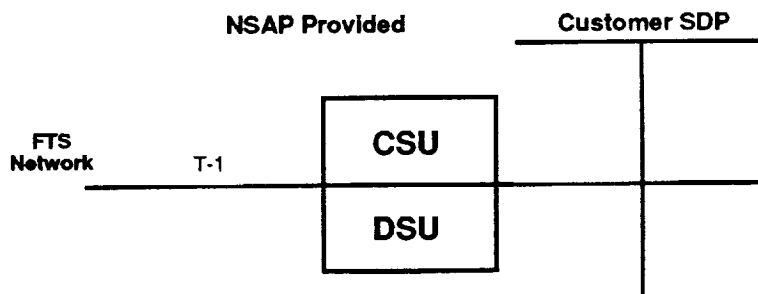
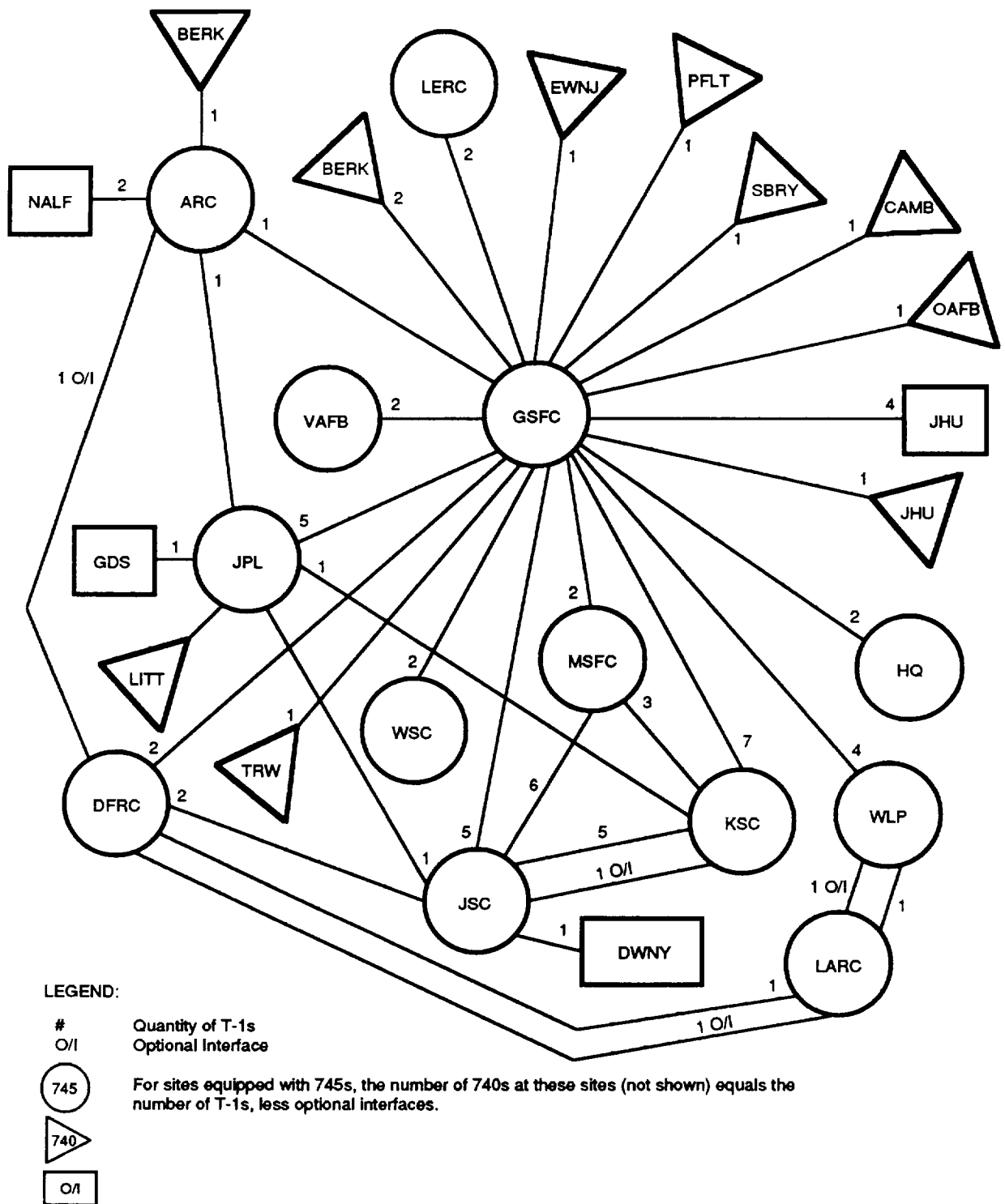
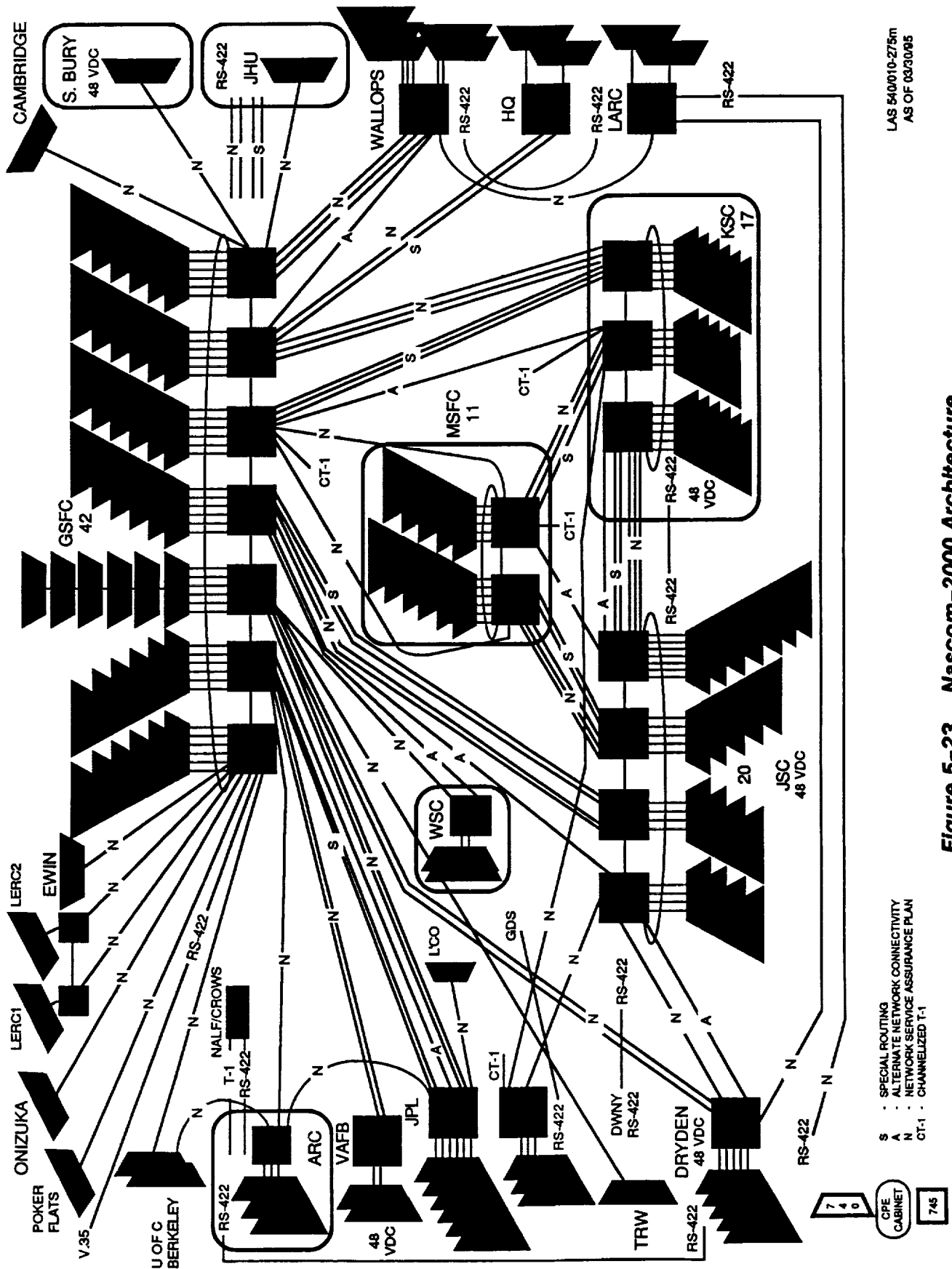


Figure 5-21. Typical of Site T-1



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Figure 5-22. Nascom-2000 Topology



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Figure 5-23. Nascom-2000 Architecture

5.13.4.1 Asynchronous Digital Data

The ACCULINK 740 multiplexer is capable of directly interfacing (at the channel level) with asynchronous digital data rates of 300, 1200, 2400, 4800, 9600, and 19200 kb/s.

5.13.4.2 Synchronous Digital Data

The ACCULINK 740 multiplexer is capable of directly interfacing (at the channel level) with synchronous digital data rates in the range between 1200 b/s and 1.536 Mb/s as follows: rates between 1200 b/s and 307.2 kb/s are available in 400 b/s increments; rates between 308 kb/s and 1.536 Mb/s are available in 2 kb/s increments. Electrical interfaces supported by Nascom-2000 include RS-422 (balanced), RS-423 (unbalanced), RS-232-C, and CCITT V.35.

5.13.4.3 Voice

The ACCULINK 740 multiplexer inputs and outputs 3 kHz analog voice at the channel I/O interface. Voice modules are available to digitally encode the analog voice signal for transmission at one of the following line rates: 64 kb/s PCM (this is the "standard" line rate that Nascom is using for its voice circuits transported over Nascom-2000 services; the use of other rates may be anticipated, e.g., 32 kb/s, as system RMA data are collected and network performance is thoroughly understood), 32 kb/s ADPCM, and 24 kb/s ADPCM. All standard signalling schemes typically employed by Nascom are capable of being supported.

5.13.4.4 Analog Data

Analog data, facsimile, and modem lines are also supported by the ACCULINK 740 voice module with the line rate set for 64 kb/s.

5.13.5 Nascom-2000 Network Management and Control

The GSA's contract with AT&T for FTS2000 Network A services includes network management. From its control center in Oakton, VA, AT&T manages its entire FTS2000 system, of which Nascom-2000 is only a small piece. Nascom-2000 is provided with a robust capability to control the multiplexers provided by AT&T as Customer Premises Equipment (CPE). The control system supplied with the equipment is UNIX-based on a SUN workstation and proprietary; it is not SNMP compliant. The Nascom technical control performs a control and monitoring function for their CPE and T-1 spans. However, the management and control system made available to Nascom is not enabled to see inside the AT&T transmission services network cloud.

5.13.5.1

The NMS enables Nascom operators to perform node and link diagnostics by remote commands from the Control Terminal workstation. Separate node and link diagnostic menus are provided to enable the network operator to verify operation of common equipment. Using the aggregate diagnostics menu, an operator can command internal and external loopbacks to isolate and define a fault.

5.13.5.2

The NMS collects statistics on node and network performance. A typical display for channel group performance shows errored seconds (any one-second interval during which a channel group lost synchronization), and failed seconds (the occurrence of 10 consecutive errored seconds). Additionally, equipment and facility alarm status information is presented.

5.13.5.3

Nascom-2000 equipment automatically generates event messages. An event message will belong to one of eight categories:

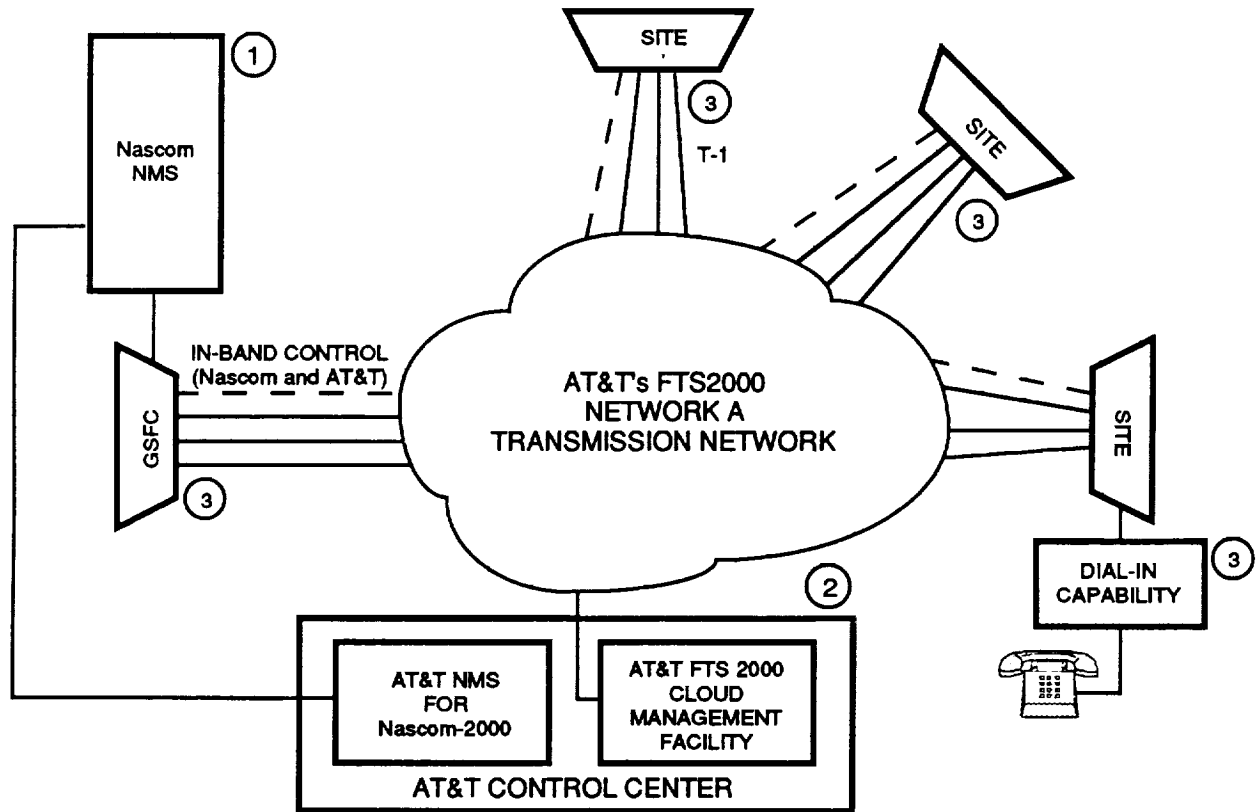
- a. Configuration Status.
- b. Facility Alarms.
- c. Node Alarms.
- d. Node Errors.
- e. System Status.
- f. Statistics.
- g. Network Call Status.
- h. Channel Group Accounting.

By use of the Message Log Menu, the operator can select which message to enable and the destination file (message log) for each.

Figure 5-24 provides a representational diagram of the Nascom-2000 NMS and the FTS2000 Network A vendor.

5.14 MODNET/NOLAN

The MODNET provides HYPERchannel and DECnet operational data interfaces on a Directorate-wide basis on the campus of Goddard Space Flight Center. Over 200 host computer systems are linked by MODNET. NOLAN extends this operational interconnection to Directorate computers using the TCP/IP protocol. NOLAN nodes and interfaces extend off-center to facilities as far away as Berkely, California, and Poker Flats, Alaska. IP interfaces on the MODNET are also available and in use by eight GSFC facilities. MODNET and NOLAN are presented in detail in Section 14, paragraph 14.5.8.



NOTES:

- ① Nascom control and diagnostics for CPE only
- ② AT&T control over entire network
- ③ Dial-in capability (air-gap and password protected; available to AT&T with Nascom permission on a case-by-case basis)

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Figure 5-24. Shared NMS Capabilities



Section 6. Low-Speed Network

6.1 General

6.1.1 Overview

The Low-Speed Network (LSN) consists of two logically and physically separate low-speed systems: the Tracking Data System (TDS) and the Administrative Message System (AMS). Their communication processing and switching equipment is located in the Nascom Primary Switching Center at GSFC. Network users provide their own communication terminals. These terminals are often personal computers with software packages enabling them to function as communication terminals.

The service capacity of the TDS is presently limited to a maximum of 95 ports for tracking and data messages; an additional two ports are reserved for Nascom operator use in accessing the system. The TDS was designed and implemented to be transparent to those users previously provided TTY and tracking data message services, except that 5-level Baudot-code-formatted messages are no longer supported by Nascom. The AMS, essentially an electronic mail system, has the capacity to support in excess of 256 user IDs (electronic mail accounts), and is used for the operational communication of human readable text messages. More than 125 network locations are interfaced by the Nascom LSN. End-user personal computers are used for sending and retrieving administrative electronic mail messages via a host system at GSFC.

6.1.2 System Definition

The term "low-speed data," as used in this document, is defined as all digital data up to, and including 1200 b/s, and all analog data requiring less than the normal voice bandwidth (3 kHz) analog for transmission.

6.1.3 Current Applications Overview

Applications of the Nascom LSN System are summarized in the following paragraphs:

- a. The Nascom Network provides, by various facilities and techniques, full-period TDS (low-speed data communications) channels to GN and DSN sites; to the NASA mission control and operations management centers; and to various other points as needed. Most circuits are operated as Full-duplex (FDX) private line services—routed direct or via the switching centers to their terminal points in accordance with the basic GSFC message-switched, star-configured network arrangement. A few TDS circuits are arranged for Simplex (SPX) (one-way) operation. Interswitching center orderwires are operated on a Half-duplex (HDX) (two-way nonsimultaneous) mode. Temporary leased circuits are used when they meet the requirements of availability and reliability for mission operations. All circuits are terminated and all TDS traffic is message-switched in the GSFC MSS.

- b. LSN channels are provided to selected Ground Network (GN) sites, selected Deep Space Communications Complexes (DSCCs), and various DoD tracking sites in support of Space Transportation System (STS) missions. User equipment interfacing the LSN channels at these sites generate fixed length S-band and C-band tracking messages. The S-band tracking data are a fixed length of 75 8-bit characters (bytes) and are formatted in the Universal Tracking Data Format. C-band tracking data are a fixed length of 56 8-bit characters and are formatted in the Radar 46-character format. Both S-band and C-band tracking data messages are received at a sample rate of one sample per 10 seconds; each tracking data type is packed at the rate of one frame per 4800-bit block.
- c. LSN channels at these sites also generate text data such as briefing messages and other messages that consist of text rather than numeric data. These text messages are handled by an electronic mail system that is physically distinct from the system handling the tracking data.
- d. Tracking data includes, but is not necessarily limited to, Interrange Vectors (IRVs), Improved Interrange Vectors (IIRVs), Internet Predicts (INPs), and C-band and S-band tracking data. The GSFC crypto center functions as a refile point between the Nascom TDS and the military networks. This facility also performs a refile function into commercial teletype networks for support to other federal agencies and designated locations.

6.1.4 American Standard Code For Information Interchange

ASCII was approved in 1968 as a government standard for adoption within all government data processing and telecommunication systems. Procedures for implementing the program were developed and disseminated by NIST and the NCS. The Nascom Network has effected ASCII conversion. Interfaces with foreign governments or lease of private lines from foreign carriers may still require special consideration.

6.2 Nascom Low-Speed Network

6.2.1 Network Description

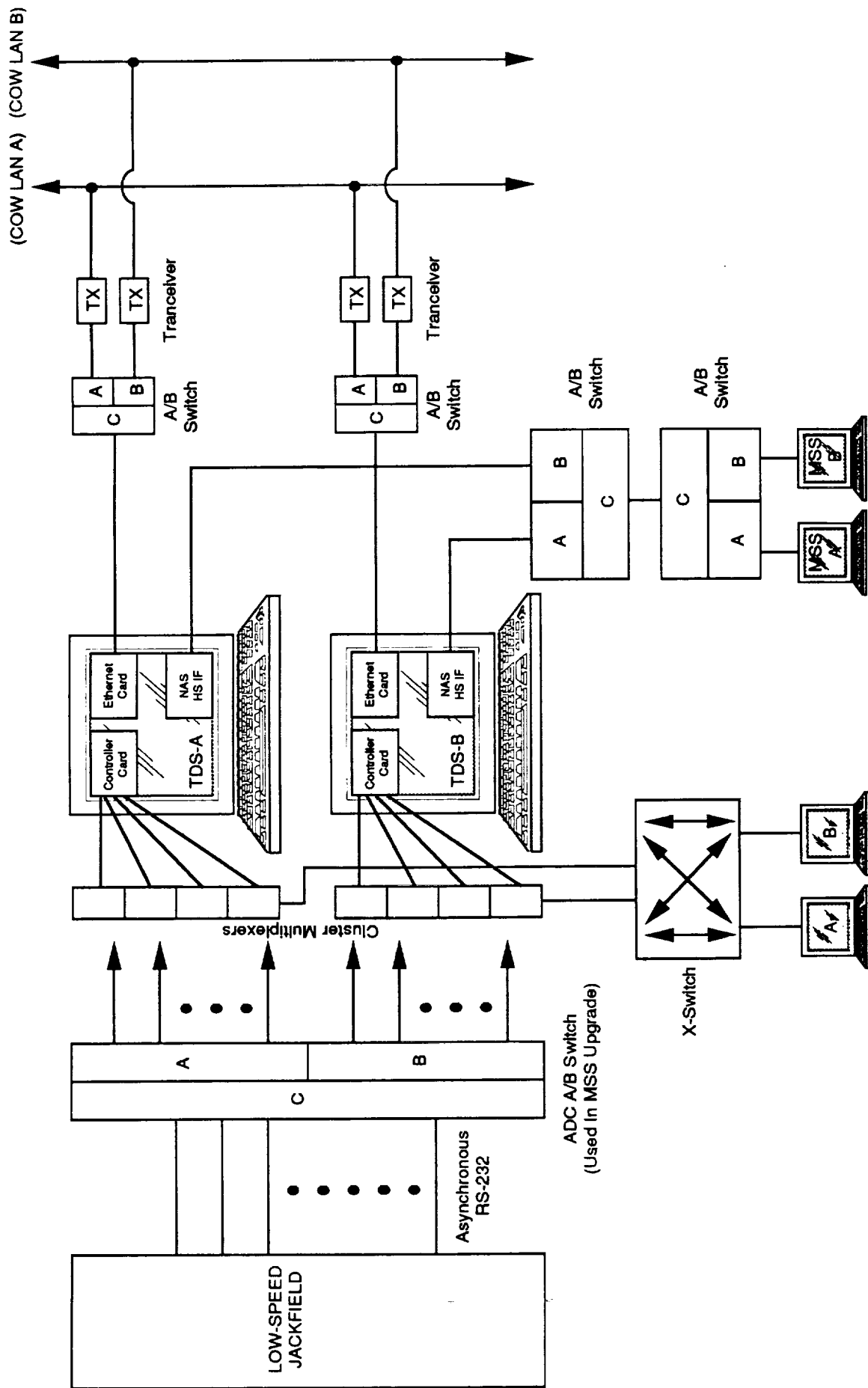
6.2.1.1 Network Configuration

The Nascom LSN consists of two systems: the TDS and the AMS. The TDS portion of the LSN is configured as shown in Figure 6-1. The AMS portion of the LSN is configured as shown in Figure 6-2. Because the TDS and the AMS are logically and physically distinct systems, they do not interface with each other.

6.2.1.2 TDS Network Elements

The LSN TDS Network consists of the following system elements: (1) GSFC TDS, (2) TDS circuits, and (3) TDS terminal equipment.

- a. GSFC TDS. There are two TDS computers (TDS-A and TDS-B) to provide both an online system and a redundant backup system. This ensures that the TDS will meet



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Figure 6-1. TDS Architecture

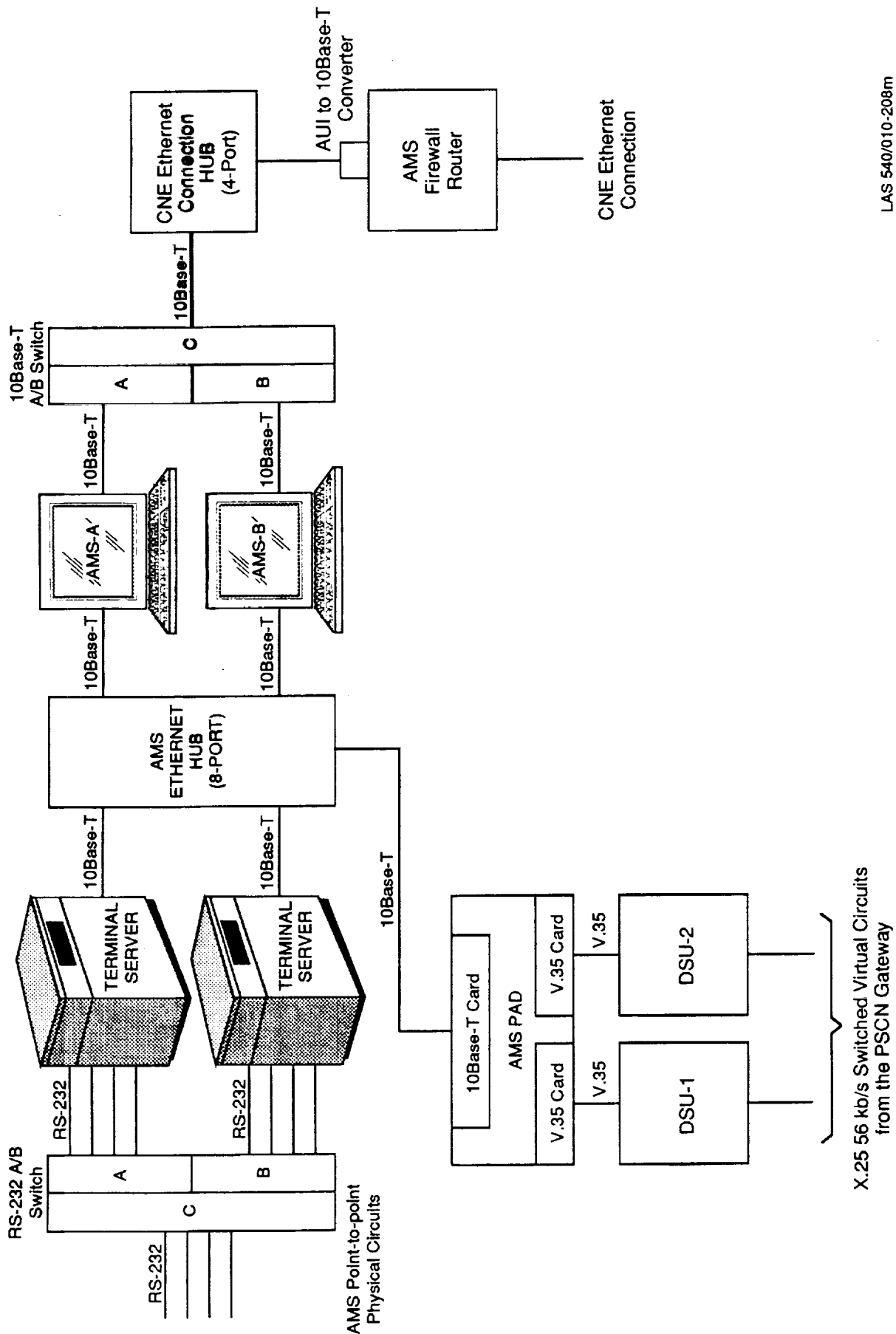


Figure 6-2. AMS Architecture

the established system availability requirements. The TDS, located in the Technical Control area (Room E-171, Bldg 14) of the Nascom Primary Switching Center, includes two MPX Model 6300, 80486/50MHz 19-inch, rack-mounted personal computers. The following cards are installed in each computer: Ethernet LAN Interface, High-Speed Nascom Transmit/Receive, Cluster Multiplexer Host Controller, SCSI Controller, Disk and I/O Controller, and Video Accelerator Card. Each computer has a 420 megabyte hard disk drive, a 3.5-inch diskette drive, and a 14-inch, rack-mounted monitor. Collocated in each rack are four Equinox cluster multiplexers. These multiplexers terminate all RS-232-C low-speed serial lines. Each multiplexer can support up to 24 circuits for a TDS system maximum of 96 ports. The TDS computers encapsulate low-speed tracking data messages within Nascom 4800-bit blocks for subsequent transmission to the high-speed port interfaces of the MSS (supporting rates of from 9.6 kb/s to 224 kb/s). These messages are relayed to destinations such as the Flight Dynamics Facility, the GRO Remote Terminal System (GRTS), and JSC. In the other direction, the TDS computers decapsulate 4800-bit blocks containing tracking data as they come from the high-speed MSS ports, transmitting them to their destinations as low-speed TDS messages.

TDS user communication terminal (port) to TDS user communication terminal message traffic is also possible. For switching purposes, the TDS computers again must utilize the high-speed switching capability of the MSS. Low-speed tracking data messages interface with the TDS via RS-232-C serial communication lines. Each low-speed tracking data message contains the TDS routing indicator(s) of the addressee(s). As the low-speed messages are encapsulated into 4800-bit Nascom blocks by the TDS computer, the TDS sets the MSS destination code to indicate that the TDS is the destination. The TDS then transmits the 4800-bit blocks to the MSS where the blocks are switched back to the TDS. The TDS then decapsulates the tracking-data messages and routes them to the addressed TDS user communication terminal(s) based on their LSN routing indicator(s).

- b. **TDS Circuits.** TDS circuits are generally operated as full-period circuits obtained as private line leased service, or derived through FDM or TDM subchannelization of other Nascom circuits. Temporary leased circuits are used when they meet the requirements of availability and reliability for mission operations.
- c. **TDS Terminal Equipment.** Users provide their own communications terminal equipment. An Intel (or equivalent) 80286 (or higher) processor is required for satisfactory interoperability with the TDS.

6.2.1.3 TDS Network Interfaces

The Nascom TDS has the capacity to interface with up to 94 locations. Included are the overseas Nascom Interface Facilities at the Deep Space Network's Communications Complexes (DSCCs) at Madrid, Spain and Canberra, Australia, as well as DoD tracking stations

and various other NASA facilities. The LSN interfaces are described in the following paragraphs:

- a. Several low-speed data links are also provided between the TDS and the Flight Dynamics Facility (FDF) Display Management System Front-end Processors for transfer of acquisition data, scheduling aids, and equator crossing data. This data is used for nonreal-time operations.
- b. Another low-speed system to high-speed TDS transfer interface has been arranged for the FDF Nascom Interface System (NIS) through which the Flight Dynamics Facility Computers HDS 8063s receive and record all GN metric data (high-speed and low-speed) and related information on a continuous, uninterrupted basis over the high-speed data lines. This interface is discussed in paragraph 14.5.6.1 and illustrated in Figure 14-12. These lines are operated at speeds of 224 kb/s (incoming to FDF) and 56 kb/s (outgoing from FDF). The real-time tracking data header codes (DD/JJ/GDCS) gain access to these interfaces. Acquisition data messages are transmitted to the network by the FDF via the 56 kb/s interface. These are distributed to the GN and other locations via the TDS.
- c. Additional high-speed transfer interfaces exist between the TDS and the FDF at 56/224 kb/s FDX, in which 4800-bit block encapsulated tracking data and acquisition data (ASCII format) messages are interchanged. These wideband interfaces are also discussed in paragraph 14.5.6.1 and illustrated in Figure 14-12.
- d. TDS-A and TDS-B are both directly cabled into the Combined Operator Workstations (COWs) A and B via port 7 of the TDS cluster multiplexers. As a space-saving alternative to an additional display terminal for TDS, the MSS COW console is used to present the TDS operator interface. Terminal emulation is provided in its own window labeled "TRACKING DATA SYSTEM." When not in use, the window can be minimized to an icon labeled "TDS." An A/B type X-switch has been installed to provide physical connectivity between the online TDS and the online COW, and between the offline TDS and the offline COW.
- e. TDS-A and TDS-B are both networked with the COW LAN A and COW LAN B via the LAN interface card in the TDS racks. This provides the TDS with all the resources available on the COW's LAN (such as print services). Typically, hardcopies are made of log files and fixed format reports such as detailed configuration listings.
- f. TDS-A and TDS-B are interfaced to MSU-A and MSU-B, respectively, via the High-Speed Nascom Transmit/Receive card. This interface provides the MSS-to-TDS and TDS-to-MSS traffic flow. Nascom 4800-bit blocks flow from the MSS into the TDS where they are decapsulated into their fundamental low-speed tracking data messages. Each low-speed tracking data message contains low-speed routing indicators. TDS routes messages to the low-speed tracking destination sites using the message routing indicators. Conversely, low-speed tracking data messages destined for a high-speed addressee enter the TDS via the cluster multiplexers. Each low-speed tracking data message contains its destinations' low-speed routing indi-

cators. As the low-speed messages are encapsulated into 4800-bit Nascom blocks, the TDS computer translates the destination LSN routing indicators to their corresponding MSS destination codes. The TDS then transmits the 4800-bit block to the MSS, where it is switched to the appropriate high-speed system destination port.

6.2.1.4 Obtaining Service

To obtain a circuit into the TDS, the requesting party follows the guidelines outlined in NASCOP Volume 1 and submits the request, in writing, to the Operations Management Branch Head, Code 542. The request will be considered and, if accepted, will be forwarded to the Communications Management Section for circuit activation.

6.2.1.5 AMS Network Elements

The LSN AMS Network consists of the following system elements:

- a. GSFC AMS.
 - b. X.25 circuits.
 - c. End users' personal computers.
1. GSFC AMS. Two Sun Model Sparc 10 Unix-based workstations comprise the core of the AMS. Each station has two external hard drives, a 4mm tape drive, a 150MB tape drive, a CD ROM drive, a 19-inch monitor, and a laser printer. Both work stations are located in Room N165, Building 3. An AMS interface rack housing two MSFC-provided DSUs, a Packet Assembler-Disassembler (PAD) with triple redundant power supplies, an 8-port Ethernet hub, a 4-port Ethernet hub, and a firewall router is also located in the same room.

The AMS computers retain administrative connectivity with all existing low-speed network elements, provide user IDs that match the current MSS message routing identifiers (e.g., GYSS), and a mechanism to create and modify message routing lists. Nascom assumes, that all AMS users have access to telephone communication lines, or access to Internet, and have access to sufficient computer equipment of the type required (workstation, Apple, IBM, and/or IBM clone) to connect to the AMS. The two AMS computers (AMS-A and AMS-B) are used to provide an online system and a redundant backup system. This ensures that the AMS will meet the established system availability requirements.
 2. X.25 Circuits. As shown in Figure 6-2, there are three options for connecting to the AMS: NASA Packet Switching System (NPSS), Internet (via GSFC's Center-wide Network Environment [CNE]), and dedicated circuits. Most users will access AMS via the NPSS, although the connectivity method may vary. Access to the NPSS is accomplished by direct dialing or connecting via an intermediary system such as GSFC's ROLM administrative telephone system switching equipment. An AMS User's Guide has been published listing the dial telephone numbers and describing in detail how to access the AMS. Refer to paragraph 6.2.1.7 for information on obtaining AMS service.
 3. End User Personal Computers. The AMS will shift a number of responsibilities from the MSS Operations Center to the end users. The minimum equipment

required by users needing AMS access via NPSS is a PC or Macintosh computer, modem, and communications software such as Procomm™ or White Knight™. Logon scripts to automate the logon sequence will be available for certain communication packages.

6.2.1.6 AMS Network Interfaces

The Nascom AMS has a design capability to support more than 256 asynchronous communication users; however, a design limitation precludes more than 40 simultaneous physical connections. The AMS interfaces are described in the following paragraphs:

- a. The MSFC-provided DSUs and PAD allow the NPSS connection to AMS via MSFC's Program Support Communications Network (PSCN) Gateway located in Room 55 of GSFC's Building 1. Two 56kb/s circuits are terminated by the DSUs. Both DSUs are interfaced with the PAD via V.35 communications cards. The PAD's Ethernet card then interfaces with both AMS computers.
- b. The AMS firewall router provides the physical connection to GSFC's Centerwide Network Environment (CNE), thereby letting Internet users send and receive electronic mail messages via the AMS. The router is set up as a firewall, allowing only Simple Mail Transfer Protocol (SMTP) and Point-of-Presence (POP) mail exchange connections. No login access to the AMS is permitted from Internet. The router interfaces one AMS computer at a time through an A/B switch. In the event of an AMS computer failure, the A/B switch is manually operated to provide access to the standby system.
- c. Terminal servers (mounted in the TDS equipment racks to conserve space) provide the dedicated connection to the AMS. Asynchronous serial lines are terminated on these servers. The servers convert the serial lines to Ethernet, where they are hubbed to the AMS computers. This service is limited to users who have a security risk when accessing the AMS in the previous ways, and must be approved by GSFC management.

6.2.1.7 Obtaining Service

To obtain an account on the AMS, the requesting party follows the guidelines outlined in NASCOP Volume I, fills out the NASCOM AMS Application Form, and submits the form to the Operations Management Branch Head, Code 542. The request will be considered and, if accepted, will be forwarded to the Communications Management Section for account activation. Forms are available by calling the AMS Support Desk at (410) 286-4700.

6.2.2 GSFC LSN Technical Control Facility

The technical control arrangement provided for the System is described in the following paragraphs.

- a. The government-owned technical control facility at GSFC includes patch bays for access to all circuits and equipment for special circuit configuration, circuit monitor-

ing and testing, and circuit and equipment restoration-replacement. Also included are a Signal Monitoring System for indicating circuit activity and status.

- b. Similar interface and control facilities are provided at Nascom Interface Facilities at Madrid and Canberra. Patch and test facilities are also provided at the GN sites and other NIFs in the network.



Section 7. Voice System

7.1 General

7.1.1 System Definition

The voice system, as an integral part of the Nascom Network, can be defined as a system of full-period leased or derived four-wire voice circuits (nominal 3-kHz bands), many of which interconnect GSFC to all permanent NASA tracking and data acquisition-sites and various other terminal points in the Nascom Network. All Nascom voice circuits which radiate from GSFC have an interface with the VSS. Many other voice circuits are provided by Nascom directly between points (e.g., JSC and KSC) as independent voice system elements.

7.1.2 Voice System Capabilities

The voice system can provide the following capabilities:

- a. Switch and conference four-wire voice channels at GSFC or other tributary switching centers.
- b. Interconnect local two-wire voice channels at the switching centers.
- c. Interconnect or reterminate alternate voice/facsimile and alternate voice/data channels.
- d. Route voice circuits either directly to the GSFC VSS or through the Nascom interface facilities where conferencing, monitoring, and test facilities are available.
- e. Interconnect other points as needed to meet NASA mission operational needs with four-wire voice circuits.

7.2 Nascom Voice System Network

7.2.1 Network Description

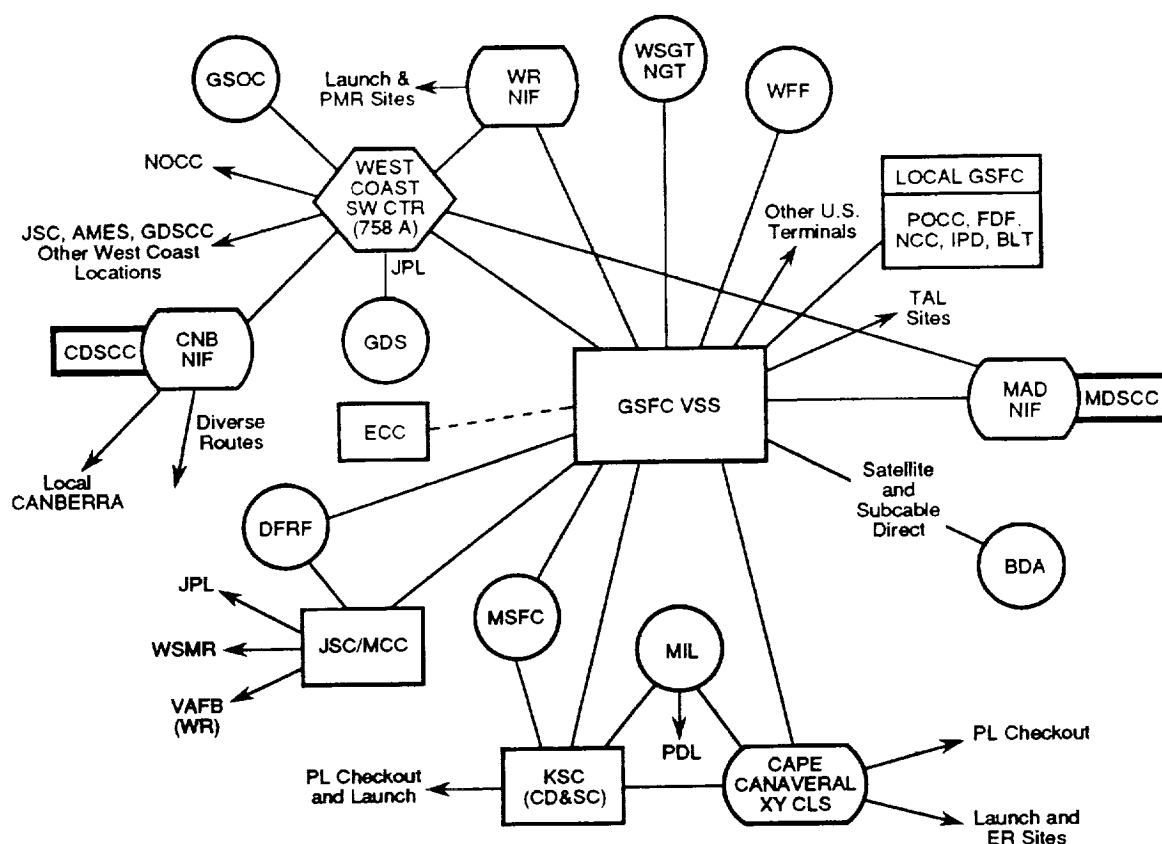
7.2.1.1 Network Configuration

The Nascom voice network configuration is illustrated in Figure 7-1. The GSFC VSS is shown as a principal hub of the network, but there are individual voice circuits or groups of circuits which are not VSS switched that are either routed through the Nascom intermediate switching center (WCSC) or directly between other points with no GSFC VSS connectivity.

7.2.1.2 Network Elements

The Nascom voice network primarily consists of the following elements:

- a. The VSS system at GSFC.
- b. Remote switching and technical control facilities at tributary switching centers.
- c. Full-period, leased, four-wire, voice-only and alternate voice/data circuits.
- d. Voice technical control facility at GSFC.



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Figure 7-1. Nascom Voice Network Configuration-Voice/Data Channels

- e. Derived four-wire secure and nonsecure voice circuits in GFE wideband digital multiplexing systems.
- f. User four-wire voice terminating equipment.
- g. Emergency Control Center (ECC) at GSFC.

7.2.1.3 Network Interfaces

The Nascom voice system interfaces to a range of NASA facilities and user locations to which it provides operational support for all of the NASA manned flight, scientific satellite, and deep space projects. The users interface the four-wire voice system locally through their own compatible voice terminal equipment, or through Nascom-provided terminal equipment. The NASA facilities are NASA network tracking stations, NASA network control centers, mission control centers, and various other NASA, DoD, and cooperating agency locations. By cooperative arrangement with NASA's International Partner Agencies (IPAs), the Nascom voice system interfaces with their designated facilities as well.

7.2.2 Role of the VSS

The four-wire VSS uses digital switching technology. The switch is designed with consideration for a limited interconnect capability into the emerging Integrated Services Digital Network (ISDN). Other VSS features are as follows:

- a. The system is expandable in a modular fashion. It is equipped with an initial capability to terminate 2048 four-wire lines with growth capability to 4000 four-wire lines. This latter capability was delivered with the common equipment (i.e., computers, peripherals, master consoles, etc.) having full system capability built in; other equipment such as the switching and conferencing equipment are modularly expandable. The system has no single point of failure within the switching matrix and is fully redundant within the control systems.
- b. The four-wire VSS provides switching, conferencing, and monitoring capability for 2048 line circuits, including 10 two-wire dial lines. The remaining 2038 circuits are four-wire private line, long-haul or local circuits, with manual ringdown signaling. The two-wire dial line circuits are equipped with echo cancelers. An analog frame and analog jackfield are provided for all 2048 circuits. (An additional 1952 analog jackfield and distribution frame appearances are also in place to support VSS expansion to a total of 4000 ports.) The four-wire VSS is controlled by two Master Control Consoles (MCC) that operate in parallel. In addition, four Real-Time Consoles (RTC) are provided that are configurable from the MCCs. Once configured, the RTCs, which are pushbutton operated, can quickly switch, conference, and monitor the selected circuits in a real-time operational scenario. Printers for status information are also provided by the system. Preplanned conferences can be stored in MCC memory and executed when required.

7.2.3 Voice Circuit Performance

7.2.3.1 Circuit Performance Requirements

Although there are no specified circuit parameters for voice circuits, Nascom has subscribed to and uses commonly accepted standard telephone operating procedures established by international agreements and practices. These procedures are detailed in the appropriate section of NASCOP. Circuit testing objectives are described in detail in Appendix C.

7.2.3.2 Signaling Standard

Signaling used on the Nascom Network is a mixture of 1000/20 Hz and 2600 Hz Single Frequency (SF) in the U.S., and 1000/20 Hz on all trunks and circuits used in the overseas network.

7.2.4 GSFC Voice Technical Control System

7.2.4.1 Voice Control Configuration

Figure 7-2 illustrates the Nascom voice control facility configuration at GSFC.

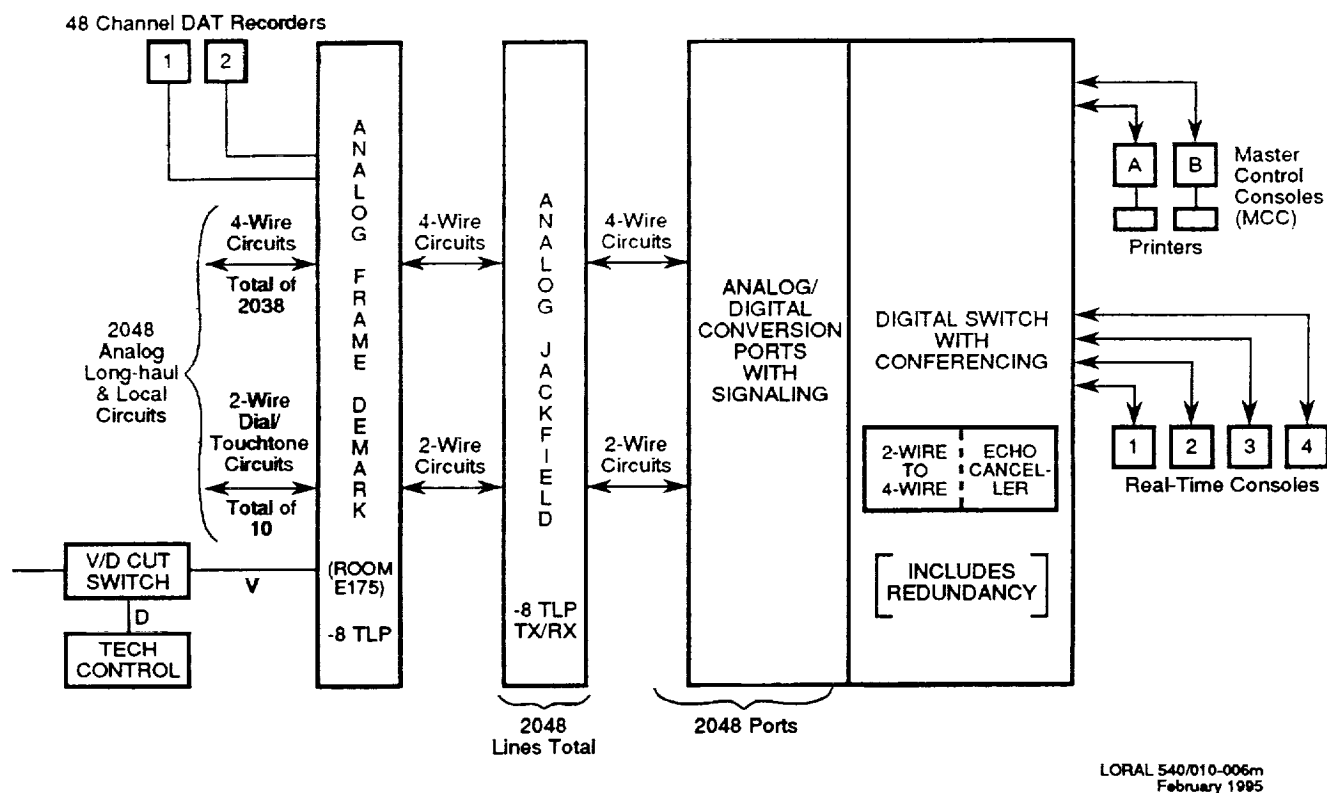


Figure 7-2. Four-wire Voice Switching System Configuration

7.2.4.2 Test and Measurement Facility

The voice control facility includes extensive jackfield and test equipment for testing, monitoring, and restoring voice channels. Multichannel tape recorders are provided to record selected voice channels. The tape recorders are used to analyze traffic loading, to determine channel quality during a mission, and for historical purposes. All jackfields and test equipment are government owned and all VSS switched voice circuits have jack appearances.

7.2.5 Alternate Voice/Data Circuits

7.2.5.1 Data Use of AVD Circuits

Leased AVD refers to circuits which are tariffed and conditioned by the common carrier to allow the shared use of the voice bandwidth circuit for transmission of analog voice or serial high-speed digital data. Alternating use of AVD circuits between the voice and data modes requires end-to-end coordination of users for switching data terminals and modems in and out of the circuit, which is normally in the voice mode. Circuits which are normally used for voice transmission and which are terminated on the VSS and which have been properly tariffed and conditioned by the common carriers for the data option, can be conveniently

switched by VSS for data or voice communications. This makes data transmissions possible between all points (via VSS) that are equipped with compatible data terminal equipment.

7.2.5.2 AVD Circuit Control Arrangement

All voice-only or AVD circuits are first routed through the voice control jackfields before extension into the VSS. However, the voice/ data circuits are also routed through a mode switch (voice/data cut switch) arrangement and are normally positioned in either a voice or digital data mode depending on normal use. In digital data mode, these voice/data circuits bypass VSS and are routed to the Nascom data technical control facility where high-speed digital data circuits are normally switched, tested, and monitored.

7.2.5.3

With the conversion of Nascom domestic voice circuitry to a single carrier by the GSA FTS2000 Network A vendor (refer to Section 5 for a more detailed description of FTS2000 and Nascom-2000), AVD circuits are supportable only to those few domestic locations not serviced by FTS2000/Nascom-2000. The NOCS (refer to section 5) again separates voice and data onto separate multiplexer channels for the overseas and IPA locations interfaced by NOCS. Therefore, fewer and fewer AVD circuits are supported by Nascom.

7.2.6 Nascom Voice System Network Responsibility

7.2.6.1 Continental U.S. Locations

The Nascom Network responsibility for long-haul voice lines terminates at the distribution frame of all NASA Network stations. The respective DSN and STDN organizations (sometimes through the local carriers involved) provide four-wire termination equipment for circuit termination as part of operational systems at the remote tracking sites. At other user terminal points of the Nascom Network, generally in the U.S., Nascom provides only basic terminal equipment under lease arrangement.

7.2.6.2 Overseas Locations

At overseas user terminal locations, Nascom will provide four-wire terminating equipment where neither the terminal station nor the carrier can provide it. These terminations generally consist of one or more push-to-talk handsets with full line signaling capability and may be arranged in various configurations to meet the particular requirements. In all instances, bridging equipment is included for multiple stations. Multiple line arrangements with patching facilities for engineering reconfigurations, monitor speakers, etc., can also be provided. These terminals are often referred to as line terminal units. In a few instances the voice terminal is included in a combination voice/data terminal configuration incorporating data terminal and test equipment with alternate voice and data usage capability. In these cases the terminals are often referred to as Nascom voice/data terminals.

7.3 Nascom Voice System Distribution

7.3.1 Review of Voice System Distribution

Voice circuits are now acquired using one of three basic approaches: (1) Nascom-2000 circuitry, (2) NOCS, and (3) individual circuits to those locations not serviced by Nas-

com-2000 or NOCS, and leased from domestic or foreign common carriers. There are approximately 1507 voice circuits that terminate on the VSS. This number includes both external GSFC long and short-haul circuits and local on-site circuits.

7.3.2 VSS-switched Circuit Distribution System

7.3.2.1 System Description

An overview of the distribution configuration of the VSS-switched voice system is shown in Figure 7-1. Voice circuits originating in GSFC voice control, going to the tracking stations are routed either directly or through a Nascom interface facility. These circuits-to-network tracking stations are routed through reliable common carrier landlines, undersea cables, and communication satellites. Geographic diversity is employed where available and feasible, particularly on trunks between switching centers and NIFs to enhance reliability of voice communications to individual sites, and in the voice network generally. Section 13 refers to this geographic diversity.

7.3.2.2 Nascom Operational Management Responsibility

Nascom is fully responsible for the establishment, operations and maintenance of all voice circuits terminating on the GSFC VSS facility. Additionally, Nascom provides the requirements, engineering analysis, and procurement for new services. When the voice circuits become operational, Nascom assumes the responsibility for testing and monitoring of the voice circuits through the voice control facility, and for attending the circuits terminated on the consoles. The responsibility also includes trouble reporting, interface with the common carriers for fault isolation and circuit restoration; it extends to circuit trouble recordkeeping, utilization logging, circuit availability analysis, and lease accounting for reconciliation with the carriers.

7.3.3 Nascom-2000 Circuit Distributions

Nascom-2000 utilizes ACCULINK Model 740 programmable, time division, point-to-point, T1 multiplexers, and ACCULINK Model 745 switching multiplexers to accomplish transmission of voice, and both synchronous and asynchronous analog and digital data. Currently, GSFC has seven Model 745s, and 42 Model 740 multiplexers installed. Refer to Section 5 for a description of Nascom-2000.

Table 7-1 lists the number of VSS circuits between GSFC and remote sites. The first column shows the T1s installed from GSFC to the various sites. All circuits listed terminate on the VSS. Each T1 multiplexer has bandwidth reserved for voice and data. The table shows the bandwidth reserved and assigned for voice circuits only.

7.3.4 Non-VSS Circuit Distributions

7.3.4.1 Remote Site Nascom-2000 Network

Table 7-2 lists the major groupings of Nascom-2000 circuits that do not terminate in the GSFC VSS or Voice Technical Control Facility, but are instead routed directly between the

indicated locations. The Nascom-2000 T1 spans that are installed between the site pairs carry both voice and data traffic. Not shown in the table are the FTS2000 Network A voice order wire lines to those locations having Model 745 (T1) switching multiplexers. Column one of the table lists each site pair. The remaining columns reflect the same information as their corresponding columns in Table 7-1.

Table 7-1. VSS Circuits via Nascom-2000 Transport Services

| Goddard to | No. of T1s | No. of Channels Reserved for Voice Circuits and Line Rates | No. of Channels Assigned Voice Circuits and Line Rates |
|---|-------------------|---|---|
| Ames Research Center | 1 | 16 @ 64kb/s | 7 @ 64kb/s |
| University of California, Berkeley | 1 | 16 @ 64kb/s | None |
| Cambridge, MA | 1 | 16 @ 64kb/s | 2 @ 64kb/s |
| Dryden Flight Research Facility | 2 | 32 @ 64kb/s | 13 @ 64kb/s |
| East Windsor, NJ (Martin Marietta Corporation) | 1 | 16 @ 64kb/s | 1 @ 64kb/s |
| Johnson Space Center | 5 | 80 @ 64kb/s | 52 @ 64kb/s |
| Jet Propulsion Laboratory | 4 | 64 @ 64kb/s | 28 @ 64kb/s |
| NASA Headquarters | 2 | 32 @ 64kb/s | 20 @ 64kb/s |
| Vandenberg Air Force Base | 2 | 32 @ 64kb/s | 21 @ 64kb/s |
| White Sands Complex | 2 | 32 @ 64kb/s | 29 @ 64kb/s |
| Kennedy Space Center | 6 | 96 @ 64kb/s | 47 @ 64kb/s |
| Johns Hopkins University | 1 | 16 @ 64kb/s | 6 @ 64kb/s |
| Marshall Space Flight Center | 2 | 32 @ 64kb/s | 17 @ 64kb/s |
| Lewis Research Center | 2 | 32 @ 64kb/s | 24 @ 64kb/s |
| Wallops Flight Facility | 4 | 58 @ 64kb/s | 10 @ 64kb/s |
| Southbury, CO (Inmarsat) | 1 | 17 @ 64kb/s | 6 @ 64kb/s |
| Onizuka Air Force Base | 1 | 16 @ 64kb/s | 6 @ 64kb/s |
| TRW, Los Angeles | 1 | 16 @ 64kb/s | 9 @ 64kb/s |
| Poker Flat, AK | 1 | 16 @ 64kb/s | 2 @ 64kb/s |
| Langley Research Center | 1 | 16 @ 64kb/s | None |

7.3.4.2 Nascom Responsibility

The responsibilities of Nascom for the non-GSFC terminating voice circuit distributions are generally the same as in paragraph 7.3.2.2 in the areas of implementation and administration. However, ongoing operational responsibilities such as maintenance, trouble reporting, fault isolation, restoration, and interface with the carriers are delegated to the sites. Nascom provides support where elevation of problems with the common carriers may be needed. Nascom submits daily communications reports for the circuits and communication terminals.

Table 7-2. Non-VSS-Switched Voice System Circuits

| From/To | No. of T1s | No. of Channels Reserved for Voice Circuits and Line Rates | No. of Channels Assigned Voice Circuits and Line Rates |
|-----------|------------|--|--|
| ARC/JPL | 1 | 16 @ 64kb/s | 3 @ 64kb/s |
| ARC/BERK | 1 | 16 @ 64kb/s | None |
| BERK/ARC | 1 | 16 @ 64kb/s | None |
| DFRF/LaRC | 1 | 16 @ 64kb/s | 8 @ 64kb/s |
| DFRF/JSC | 2 | 32 @ 64kb/s | 24 @ 64kb/s |
| JPL/JSC | 1 | 16 @ 64kb/s | 12 @ 64kb/s |
| JPL/LITT | 1 | 16 @ 64kb/s | 4 @ 64kb/s |
| JPL/KSC | 1 | 16 @ 64kb/s | None |
| JPL/GDS | 1 | None | None |
| JSC/KSC | 5 | 99 @ 64kb/s | 83 @ 64kb/s |
| JSC/MSFC | 6 | 96 @ 64kb/s | 71 @ 64kb/s |
| JSC/DFRF | 1 | 16 @ 64kb/s | 12 @ 64kb/s |
| KSC/MSFC | 3 | 52 @ 64kb/s | 28 @ 64kb/s |

7.3.4.3 JSC/Nascom Voice System Arrangement

JSC terminates all Nascom-provided 4-wire circuits on the Digital Voice Intercom System (DVIS), a digital electronic switching and conferencing system, located in Building 30 at JSC. The JSC/MCC assumes a high degree of operational responsibility with respect to all non-GSFC Nascom-provided operational voice lines terminating in the DVIS, in connection with the Shuttle program. Enumeration, routing, termination, and functionality of all Nascom-provided voice lines terminating at JSC is provided in the publication, "Longlines Communications Guide," prepared by JSC/Allied Signal Technical Service.

7.3.4.4 Nascom-JPL Voice Circuit Arrangement

Voice/data technical control facilities are provided at JPL to through-connect voice circuits from other NASA centers and sites in the west coast area to GSFC, as well as for local terminal distribution, facility control, test, and restoration operations. JPL assumes operational responsibility for these remote Nascom-provided circuits.

7.3.4.5 WR AVD Circuit Arrangement

The AVD circuits provided at WR, Vandenberg Air Force Base (AFB), CA, are described in the following paragraphs.

- a. System Description. All Nascom alternate voice/data circuits at VAFB are normally configured for voice. When a circuit is data-configured, the Data Switching Center (DSC) activates that circuit's cut key, which causes the circuit to bypass the voice

switch and terminate on the digital switch in Building 7000. All NASA-associated modems at Vandenberg are located within the DSC, Building 7000. The data switch is manned 24 hours per day, 7 days per week. During special support periods, a communications order wire is manned linking WR/JSC/ GSFC. The data switch is a completely automated, computer controlled, fully redundant center with a capability of switching any of its inputs to any of its outputs. Primary and backup circuits are collocated on the switch and are assigned identical inputs/outputs.

- b. Nascom Support Arrangement. Test equipment at the switch is located to the rear of the facility, adjacent to the audio patch panel. This provides the operator with the capability to perform long-line (circuit) checks, including C-2 (equalization and delay) and D-1 (harmonic distortion and signal-to-noise ratio) parameters. The operator may also perform modem checks on any of the assigned modems with both the analog and digital inputs/outputs appearing within the data switch. Currently, all Nascom data into and out of the Vandenberg complex is routed via various coaxial and microwave systems.

7.3.5 Space Shuttle/Voice Circuit Configurations

Extensive voice circuit support configurations are provided by Nascom for STS operations. Networks are provided for the following support operations:

- a. Air-to-Ground (A-G) voice extension/distribution.
- b. Tracking operations coordination.
- c. Launch and landing support coordination
- d. General site and message coordination.
- e. Video operations coordination.
- f. Range safety coordination.
- g. Scheduling coordination.
- h. Contingency landing coordination.

A description of the networks which provide this support is contained in Section 14.

7.4 Four-wire Voice Circuit Terminating Package

7.4.1 Background

Nascom currently supports numerous remote locations (e.g. spacecraft contractors, compatibility test sites, laboratories, principal investigator locations, etc.) with operational voice and data service over four-wire VSS switched lines. These locations are provided with circuit terminating arrangements utilizing now out-dated 1000/20 cycle signaling and telephone instruments, usually via the local telephone company. Also, Nascom is frequently faced with new location requirements and with short-notice requirements to extend voice services to unexpected or unplanned new user locations. These requirements are sometimes difficult to meet in a timely manner.

7.4.2 Concept

Nascom now has on the shelf, ready for issue, a quantity of four-wire voice Circuit Terminating Packages (CTP). These CTPs enable deploying users to take with them or remote users to order from Nascom, a user installable hardware package requiring only a power source and a four-wire line over which a voice circuit can be established back to the Nascom VSS (or to some other designated location). In addition, there is a standard package which allows up to five stations to be conferenced to the line using a 6-way conference bridge. By adding a second bridge to the package, up to nine stations can be accommodated. Power supplies for 50/60 Hz and 110/230 volts, as required by the end location, are part of the CTP. For locations where the power source physical interfaces are unique to that location, e.g. Germany's CEKON sockets, plugs or adapters may have to be purchased by the user and fitted to the power cord at the remote location. Users may also have to supply 4-wire telephone cable where distances from the 4-wire bridges to the stations exceed the length of cord supplied by Nascom.

NOTE

The Nascom-supplied, 6-way bridges operate only on 110 volts, 60 Hz power.

7.4.3 Implementation Activity

Nascom has selected the PADS Development Labs, Inc. Series 100 Voice Terminal as the basis for the circuit termination package. To complete the package, Nascom supplies appropriate Wescom bridge(s), power supply, power cord, 8-wire telephone cords with RJ 45 connectors on each end, terminal blocks, and installation instructions. CTPs have been deployed to Huntsville, AL and Tokyo, Japan. CTPs with 6-way bridges have also been shipped to Moron and Zaragoza, Spain.

7.5 Voice Distribution System (VDS)

7.5.1 Background Information

To provide GSFC POCCs and other local users with a campus wide operational voice distribution capability that is reliable, flexible, and permits a high degree of user interaction with the system for control of each user's voice circuit/loop allocations, Nascom contracted with COMPUNETICS, Inc. to furnish and install a voice switching system to meet the GSFC requirements for on-campus operational voice switching and distribution. Two significant requirements met by the VDS are the incorporation of digital switching technology and compliance with applicable ISDN standards for 2B + D service.

The VDS system was installed in 1992 to provide operational voice communications between POCCs for scheduling, command and control, and element coordination. Users were cutover from the old voice intercom system to the VDS for operational support during the first half of FY 93. Acceptance testing was completed in October 1993.

7.5.2 System Hardware and Configuration

The VDS switch is installed in Building 14 and comprises 12 equipment bays allocated as follows:

- a. 1 Switch Control Bay.
- b. 4 ISDN Bays.
- c. 1 Analog Line Interface Bay (2 & 4 Wire).
- d. 1 Input Switch Bay.
- e. 2 Conference Bays.
- f. 1 Output Switch Bay.
- g. 2 TDM/OSS Bays.

Also located in Building 14 is the Maintenance and Administration Position (MAP) for the VDS. The MAP resides on redundant PCs. The VDS UPS is colocated in Building 3 with the VSS UPS.

Power for the VDS bays is supplied as 208 Vac single phase from two 208 Vac inverters. The two MAPs are supplied 120 Vac single phase from one 120 Vac inverter. All three inverters are fed by four banks of 48 Vdc lead-calcium batteries. These battery banks are supplied by six identical rectifier units which in turn are fed by 208 Vac three phase commercial power. The batteries also provide 48 Vdc power to breaker panels located in the telephone closets where it is distributed to the individual instruments. The batteries are capable of providing 4 hours of backup power at full load without recharge. A power monitoring system displays voltage and current levels and alarm conditions.

Switch architecture supports path verification and an availability number that should approach 100%. Each circuit through the switch between any two ports is a physical path; TDM techniques whereby multiple ports time share a path are not employed. The system controller is triple redundant and performs Input/Output port path verification prior to establishing a connection; idle paths are periodically checked, and if a fault is found, that path is disabled and alarmed/reported at the MAP. Figure 7-3 depicts a functional representation of the VDS.

Allocated to users across the Goddard campus are 600 ISDN Instruments and 6 POCC Utilization Management Positions (PUMPs) the latter of which enable the POCC managers to prepare, store, and control the configuration of their allocated circuits and loops to their instruments. Table 7-3 summarizes the VDS system capability.

7.5.3 VDS Instrument Features

There are four different types of instruments that the VDS offers to its users: Keyset (KS), Mechanical Keyset (MKI) and Single Line Instrument (SLI) and Digital Keyset (DKS). The following paragraphs describe each instrument type.

7.5.3.1 Keysets (KS)

The KS provides a 28 key electroluminescent touchscreen, 12 elastomeric standard dial telephone keys, a 1.5 watt speaker and handset with a push-to-talk feature mounted on a 7 x

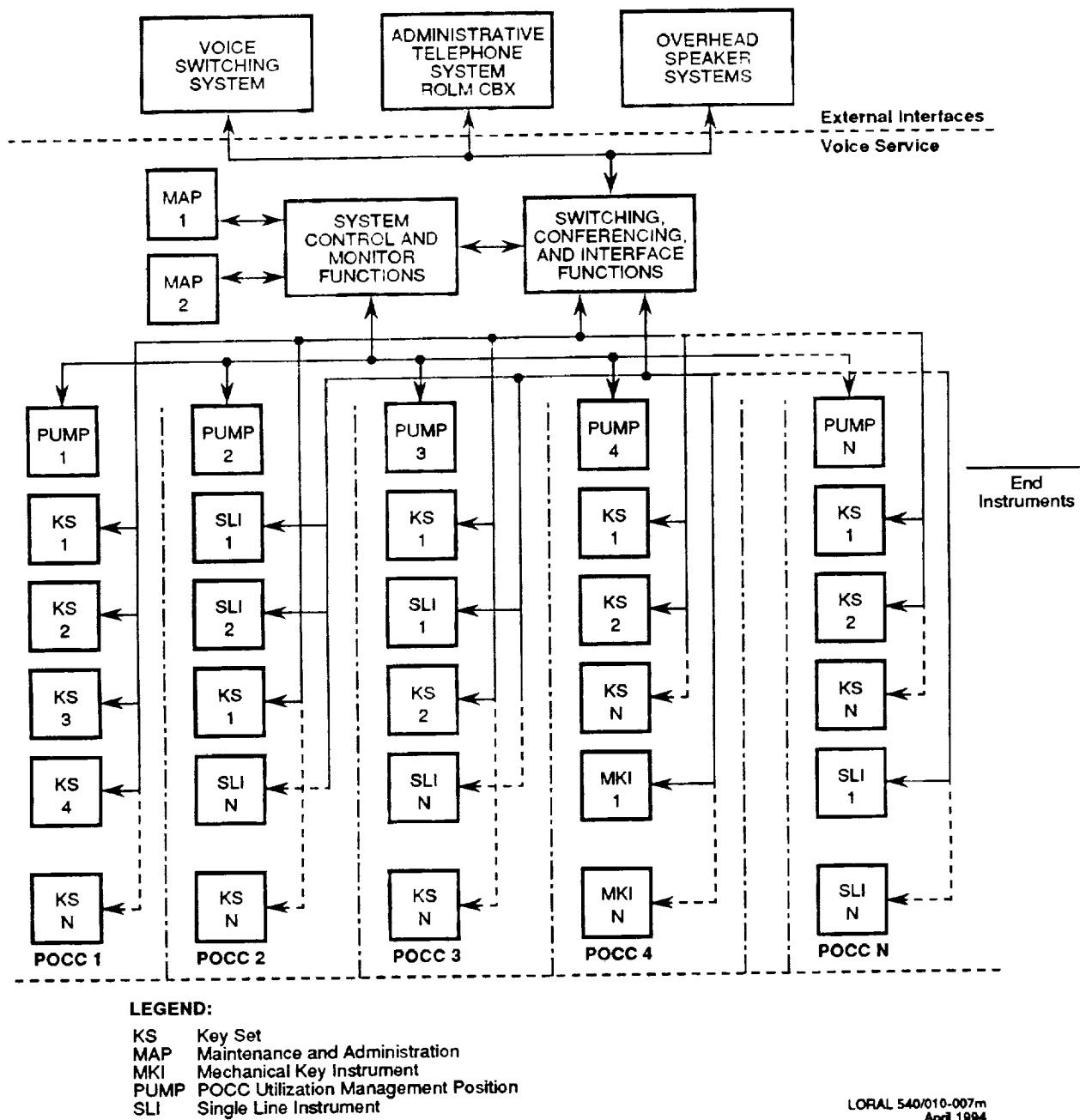


Figure 7-3. Voice Distribution System Operational Block Diagram

19 inch EIA standard panel. Electronically, the KS stores 10 touchscreen pages, each page with 28 keys, for a total capacity of 280 circuits. The KS supports local SCAMA lines, CCLs, CBX, VDL and DI circuits. With the exception of the DI circuit which is talk/listen only, the KS may terminate these circuits in one of three selectable modes: talk/listen, loudspeaker monitor, handset monitor. Additionally, the KS is equipped with a HOLD and Active Circuit Indication features.

7.5.3.2 Mechanical Keyset (MKI)

The MKI provides a desk-mounted (with reversible base for wall mounting) instrument equipped with hookswitch, elastomeric keypad, and push-to-talk handset. Electronically, the MKI has a page selector capability of two pages at ten circuits per page for a total capacity of 20 circuits. The MKI terminates the same kinds of circuits as the KS and in the same modes. Additionally, the MKI is equipped with HOLD and SIGNAL button features.

Table 7-3. Summary of VDS Capabilities

| Communication Service Type | Ports Installed | Maximum No. Ports | Ports Assigned |
|--|-----------------|-------------------|----------------|
| Integrated Services Digital Network (ISDN) | 1280 | 1280 | 611 |
| Four-Wire (4W) | 832 | 1152 | 364 |
| Two-Wire (2W) | 384 | 384 | 177 |
| Overhead Speaker (OSS) | 960 | 960 | 50 |

7.5.3.3 Single Line Instrument (SLI)

The SLI provides a desk-mounted (with reversible base for wall mounting) instrument equipped with hookswitch, elastomeric keypad, and push-to-talk handset. Electronically, the SLI can terminate only one circuit at a time, and that circuit may be terminated in the same modes as the MKI or KS. The SLI also has Signal Button, Hold Button, and Busy Lamp features.

7.5.3.4 Digital Keyset (DKS)

The DKS provides a desk-mounted (with reversible base for wall mounting) instrument equipped with a hookswitch, elastomeric keypad, and push-to-talk handset. Electronically, the DKS has a page selector capability of five pages at 18 circuits per page for a total capacity of 90 circuits. The DKS supports local SCAMA lines, CCLs, CBX, VDL and DI circuits. These circuits can be terminated in one of three selectable modes: talk/listen, loudspeaker monitor, and handset monitor. Additionally, the DKS is equipped with Hold and Signal keys, and an Active Circuit Indication feature.

7.5.4 MAP Functions

There are two MAP positions provided with the VDS. Both MAPs are online and function redundantly. The MAP positions are comprised of standard IBM PC-AT equivalent personal

computers equipped with a color monitor and a 3-1/2" high density floppy disk drive. The MAP performs the following functions:

- a. VDS system data base maintenance.
- b. POCC Utilization Management Position (PUMP) emulation.
- c. Report generation.
- d. User account maintenance.
- e. The MAP also comes with file transfer utilities.

7.5.5 Pump Functions

Sixteen PUMPs are provided with the system capable of incrementing that number up to a total of 25. The PUMP platform is the same as that of the MAP. Each PUMP has the capability to perform the following POCC/user functions:

- a. Configure the resources (circuits, loops, dial accesses), as allocated to the POCC by the master data base resident in the MAP, among the various instruments installed in the POCC or user facility.
- b. Save/restore individual instrument configurations.
- c. Save/restore the master POCC configuration(s).
- d. Download background configuration sets to instruments.
- e. Activate background configuration sets on instruments.
- f. Generate reports.

7.5.6 Supported Nascom and User Elements

VDS instruments serve the following Nascom and user elements on GSFC:

- a. GSFC Technical Control/Comm Manager.
- b. GSFC Voice Control.
- c. Multi-Satellite Operation Control Center (MSOCC). All POCCs associated with the MSOCC are currently supported by all three types of VDS instruments. POCC managers determine the type(s) of instrument(s) best suited to their needs.
- d. Other POCCs. The Hubble Space Telescope (HST) POCC is equipped with all three types of VDS instruments. The Extreme Ultraviolet Explorer (EUVE) is currently equipped with KS instruments.
- e. Flight Dynamics Facility (FDF). The FDF is currently equipped with all three types of VDS instruments.
- f. Network Control Center. Fourteen instrument terminal blocks and 14 instruments were provided to the NCC. The NCC is responsible for connection to the VDS switch.

- g. Principal Investigators. The Information Processing Division (IPD), Building 23, is equipped with all three types of VDS instruments installed in the POCC Data Capture Rooms.
- h. Other Facilities. Buildings 1, 5, 6, 7, 10, 21, 25, 29, and 88 are equipped with all three types of VDS instruments.

7.6 Nascom Policy on Digital Voice Transmission

7.6.1 Background

Over the years Nascom has developed an operational voice network renowned for the clarity of the delivered voice signal as heard in the listener's headset. Operationally, a principle feature of this high quality service is the near total absence of any "say again . . ." being heard on the net.

In 1991, Nascom conducted extensive testing of Commercial-Off-The-Shelf (COTS) multiplexers in preparation for a possible move of Nascom's voice service to the GSA FTS2000 contract. Various algorithms (PCM, ADPCM, and proprietary) with A/D encoding for transmission at line rates from 64 kb/s to 9.6 kb/s were employed. A key result of this test was that participants judged the voice quality to be less than that normally provided over a standard Nascom voice circuit when listening to a voice signal encoded for transmission at a line rate less than 32 kb/s. As a result of this testing, the following policy has been established.

7.6.2 Policy

Nascom is inclined not to subject its network voice quality standards to possible degradation attributable to voice signals that have been digitally encoded for transmission at a line rate less than 32 kb/s anywhere in their transmission path. Accordingly, it is Nascom policy that voice signals which are to be conferenced by Nascom systems should not have been digitally encoded for transmission at line rates less than 32 kb/s anywhere in their transmission path. Projects, programs, or operations which plan to interface to a Nascom voice conference loop any voice signal which has been digitally encoded for transmission at a line rate less than 32 kb/s anywhere in its path should advise Nascom of all pertinent details as soon as such a plan becomes known. This advisory will enable Nascom to determine how best to deal with the proposed connection and to be ready with such measures as may be necessary to maintain the quality of the conference, inclusive of terminating service to the noncompliant interface.



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000

Section 8. High-Speed Data System

8.1 General

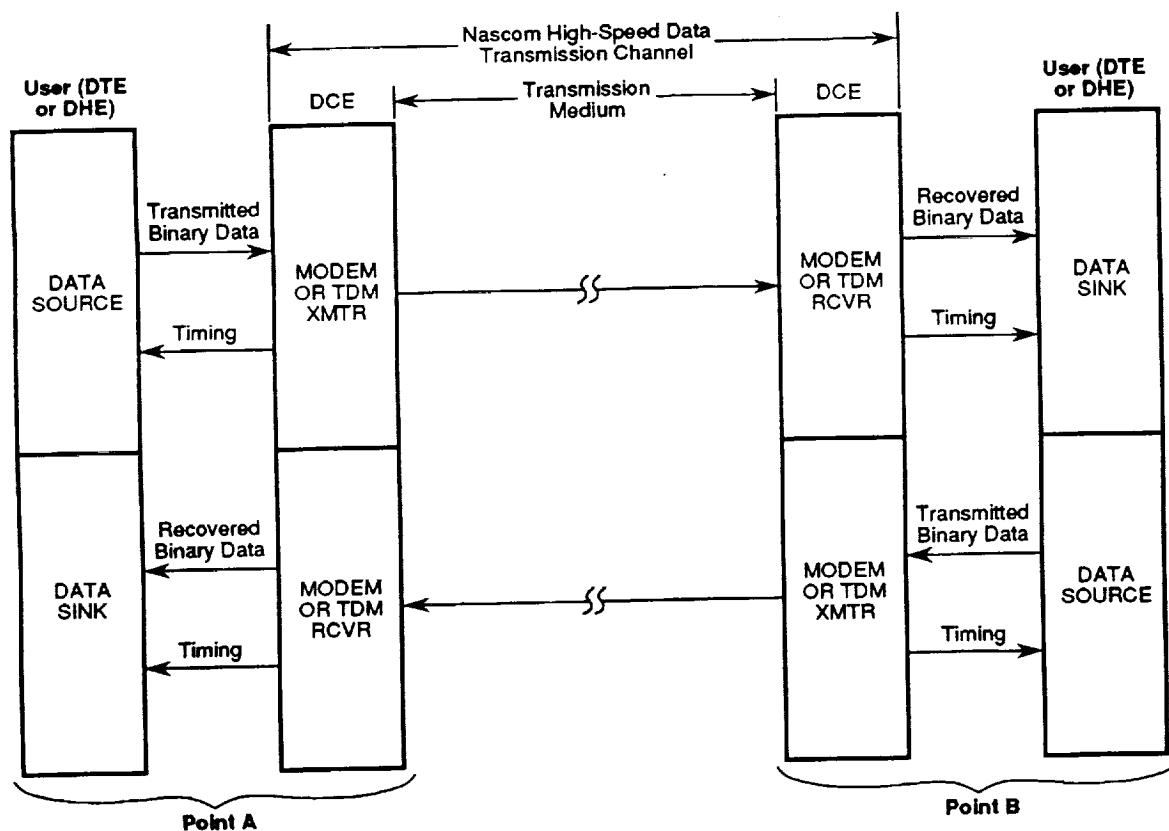
8.1.1 System Definition

The Nascom HSDS, as used in this document, is defined as the system which provides digital data service to users at baseband binary information rates above 1200 baud and up through 9.6 kb/s. Other characteristics of the high-speed data system are further defined in the following paragraphs:

- a. Most circuits supporting data at rates in this range (except those connecting overseas locations), are transported via Nascom-2000 services, and are part of a wideband aggregate.
- b. The remaining circuits, dwindling in number due to transition to Nascom-2000, are four-wire, full-period voice bandwidth channels, specially conditioned for data usage and obtained by lease from the common carriers.
- c. Nascom high-speed digital data transmission channels are further defined as point-to-point channels interfacing with user data sources and sinks, referred to as DTE. Channels may terminate in intermediate Nascom (or user) switching, encoding, or multiplexing equipment, referred to as Data Handling Equipment, (DHE). The DTE or DHE are not considered a part of the transmission channel. The transmission channel, however, will be considered to include DCE, which interfaces directly with the transmission medium. DCEs accept or deliver the baseband binary digital data signals and perform the function of adapting these signals to, or recovering them from, the transmission medium. The DCE must be compatible at both ends of the point-to-point channel (see Figure 8-1). Examples of DCE are the data set or data modem (TDM).

8.1.2 Background Information

High-speed data originated with the support of early MSFN Launch Tracking and Acquisition System (LTAS) requirements between Cape Canaveral range tracking and computation facilities, and the early GSFC real-time trajectory and orbit computation systems. Data at 1.0 and 2.0 kb/s was supported using WECO 202 modems on data-conditioned leased voice circuit facilities. High-speed data evolved to higher rates (2.4 kb/s, 4.8 kb/s, 7.2 kb/s, 9.6 kb/s) and was introduced to the networks generally by Nascom, as modem technology advanced and suitable common carrier facilities became available. The WECO 205B modem supporting 2.4 kb/s tracking data, and the WECO 203A supporting telemetry and command data at the higher rates, became the general "work-horse," and had gained wide use at the time of the consolidation of STADAN and MSFN to the STDN in 1971. The WECO 2096A has since come into major use on conventional AVD circuits operating at 9.6kb/s. Although it has been largely replaced by Wideband Data Systems, the high-speed data system continues



LEGEND:

DTE Data Terminal Equipment
DCE Data Circuit Terminating Equipment
DHE Data Handling Equipment (Nascom or User)
TDM Time Division Multiplexer

LORAL 540/010-008m
March 1995

Figure 8-1. Point-to-Point Configuration of Nascom High-speed Data Transmission Channel

as a traditional or generic system in the Nascom Network, which is available to the network users. It continues to be used for tracking and acquisition systems (some telemetry and commanding) as backup to wideband telemetry and command circuits, and other general data transport applications.

There are still modems of this type operating in the Nascom Network as of the publication date for this document. However, as high-speed data circuits are transitioned to the Nascom-2000 backbone, these modems are being deactivated. Complete removal of all high-speed data modems within the service area of Nascom-2000 is anticipated.

8.1.3 System Capabilities

The HSDS has the advantages of off-the-shelf availability of equipment and economy of line usage. As an integral part of the Nascom Network, the capabilities of the HSDS are as follows:

- a. Provides AVD channels between the GSFC switching center and domestic and overseas locations.

- b. Provides digital data-only channels between the GSFC switching center and domestic and overseas locations, including remote switching centers and NIFs.
- c. Provides GSFC through switching and/or local distribution channels.
- d. Provides digital data-only and/or AVD channels between domestic locations with no GSFC termination.
- e. Provides high-speed data assemblies at remote stations, switching centers and NIFs.
- f. Provides HSDS tech control capability for testing, monitoring, and restoration purposes at GSFC, remote switching centers and NIFs.
- g. Provides for standard block transmission and block error detection in the data transport function.

8.1.4 Nascom Policy for Data Transmission

8.1.4.1 Background

In line with the NASA Administrator's dictum of "better, cheaper, faster," Nascom is actively encouraging users of its networks to employ standards based, Commercial-Off-The-Shelf (COTS) products, inclusive of communication protocols, for transport of their data. The Transmission Control Protocol (TCP)/Internet Protocol (IP) is an example of a preferred transmission protocol. Simultaneously, Nascom is urging its current users who are using the Nascom 4800-bit block to convert their interfaces to standard ones (such as TCP/IP) in coordination with Nascom, at the earliest opportunity, but in no event later than Fiscal Year 1997.

8.1.4.2 Policy

Nascom's policy for data transport is that use of standards based data transmission protocols, such as TCP/IP, is required for new data services and interfaces being implemented with Nascom. Those users who are currently interfacing Nascom with the 4800-bit block are advised that Nascom intends to eliminate the 4800-bit block from its network by not later than FY 1997.

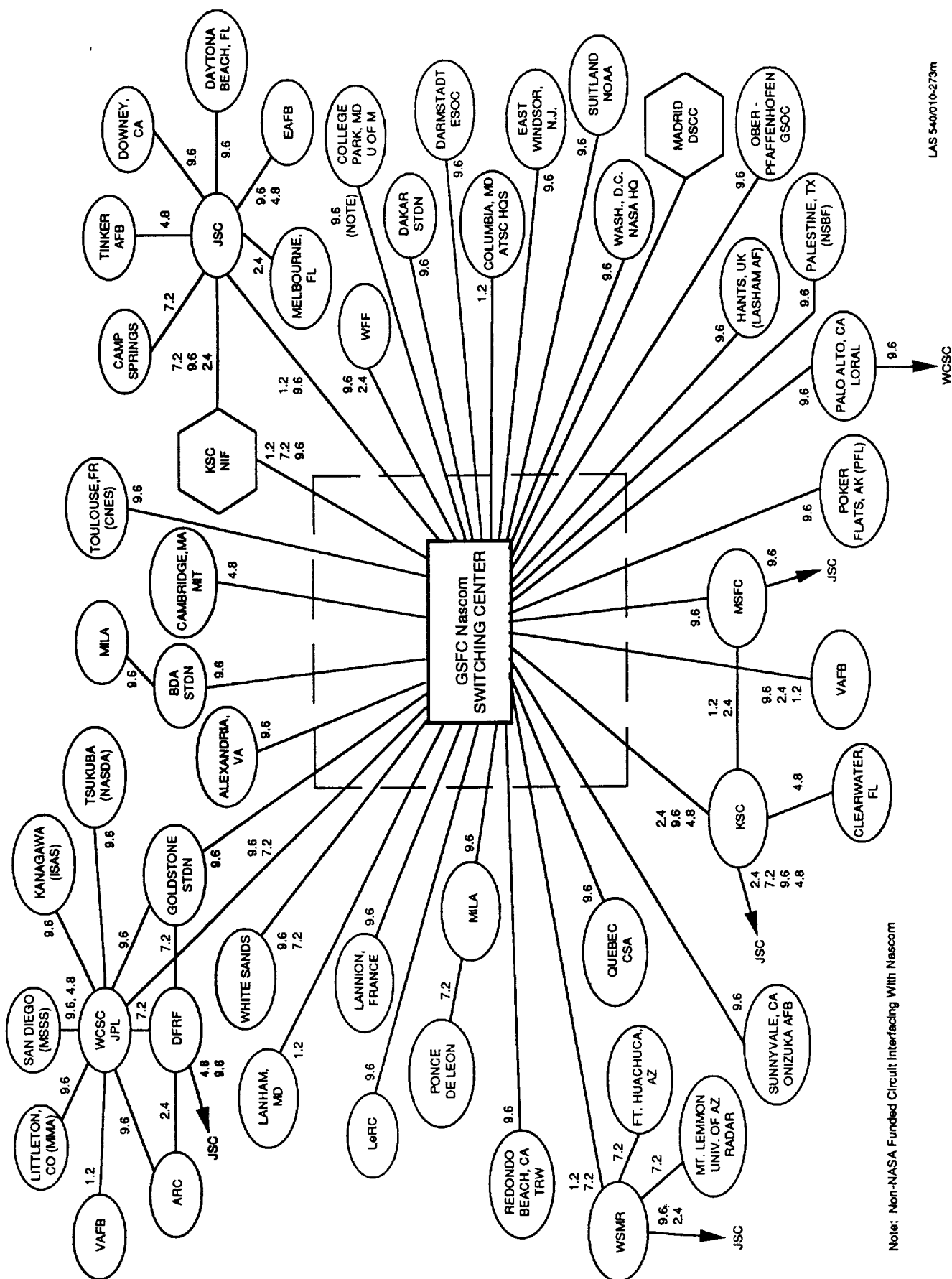
Accordingly, parties to these legacy interfaces are encouraged to commence now coordinating the conversion of their interfaces. The Nascom Mission Planner (GSFC Code 542.1) assigned to the mission can provide detailed information to help with planning the conversion of each interface.

8.2 HSDS System Description

8.2.1 System Configuration

In terms of switching characteristics, there are two basic network configurations for HSDS: circuit-switched and message-switched circuits. The general network configuration for the HSDS circuits is illustrated in Figure 8-2.

- a. A Nascom high-speed digital data channel is normally leased from the communication carrier(s) as a complete point-to-point private line communications service,



Note: Non-NASA Funded Circuit Interfacing With Nascom

LAS 540/010-273m

Figure 8-2. Nascom High-speed, Circuit-switched Network Connectivity (Major Elements)

including the DCE. However, on channels extending between U.S. points to foreign points, Nascom (or the international user) furnishes the DCE at the foreign end in order to maintain DCE compatibility. A point-to-point data channel may involve facilities and services of two or more communications carriers.

- b. The DCE on Nascom high-speed digital data channels, almost without exception, are synchronous transmission systems which are more efficient (achieve higher data rates and better bit error performance relative to bandwidth) than other types of transmission systems. This higher efficiency results from a fixed precise timing of bit periods by the DCE. The timing information is usually provided to the DCE or DTE in parallel with the data stream.
- c. Most Nascom high-speed data channels, in lieu of being fully leased point-to-point channels provided by domestic private communications carriers or overseas channels provided by Nascom Overseas Communication System (NOCS), are Nascom-derived (in their entire length or in part) from wideband channel facilities provided by Nascom-2000.

8.2.2 System Elements

The basic HSDS configuration consists of the following system elements:

- a. Nascom-2000 data quality channels based on T-1 specifications for domestic carriers.
- b. Leased four-wire, full-period, data quality channels based on C-2 or D-1 specifications for domestic carriers and CCITT M1020 specifications for international and foreign carriers, and derived digital channels.
- c. Remote site and switching center high-speed data assemblies that include the modem and associated patching, testing, and error detection equipment and related documentation. Depending on the user requirement, an assembly may also include Block Error Detector (BED) and the line driver equipment. The modem or data set is full-duplex and uses amplitude modulation to transmit the serial binary data. In addition, unique data sets are used for special projects as required. The standard data rates of 2400 b/s and 9600 b/s are used throughout the network. Other fixed data rates and asynchronous data may be transmitted only between certain designated fixed locations.
- d. HSDS tech control facility at the GSFC switching center, including patch, test and monitoring equipment, and a pool of modems.
- e. Nascom switching facilities that are either circuit switched or message switched.

8.2.3 GSFC Switching Center

8.2.3.1 GSFC HSDS Overview

The Nascom high-speed data system at GSFC consists of the DCE for all long-haul data channels, local GSFC data distribution channels, central switching facilities for the "star-con-

figured" network, and central data technical control facilities. The central switching function for high-speed data is divided into two functionally and physically distinct subsystems: circuit switched and message switched. The circuit-switched system and local distribution facilities will be described here. Technical control facilities will be mentioned only as necessary in the context of these subsystems and will be addressed specifically in paragraph 8.2.5.

8.2.3.2 Circuit Switching System

Circuit switching is the routine operational switching performed by Nascom in response to schedules or real-time requests. The switching is done manually, using the analog and digital patch panels or the digital matrix switch to accomplish the direct interconnection of long-haul point-to-point and/or local GSFC data channels (see Figure 8-3). This definition distinguishes such switching operations from message switching and those switching functions performed for trouble isolation, circuit testing, and restoration.

8.2.3.3 Local Distribution Channels

Long-haul data channels extend into Voice and Data Technical Control. For the most part, government-owned cables (twisted pair, coaxial, and fiber optic) provided through GSFC Code 543 are the facilities used for intra-GSFC local data channels to the POCCs, IPD,

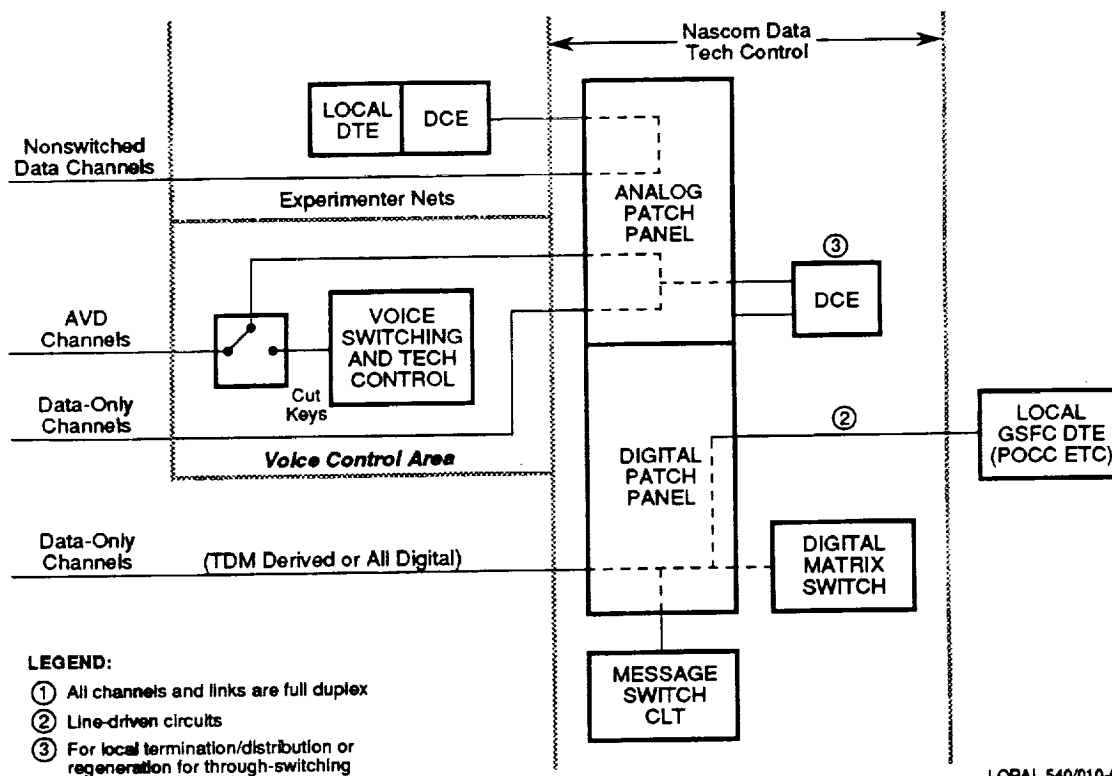


Figure 8-3. Internal GSFC Routing and Control, Circuit-switched, High-speed Data Channels and Equipment

NCC, etc. Nascom fabricates baseband digital transmission systems for use on these cables, called "line drivers." The line drivers extend the standard RS-232-C interface to the user DTE. Where the GSFC user DTE is the center for a high-speed data distribution net, or where it is a terminal on a dedicated off-net circuit, the Nascom DCE is collocated with the user DTE. In such cases, the data channel to the DCE and to the communications carrier requires no Nascom switching function and is routed only to Data Technical Control.

8.2.3.4 Circuit-switched Circuits

Some of the DSN overseas high-speed data channels and a few local experimenter circuits are circuit switched at GSFC to one of several available trunks interfacing between GSFC and the JPL WCSC. Since DSCC contacts with interplanetary spacecraft are of long duration (e.g., 8 to 10 hours), scheduled circuit switching is suitable for the DSCC operation; message switching is not required. In the STDN, high-speed data channels are circuit switched when used for nonstandard data format transmissions and when used for long duration tape playbacks (standard block transmission). The STDN high-speed data channels are currently divided between the circuit- and message switched systems, with evolution from circuit to message switching. At the present time, each STDN site can be provided with at least one circuit-switched high-speed data channel (9.6 kb/s). Local GSFC POCCs and the IPD are all equipped with local high-speed channel interfaces to the patch facilities for scheduled interconnections with the STDN sites for such data transmissions. Channels in the trunk pools between switching centers require coordinated circuit switching actions at both ends, usually in response to the scheduling system. Launch support data transmissions which have critical delay constraints (e.g., C-band radar and acquisition data between the ER CCC Impact Predictor, Range Safety, and NASA radars) are also circuit-switched at GSFC. Connection of two long-haul point-to-point data channels made at GSFC patch facilities effectively connects DCE to DCE and results in data regeneration in the end-to-end data channel. Figure 8-3 illustrates the major elements in the circuit-switched network.

8.2.3.5 Message-switched Circuits

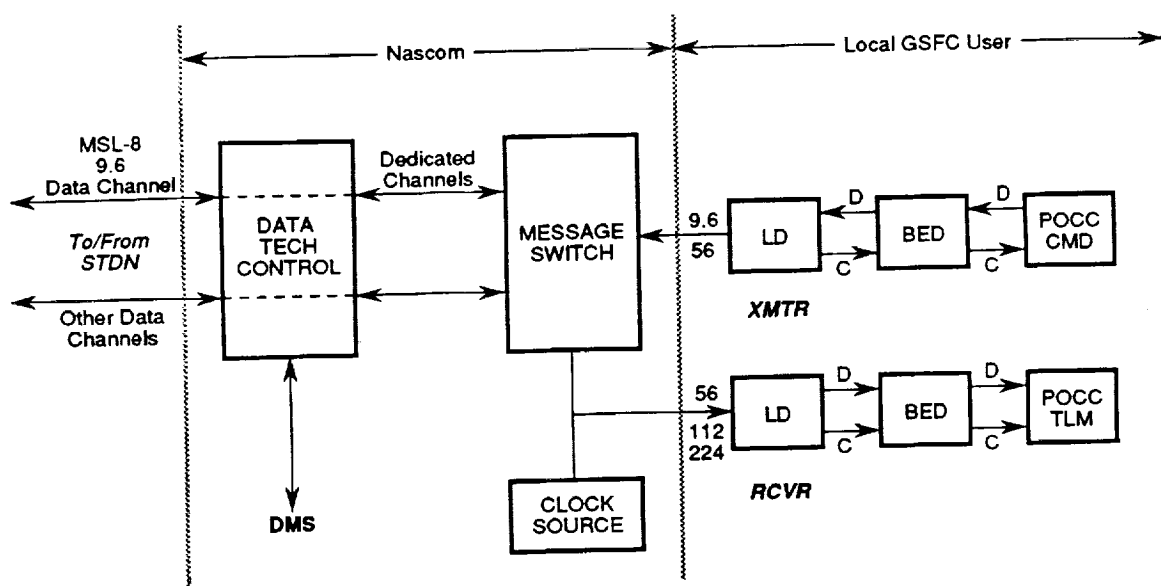
Figure 8-4 illustrates the routing of message-switched circuits through the HSDS tech control. A typical example is the HSDS routing between a local GSFC user and the STDN. Each site is provided with a dedicated full-duplex 9.6 kb/s high-speed data channel, designated MSL-8. These high-speed 9.6 kb/s channels can be patched and configured in real-time into the MSS when the prime 56-kb/s wideband channels are out of service. All traffic is normally through the 56-kb/s channels. Some local GSFC inputs to the message switch from the POCC/users are currently at 9.6 kb/s via line-driven circuits which terminate on the U3760 Communications Controller and use a digital interface.

8.2.4 Remote Switching Centers and NIFs

8.2.4.1 Remote Switching Center HSDS Overview

An overview of the HSDS configuration at the remote switching center and NIFs is presented in the following paragraphs:

- a. The remote Nascom interface facilities at Canberra and Madrid, and the WCSC at JPL are provided with Nascom high-speed data assemblies which include the same



LEGEND:

C Clock with direction indicated
D Data with direction indicated
LD Line Driver

All data transmission rates are in kb/s

LORAL 540/010-011m
March 1985

Figure 8-4. Local GSFC Routing Message-switched Channels

type of DCE, patch and test equipment as described for the STDN sites. However, these installations are larger, and include more of the same equipment, but operated differently. The assemblies are installed, maintained, and operated under Nascom arrangements. (Refer to paragraphs 3.3, 3.5 and 3.6.) The NIFs perform additional functions in the high-speed network, and the assemblies also include multiplex equipment that derives data-only and high-speed channels on Nascom wideband trunks (Madrid and JPL).

- b. The additional functions are Nascom Network switching and operational configuration, in response to STDN-DSN operational scheduling. This function is largely accomplished via the patch facilities. A data regeneration (repeater) function is accomplished in the remote switching center and NIFs where trunk channels and end-link channels are interconnected. The degrading influences of the respective analog segments of an end-to-end configuration are effectively isolated from each other by this segmentation.
- c. A Nascom-oriented monitoring and tech control function is also performed at these locations. BED equipment is used in the monitoring rather than the inline configura-

tion. These interconnection points are also trouble isolation points between different areas of communications carrier responsibility.

- d. At the WCSC, the same functions are implemented differently. Nascom provides DCE and test equipment to the JPL/CCT, which integrates the equipment into their own terminal and control facilities. The facilities and functions combine JPL/DSN Network and user termination, distribution, and technical control functions, with Nascom through-connection and technical control functions, e.g., DSN/Goldstone (GDS), Ames Research Center (ARC), and WR circuits routed via the WCSC.

8.2.4.2 Remote Switching Center HSDS Configuration

Figure 8-5 illustrates the functional HSDS circuit configuration for the remote switching center.

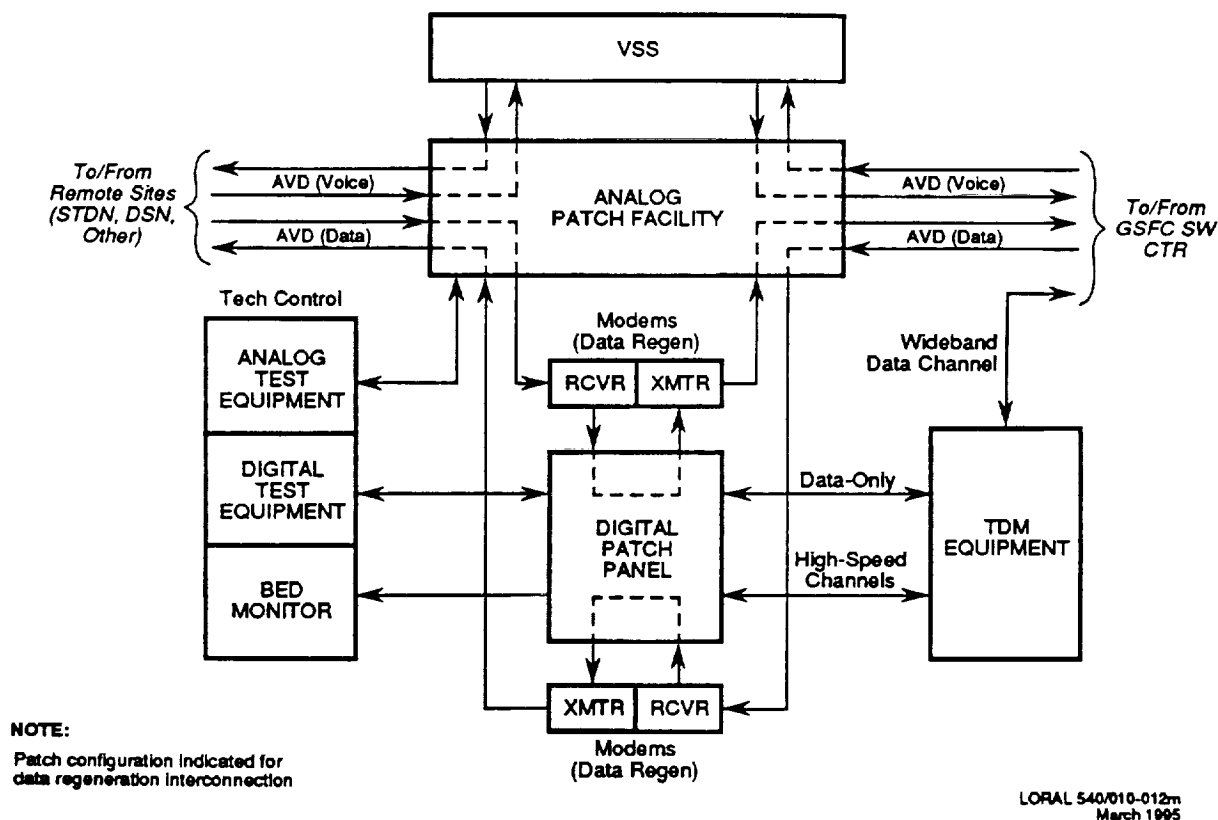


Figure 8-5. Remote Switching Center High-speed Data Functional Configuration

8.2.5 HSDS Technical Control Facility

8.2.5.1 HSDS Technical Control Overview

The technical control function is defined as the monitoring of circuits to detect degradation of service, the testing of circuits for trouble isolation in events of observation or reports of service outages or degradations, and the reconfigurations and switching activities related to restoration of service from such outage. The Nascom high-speed data technical control in the GSFC, Building 14, area includes: digital and analog patch panels through which all high-speed data channels and GSFC DCE are routed for test access and reconfiguration/restoration capability, various analog and digital test and monitoring equipment, and voice and data order wires to various U.S. and foreign communications carriers wire rooms and test centers for test and restoration coordination. These Technical Control activities also include coordination with all terminal points on the network as necessary on network coordination circuits.

8.2.5.2 Digital Test Equipment

The major digital test equipment associated with the digital patch fields or matrix switches are described in the following paragraphs:

- a. **Block Error Detection Equipment.** BEDs are pooled on a patch field for monitoring user's data streams to determine, on a selective basis, in-service performance of the channel and for out-of-service trouble isolation functions with capabilities as programmable source of test pattern generation for internal or external test.
- b. **Data Transmission Test Sets (DTTS).** DTTS used on circuits taken for test transmit pseudorandom bit patterns at various rates, and can receive, detect, count, and display errors (bit and block) for obtaining error rate performance on data channels. They display cumulative blocks (or bits) received and cumulative blocks (or bits) received in error. DTTS are provided at all terminals in STDN, DSN, NIFs, and selected other locations.
- c. **Print-Punch Recorder.** Print-punch recorders are used in conjunction with DTTS and are provided at some locations where a permanent recording of error rate measurements made on data channels is required. Print-punch recorders can record on basis of time intervals (variable), bit-count intervals (variable), and time tag dropouts.

8.2.5.3 Analog Test Equipment

- a. **Impulse Noise Measuring Equipment.** The impulse noise measuring set counts impulse noise over a particular time interval, for up to 3 preset amplitude thresholds.
- b. **Audio Frequency Test Set.** The audio frequency test set (with C-message weighing filters) measures noise levels and Signal-to-Noise (S/N) ratios on channels in accordance with standard telephone noise measurement procedures on circuits taken for test.
- c. **Phase Jitter Meter.** The phase jitter meter is used to measure the random, rapid phase shifting of a reference tone caused by the circuit being tested.

- d. Spectrum Analyzer. The Spectrum Analyzer is used to measure energy distribution within the voice-band circuit.
- e. Frequency Counter. The frequency counter is used to measure frequencies of incoming and outgoing audio analog signals.

8.2.6 HSDS System Interfaces

The HSDS provides system interfaces for the following facilities:

- a. Local GSFC facilities and users.
- b. Remote site facilities of STDN and DSN.
- c. Remote switching center and NIF facilities.

8.3 HSDS System Operation

This paragraph describes the two main HSDS services provided by Nascom, system operation of GSFC-controlled HSDS, remote switching center HSDS, and the HSDS performance standards.

8.3.1 High-speed Channel Service

8.3.1.1 Nascom-2000 Channel Service Overview

A data channel obtained from the Nascom-2000 backbone is referred to as a Nascom-2000 data channel. High-speed Nascom-2000 data channels transport individual high-speed data flows/circuits within the multiplexed aggregate (T-1 or fractional T-1) wideband circuit. HSDS electrical and physical interfaces, as well as the data rates supported by Nascom-2000, are described in the following paragraphs.

The Model 740 multiplexer, used by Nascom-2000 for transport of the HSDS circuits, offers a choice of four electrical interfaces: RS-232-C, RS-422 (balanced), RS-423 (unbalanced), MIL STD 188-114 (balanced and unbalanced), and CCITT V.35. Balanced interfaces are accessible for testing end-to-end user terminations via the wideband jackfield in the data technical control area. The remaining interface types, mostly unbalanced, are accessible via the high-speed jackfield in the data technical control area. Data rates supported by the HSDS are 2.4, 4.8, 7.2, and 9.6 kb/s. Additionally, the multiplexer supports channel data rates of 300 b/s, and 1.2, 19.2, 56, and 64 kb/s. These data rates lie outside the range prescribed by Nascom for its HSDS.

8.3.1.2 Overseas Channel Service Overview

- a. Channel Specification. Nascom overseas data and voice channels are increasingly being converted from individual carrier circuits to multiplexed wideband links to reduce both carrier costs and increase operational flexibility. The bandwidth of the aggregates on these multiplexed data links ranges from 64 kb/s up to T-1. The Nascom standard multiplexer for these data links is the Ascom Timeplex Link/2+™ although the General DataComm Megamux Plus is installed on the Nascom-GSOC

data link. (The Nascom-GSOC data link is an example of the reuse of equipment procured to support one specific mission [Spacelab D-2] by changing its configuration to enable it to support current and future voice and data transport requirements.) Multiplexer cards installed for data handling utilize RS-232 interfaces and support Nascom's low-speed data rates. Multiplexer cards installed for voice circuits are operated at 64 kb/s using PCM, and 32 kb/s using ADPCM. Recent versions of this type of voice card have modified the 32 kb/s channel with the ability to send 9.6 kb/s fax. Standard 19-inch racks are used to house the multiplexer and associated patch and test/diagnostic equipment described in the following paragraph.

- b. **Communication Rack Equipment.** Generic equipment racks are assembled by Nascom and shipped to overseas locations requiring data and voice circuits into Nascom. In addition to the ascom Timeplex Link/2 + TM multiplexer populated with voice and data cards to satisfy specific user requirements, the following equipments are also furnished: a Fireberd voice/data test set, a 4-channel analog oscilloscope, aggregate data and voice patch panels, and a terminal with keyboard to communicate with the Link/2 + TM multiplexer. Figure 8-6 shows the JPL to Madrid multiplexed data link and is presented as an example of how Nascom integrates its HSDS data flows into multiplexed wideband data links to overseas locations.

8.3.2 Circuit Standards and Parameter Objectives

Both national and international standards are used to form the Nascom standards and parameter objectives for high-speed digital and analog data channels. Details are found in Appendix D. More specific technical information is found in the appropriate sections of NASCOP.

8.3.3 Nascom Support Services

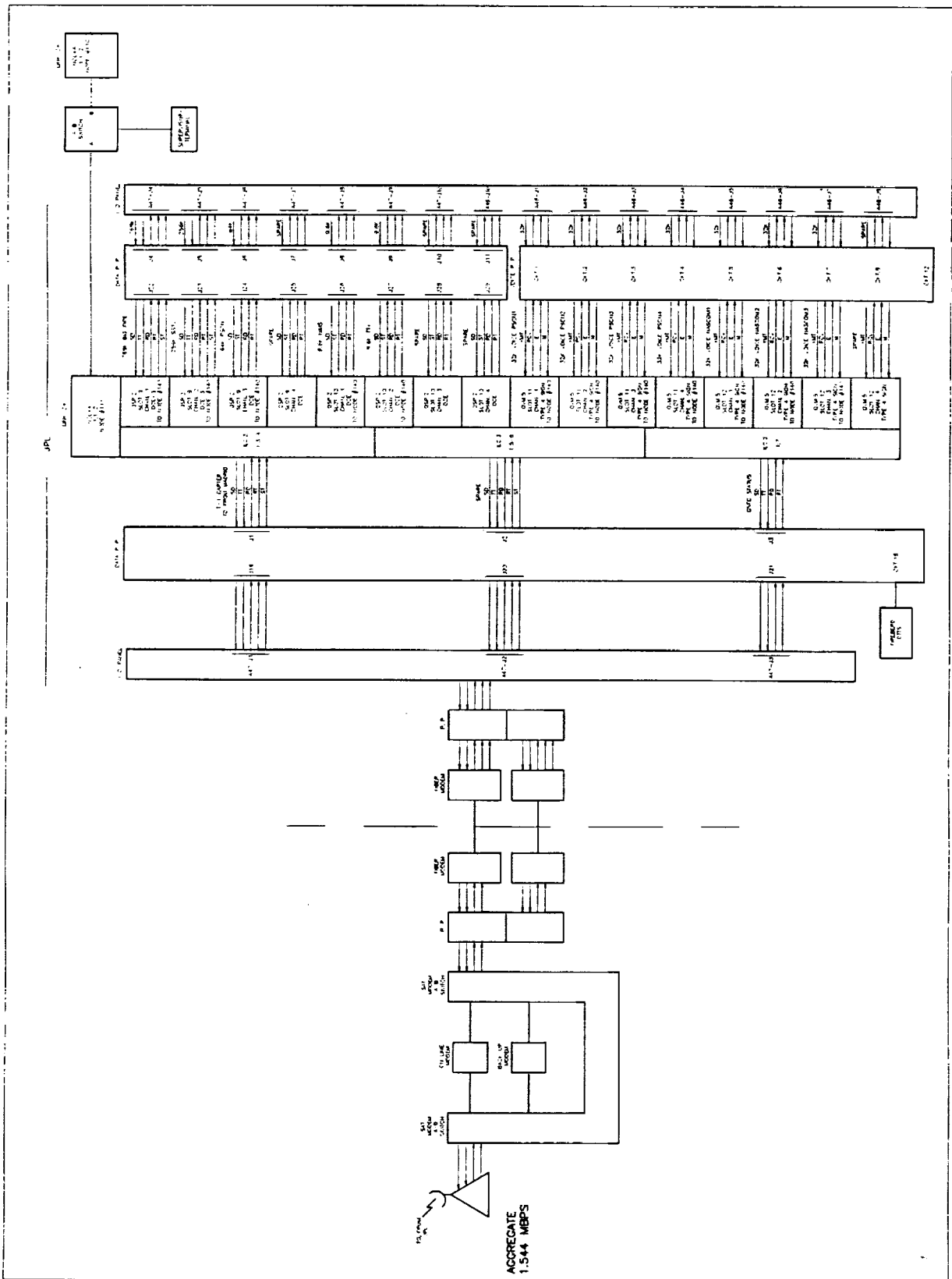
Nascom provides a wide range of support services for the HSDS users that includes:

- a. Engineering study and design.
- b. Circuit and equipment procurement.
- c. System installation.
- d. Recordkeeping.
- e. Accounting.
- f. Operation and maintenance.
- g. Tech control function for testing, monitoring, and restoring HSDS circuits.

Additionally, Nascom provides the capabilities and facilities for HSDS users as described in the following paragraphs:

8.3.3.1 Provision for Standard Block Transmission

Data transmitted via Nascom high-speed digital data channels in the DSN Network is formatted in the user DTE in either a 1200- or 4800-bit block format. The GN transfers only





4800-bit block formatted data. These blocks contain a standard Network Control Header, called a "Nascom Header," which enables Nascom message switching and routing of these blocks of data where it is required. The combination of header, trailer, and fixed block size enables real-time Nascom monitoring of operational data streams to determine the performance of the channel without removing it from service. Users may also employ this error detection coding for internal data handling and end-to-end retransmission strategies. The Network Control Header is 48 bits in length and includes a fixed block sync detection code and other variable subfields that are designated by Nascom to accomplish its internal message routing function. These routing codes are assigned by Nascom to the user terminals sending traffic via this system. (Refer to Appendix C.)

8.3.3.2 Provision for Block Error Detection

Nascom has provided BED equipment to STDN and selected other terminals. Similar encoder/decoder equipment at DSN stations was provided by DSN. At these stations, encoder/decoder equipment is interposed between the Nascom DCE and the site DTE. Nascom has also provided such equipment at GSFC, in the various POCCs, NCC, and IPD. The DSN-provided coding equipment and STDN equipment perform a similar function but are not compatible. The support services provided by Nascom are described in the following paragraphs:

- a. The DSN encoder/decoder functions with 1200-, 2400-, or 4800-bit block sizes, and 22- or 33-bit polynomial codes. This equipment performs inline encoding and decoding for the users. The Nascom Switching Center and Technical Control at GSFC is equipped to selectively monitor and test the 22-bit polynomial codes. When used as monitors, the BEDs do not modify the user's data blocks.
- b. The BEDs at the GN sites are arranged on a switchable basis, permitting bypass of the BEDs for non-DDPS data formats that may remain in use in the GN.
- c. The Nascom/STDN BED encoders compute a 22-bit polynomial error control code word based on the 4800-bit block received from any formatting source DTE. The BED encoder inserts this computed code word into the error control word field. The BED decoder at the receiving end similarly computes a code word, makes a comparison of the code words to verify a good data block or sets error flags into those data blocks (modifies the Error Status Word) that have been errored in transmission before delivery to the data sink.
- d. The BEDs have a maximum transfer rate of 500 kb/s via synchronous data modems. They can be switch-selected to operate with 2400- or 9600-bit data blocks, in addition to the standard 4800-bit block. They can also be field-modified to operate to 1.544 Mb/s.
- e. Blocks through the BED need not be contiguous. The BED encoder interface with the DTE is functionally identical to a data modem (DCE) interface, and is designed according to Nascom Standard 844-71-03. The BED decoder interface with the DTE is also functionally identical to a standard RS-232-C modem interface. Delay through the decoder is 25-bit times. The BED decoder will pass all data to the sink DTE regardless of sync code recognizability.

- f. Error status bits are preset to "1s" in the encoder. The encoder will always overwrite the Error Control Word field of the originator's data block. The decoder sets the first status bit to "0" for a correctly received block, and to a "1" for an incorrectly received block. The second bit is reserved for special cases where a second decoder is used on a second segment of the line. The decoder does not modify the error control word. The decoder has dynamic sync error tolerance that detects and corrects sync code errors within a preset range. Sync bits and error status bits are not included in the encoding calculation.
- g. Synchronization words are regenerated, error-free, by the decoder.
- h. The performance of the BED in terms of undetected block error rate (fraction of transmitted blocks received with bit errors that fail to be detected by the power of the polynomial) is dependent somewhat on channel block error rate and distribution of errors within blocks. Based on available Nascom channel performance statistics for 7.2 kb/s with 1200-bit blocks and a Bit Error Rate (BER) of 1×10^{-5} , the undetected block error rate is approximately 1×10^{-11} .
- i. The block error rate represents about 5×10^6 hours mean-time between undetected block errors. Block loss rate due to excessive header errors or false synchronization (fraction of transmitted blocks not recovered from received data stream) ranges from 0.014 percent for contiguous blocks to 0.04 percent for noncontiguous blocks.

Section 9. Wideband Data System

9.1 General

9.1.1 System Definition

The Wideband Data System (WBDS), as used in this document, refers to a system that handles wideband data for communications. Wideband data is defined as all baseband digital data in excess of 9.6 kb/s, and any analog data requiring greater than nominal voice bandwidth (4 kHz) channels or 9.6-kb/s digital channels for transmission. Video data is included in a separate category. (Refer to Section 10.)

9.1.2 Background Information

The use of wideband data channels in the Nascom Network since its inception has evolved with advances in communications technology and the availability of new facilities and private line services leased from the common carriers. Requirements for higher bandwidths originated with meteorological and Apollo programs, and have been driven and paced by their follow-ons, and by other programs. Wideband data transmission and handling does not differ, basically, from that of the high-speed data, except that the facilities and equipment are selected for the higher bit rates. Both analog and digital transmission facilities are used. Some digital facilities have analog extensions as part of the total service. Presently within the U.S. a great variety of wideband transmission channels and data rates exist in the circuits leased from commercial carriers. The most prevalent category of wideband transmission channel to overseas GN and DSN locations and trunk channels between GSFC and the Madrid and Canberra DSCCs has been the 56 kb/s digital data service. This evolution continues to be dynamic, and bandwidth to these locations has been expanded to 224 kb/s, 512 kb/s, and 1.544 Mb/s.

9.1.3 System Capabilities

The WBDS is currently designed and implemented by Nascom to provide the following capabilities:

- a. A wide variety of point-to-point, full-period, wideband synchronous digital data transmission channels capable of operating at digital rates of: 56; 224; 512; 1544; 2048; and 50,000 kb/s.
- b. A wideband DCE including modems that can accept and deliver baseband digital signals up to these rates, including analog/digital conversion equipment for voice and video, and TDM multiplexers for deriving other channels.
- c. Long-haul wideband multiplexed data channels between GSFC and overseas locations.
- d. Local and long-haul wideband data channels between GSFC and U.S. locations, and between other U.S. locations.

- e. Certain unique wideband channel TDM submultiplexing between points to meet unique requirements.
- f. Either circuit-switching or message-switching facilities at GSFC for local or remote distribution service.
- g. Standard block transmission, block error detection, technical control, and test and monitoring capabilities for wideband facilities in the networks.

9.1.4 Nascom Policy for Data Transmission

9.1.4.1 Background

In line with the NASA Administrator's dictum of "better, cheaper, faster," Nascom is actively encouraging users of its networks to employ standards based, Commercial-Off-The-Shelf (COTS) products, inclusive of communication protocols, for transport of their data. The Transmission Control Protocol (TCP)/Internet Protocol (IP) is an example of a preferred transmission protocol.

Simultaneously, Nascom is urging its current users who are using the Nascom 4800-bit block to convert their interfaces to standard ones (such as TCP/IP) in coordination with Nascom, at the earliest opportunity, but in no event later than Fiscal Year 1997.

9.1.4.2 Policy

Nascom's policy for data transport is that use of standards based data transmission protocols, such as TCP/IP, is required for new data services and interfaces being implemented with Nascom.

Those users who are currently interfacing Nascom with the 4800-bit block are advised that Nascom intends to eliminate the 4800-bit block from its network by not later than FY 1997.

Accordingly, parties to these legacy interfaces are encouraged to commence now coordinating the conversion of their interfaces. The Nascom Mission Planner (GSFC Code 542.1) assigned to the mission can provide detailed information to help with planning the conversion of each interface.

9.2 WBDS System Description

9.2.1 System Configuration

The overview network configuration of circuits in the WBDS is shown in Figure 9-1. The WBDS network circuits with data rates indicated on this figure are services leased from commercial carriers in the United States, (including Alaska) and to foreign locations served by communication satellites. A major hub of the WBDS services is the GSFC Nascom Switching Center, where the wideband data circuits and trunk channels branch out radially to various local, domestic, and overseas NASA and cooperating agency locations. BDA is provided with one full-duplex 512 kb/s wideband channel and MIL is provided with both 56 and 224 kb/s services. Overseas DSN locations are also provided with 64 kb/s services and a

1544 kb/s service. NASA installations served by the United States portion of Nascom are provided with a variety of wideband services for 56 kb/s, 224 kb/s, 1.344 Mb/s, 1.544 Mb/s, 2.048 Mb/s, and 50.0 Mb/s data transmission rates. As can be seen from Figure 9-1, JSC, MSFC, KSC, WCSC, WSC, and the Nascom Interface Facilities at Madrid and Canberra are also major wideband circuit terminating locations. On Goddard, government owned fiber optic, coaxial and twisted pair cables provided through Code 543 supply the greater part of the inter-building wideband transport media supporting the POCCs, Information Processing Division (IPD), the Goddard Network Control Center and other mission-oriented functions and facilities. Nascom supplies digital receiver/driver assemblies as needed to interface data circuits to these cables. Other features of the WBDS network configuration are described in the following paragraphs:

- a. The wideband digital data services are implemented in a variety of ways depending on the locations and carriers involved (e.g., whether extended to overseas locations or between U.S., locations). An individual end-to-end circuit may be implemented in a mixture of communications carrier facilities and services. Within the U.S., end-to-end service is obtained from a single communications carrier, where possible.
- b. Within the U.S., a few of the wideband leased services have Nascom-furnished TDM systems applied for subchannel service derivations between NASA centers and other locations. Such systems normally extend directly between centers, i.e., not terminated at the GSFC Nascom Switching Center.
- c. Within the United States, most wideband services are now provided via Nascom-2000 (reference Section 5). For overseas locations, especially the International Partner Agencies and NASA ground stations with which Nascom has continuing, long term interface support requirements, the Nascom Overseas Communication System (NOCS) continues to consolidate individual voice and data circuits onto its multiplexed wideband data links. NOCS is described in detail at the end of this section.

9.2.2 System Elements

Basically, the system elements of WBDS include:

- a. GSFC Nascom Switching Center, which houses many WBDS terminals, and the primary WBDS tech control, switching, monitoring, and test facilities.
- b. Wideband data channels and trunk circuits leased from U.S. and foreign common carriers.
- c. Remote station and remote switching center wideband data assemblies that include the modem or data set, patchfields, BED, line drivers, and test and monitoring equipment.
- d. Nascom TDM equipment at various points in the network, submultiplexing and deriving many types of channels from the leased common carrier circuits.

9.2.3 Circuit Performance Standard

Nascom has established error performance and availability objectives for wideband data services to overseas and U.S. locations drawn from various carrier and regulatory agency recommendations and through operating and test experience. These are detailed in Appendix C.

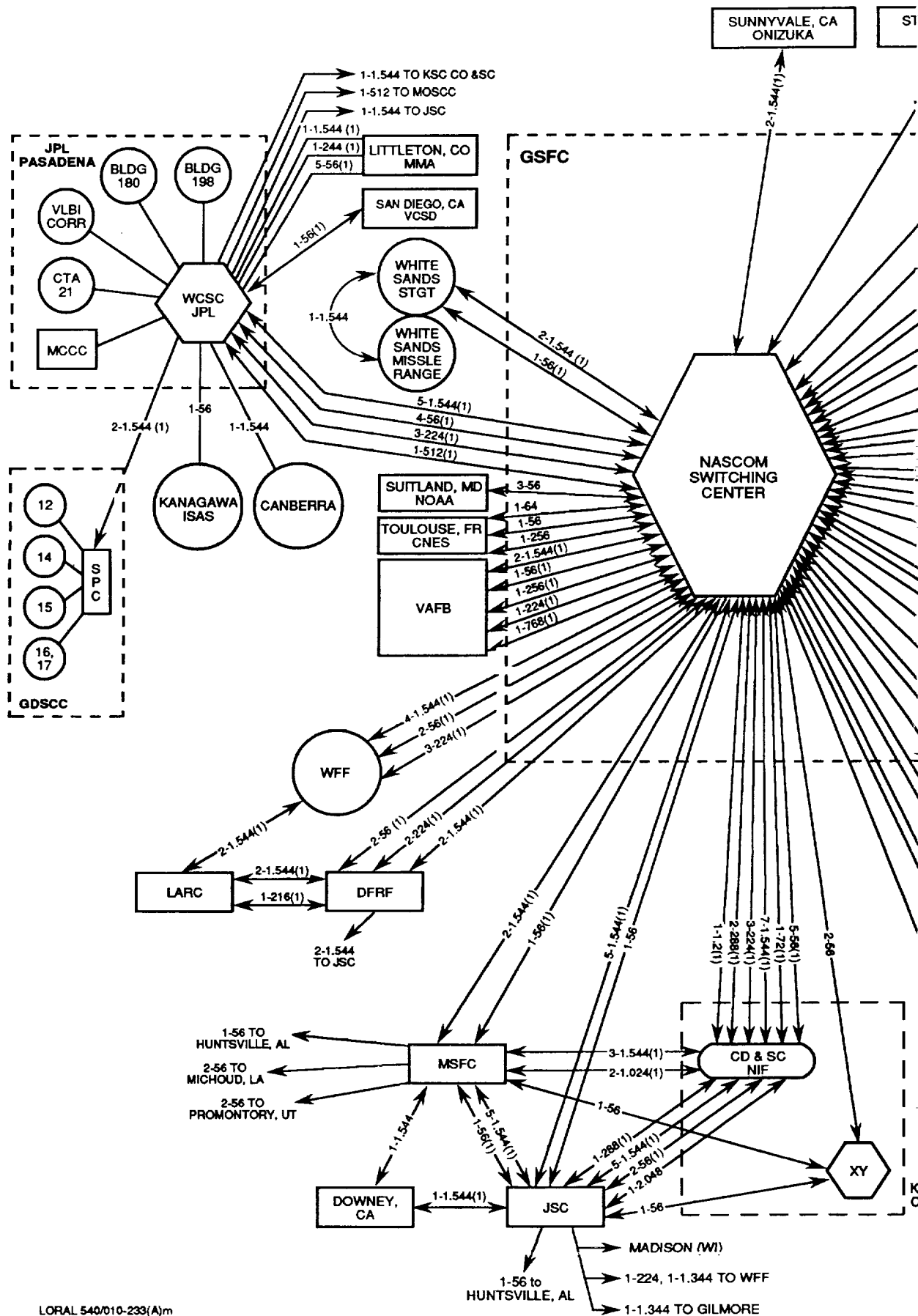
9.2.4 Block Error Detection for WBDS Channels

Similar to high-speed data, standard 4800-bit block transmission is employed on the GN, SN, and DSN networks. (Refer to Appendix C.) Nascom has provided BED equipment to GN and other selected remote user terminals. Similar encoder/decoder equipment at DSN stations is provided by the DSN/GCF. At these stations, encoder/decoder equipment is interposed between the Nascom DCE and the site DTE. Nascom has also provided such equipment at GSFC – in the various POCCs, NCC, and IPD. The DSN-provided coding equipment and GN equipment perform a similar function, but are not fully compatible. The BED operation is described in the following paragraphs.

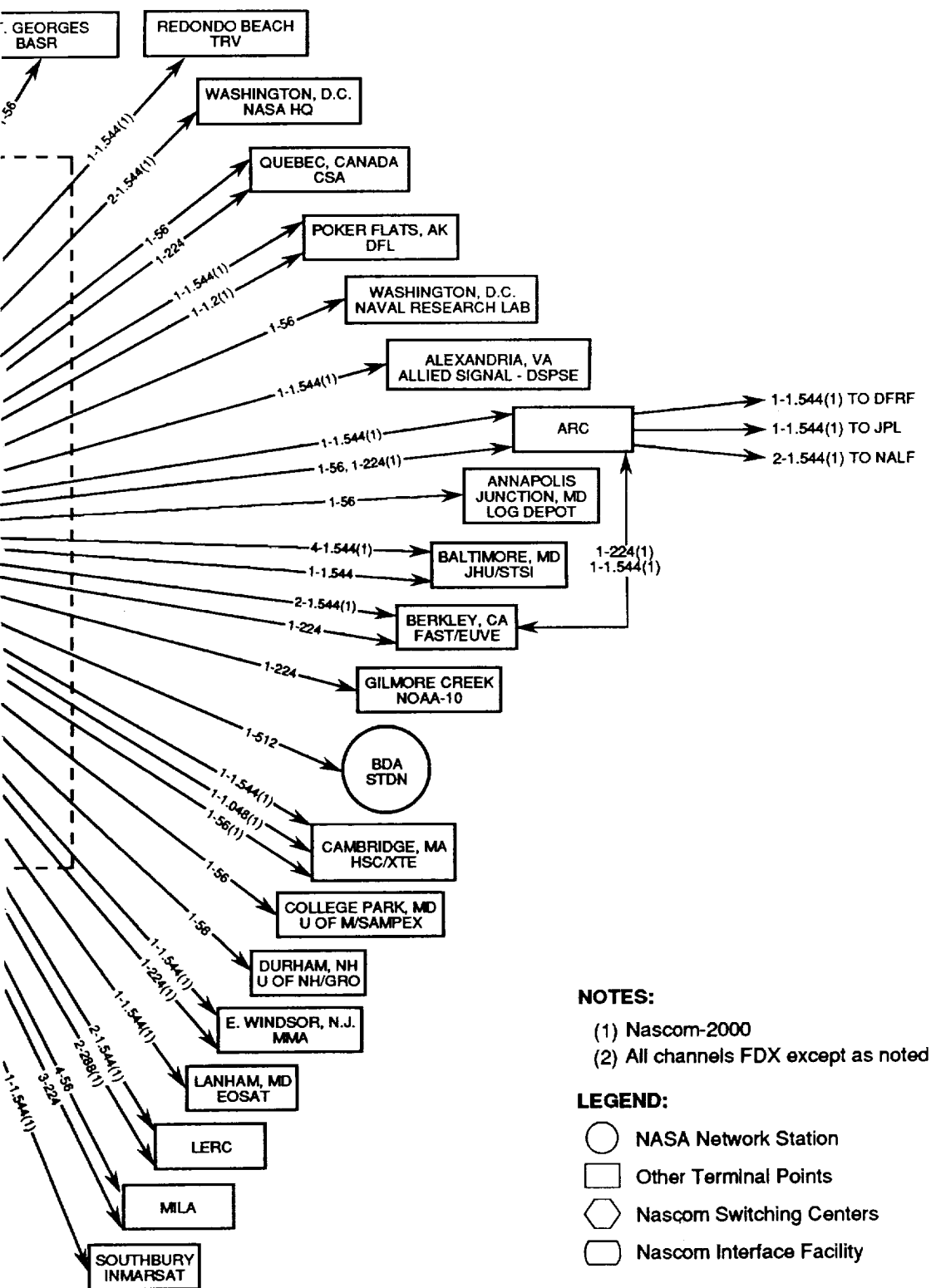
9.2.4.1 WBDS BED Operation

A typical operation is for the BED encoders to compute a 22-bit polynomial error control code word based on the 4800-bit block received from any formatting source DTE. The BED encoder inserts this computer code word into the error control word field. The BED decoder at the receiving end similarly computes a code word to verify a good data block or sets error flags into those data blocks (modifies the Error Status Word) that have erred in the transmission before delivery to the data sink. The other aspects of the BED operation are described in the following paragraphs:

- a. The BEDs have a maximum transfer rate of 1544 kb/s via synchronous data modems. They can be switch-selected to operate with 2400- or 9600-bit data blocks, in addition to the standard 4800-bit block.
- b. Blocks sent through the BED need not be contiguous. The BED encoder interface with the DTE is functionally identical to a data modem (DCE) interface, and is designed according to Nascom Standard 844-71-03. The BED decoder interface with the DTE is also functionally identical to a standard RS-232-C modem interface. Delay through the decoder is 25 bit times. The BED decoder will pass all data to the sink DTE regardless of sync code recognizability.
- c. Error status bits are preset to "1's" in the encoder. The encoder will always overwrite the Error Control Word field of the originator's data block. The decoder sets the first status bit to "0" for a correctly received block, and to "1" for an incorrectly received block. The second bit is reserved for special cases where a second decoder is used on a second segment of the line. The decoder does not modify the error control word. The decoder has dynamic sync error tolerance that detects and corrects sync code errors within a preset range. Sync bits and error status bits are not included in the encoding calculation. Synchronization words are regenerated, error-free, by the decoder.







**Figure 9-1. Wideband Nascom Network Overview
(Leased Common Carrrier Circuits)**

- d. The performance of the BED in terms of undetected block error rate (fraction of transmitted blocks received with bit errors that fail to be detected by the power of the polynomial) is dependent somewhat on channel block error rate and distribution of errors within blocks. Based on available Nascom channel performance statistics for 7.2 kb/s with 1200-bit blocks and a BER of 1×10^{-5} , the undetected block error rate is approximately 1×10^{-11} .
- e. This represents about $5 \times 10 + 6$ hours mean time between undetected block errors. Block loss rate due to excessive header errors or false synchronization (fraction of transmitted blocks not recovered from received data stream) ranges from 0.014 percent for contiguous blocks to 0.04 percent for noncontiguous blocks.

9.2.4.2 DSN Encoder-Decoder

The DSN encoder functions with 1200-, 2400-, or 4800-bit block sizes, and 22- or 33-bit polynomial codes. The equipment performs inline encoding and decoding for the users. Nascom Switching Centers and technical control at GSFC are equipped to selectively monitor and test both types of data streams. When used as monitors, the BEDs do not modify the user's data blocks.

9.2.4.3 GN Encoder-Decoder

The BEDs at the GN sites are arranged on a switchable basis, permitting bypass of the BEDs for non-DDPS data formats that may remain in use in the GN. The Nascom/GN BED encoders compute a 22-bit polynomial error control code word based on the 4800-bit block received from any formatting source code.

9.2.5 WBDS Services for Overseas Communications

These paragraphs describe the traditional facilities and services between GSFC and overseas locations.

9.2.5.1 Communications Satellite System Facilities

Most wideband data channels to foreign overseas locations are implemented via the communications satellite systems, which include the Earth stations of the foreign overseas communications carriers and the Intelsat system. The links between the foreign Earth stations and the remote GN stations or Nascom Switching Centers, and between the Nascom Switching Centers and GN or DSN, are implemented on combinations of terrestrial cable and microwave facilities provided by the foreign carriers and NASA. The U.S. end links are normally implemented via Nascom-2000 services when the data rates are 1.544 Mb/s or lower.

9.2.5.2 Intelsat Single-Channel-Per-Carrier Service

The International Satellite Consortium (Intelsat) has offered for sometime, relatively cost-effective means of extending the 56-kb/s service internationally, by using a communications satellite system called the SCPC. All of Nascom's existing 56 kb/s overseas services are currently implemented with SCPC. The operation and effectiveness of the SCPC system is discussed in the following:

- a. A single voice channel in the space segment, normally occupied by 64 kb/s Pulse Code Modulation (PCM), is displaced by preassigning it (setting it out of a pool of

voice channels), normally operated in a demand assignment switched voice system. The acronym for this demand assignment system is SPADE (Single-Channel-Per-Carrier Pulse Code Modulation Multiple Access). This system allocates a satellite transponder to a community of low-density international voice traffic users. This transponder is frequency-divided into 800 individual carriers spaced 45 kHz apart (SCPC) on each of which a PCM voice channel can be developed on each. Nascom leases these preassigned SCPC channels full-period. The voice digitizing equipment is bypassed, and a 56-kb/s clear channel service is provided by the carrier involved.

- b. The cost effectiveness of this lease is derived from the fact that only one voice channel is displaced by the 56-kb/s service. At the present time, this cost effectiveness is partially diluted by the analog extension end links that displace 12 voice channels.

9.2.5.3 Overseas 56-kb/s Service Extension

Where necessary, the foreign terrestrial end links of the overseas 56-kb/s wideband data services are implemented on a 48-kHz analog bandwidth group channel of the FDM hierarchy commonly used internationally in the transmission media of telephone plant facilities. This group channel displaces a capacity of 12 voice channels. Nascom leases the 48-kHz channel from the foreign carrier and develops the digital data service by providing wideband data terminals at each end of the 48-kHz channel end link. The equipment required for the operation of this service is described in the following:

- a. These Nascom-provided terminals include WECO data sets and modems and the test equipment necessary for operation and maintenance of this 48-kHz portion of the end-to-end data service.
- b. The data set on this portion of the network is the WECO 303C, which is a full-duplex, synchronous data set originally designed to operate at 50 kb/s, but modified by NASA for 56-kb/s operation on the 48-kHz analog channels. This modem presents an unbalanced current digital interface. The data set has the scrambling/descrambling feature for bit sequence independence, with internal or external clock options. Nascom uses the WECO LWM-6 modem for frequency translation to the communications carrier's 60- to 108-kHz group-band channel. A WECO Wideband Loop Repeater (WLR-5) is used in place of the LWM-6 if the segment of the circuit is a hardwire cable rather than a 60- to 108-kHz channel. On these channels, Nascom has access to the analog interface for test purposes.

9.2.6 Common Carrier Services Between U.S. Locations

To support requirements at those domestic locations where Nascom-2000 services are not available (including Alternate Network Connectivity), Nascom continues to lease circuits competitively. The following paragraphs pertain only to this increasingly less frequent situation.

9.2.6.1 Terrestrial Carrier Services

There are many wideband digital service offerings available from local and long distance communications carriers. Principally, all-digital T-carrier facilities are in use via wire cable and microwave systems, for the shorter LAN/Nascom wideband services. Fiber optic facilities are also coming into use. The commercial carrier's T-1 networks provide Nascom with 56, 224 kb/s, and 1.544 Mb/s short-haul services. AT&T Dataphone Digital Service (DDS) is also available in 96 "digital cities," which includes a 56-kb/s digital data service offering. Integrated Services Digital Networks (ISDN) offerings make flexible wideband digital data services available in metropolitan areas at 16, 64, and 128 kb/s (Basic Rate Interface) and digital data rates in 384-kb/s multiples up to 1536-kb/s, with the Primary Rate Interface. Generally, terrestrial facilities are not currently competitive with domestic satellite systems at distances beyond 100-200 miles. Nevertheless, ISDN offerings are expected to be extended as a wide area network service via various transmission media.

9.2.6.2 Domsat Carrier Service

The Domsat services are in competition with the terrestrial services on the long-haul data transport services. Domsat implements the digital data transport by using SCPC services and other techniques such as TDM. The other considerations for implementing this service are as follows:

- a. Unless the Domsat carrier is able to locate an Earth station at the customer's premises, or the Domsat carrier is able to build its own terrestrial microwave facilities in the proximity of the customer's location, those carriers are dependent on acquiring a terrestrial extension as part of their service to the customer. Thus, the configuration of facilities for each end-to-end service varies with each case.
- b. In many cases, the Domsat carriers had found it feasible to locate Earth stations in close proximity to NASA installations to satisfy NASA and other government communications service requirements. As a result, higher data rates became cost effective in the U.S. portion of the Nascom Network. Prior to Nascom-2000 implementation, services were being provided at 56-kb/s, 224-kb/s, 1.344-Mb/s, 2.048-Mb/s, 1.544-Mb/s, 2.5-Mb/s, 4.0-Mb/s, 6.0-Mb/s, 15.06-Mb/s, and 50.0-Mb/s data transmission rates. As noted in the Section 5 description of Nascom-2000 services, data rates up to 1.544 Mb/s can be directly interfaced, with the exception of isochronous signals. Data rates in excess of 1.544 Mb/s must still be transported via services other than those offered by the NSAP modification to GSA's FTS2000 Network A contract (Nascom-2000). Data destined to locations that are neither served nor serviceable under FTS2000 NSAP must also be transported via services obtained through competitive processes.

9.3 Nascom Overseas Communication System

The following paragraphs describe the requirements, architecture, equipment, facilities, and services between GSFC and several overseas locations. Also introduced is the Gamma Ray Observatory (GRO) Remote Terminal System (GRTS) that uses selected links of the NOCS for transmission of data.

9.3.1 Background Information

To facilitate and enable closure of the Madrid Switching Center, Nascom agreed to establish multiplexed data links between NASA stations in the United States, principally GSFC and JPL. As these new data links were established, the interfaces between Madrid and facilities of the European International Partner Agencies were deactivated and the Madrid Switching Center function terminated. By agreeing to a largely common architecture, cost savings also resulted. Previously, each new requirement entailed the lease of a new circuit; requirements can now be satisfied by putting the service onto the in-place multiplexed data link. Startup and turn-down costs associated with individual circuit activation and deactivation are no longer incurred.

This concept of providing multiplexed data trunk circuits between Nascom switching facilities at GSFC and European locations was then extended to encompass NASA tracking stations in Bermuda and Australia, and with the National Space Development Agency of Japan (NAS-DA). Sharing of the bandwidth between JPL and its two overseas tracking stations enables both Nascom and PSCN requirements to be met by a common resource, thus progressing an OSC objective of a common transmission infrastructure.

9.3.2 Requirements

Wherever possible, wideband multiplexed services are to be provided using NOCS. The aggregate data interface standard is RS-422 (or equivalent) for all sites. However, should a particular site not be able to support a balanced aggregate interface, a different interface may be negotiated. Standard voice channel interfaces are 4-wire with no signaling (E&M or otherwise) being supported. For data channels, interface standards are RS-232 for data rates of 9.6 kb/s and below, and RS-422 balanced, RS-423 unbalanced, or CCITT V.35 for channel rates above 9.6 kb/s. The following sites are currently supported by NOCS.

European Segment:

- a. GSFC - GSOC, Oberpfaffenhofen, Germany.
- b. GSFC - CNES, Toulouse, France.
- c. GSFC - ESOC, Darmstadt, Germany.
- d. GSFC - ESOC, Villafranca, Spain.

Other Segments:

- a. GSFC - BDA.
- b. GSFC - JPL.
- c. GSFC - WSC.
- d. GSFC - TKSC, Tsukuba, Japan.

Segments Bypassing GSFC:

- a. WSC ETGT - Canberra RGRT.
- b. JPL - Canberra DSCC.
- c. JPL - Madrid DSCC.

9.3.3 Architecture

The standard multiplexer selected by Nascom for use on its international data link circuits, and for similar requirements between NASA sites located within the United States, is the ascom Timeplex Link/2 + TM. For the GSFC - GSOC link, an exception to this standard was agreed upon. The DLR had purchased GDC Megamux Plus time division multiplexers for transport of its Spacelab D2 data from GSFC to GSOC. Since there were still unallocated GSOC GDC resources available, the equipment was reused on this NOCS link. Both multiplexers are capable of directly interfacing (at the channel level) with voice (including facsimile) and data (asynchronous, synchronous, and isochronous) provided that the appropriate channel cards are installed. Figure 9-2 depicts the NOCS architecture.

9.3.3.1 Circuits

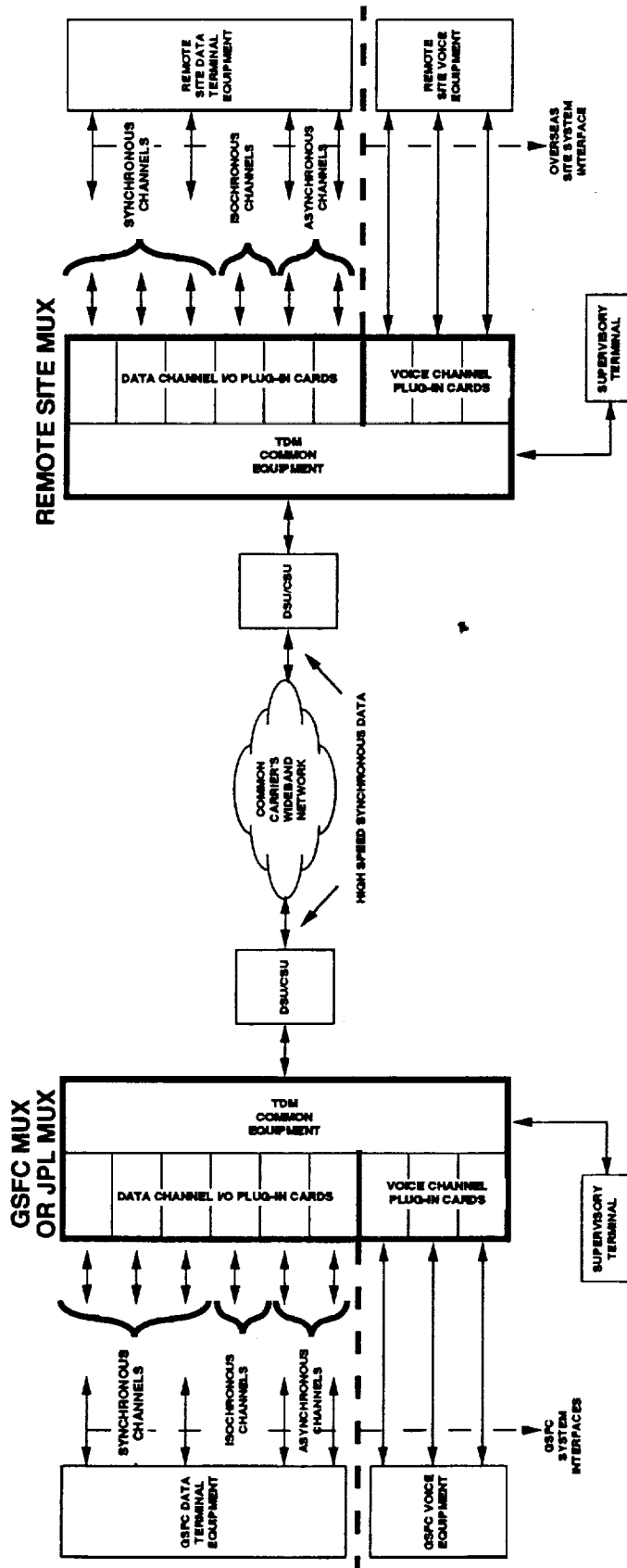
Circuits between GSFC and European locations, i.e., GSOC, ESOC, and CNES, have traditionally been individual voice, data, and AVD circuits. These individual circuits either have been or are being considered for cutover to individual port/channel interfaces on the transport multiplexers. The NOCS multiplexers have been installed to terminate each end of a wideband data link circuit operating at least 64 kb/s, with higher rates (up to T-1 or E-1) available as requirements may justify. Common aggregate data links being utilized are 64 kb/s, 72 kb/s, 112 kb/s, 512 kb/s, 1.544 Mb/s, and 2.048 Mb/s. This architecture is expected to reduce the cost incurred in leasing individual voice and data circuits between GSFC and overseas locations. Aggregate data links are chosen to support existing and projected near-term requirements and can be reconfigured for changing needs. At GSFC, voice channels are normally interfaced to the VSS. Data channel interfaces at GSFC may be through either the DMS or the MSS. The application drawing in Figure 9-3 shows a typical NOCS point-to-point data link circuit from end-to-end.

9.3.3.2 Station Equipment

The time division multiplexer equipment used in the NOCS is supplied by ascom Timeplex and General DataComm. A typical rack elevation for a complete NOCS terminal (ascom Timeplex equipped) is shown in Figure 9-4. A description of station equipment may be found in the *Nascom Overseas Communications Systems (NOCS) Requirements/ Implementation Design Document*, 541-210, Volume 1, February 1995. Descriptive material from that document is excerpted here to provide the reader with a better understanding of NOCS capabilities.

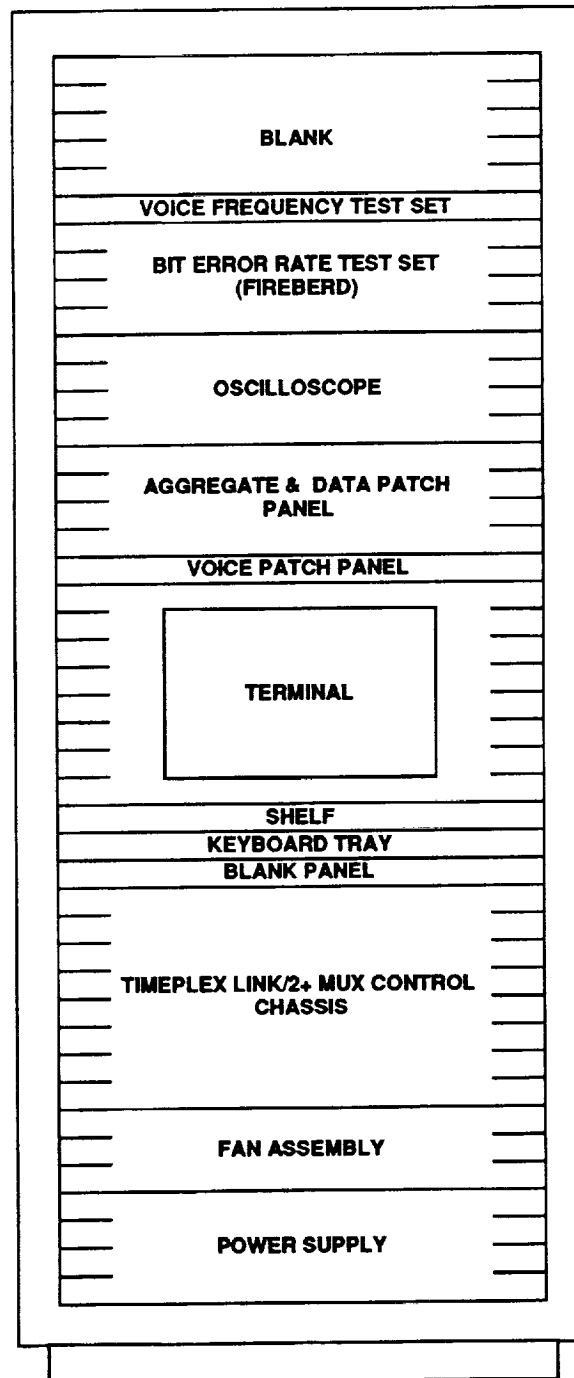
- a. ascom Timeplex Link/2 + TM. The ascom Timeplex Link/2 + TM family of equipment is based on a modular design and, with purchase of its Network Management System software, is capable of being remotely managed and controlled as a network. However, at this time, Nascom has not procured the NMS software and is essentially operating the system as a collection of point-to-point links. For control and monitor purposes, remote commanding of the multiplexer equipment terminating each end of a data link is a capability of the equipment employed by Nascom. Module redundancy, in the frame (nest), is provided for the power supply, common control, and aggregate interface cards; this allows for failover to the backup module in the





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Figure 9-3. Typical of Mux Application In a NOCS End-to-End Link



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Figure 9-4. Typical Rack Elevation Drawing for a Complete Mux Subsystem

event of a primary failure. Port and channel cards are spared on-site, but not in the nest. Removal and replacement of failed port and channel interface modules require the intervention of an operator/technician. A description of some of these modules follows:

1. The Network Module (NCL or NCL+) maintains control of the data flow within the multiplexer. Speeds from 45.5 b/s up to 2048 kb/s are supported. The NCL+ offers a phase lock loop feature. Some of the functions performed by this module are (1) the initialization and supervision of the interactions between all modules in the nest, (2) receive and process NMS commands or those generated for basic link control and monitoring, (3) detect and report alarm conditions, and (4) control system clock source selection and nodal timing distribution.
2. The Interlink Module (ILC) is the aggregate interface card that actually terminates a point-to-point data link. This module supports link speeds from 4.8 kb/s up to 2048 kb/s. Nascom uses the ILC.2S (S indicates a satellite buffering feature) for its RS-422 interfaces on data links with a satellite hop(s) in their path.
3. The Quad Synchronous Module (QSC) supports synchronous data rates from 50 baud up to 256 kb/s. Each module supports up to four port interfaces. Modules are subcategorized by the electrical interface standard employed:
 - (a) QSC: RS-232/CCITT V.24 port interface.
 - (b) QSC.2: RS-422/CCITT V.11 port interface.
 - (c) QSC.4: CCITT V.35.
4. The Quad Synchronous Processor (QSP) supports synchronous data rates from 50 baud up to 1.544 Mb/s. Each module supports up to four port interfaces. Modules are subcategorized by the electrical interface standard employed:
 - (a) QSP: RS-232/CCITT V.24 port interface.
 - (b) QSP.2: RS-422/CCITT V.11 port interface.
 - (c) QSP.4: CCITT V.35.
5. The Quad Asynchronous Module (QAM) module supports up to four port interfaces. Modules are subcategorized by the electrical interface standard employed:
 - (a) QAM: RS-232/CCITT V.24 port interface.
 - (b) QAM.2: RS-422/CCITT V.11 port interface.
6. The Isochronous Communications Module (ICM.2) supports up to two port interfaces conforming to RS-422/CCITT V.11 electrical interface standards.
7. Two families of voice modules are available: Quad Voice Module (QVM) and Enhanced Voice Module (EVM). Each member of these two families of voice modules supports up to four voice channel interfaces. Differences between

modules and families are attributable to line speed and to the encoding algorithm used. The following two modules may be considered as standard in NOCS:

- (a) QVM.3: Voice is Pulse Code Modulation (PCM) encoded for a line rate of 64 kb/s, or Adaptive Differential PCM (ADPCM) encoded for a line rate of 32 kb/s.
- (b) EVM.3: Voice is PCM encoded for a line rate of 64 kb/s, or Codebook Excited Linear Predictive (CELP) encoded for (selectable) line rates of 16 kb/s, 8 kb/s, or 5.33 kb/s.

b. GDC Megamux

The GDC Megamux Plus TDM, used only on the NOCS DLR/GSOC link, is a symmetrical, self-contained time division multiplexer. It is capable of multiplexing up to 54 channels of voice and synchronous, asynchronous, and isochronous data. The equipment utilized on the DLR GSOC circuit is reused from the DLR's Space-lab D2 mission of April/May 1993. With the GDC equipment, each channel module supports one port interface. When the NOCS data link was initially activated with the DLR/GSOC, the Megamux Plus was configured for three 9.6 kb/s synchronous data channels, one 300 baud asynchronous data channel employing GDC's Universal Data Card modules, and two 16 kb/s voice channels employing GDC's Universal Voice Card/ADPCM version modules. Megamux Plus equipment is an exception within NOCS and is not available for use to meet other NOCS requirements.

9.3.3.3 Multiplexer Installations

NOCS nodes at the ends of each data link (for which multiplexer application drawings have been developed) are shown in Figures 9-5 through 9-13. These drawings are excerpted directly from the Nascom Overseas Communications Systems (NOCS) Requirements/ Implementation Design Document. With the one exception of the GSFC-GSOC link that was implemented with GDC equipment, the system employs Timeplex Link/2+™ TDMs throughout. One of the drivers for implementing NOCS was flexibility with respect to signals transported; any multiplexer's channelization may vary from that just portrayed.

a. European Segment:

- 1. GSFC-GSOC (GDC Megamux Plus): Figures 9-5A (GSFC) and 9-5B (GSOC).
- 2. GSFC-CNES, GSFC-ESOC, and GSFC-VILSPA: Figures 9-6A (GSFC), 9-6B (CNES), 9-6C (ESOC), and 9-6D (VILSPA).

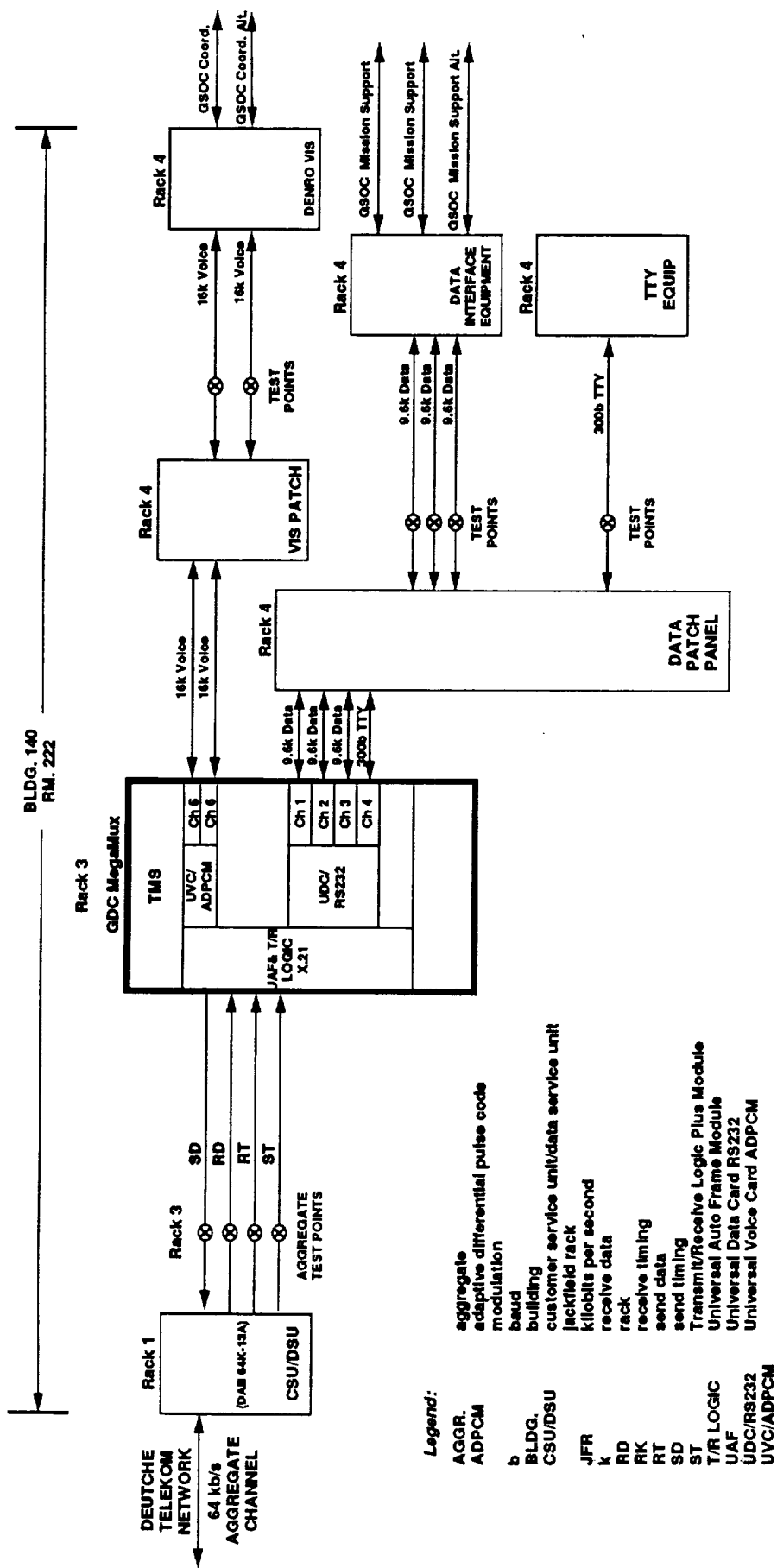
b. Other Segments:

- 1. GSFC-BDA: Figures 9-7A (GSFC) and 9-7B (Bermuda).
- 2. GSFC-JPL: Figures 9-8A (GSFC) and 9-8B (JPL).
- 3. GSFC-WSC (GRTS): Figures 9-9A (GSFC Node 5) and 9-9B (WSC ETGT Node 3).
- 4. GSFC-TKSC (NASDA), Japan: Figures 9-10A (GSFC) and 9-10B (Tsukuba).

c. Segments Bypassing GSFC:

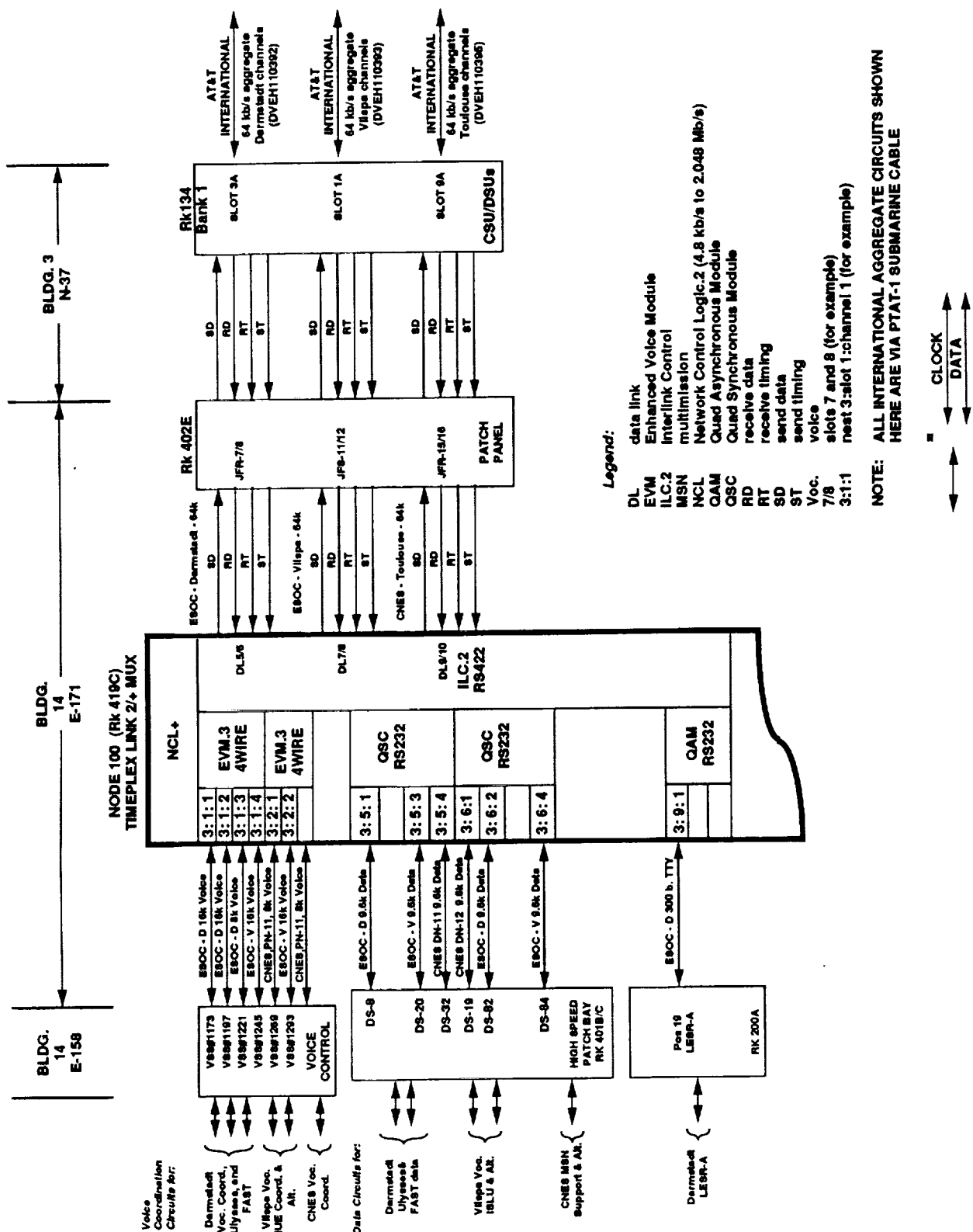
- 1. Planned RGRT (Node 2) – ETGT (Node3) Interfaces: Figure 9–11.**
- 2. JPL–Canberra DSCC: Figures 9–12A (JPL) and 9–12B (CDSCC).**
- 3. JPL–Madrid DSCC: Figures 9–13A (JPL) and 9–13B (MDSCC).**





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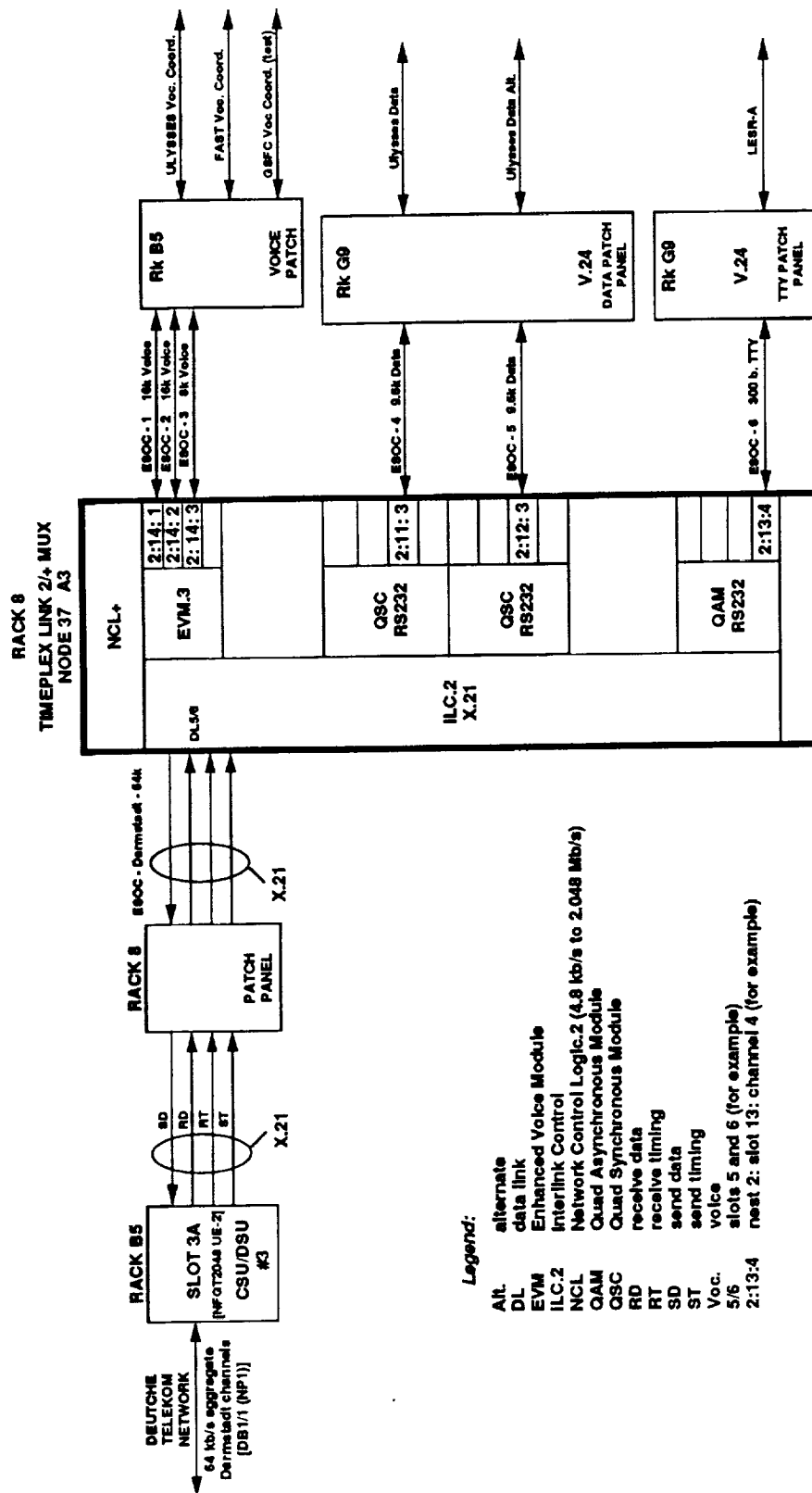
Figure 9-5B. Mux Configuration at GSOC Oberpfaffenhofen, Germany



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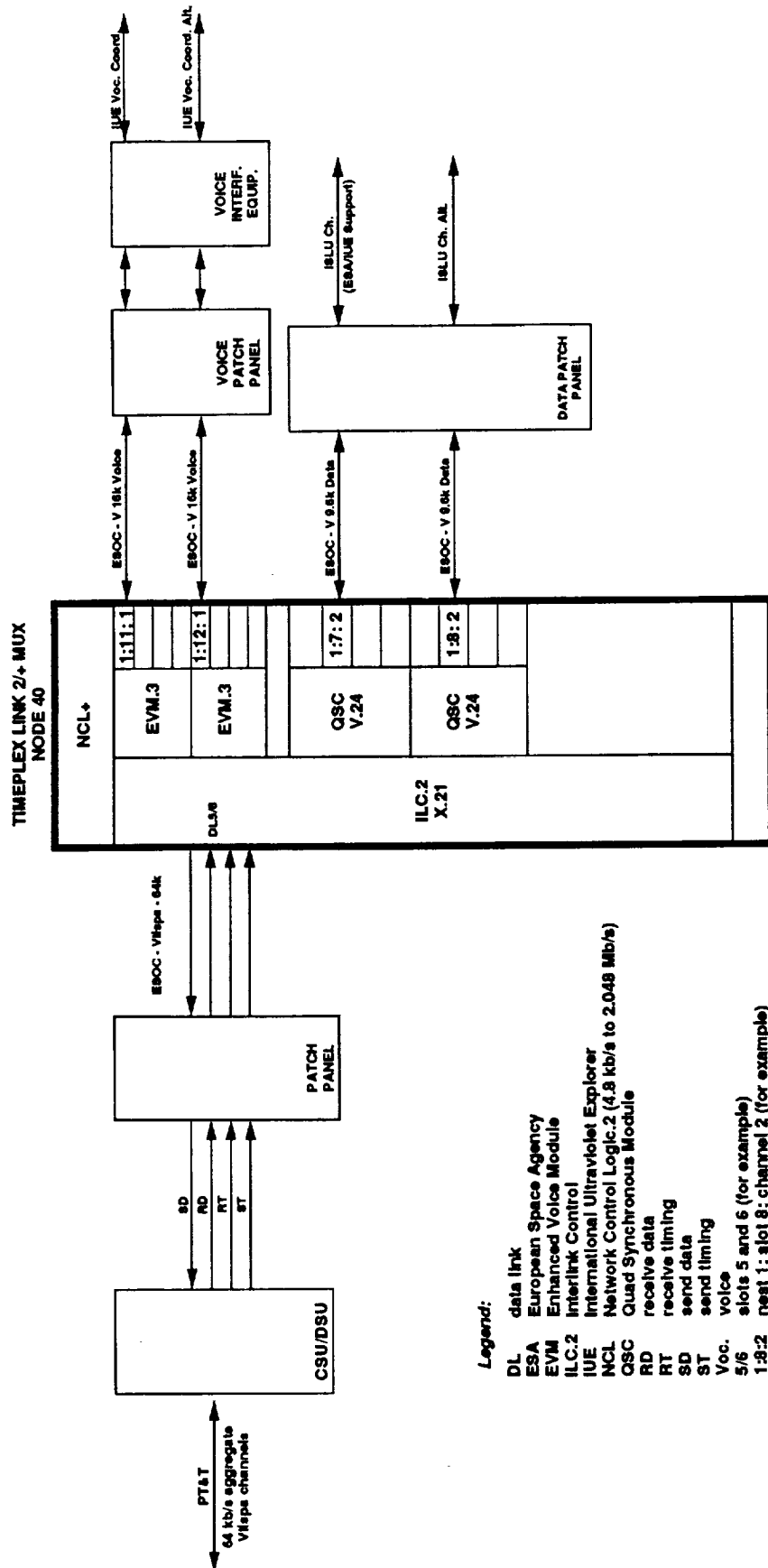
Figure 9-6A. Link/2 + Configuration at GSFC for Overseas Circuits in European Segment





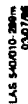
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Figure 9-6C. Mux Configuration at ESOC Darmstadt, Germany



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Figure 9-6D. Mux Configuration at ESOC Vilspa, Spain





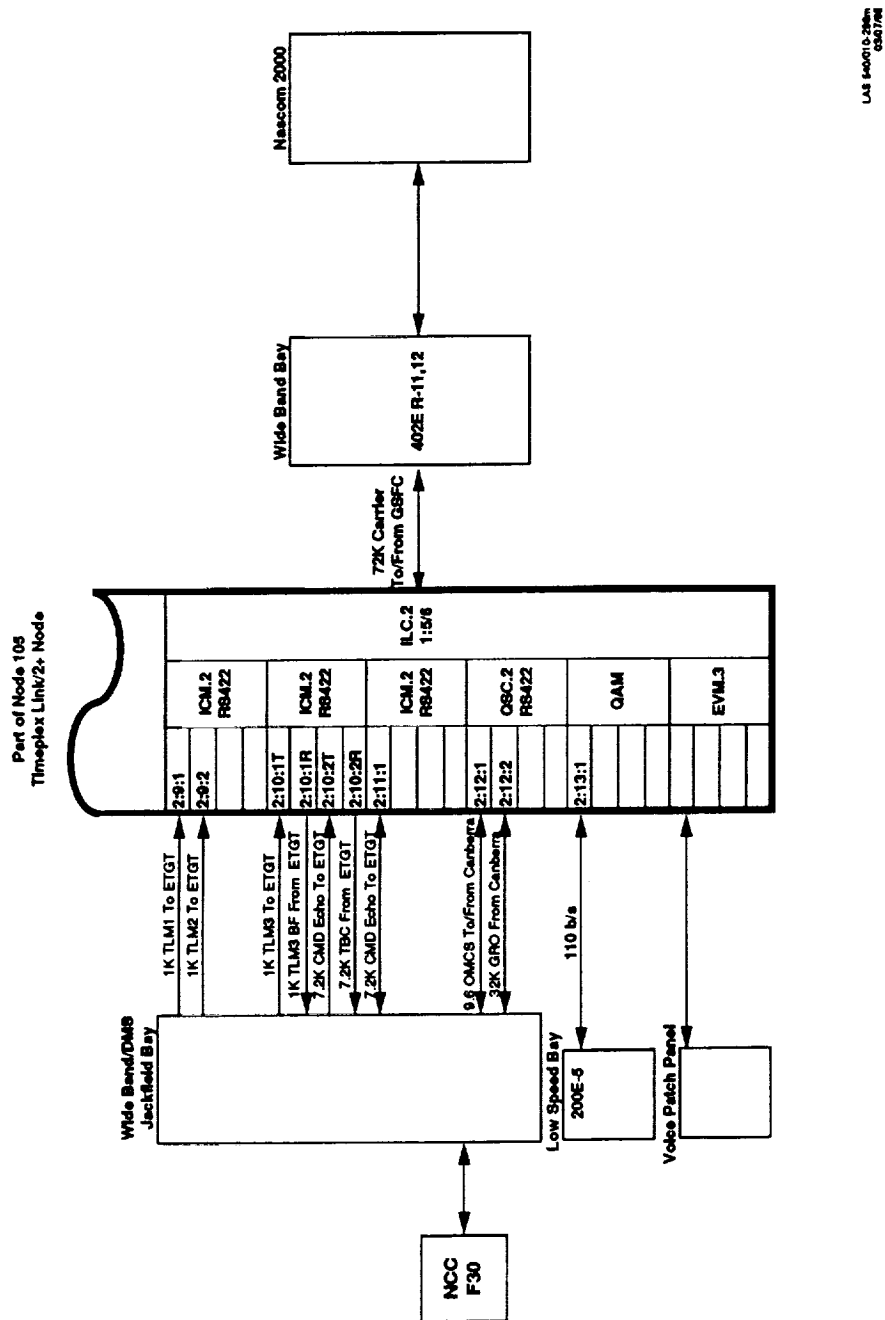
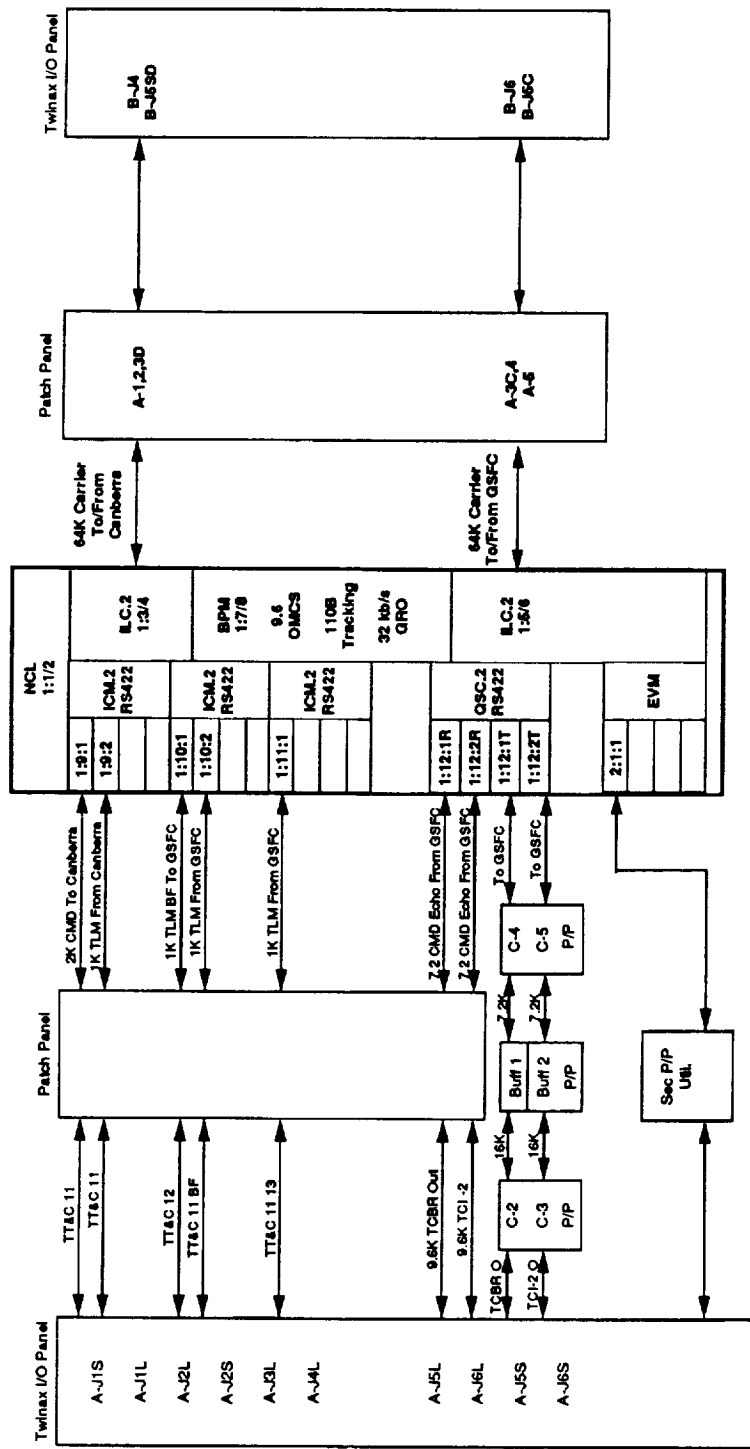


Figure 9-9A. Node 105 Mux Configuration for GRTS at GSFC



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Figure 9-9B. Mux Configuration at WSC for GSFC and Canberra (Node 3)

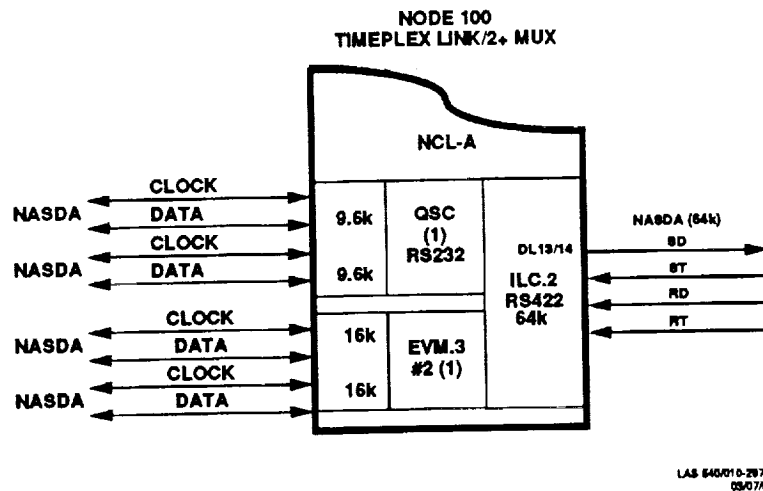


Figure 9-10A. Mux Configuration at GSFC for NASDA

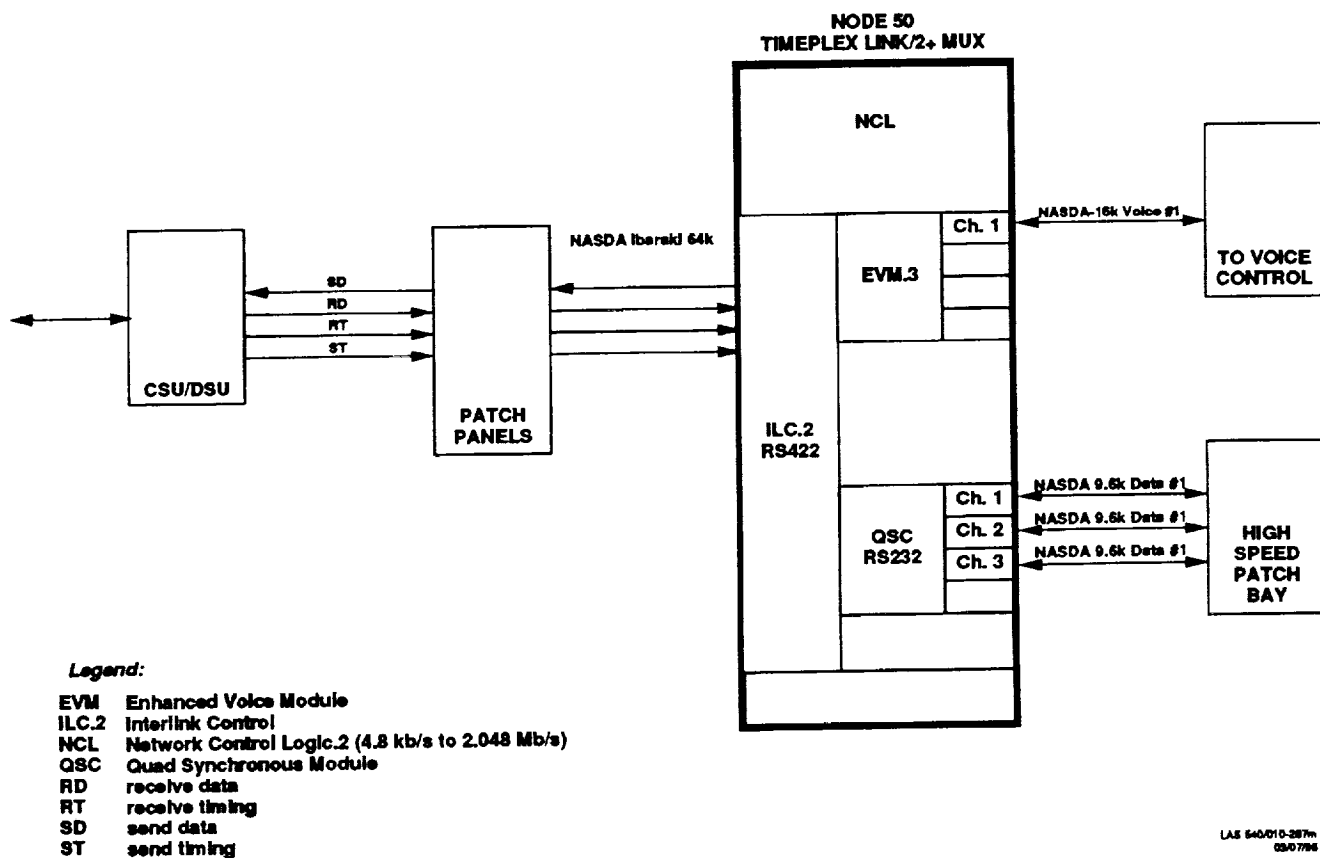
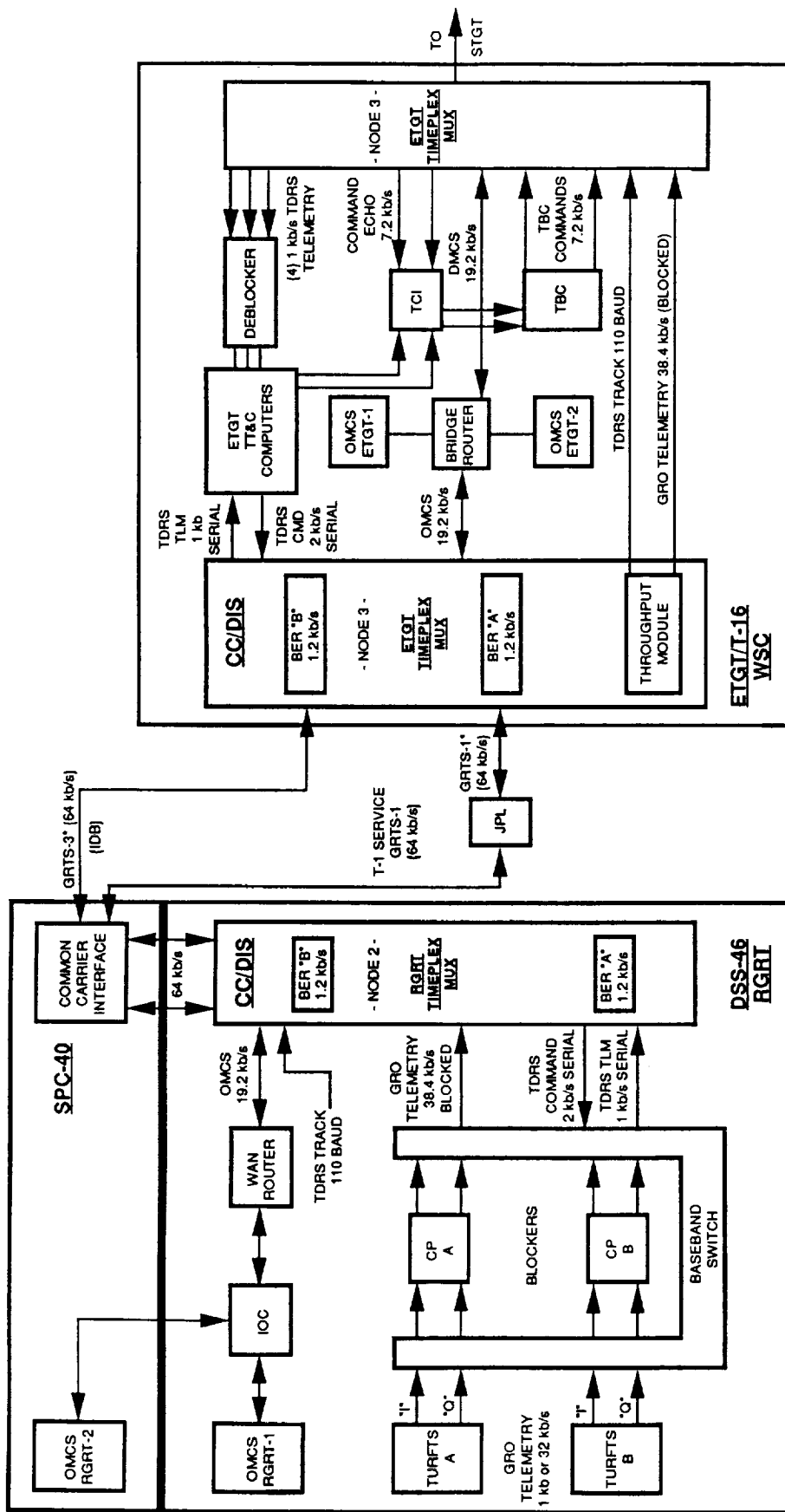


Figure 9-10B. Mux Configuration at TKSC (NASDA), Japan



LEGEND:

A Diagnostics Channel
 CC/DIS Common Carrier/Data Interface System
 CP Communications Processor
 DSS Deep Space Station
 ETGT Extended TDRS Ground Terminal
 GRO Remote Terminal System
 IOC Input/Output Controller
 OMCS Operations Monitor and Control System
 RGRT Remote Ground Relay Terminal
 SPC Signal Processing Center
 TBC TDRS Block Concentrator
 TCI TDRS Command Interface
 TDRS Tracking and Data Relay System
 TT&C Telemetry, Tracking and Command
 TURFIS TDRS User Radio Frequency Test Set
 WAN Wide Area Network

* RGRT TO ETGT/T-16

CIRCUIT 1 ("GRTS-1")
 TDRS CMO (2 kb/s) SIMPLEX
 TDRS TLM (1 kb) SIMPLEX
 MAINTENANCE BER "A" (1.2 kb/s) DUPLEX
 CIRCUIT 2 ("GRTS-3")
 OMCS (19.2 kb/s) DUPLEX
 GRO TELEMETRY (1 kb/32 kb/s) 38.4 kb/s SIMPLEX
 TDRS TRACK (110 BAUD) SIMPLEX
 MAINTENANCE BER "B" (1.2 kb/s) DUPLEX

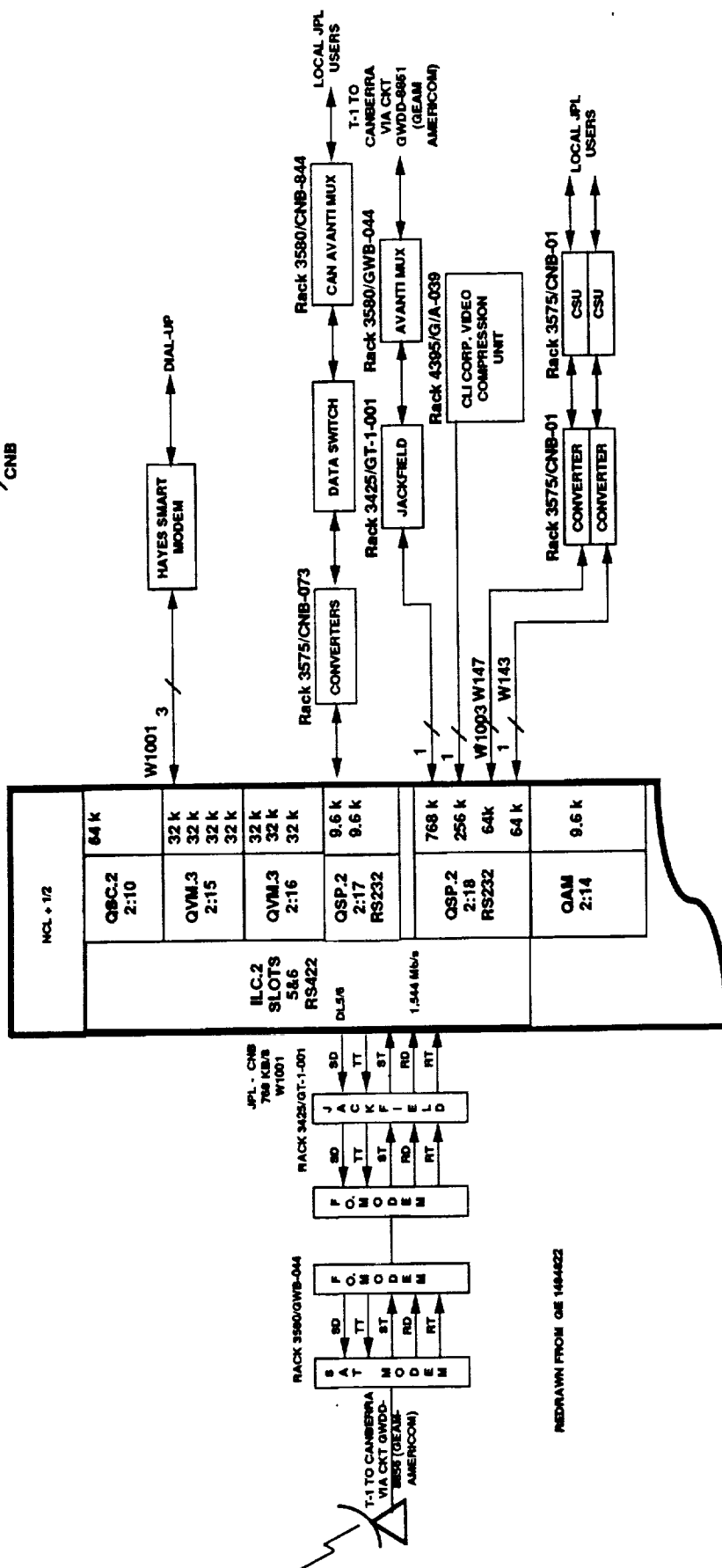
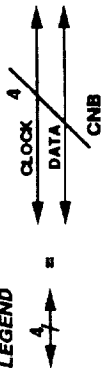
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Figure 9-11. Planned RGRT/DSS 46 to ETGT/T-16 Interfaces

TIMEPLEX LINK 2/4 MUX NODE 110

Rack 5353/GT-1-305

LEGEND



REDRAWN FROM GE 1484022

UAS 640010 300m
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Figure 9-12A. Mux Configuration at JPL for CDSCC, Canberra, Australia



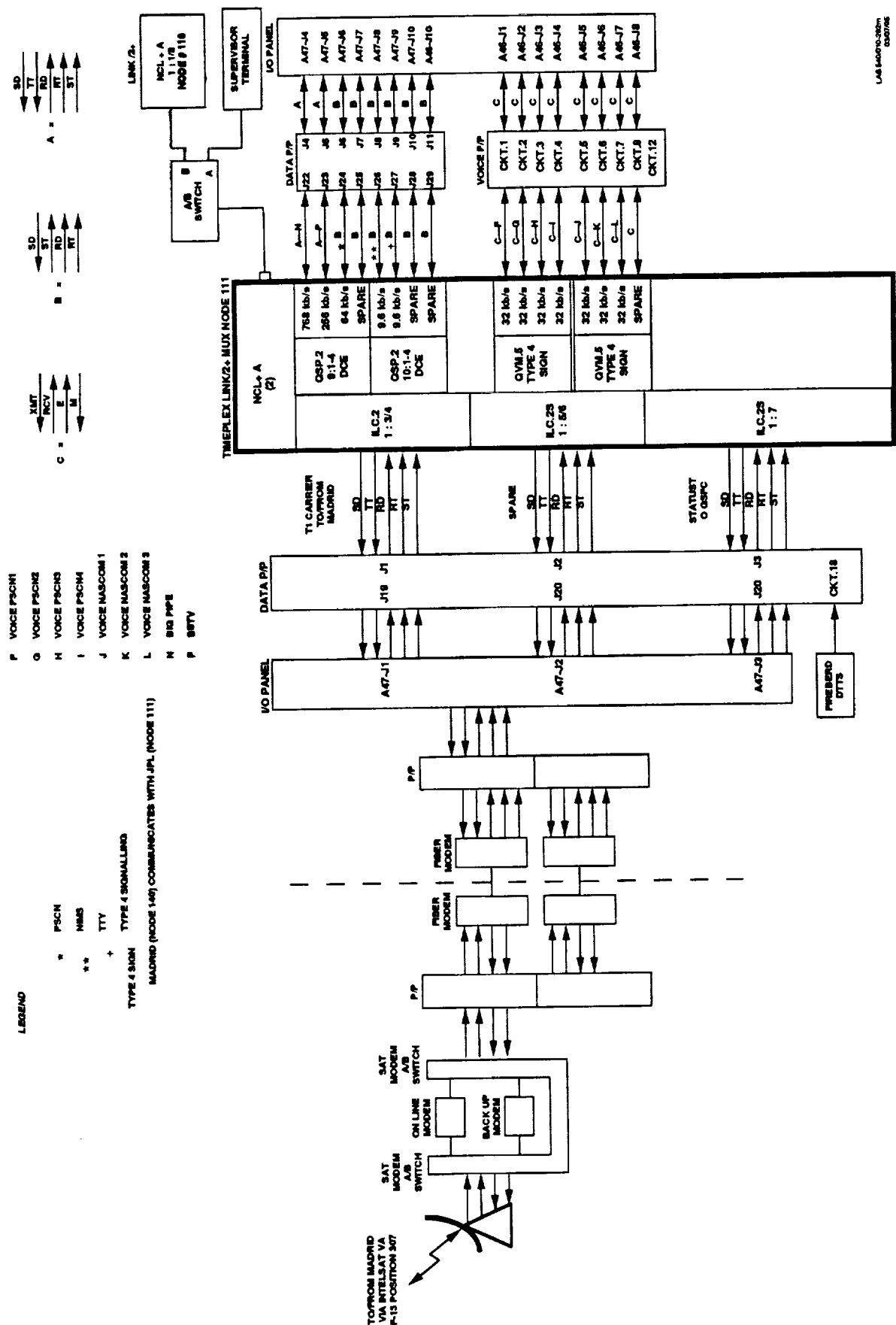


Figure 9-13A. Mux Configuration at JPL for Madrid



Figure 9-13B. Mux Configuration at Madrid



Section 10. Video System

10.1 General

10.1.1 System Definition

For the purpose of this document, the following terms are defined:

- a. The video system, as configured by Nascom, can be defined as a system that refers collectively to the people, video and switching facilities, circuit interconnections, and methods to provide operational mission phase video monitoring coverage, operational support video conferencing, general television broadcast for the Space Shuttle program, and video for local television distribution at the GSFC system level. The video system, as used in this document, has a broad meaning that includes synchronized audio, television signals, and general voice networking for coordination of video operations.
- b. The Nascom video network is a generic term referring collectively to a domestic and/or overseas interconnection of circuits, switching, and terminal facilities that are established and operated by or for Nascom to provide operational video support, particularly to the Space Shuttle program.

10.1.2 Background Information

10.1.2.1 Nascom Video Network Origins

The Nascom Video Network had its origins in the early days of NASA to provide its Public Affairs Office (PAO) with launch day coverage of important NASA launch events. In the early days, this coverage was provided by calling up AT&T occasional use TV services from Cape Canaveral to GSFC. With the growth of the manned space program there evolved the true operational video interconnection of the JSC/MCC with the KSC/LCC for prelaunch and launch monitoring support activities. This coverage then expanded to include spacecraft engine test firings, and with the advent of communications satellite TV capabilities, the relay of reentry events and orbital video. Nascom employed the services and facilities of domestic, foreign and INTELSAT communications carriers to extend orbital downlink video signals from various NASA tracking stations back to the US. During the Apollo program, lunar surface video signals were extended from overseas locations at Canberra and Madrid, and during the Apollo-Soyuz Test Program, special international video interconnections were arranged. Established for the Shuttle program, orbital coverage is now provided using full-period leased domestic satellite transponder services. In addition to the above, slow-scan overseas digital video transport for support of DSN images emerged. With the specialized, unique high-rate domestic digital transport facilities implemented for the rapid transport of Earth Observation Satellite images for the Landsat program, there evolved today's switching capability to permit time-sharing the leased transponder services to support both Shuttle missions and other programs.

10.1.2.2 GSFC Video System

The video system at GSFC can be traced back to 1962 when it began as an administrative television function for Code 200. The original system consisted of the administrative TV system in Building 8 with the associated underground cabling network in 12 buildings. The system was installed in 1962 and transferred from Code 200 to Code 500 in 1965. At that time, a few coaxial cables between Buildings 3, 21, 7, 10, and 15 had been installed for the Orbiting Geophysical Observatory Project to transport command and control signals for on-ground spacecraft testing. The original CCTV center in Building 8 was combined with the installed CCTV systems in Building 14 Network and Projects Control Centers to provide operational, project, and PAO support for all missions conducted at GSFC. With the merger of Code 500 and Code 800 in 1985, the GSFC Video System function was transferred from the Data Communications-CCTV Section, Code 513.2, to the Nascom Division, Code 540. The video system, under Code 540, continued to grow as a result of the demands placed on it by the space program.

10.1.2.3 NASA Administrative Video Teleconferencing

NASA administrative intercenter video teleconferencing activity is conducted frequently and is the responsibility of MSFC. This activity is conducted using facilities of the MSFC administered NASA Program Support Communications Network (PSCN). The Telecommunications Branch of Nascom, Code 543, is responsible for local GSFC, WFF, and NASA Headquarters administrative video distribution facilities and for the GSFC gateway interface to the PSCN for intercenter video teleconferencing activities. In the past, before the PSCN established its current video conferencing capabilities, the Nascom Video Network capabilities had been used extensively to support administrative video teleconferencing activities, strictly on a non-interference basis with operational usage. This practice has been discontinued. Because the Nascom Division's Telecommunications Branch, Code 543, provides administrative video support functions for GSFC and supports some operational video using GSFC administrative video facilities, an overview of the GSFC administrative video system is also included.

10.1.3 System Capabilities

Configuration of the video system is controlled by Nascom to provide the following basic capabilities:

- a. A full-period, leased Domsat transponder service, with NASA controlling the time-shared uplink access from each of various NASA and DoD locations. The service provides video broadcast to the other locations, principally for Shuttle mission-related activities.
- b. TV analog-digital conversion-compression capabilities at certain locations for use with video conferencing activities via existing wideband digital links.
- c. Mission-related operational video conferencing, local (GSFC) CCTV and video distribution, video test and quality monitoring capabilities at GSFC.
- d. Control of TV signal switching to accommodate off-site distribution of mission events video, including distribution to NASA Headquarters (NASA HQ) which in

turn makes releases to commercial TV broadcast networks, the White House, and Capitol Hill.

10.2 Nascom Video System Description

10.2.1 Shuttle Video Network (SVN)

10.2.1.1 SVN System Description

The facilities and capabilities provided by Nascom for the SVN constitute the major Nascom operational video system element. The principal element of the SVN is the multiple access full-period Nascom Shuttle Video Transponder Service (NVTS) leased from a Domsat common carrier. The NVTS is augmented by several occasional-use service call-ups to cover prelaunch, launch, landing, and contingency landing situations. The SVN is also augmented by the GSFC video network capabilities for support of Shuttle mission activities. This includes video conferencing and local GSFC and offsite TV distributions (i.e., NASA HQ), PAO releases to the commercial video broadcast networks, and video signal quality measurement.

10.2.1.2 Nascom Video System Support

As indicated in Figures 10-1 and 10-2, Shuttle video service is provided by leasing Transponders 5 and 3 of GTE's Space Net 2 domestic communications satellite on a full-period basis. These transponders provide video links between JSC, KSC-MIL, GSFC, MSFC, DFRF, VAFB, and selected GN-DSN Shuttle-supporting stations. All locations are provided with collocated Earth stations except for MIL which obtains transmit access through the KSC GEAM Earth station. Operational use of this service is scheduled with the Nascom Operations TV Manager in Building 14, who interfaces by voice with GEAM, directing the scheduling and controlling the transmit access to these services. The SN2-5 is designated as "NASA Select One" and SN2-3 is designated as "NASA Select Two". The NASA Administrator has indicated that coverage of Shuttle and other NASA events should be given the widest possible dissemination; however, the first priority for use of these services is providing operational support to Shuttle and other NASA spacecraft. Specific support provided by the Nascom Video System is described as follows:

a. NASA Select One (Transponder SN2-5)

1. The KSC uplinks launch support scenes and information from roughly launch minus 5 hours through the lift-off sequences. When Shuttle is out of view of KSC controlled cameras and the playbacks have all been accomplished, the Uplink is transferred from KSC to JSC.
2. JSC normally maintains the uplink capability throughout orbital support periods. This allows JSC to uplink the color converted Shuttle video which is normally not available until after payload bay doors opening. Since video communications via TDRSS cannot be established prior to payload bay doors opening, any earlier Shuttle video transmission is via FM and can only be received by either MIL, GDS, or VAFB. In such cases, the SN2-5 uplink is

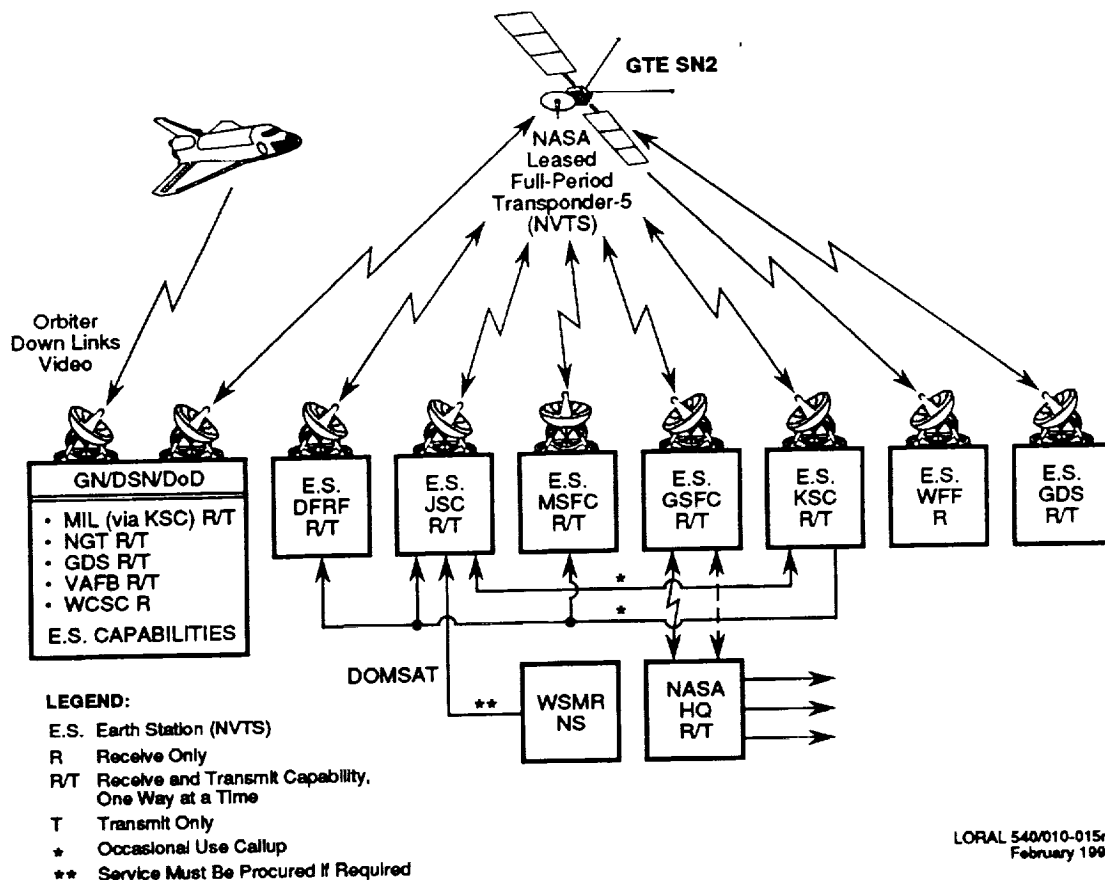
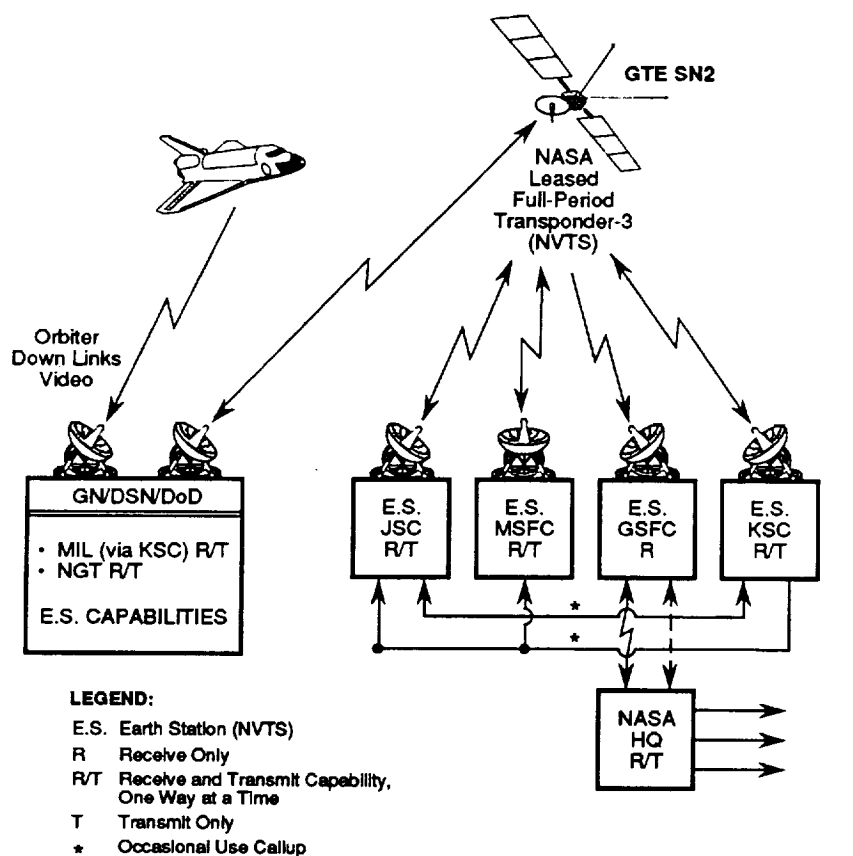


Figure 10-1. Shuttle Video Network Configuration (Transponder 5)

switched to the station receiving the FM downlinked video for transmission to JSC. JSC then color converts this video, records it on tape and holds it until the station receiving the FM video downlink experiences LOS with Shuttle. The SN2-3/5 uplink is then switched to JSC for transmission of the color converted (NTSC) video. JSC normally maintains its uplink capability on SN2-5 until the payload bay doors are closed (prior to reentry phase) at which time the uplink is switched to DFRF (for an Edwards AFB landing) or to KSC (for a landing at KSC) to cover the landing and post landing phases of the Mission. VAFB long range optical cameras are normally the first to receive pictures of the Shuttle during reentry for an Edwards landing.

When VAFB reports the Shuttle to be in view of their optical cameras, the SN2-3/5 uplink is transferred to VAFB and remains with them until acquisition of Shuttle via DFRF optical cameras at which time uplink is transferred back to DFRF. The uplink remains with DFRF through landing, crew egress, crew welcome and any other crew activity at DFRF. For a KSC landing, an analogous situation occurs as the Shuttle comes in view of the KSC/ER optical cameras except that the uplink remains with KSC during the descent, landing and post-landing phases.



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Figure 10-2. Shuttle Video Network Configuration (Transponder 3)

b. NASA Select Two (Transponder SN2-3)

1. Using SN2-3, KSC uplinks the multiplexed JSC Mission Evaluation Room (MER) and MSFC HOSC ice team selected pad camera video commencing early in the minus count (approximately L minus 12 hours) through liftoff.
 2. After payload bay doors are opened, the SN2-3 uplink is transferred to NGT. This switch enables NGT to transmit either K-band Shuttle field sequential video, 48 Mb/s STAT MUX data, or up to 4.2 MHz analog to GSFC, JSC, and MSFC. The SN2-3 uplink normally remains with NGT throughout the mission.
- c. White Sands Space Harbor (Northrup Strip).** There is no in-place video service capability from the White Sands Space Harbor (Northrup Strip) (WSSH NS) to JSC and GSFC for Abort-Once-Around (AOA) or End-of-Mission (EOM) landing support. After a determination has been made that the WSSH NS will be used for either an AOA or EOM landing, an arrangement with a commercial carrier is made for temporary video service, uplinking video from NS.

10.2.1.3 Video Network Configuration

The configuration of the GSFC Video Network is illustrated in Figure 10-3. The network branches out radially from GSFC to NASA HQ, WFF and the Johns Hopkins University Space Telescope news facility at Baltimore, MD. The GSFC Video Network also has interfaces with Nascom-2000 (for compressed 384 kb/s digital video transmission) and the Nascom Shuttle Video Network. At GSFC, the hub of the video system is the TV central control facility located in Building 8. The video system facilities at GSFC include the Building 14 CCTV, Building 88 (GSFC Visitor Center) TV news facility, Buildings 8 and 3 video-audio auditoriums, Building 8 video conference room, Building 14 Nascom-2000 interface, Building 1 PSCN gateway interface, and GEAM earth station for the satellite interface and gateway to the Shuttle Video Network. These facilities are connected by an extensive underground cable system consisting of two cable networks, the CCTV and the multi-pair-coaxial. The CCTV network is configured for video, TV-radio, audio, and data. The multi-pair-coaxial network is designed and installed for the distribution of data, video, audio, and TV-radio signals. Code 542 operates and maintains the Building 14 Nascom-2000 interface, and their extensions. The remaining facilities are under the jurisdiction of Code 543.

10.2.1.4 Network Elements

The GSFC Video Network, as illustrated in Figure 10-3, consists of the following physical network elements:

- a. GSFC video system facilities that include:
 1. Building 8 TV Central Control.
 2. Building 14 CCTV facility.
 3. Building 1 PSCN interface.
 4. Building 14 Nascom/gateway facility.
 5. Building 25 transponder gateway to all NASA centers and other terminals, including SVN.
 6. Building 88 PAO news facility.
 7. Buildings 3 and 8 audio-video auditoriums.
 8. Leased AT&T fiber optic links to NASA HQ video system.
 9. Leased AT&T fiber optic link to WASH 1.
 10. Building 8 video conference room.
 11. Local GSFC coaxial and fiber optic CCTV distribution facilities.
- b. NASA HQ Video System, illustrated in Figure 10-4.
- c. Johns Hopkins University Space Telescope PAO video facility at Baltimore, MD.

10.2.2 GSFC Video System Services

10.2.2.1 NASA Select/Shuttle Video Service

Nascom leases two complete transponders on a full-period basis on GTE's SN2 DOMSAT which serve to provide commercial grade TV service to NASA/DoD locations. All video

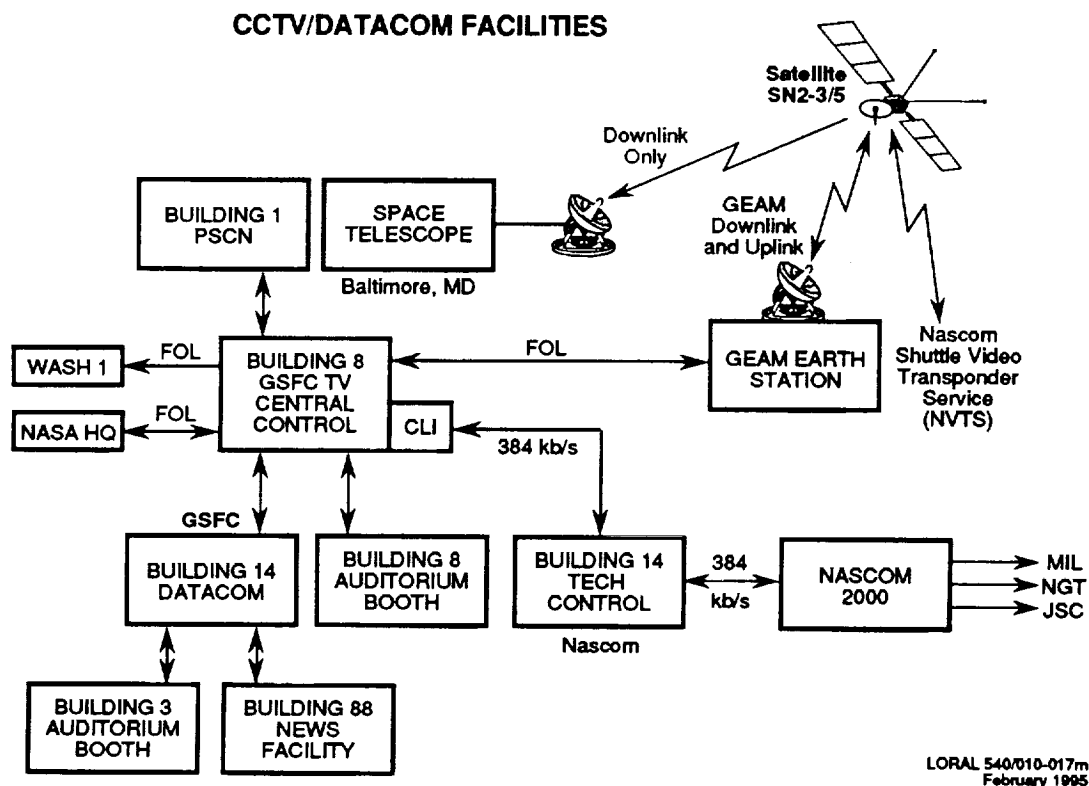


Figure 10-3. GSFC Video Network Facilities Configuration

transmitted via the two Nascom leased transponders on the GTE SN2 satellite is received by all stations in the Nascom Video Network. The launch, landing, and certain orbital video is extended to NASA's Washington Television Operations Center (TVOC) for release to the commercial networks. Video validation testing between GDS, JSC, NGT, MSFC, KSC/MIL, and DFRF is conducted prior to each launch. All video engineering, implementation, scheduling, procedures development, and operational control over use of the video system are exercised by the Nascom Division, Engineering Branch, Code 541, and the Operations Management Branch, Code 542. NASA Select Video local distribution is provided by Code 543 at GSFC for ground-based coverage of prelaunch, launch, and post-launch events; Orbiter downlink television; and ground-based coverage of landing and post-landing operations. As time permits, press briefings and news announcements are included in NASA Select programming for all mission phases. Television programming depicting key Space Shuttle activities that is to be externally distributed is selected by the NASA producer from the video-audio scenes available to the NASA producer. This service is intended to satisfy

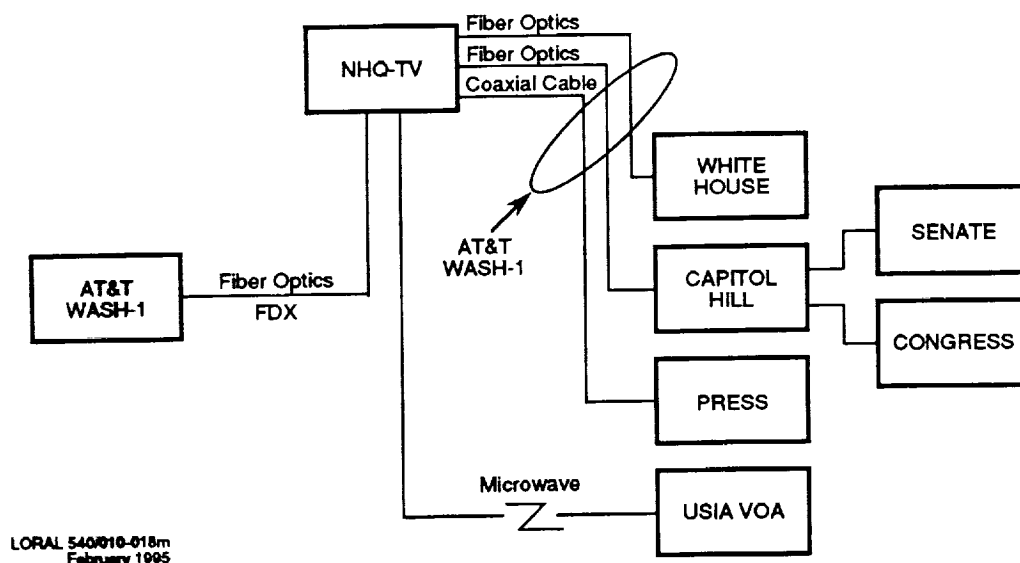


Figure 10-4. NASA Headquarters-NASA Select/WASH-1 Video and Audio Distribution System Configuration

operational, scientific, and documentary needs of local users such as the White House, Senate, Congress, and the press. The other features of this service are described in the following paragraphs:

- a. The Nascom Shuttle Video Transponder Service is augmented with a NASA-owned microwave link for two-way video transmission between GSFC and NASA HQ. Coverage is provided for launch, Shuttle mission monitoring and video teleconferencing. Nascom also leases a two-way full-period commercial fiber optic TV link between GSFC and NASA HQ to provide a backup to the NASA-owned microwave link. See Figure 10-3 for the NASA Select/ WASH 1 Video and Audio Distribution System configuration. When requested, this TV link is routed via Washington, DC, through NASA's TVOC for PAO release to the broadcast networks on a reimbursable basis.
- b. A monitoring and service evaluation capability is provided by Nascom Code 543, with answer service units located at GSFC, JSC, and KSC. These units monitor 37 TV parameters to determine conformance of the GE video transponder service to industry standards. Comparison is made at the modulation/demodulation points of the service for discrepancies between the uplink and downlink. Parameters are

transmitted to remote locations and GSFC TV Control via 1200- baud circuits terminating on Texas Instruments Silent 700 printers.

- c. The NVTs is also used to support the following services:
 - 1. Other Mission Video Coverage. The NVTs provides non-interference basis video coverage for NASA launches of non-Shuttle missions as required by project management and by the PAO.
 - 2. NASA Video Conferencing Service. The GTE SN2-5 transponder may be used for operational video teleconferencing services. When so used, technical support is provided by Code 543 with scheduling performed by Code 542.2.

10.2.2.2 Compressed Digital Video Teleconferencing Service

After the PSCN established a video teleconferencing service, Nascom restructured its video teleconferencing capability to support operational video conferencing activity. Compressed digital video is transported using 384 kb/s Codecs at the following sites: NGT, JSC, Naval Auxiliary Landing Field (NALF), Ames Research Center (ARC), Dryden Flight Research Facility (DFRF), MIL, and GSFC.

10.2.2.3 GSFC Telecommunications Network References

Additional information concerning the GSFC Video Network may be found in 543-001, GSFC Telecommunications Network Development Plan, and 543-002, GSFC Telecommunications Network Operating Procedures.

10.3 Video System Operation

10.3.1 Video Conferencing

10.3.1.1 Overview of PSCN Video Conferencing

NASA defines Video Conferencing (VC) as allowing two or more people in different locations to communicate across great distances with both speed and vision, often including graphics displays and the exchange of data and documents. VC allows many participants to hold meetings, seminars, and conferences during which they communicate, interact, and most importantly react among themselves as if they were actually present at the same location. The remainder of the Section offers descriptions at both the NASA network level and the GSFC system level.

10.3.1.2 NASA Video Network

The NASA Video Network combines the resources of several video systems: simplex system, duplex digital system, and the Codec system. The following paragraphs describe these systems in more detail.

- a. Simplex Analog System. Analog video plus its associated audio signal is uplinked from the center(s) to a satellite in a geosynchronous orbit. In the simplex mode, only

one NASA center uplinks while the others are in a receive-only mode. During the course of the video event, the NASA centers may rotate the uplink capability using a manual switching process coordinated by the Nascom Video Network. If required, MSFC's PSCN provides an audio teleconference capability to non-video equipped locations enabling them to participate non-visually in the conference.

- b. **Duplex Digital System.** In the duplex signal mode, the Codec is used to convert the analog picture signal into a digital form for transmission via a Nascom-2000 T-1 carrier. At the receive end, the digital signal is demultiplexed and converted back to analog. The Codec is used in the NASA Video Conference to provide duplex full motion and still-frame graphics within a 384 kb/s bandwidth. The Codec was designed for two-party conferences.
- c. **Codec System.** The codec used in the NASA video system compresses a 90-Mb/s color television signal generated by a video camera into a 384 kb/s digital signal for transmission via a Nascom-2000 T-1 carrier. The compressed signal coming out of the codec provides duplex motion and still-frame graphic displays. This type of compression is called differential transform coding. This technique uses intraframe coding to process segments and interframe coding from one frame to another.

10.3.1.3 GSFC Video System

At the GSFC system level, the video system is a composite of an analog segment and a digital segment (T-1 carrier mode). Various NASA or contractor organizations operate and maintain the system elements. Code 543 is responsible for the systems elements installed in the Building 8 TV Central Control facility, video facilities at NASA HQ, and the microwave radio link between them. The video facilities in Building 25 that provide the gateway to other NASA centers are managed by Code 542.

10.3.2 Television Broadcast

For television broadcasts, a standard program consists of Shuttle launch scenes as viewed by a selection of cameras at KSC followed by on-orbit Shuttle interior scenes during the mission. The mission program may be said to conclude with landing scenes and post-landing coverage. As shown in Figures 10-1 and 10-2, the source of signals for television broadcast varies. The television broadcast signal may require video processing by JSC before reaching GSFC, e.g., the Shuttle's field sequential video format requires conversion to NTSC format and audio lip-synching prior to broadcast.

Section 11. Baseline Data System Network

11.1 General

11.1.1 System Definition and Application

The BDS can be defined as a tri-nodal, redundant broadcast, and multiplexed data network designed, developed, and implemented by Nascom, principally to serve as the ground data transport system for the SN. It provides for the ground extension of the TDRSS forward and return link user services in the relatively low data rate ranges. The BDS also provides for other SN-related operational data traffic among the three nodes; WSC, GSFC, and JSC. Additionally, it is used to provide for transport of Orbiter payload user integration services traffic between GSFC and JSC, and Orbiter GN-related traffic between GSFC and JSC. In the system sense, it includes the ancillary Nascom CSS scheduling and control interfaces, the DLMS, and the GSFC/Nascom DMS, for user access to the BDS Network at GSFC.

11.1.2 Background Information

With the advent of the TDRSS, the Nascom Network has extended the TDRSS forward link and return link services by providing data transport systems between the WSC and major user spacecraft control centers and data processing facilities at GSFC, JSC, and MSFC. Both the TDRSS and Nascom Network unique systems are elements of the SN. Nascom has implemented two distinct multichannel transport systems that extend the TDRS "bent-pipe" concept of operation, i.e., extends the SN gateway user service bit-stream interfaces (space-ground links) to the ground-located SN users. One of these is the BDS that supports the Type I interfaces (10 b/s to 2 Mb/s). The other is the High Data Rate System that is described in Section 12. The BDS extends the Type I forward and return space-ground links directly between the gateway and the JSC and GSFC locations. In the mid-1980's, a tandem link between GSFC and MSFC was added which extended the BDS to MSFC.

11.1.3 System Capabilities

The BDS is designed by Nascom to provide the following capabilities:

- a. Transport of return link user Type I services at JSC and GSFC.
- b. Return link switching distribution at GSFC.
- c. Forward link transport services.
- d. Forward link switching access at GSFC.
- e. GSFC/MSFC MDM extension.
- f. Transport for Orbiter attached payload user and Orbiter GN traffic between JSC and GSFC.
- g. Transport of SN operational support traffic among WSC, JSC, and GSFC/NCC.
- h. Automated scheduling control and monitoring capability for the BDS.

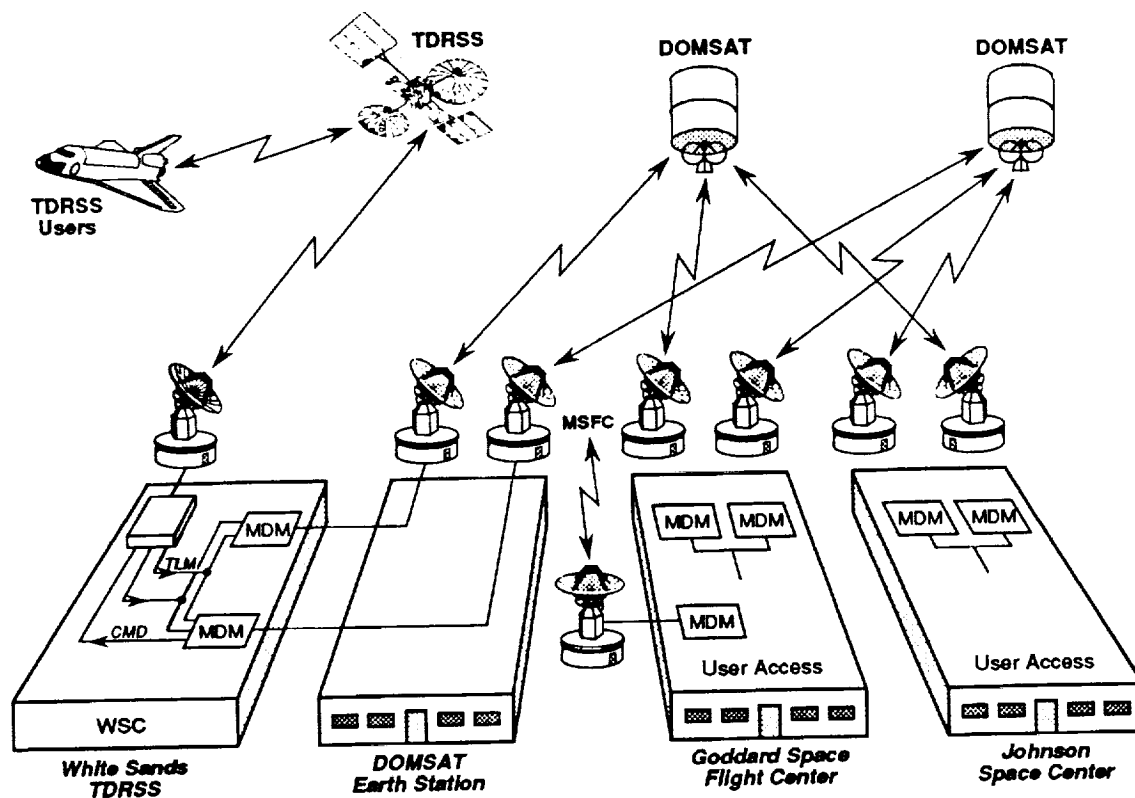
11.2 BDS System Description

11.2.1 System Configuration

The system overview and configuration of the BDS are illustrated in Figures 11-1 and 11-2. The BDS system provides the capability to interface up to 100 return link channels from WSC toward GSFC and JSC, 36 forward link channels from GSFC toward WSC and JSC, 30 channels from JSC toward WSC and GSFC, and 20 channels at JSC from WSC and GSFC. The BDS is used by Nascom to extend lower rate TDRSS Type I return link service interfaces from WSGT to the DMS located at GSFC, and where applicable, to the Shuttle Data Select Switch (SDSS) located at JSC. The system is also used to extend forward links from GSFC and JSC to forward link services at WSGT. Additionally, it is used for the transport of remote user POCC interchange traffic between GSFC and JSC for attached payload or free-fliers in attached Orbiter or rendezvous phases. The BDS also transports TDRSS scheduling, status, tracking, and control traffic among the NCC, WSGT, WSC, and JSC.

11.2.2 System Elements

The BDS consists of the baseline CCBTS and a baseline MDM Data Subsystem. The BDS is provided with ancillary systems such as the Downlink Monitoring System and the DMS to accomplish its operational objective.



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Figure 11-1. Baseline Data System Overview

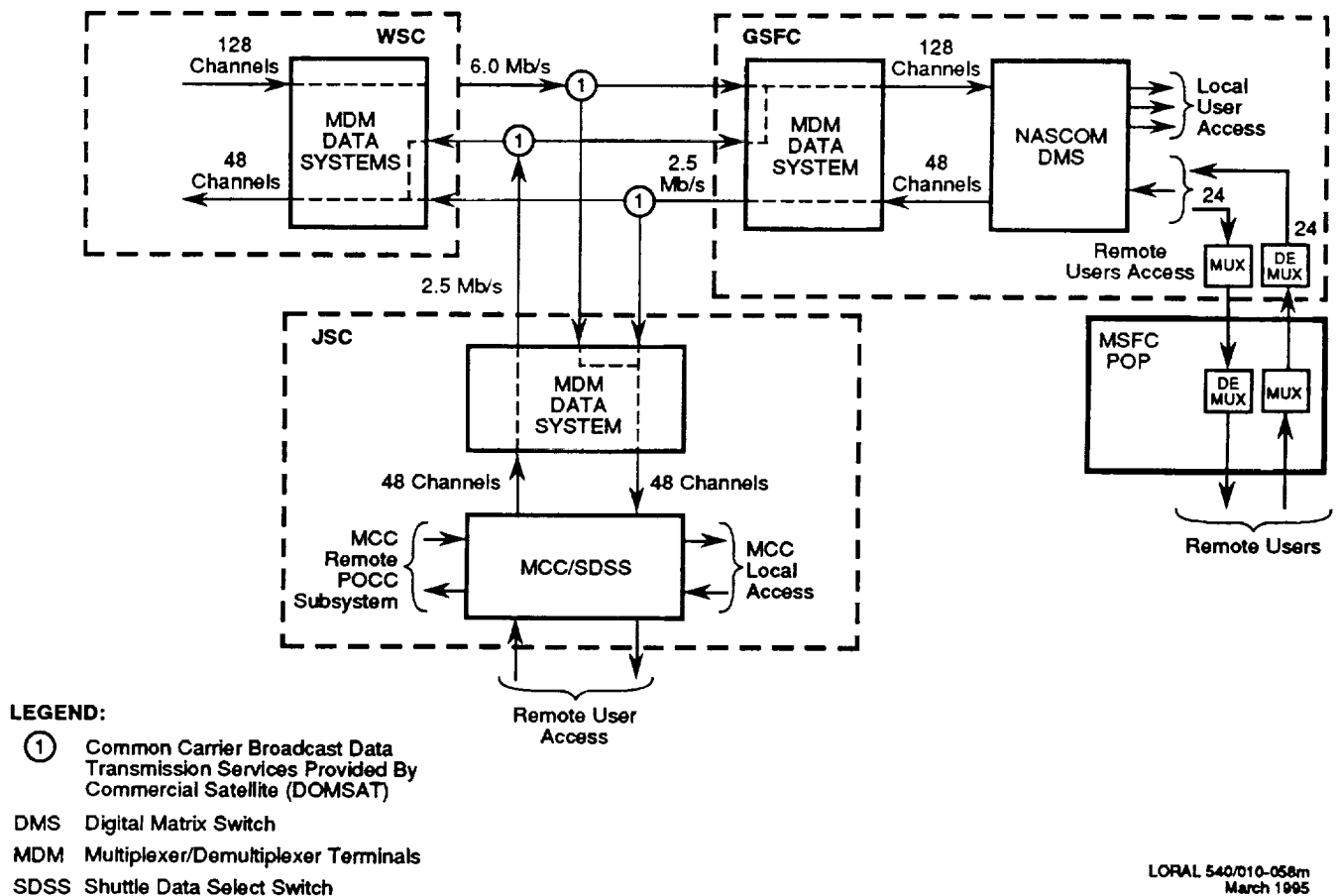


Figure 11-2. Nascom BDS Configuration

The MDM Data System and the DMS are provided with standalone descriptions in paragraphs 5.6 and 5.3, respectively.

11.2.3 System Interfaces

The BDS interfaces the SN at one end and the user systems at GSFC and JSC at the other end. Other remote ground-located user systems interface the SN through GSFC via tandem links. Included in this category is the system interface to the user systems at MSFC, which are connected via an MDM-equipped, 24-channel wideband link between GSFC and MSFC. The SN and user interfaces are described in detail in paragraph 14.4. A summary of these interfaces follows:

- a. SN interfaces that include:
 - 1. All return link interfaces at WSC and GSFC.
 - 2. All forward link interfaces at WSC and GSFC.
- b. User interfaces that include:
 - 1. GSFC user interfaces for the DMS return link output and forward link input.
 - 2. JSC user interfaces for R/L service and forward link service.

11.3 CCBTS System Description

11.3.1 System Configuration

The system configuration of the CCBTS is illustrated in Figure 11-3. The configuration provides both satellite and earth station diversity. The CCBTS operates as a redundant broadcast system. It provides prime and alternate full-period data services on separate C-band domestic communication satellites of a commercial common carrier. The redundant configuration provides Nascom with the capability to restore services rapidly in the event of prime system outage.

11.3.2 System Components

The main system components of the CCBTS are:

- Prime and alternate C-band Domsats for satellite diversity.
- Prime and alternate dedicated Earth stations at three sites, WSC, GSFC, and JSC, for Earth station diversity.

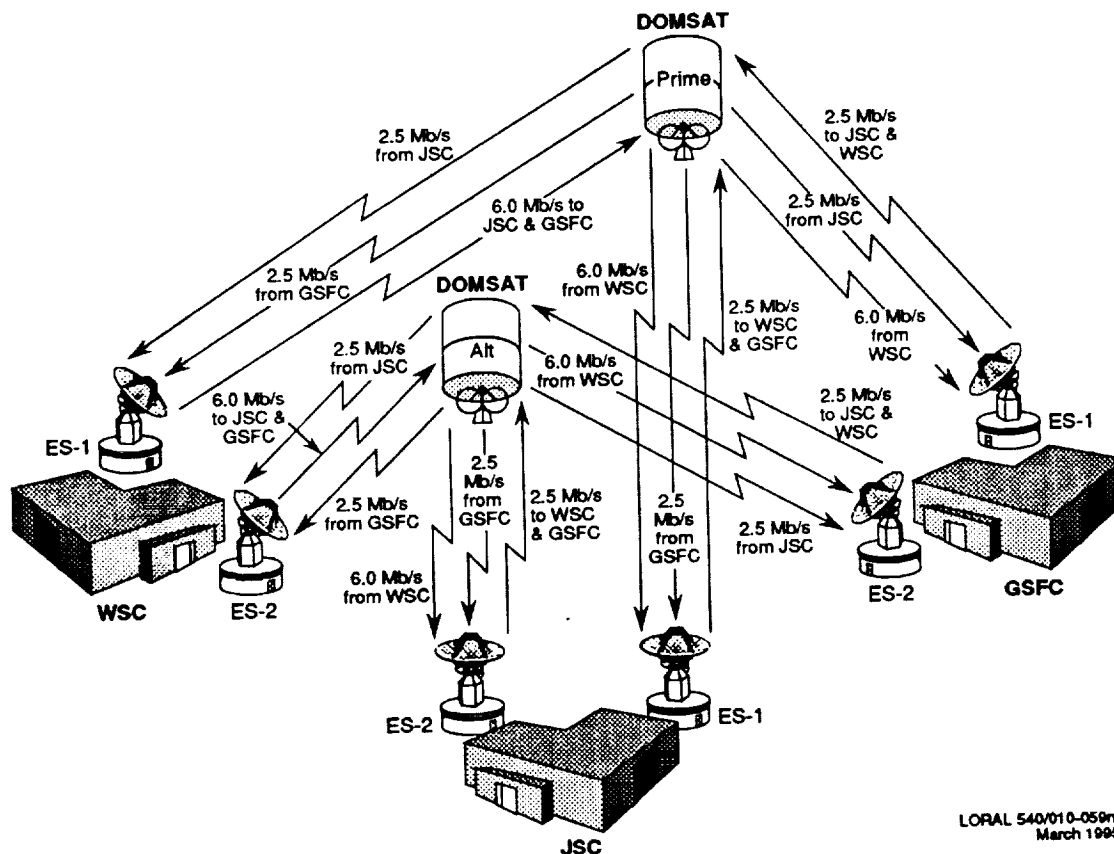


Figure 11-3. Common Carrier Broadcast Data Transmission Services (CCBTS)-Prime and Alternate

11.3.3 System Operation

Broadcast means that each prime Earth station at each of the three sites transmits one uplink to a prime domestic satellite, which translates the signal to a downlink frequency for simultaneous reception of the common downlink at each of the other two sites. Redundancy is provided by each site transmitting to a second uplink via the alternate Earth station, with identical data in the baseband, to an alternate domestic satellite. The alternate domestic satellite translates the signal to a downlink frequency for simultaneous reception of the alternate signal at each of the other two sites. At each of the three sites, Earth station one (ES-1) is dedicated to the prime satellite, while Earth station two (ES-2) is dedicated to the alternate satellite. Therefore, the total system is afforded both satellite and Earth station diversity. This provides Nascom with the capability to rapidly restore the services in the event of a prime system outage, while the common carrier repairs the system.

11.3.3.1 Uplinking

Each of the three sites has a prime and an alternate uplink. The prime is routed through ES-1 and the alternate is routed through ES-2. The uplinks from all three sites operate in an identical manner. Figure 11-4 depicts the MDM Data System/common carrier configuration for uplinking data typical for each site. As shown in the figure, the MDM multiplexer 1 ("A" system) transmits its composite signal to ES-1, and MDM multiplexer 2 ("B" system) simultaneously transmits the same composite signal to ES-2. For uplinking, the two multiplexers at each site are redundant to each other, and may also be considered prime and alternate.

11.3.3.2 Downlinking

Each site in the system receives two prime and two alternate downlinks (one prime and one alternate from each of the other two sites). The downlinks to all three sites operate in an identical manner. Figure 11-5 illustrates the typical MDM Data System/common carrier configuration at each site for downlinking data. As shown in the figure, WSC-originated prime uplink "A from WSC" the downlink from the prime Domsat is destined to ES-1 at both GSFC and JSC. This is the 128-channel multiplexed MDM WSC return link composite baseband signal. A corresponding 128-channel alternate baseband composite signal can be found on the alternate Domsat to ES-2. Both the prime and alternate baseband composite signals are routed to a downlink select patch panel. The downlinks at all sites are normally configured on the prime Domsat (ES-1) system and are switched to the alternate only in the case of a common carrier prime system failure. Therefore, they must be switched to the alternate downlink in the event of a prime system CCBTS outage. DLMS monitoring and switching are discussed in paragraph 11.5.2.

11.4 MDM Data System

Since the MDM Data System is provided with a detailed standalone description in paragraph 5.6, this section focuses on its role and capability in the BDS.

11.4.1 Role of the Baseline MDM Data Subsystem

The Baseline MDM Data Subsystem is designed to effectively use the low rate wideband (up to 10 Mb/s) digital transmission resource leased from the common carrier. The system

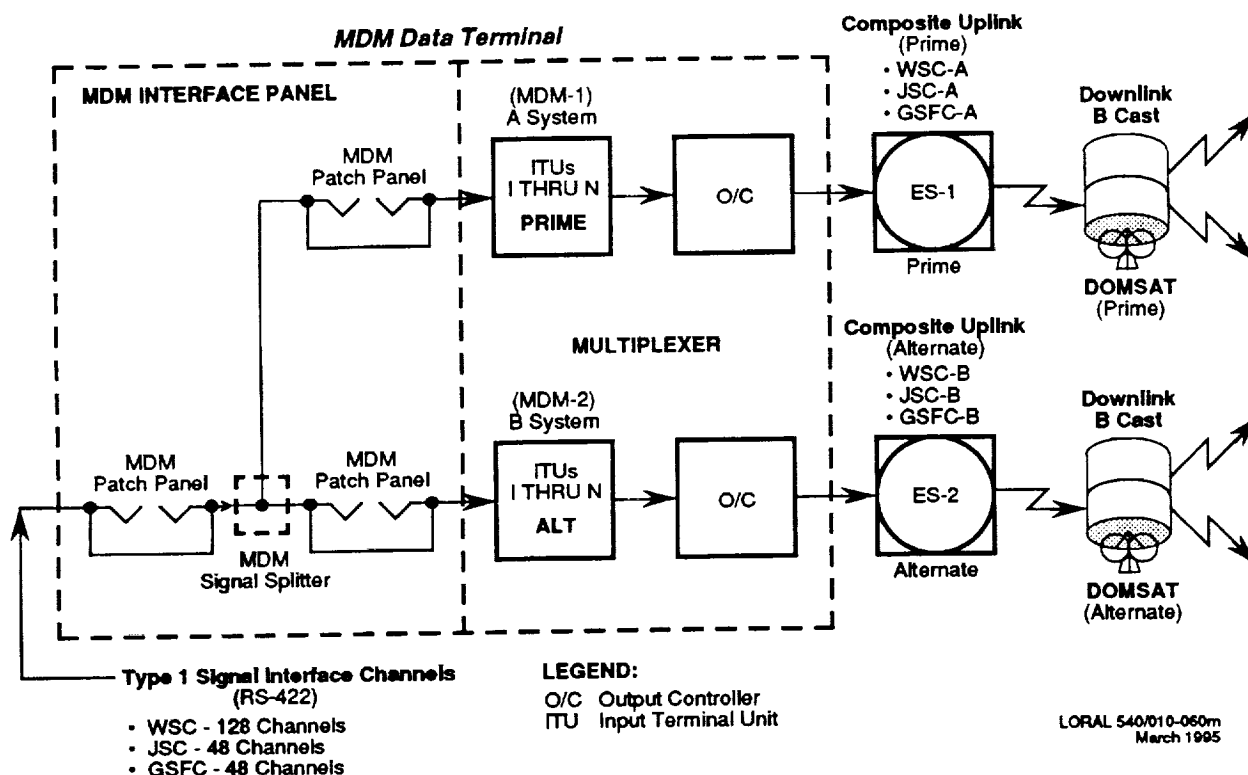


Figure 11-4. MDM-Common Carrier Configuration for Uplinking Data (Typical Site)

creates discrete digital channels that time-share the total available digital bandwidth for high efficiency utilization of the system. The Baseline MDM Data System interfaces the CCBTS at three separate locations. These locations are the WSC, GSFC, and JSC. The prime purpose of the WSC's MDM data system is to interface the CCBTS with the TDRSS ground terminal. The prime purpose of the GSFC and JSC MDM data systems is to interface the CCBTS with associated SN user spacecraft control centers and user data capture/processing facilities.

11.4.2 Baseline MDM Data Subsystem Capability

The Baseline MDM Data Subsystem consists of separate data terminals at GSFC, WSC, and JSC. (See Figure 11-2.) Operationally, the baseline MDM system has the capability of 128 return link channels from WSC to GSFC, and 48 forward link channels from GSFC to WSC. The JSC station in the baseline MDM system may be operationally considered a "drop and insert" station. JSC can insert up to 48 channels into the forward link and extract up to 48 channels from the return link from WSC and GSFC. When this occurs, the total number of channels available for scheduling between WSC and GSFC is reduced by an equivalent number.

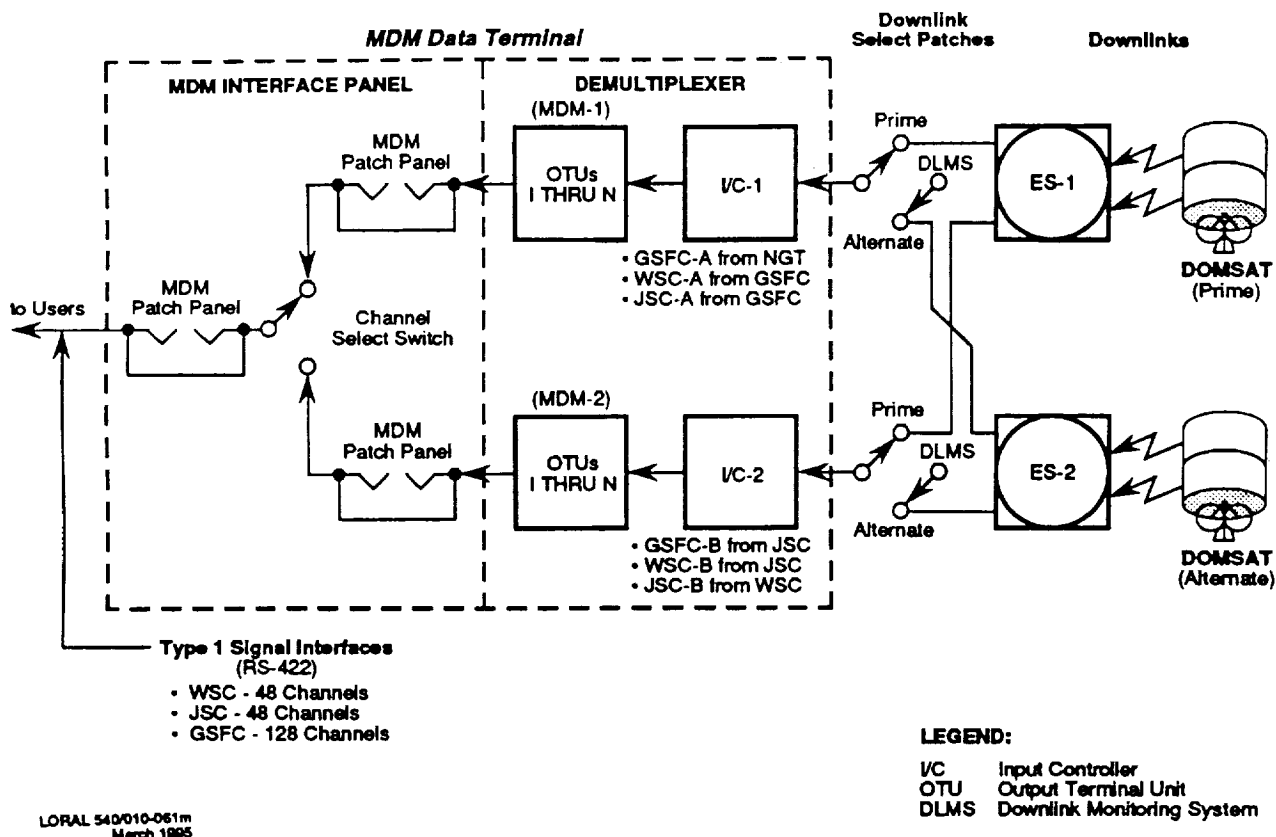


Figure 11-5. MDM-Common Carrier Configuration for Downlinking Data (Typical Site)

The MUX/DEMUX systems and channel capacities provided by the MDMR Data System at the respective locations are as follows:

- GSFC:

| | |
|-----------------|--------------|
| MUX (Broadcast) | 48 channels |
| DEMUX (WSC) | 128 channels |
| DEMUX (JSC) | 48 channels |
- JSC:

| | |
|-----------------|-------------|
| MUX (Broadcast) | 48 channels |
| DEMUX (GSFC) | 48 channels |
| DEMUX (WSC) | 48 channels |
- GSFC/MSFC Trunk:

| | |
|-----------|----------------------|
| MUX/DEMUX | 24 channels (duplex) |
|-----------|----------------------|

The above channelization represents an upgrade to the original MDM Data System capabilities. All indicated MUX/DEMUX equipment will be provided in redundancy. Connectivity is the same as per the original MDM Data System, except that spare DEMUX equipment lacking in the original MDM Data System has been added for each downlink at each location; also, a connectivity change has been implemented at the GSFC location wherein all receive channels from WSGT and JSC have been extended to the DMS in lieu of a channel termination sharing arrangement.

11.4.2.1 Data Handling

At a functional level, the baseline MDM data system consists of separately located data terminals, each controlled by a collocated common control subsystem. The data terminal controls the processing and distribution of data signals to and from multiple user or network channels. Each data terminal consists of interfaces, multiplexers, and demultiplexer equipment. The multiplexer equipment (see Figure 11-6) includes an OC rack and multiple ITU racks. The OC performs the multiplexing of individual channels into a composite serial data stream for distribution to the CCBTS. The other features of the data handling operation are described in the following paragraphs:

- a. The demultiplexer equipment (see Figure 11-7) includes an IC rack and multiple OTU racks. The IC performs the demultiplexing of the composite serial data streams from the CCBTS to individual data channels for the distribution of data to the appropriate user or network channel.
- b. Two sets of multiplexer and demultiplexer equipment are required for each data terminal. Each data terminal communicates with two separate distant-end data terminals. In addition to the two data terminals at WSC, there exists a third 10-channel data terminal to interface the WSC contingency, Line Outage Recording (LOR) playback equipment for discrete OTU channel playback to individual users.

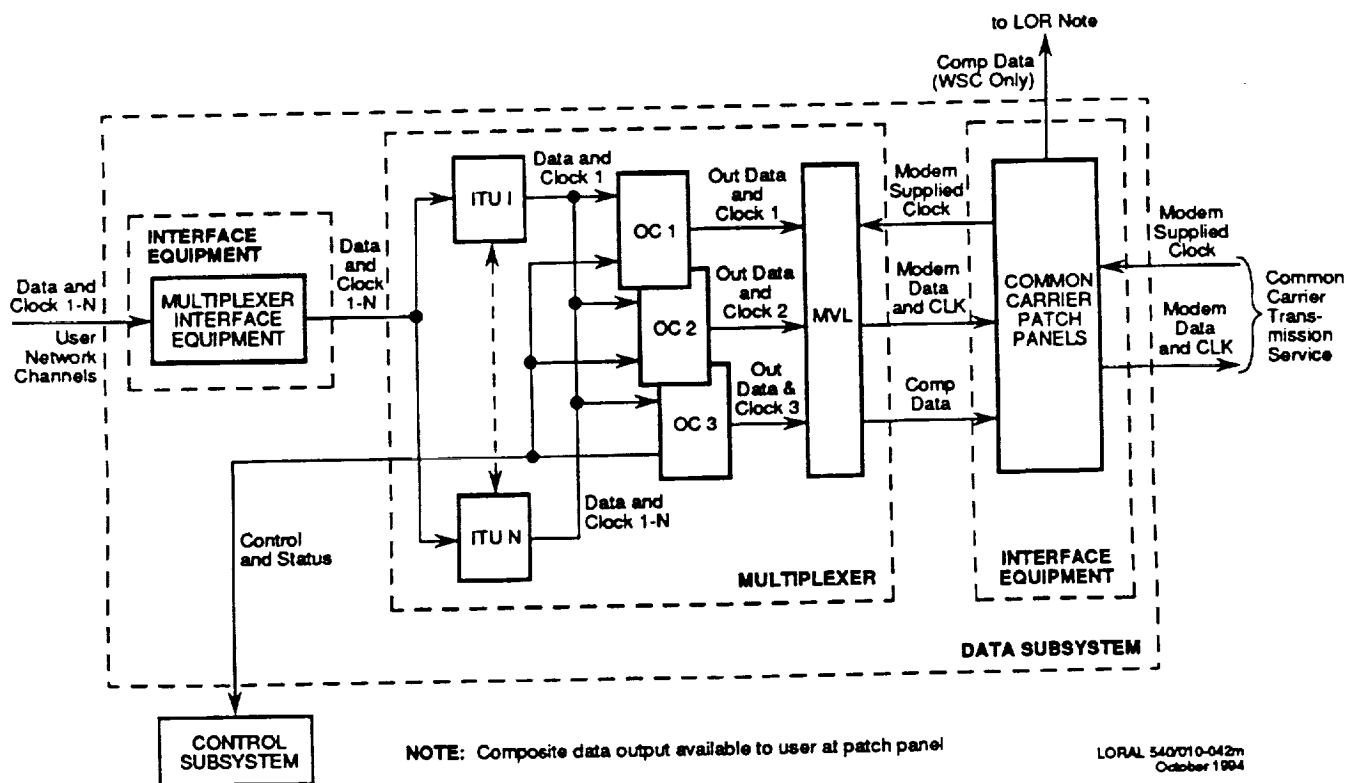


Figure 11-6. MDM Data System Multiplexer Data Flow (Typical Site)

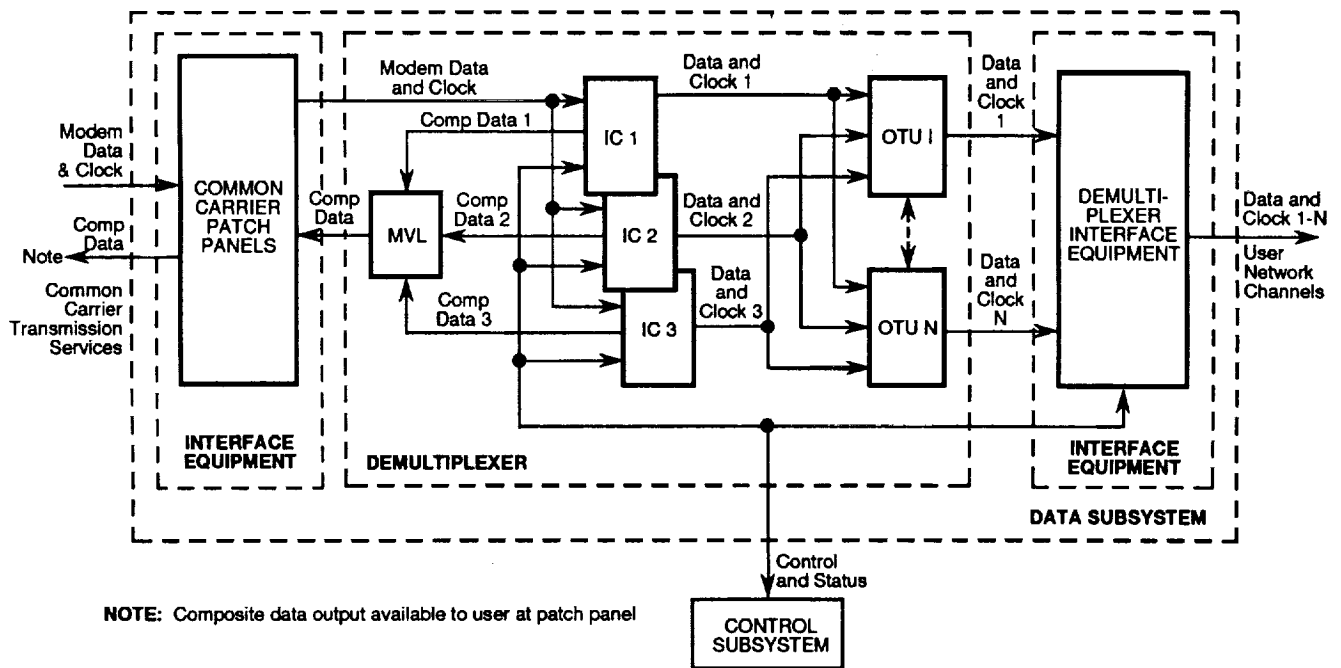


Figure 11-7. MDM Data System Demultiplexer Data Flow (Typical Site)

Additionally, the third data terminal provides a source of local test and spare equipment functions.

- c. A complete data string requires the mux of a source MDM data terminal and the demux of a destination MDM data terminal. Data is input to an ITU of a source multiplexer. On a time-division basis, the ITU output is transmitted to the OC and multiplexed into a composite data stream. The composite data is routed through the CCBTS to the demultiplexer of the destination MDM data terminal. The demultiplexer's IC time division demultiplexes the composite data stream and routes the data to an associated demultiplexer OTU. The OTU distributes the data to a specific user or network channel, completing the data string. IC and OC equipment are provided with triple modular redundancy and two out of three Majority Voting Logic (MVL). ITU and OTU channel equipments are all similar modular units provided in a quantity that allows sufficient units to function as spares. IC and OC equipment are provided with common carrier modem clock and data, and are designed to operate at rates up to 10.0 Mb/s when operating in the RS-422 aggregate interface mode; the MDM can operate at up to 20.0 Mb/s at the aggregate interface when in the ECL mode. Switching between these two modes is accomplished by a hardware switch setting. The demultiplexer provides a decoded composite data signal available on a patch basis to users who may wish to perform the demultiplexing function internally (e.g., JSC). ITU and OTU equipment are designed to operate at data rates up to 7 Mb/s. ITUs require external clock and data signals. OTUs may use either an

internal or external clock, and furnish both clock and data signal to network and user interfaces.

11.4.2.2 Control Subsystem

The control subsystem is the key to configuring the multiplexer and demultiplexer. Configuration/reconfiguration involves enabling and entering operating parameters such as data stream Identifier (ID) and expected data rates, as well as selecting operating modes such as blocked or unblocked data formats. The control subsystem allows the system operator at a remote console position to enable/configure/reconfigure the ITU and OTUs as required. Manual configuration of each ITU and OTU is possible via a manual control panel mounted on the front panel of each ITU and OTU for manual operation and maintenance purposes. Individual ITU and OTU port addresses and automatic/manual modes of operation are operator selectable from the individual ITU and OTU control panels. In addition, all OTU circuit switches can also be reconfigured automatically according to stored parameters or by the system operator as required. These circuit switches can also be reconfigured manually from a control panel on the circuit switch rack. All primary status and alarm conditions are monitored and displayed by the control subsystem. The alarm conditions are displayed on local control panels at the equipment racks as well.

11.4.2.3 Interface Equipment

The interface equipment provides the signal splitter, channel select switches, and patch panels to interface the MDM Data System with the interface channels of the users of the system (source and destinations), and with the CCBTS. The signal splitters (located in the multiplexer interface equipment) divide each user or network channel into two identical signals for application to two multiplexers at each site (see Figure 11-4). The channel select switches (located in the demultiplexer interface equipment) select data from one of two demultiplexers at each site for application to each user/network channel (see Figure 11-5). Both the multiplexer and demultiplexer interface the CCBTS through the common carrier patch panels. These normal-through patch panels provide contingency patching and link monitoring capabilities to maximize the engineering flexibility of the MDM Data System.

11.4.2.4 Data Formats

The 4800-bit block is the standard transmission format used in the MDM system. Three block formats are described in Appendix D of this document.

All data transferred between terminals of the MDM Data System are in a 4880-bit block format which includes an 80-bit link control header added as a prefix by the MDM systems. The 4800-bit block format portion is used for transport of user data. The 80-bit link control header is used exclusively by the MDM Data System for routing and message accounting purposes and is transparent to the user. The MDM inserts and removes this link control header.

11.5 Ancillary Systems

11.5.1 Brief Review of BDS Ancillary Systems

The BDS requires the use of ancillary systems to accomplish its specified objectives. The ancillary system provides auxiliary or supplementary equipment support to operation of the BDS. The ancillary systems of the BDS are as follows:

11.5.2 DLMS System Description

11.5.2.1 DLMS System Features

Nascom has engineered, procured, and installed special computing devices designated as the DLMS. Each of the four units at each location has a two-channel capability. They are principally used to either terminate or bridge a common carrier data downlink that interfaces the MDM Data System. The IC of the MDM demultiplexer decodes the polynomial of the incoming composite MDM signal and provides for a quality readout of the number of blocks transmitted, the number of blocks in error, and the number of blocks lost. The DLMS provides a similar quality readout. The DLMS monitors the performance of the baseline common carrier satellite communication service (broadcast system) at each of the three sites (WSC, JSC, and GSFC). The DLMS evaluates the quality of the prime and alternate wideband communications circuits in real time and provides local readouts.

11.5.2.2 DLMS System Configuration

The system configuration of the DLMS is illustrated in Figure 11-8. The configuration shows that the signal from the prime Earth station (ES-1) is routed through the MDM patch panel to the demultiplexer. The DLMS channel is bridged on the circuit. It also depicts a DLMS channel connected to the alternate signal from WSC, which is not normally terminated on an MDM demultiplexer. It is connected to the DLMS channel (terminate mode) through the MDM patch panel. The monitor signal from each DLMS channel is provided to a remote video monitor for operator display.

11.5.2.3 DLMS System Operations

The MDM control positions at GSFC, JSC, and WSC are provided with remote video displays. Considering the displays located at GSFC as an example, the operator will have available throughput quality readings on the following CCBTS links:

- a. WSC – prime.
- b. WSC – alternate.
- c. JSC – prime.
- d. JSC – alternate.

If the prime downlink system fails, the operator will patch the appropriate IC to the alternate downlink signal. A manual patch must be made to transfer the IC from the prime to the alternate downlink system. Four downlinks are monitored at each site in the system, which

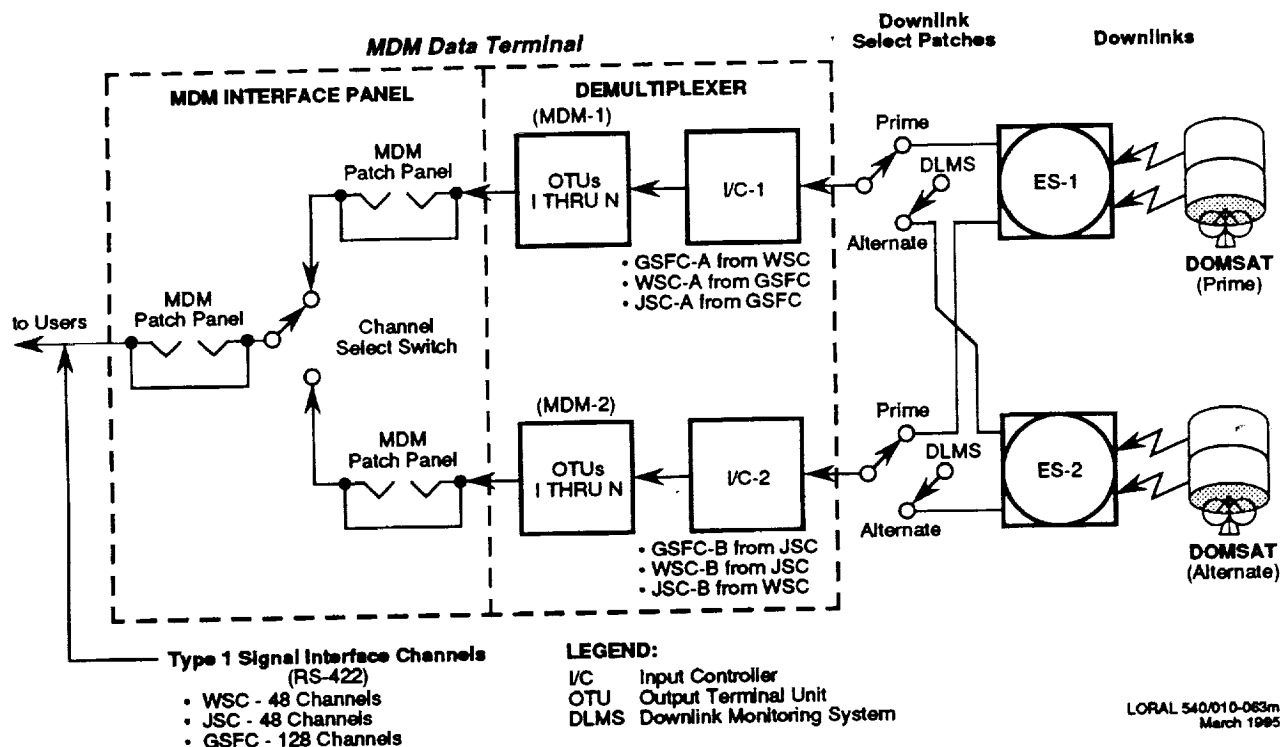


Figure 11-8. Typical Downlink Monitoring System (DLMS)

means there are twelve downlinks in the BDS. Each site is responsible for monitoring the downlink system and for switching the MDM data systems in accordance with the MDM network operating procedures as prescribed in NASCOP. The DLMS is also used for fault isolation monitoring of the MDM OC interface to the common carrier uplink.

11.5.3 DMS

The DMS is described in paragraph 5.3. This paragraph will emphasize the role of the DMS in the BDS for providing the circuit-switching function.

11.5.3.1 Role of DMS in BDS

All network and user channels of the BDS are connected on the DMS. NCC schedule requests to Nascom are satisfied by circuit switching the network and user channels for forwarding and returning data through the DMS.

11.5.3.2 DMS Return Link Operation

The DMS for the return link has 192 input ports and 192 output ports. The switch is controlled by a DEC Microvax II computer. Any input port from the network channels can be switched to any ten output ports (top user channels) for interfacing return link services to users. The first 100 input ports of the return link DMS represent the SN baseline data channels. The source channel identification number of the SN service channel is used to identify the port to be switched. The output ports of the return link DMS are used to

terminate all users of the SN-BDS service channels and become the destination channel ID for data transferred to users.

11.5.3.3 DMS Forward Link Operation

The forward link DMS is identical to the return link DMS with 192 input, 192 output ports, and a MicroVAX II as the controller. User source channels are connected to the input ports of the DMS. SN channels/destination channels are connected to the output ports. The first 36 ports represent the SN destination channels in the forward link.

11.5.3.4 DMS Control System Operations

The DMS, located at GSFC, is a three stage, solid-state circuit switch composed of a forward matrix and backup, return matrix and backup, and a control subsystem. Each of these four matrices is capable of handling 192 input and output lines. The function of the DMS in the SN is to route TDRSS/WSC/ JSC MDM traffic flows to and from users and operators of the SN via GSFC. The CSS at GSFC is used to automatically configure and monitor the status of the DMS, in accordance with the NCC schedule.

11.6 Scheduling of BDS Applications

11.6.1 Brief Review of Scheduling Operations

The Nascom Network operates with the SN in accordance with a schedule provided by the NCC. The NCC is responsible for scheduling SN services to support user data. The user has responsibility for indicating the user interface on which the data will be delivered. Nascom will configure the data transport systems used by the SN in response to direction from the NCC.

11.6.2 User Configuration Planning Process

When a project to be supported by the SN receives an approved DMR, the user is responsible for the preparation of the network configuration codes. The preparation of the configuration codes becomes an important element in the user's scheduling process. The user is responsible for generation of configuration codes for the project being supported by SN. The Mission and Data Support Manager (Codes 501 and 502) may assist a user in preparing the configuration codes. The users and DSMs are jointly responsible for selecting MDM ITU and OTU options that are offered to users by Nascom for inclusion in the configuration code.

11.6.2.1 SN Scheduling Process

The NCC Data Base Manager provides a copy of the user configuration codes to Nascom. Nascom assigns the SN source and destination channel ID and returns the updated configuration code to the Data Base Manager. The Data Base Manager issues a Data Base Change Instruction (DBCI) to the affected SN elements Data Base Coordinators (including Nascom) and enters the finalized, validated codes into the NCC software. Nascom and other SN elements, in turn, enter the DBCI information into the CSS and their computers prior to the

service start date. The entry of the validated configuration codes into the NCC software will develop a data base from which the NCC computer generates the following:

- a. Schedule Orders (SHO) to the ground terminals.
- b. Daily NES.
- c. WSC schedule.
- d. User schedule.

Table 11-1 provides an example of information transmitted to Nascom for assignment of the SN source and destination codes. (Note the configuration code identification.)

Table 11-1. Nascom Elements of the Configuration Code
Project: XYZ Type Service: MA Return Link SUPIDEN: J1295MS (1 of 2)

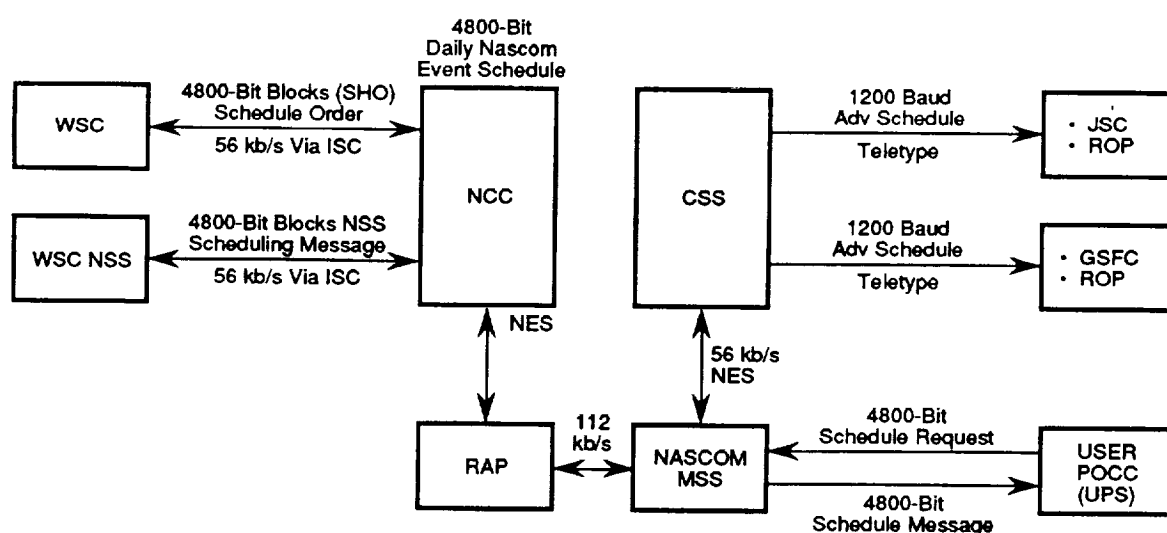
| Destination Channel ID | |
|------------------------|-------------------|
| Configuration Codes | B01 B02 B05 |
| ITU # (WSC) | 020 |
| ITU-Port Address (WSC) | 0120 |
| OTU # (GSFC) | 020 |
| ITU-Port Address (WSC) | 0120 |
| Source Channel ID | 041 |
| Destination ID #1 | S52 |
| Destination ID #2 | ----- |
| Destination ID #3 | ----- |
| Data System ID | 40/OE |
| Maximum Data Rate | 8192 BPS |
| Initial Data Rate | 512 BPS |
| Wall Interface Number | WU 041 |
| Type 1 | Y |
| Type 2 | N |
| ITU Options (WSC) | |
| Modified Header | N |
| Blocked Data Source | N |
| One-second Timeout | Y |
| Time Tag Required | N |
| OTU Options (GSFC) | |

Table 11-1. Nascom Elements of the Configuration Code
Project: XYZ Type Service: MA Return Link SUPIDEN: J1295MS (2 of 2)

| Destination Channel ID | |
|---|-----|
| Block Data Output | Y |
| Clock Tracking | N |
| Clock Clamping | N |
| Cab Enable | N |
| Internal Clock | Y |
| Digital Matrix Switch (GSFC CSS Data Base) | |
| Return Link (IN) | 046 |
| Return Link (OUT) | 050 |

11.6.2.2 Scheduling/Message Processing

Figure 11-9 shows a daily schedule data flow using the CSS. The POCC generates its scheduling request to the NCC through the POCC User Planning System (UPS). The NCC processes the scheduling request and advises the POCC if the request can be supported by the SN. If the support request is approved, the NCC builds a data base in accordance with the POCC's request and transmits at 56 kb/s the scheduling elements needed by Nascom to the CSS in the form of an NES in 4800-bit block messages. The NES is transmitted approximately 24 hours before the scheduled support start time. Table 11-2 reveals the format content definition of a typical NES message. Other aspects of the scheduling process are described in the following paragraphs:



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Figure 11-9. Daily Schedule Data Flow Using CSS

Table 11-2. Nascom Event Schedule (NES) Message Format Definition (1 of 2)

| Item Number | Number of Bytes | Data Item | Range of Values |
|-------------|-----------------|--------------------------|--|
| 1 | 2 | Message Type | 90 = Nascom control and scheduling message |
| 2 | 7 | Message ID | A unique seven character number used to reference this message |
| 3 | 2 | Message Class | 01 = Nascom Event Schedule (NES) 04 = Update 05 = Emergency |
| 4 | 7 | Supiden | Support Identification Code (See STDN 808) |
| 5 | 9 | Event Start | Start time of first stream in NES Event |
| 6 | 9 | Event Stop | Stop time of last stream to terminate in the NES |
| 7 | 3 | Station | TDE = TDRSS EAST TDW = TDRSS WEST TDS = SPARE TDRSS |
| 8 | 1 | Ground Terminal | S = STGT; W = WSGT |
| 9 | 4 | Spare | |
| 10 | 2 | Number of streams in NES | 01 - 30 |
| 11 | 2 | Data Type | Byte1: 1 = TDRSS Type 1 = TDRSS Type 2 = TDRSS TV = TDRSS Analog = UHDR Byte 2: P = Playback R = Record Spare = TDRSS Service |
| | | ASCII | |
| 12 | 9 | Stream Start Time | DDDDHHMMSS |
| 13 | 9 | Stream Stop Time | DDDDHHMMSS |
| 14 | 3 | Data Source | Nascom source code or interface Channel 1D |
| 15 | 3 | Data Stream ID | A unique code, in OCTAL notation, ranging 001-377 (000 for a FWD link) |
| 16 | 12 | Destination/Data Rate-1 | Bytes 1-3 = Destination Bytes 4-12 = Initial Data Rate |

Table 11-2. Nascom Event Schedule (NES) Message Format Definition (2 of 2)

| Item Number | Number of Bytes | Data Item | Range of Values |
|-------------|-----------------|-------------------------|---|
| 17 | 12 | Destination/Data Rate-2 | Bytes 1-3 = Destination Bytes 4-12 = Initial Data Rate |
| 18 | 12 | Destination/Data Rate-2 | Bytes 1-3 = Destination Bytes 4-12 = Initial Data Rate |
| 19-21 | 36 | Spare | |
| 22 | 1 | Modified Header | Y = Yes N = No |
| 23 | 1 | Blocked Data Source | Y = Yes N = No |
| 24 | 1 | Blocked Data Dest. | Y = Yes N = No |
| 25 | 1 | One-Second Timeout | Y = Yes N = No |
| 26 | 1 | Clock Tracking Required | Y = Yes N = No |
| 27 | 1 | Clock Clamping Required | Y = Yes N = No |
| 28 | 1 | Cab Enable | Y = Yes N = No |
| 29 | 1 | Time Tag Required | Y = Yes N = No |
| 30 | 1 | Internal Clock | Y = Yes N = No |

- a. Table 11-1 shows elements of the configuration codes for a sample project. The system will be configured for MA return link service on SN source channel 041, switched through the DMS at GSFC to user destination channel S52. The MDM will be set for the data rate and ITU/OTU options shown. This service will be available 24 hours a day. The project receives data on the interface by scheduling configuration Code B01. In the current phase for scheduling of SN interfaces, the Nascom data transport services utilized by the SN are dedicated to missions to minimize operator interaction. The CSS takes the NES received from the NCC, and reformats the NES into a message for transmission to the high-speed teletype receive only printers as backup to the CSS automated control operation. The

elements of the message that interest Nascom are the user's source and destination channel ID, the data rate, the data stream ID, and the MDM options. Figure 11-10 shows a typical reformatted teletype advanced schedule message.

- b. The CSS transmits the teletype message to the RO printers at MDM local control positions at GSFC and JSC. In the event of a CSS failure, operators at the local control positions at each site manually configure the MDM equipment for the required support in accordance with the teletype message schedule.

11.6.3 Control and Status System

A standalone description of the CSS is in paragraph 5.8. In this paragraph, the role of the CSS in BDS operations will be emphasized.

11.6.3.1 CSS Role in BDS Operation

The CSS is a major augmentation of the Nascom/SN data transport system that was needed to automate control of the Nascom/SN element. This became necessary when the level of TDRSS user scheduling activity increased to a point where manual configuration could not be relied on. The objectives of the CSS are the following:

- a. Receive NES and related update and reconfiguration messages from the NCC.

| | | | | | | | | | |
|--|----------------------|-----------------------------|----------------------------|---------------|-------------|-------------|-------------|-------------|--|
| SEQ#: 41 SUPIDEN: J1295MS STRT:102:13:59:56 STOP:102:14:55:38 STA: TDW #STRMS: 2 | | | | | | | | | |
| STRM 1 | TYPE 1 | STEAM-START 102:13:59:57 | STEAM-STOP 102:14:55:38 | SC-ID S02 | DS-ID 00 | | | | |
| BLKSRC Y | MODHDR N | TIMOUT N | TIMTAG N | BLKDST N | INTCLK Y | CLKCLP N | CLKTRK N | CABENA N | |
| ITU CLK RATE 9600 | OTU CLK RATE 125 | PORT ADDR 0102 | SRC-SITE GSFC | DMS-SW FWD | | | | | |
| DMS-IN-PORT 134 | SM-PORT 0 | MODE-SW N/A | CIRCUIT-SW A | | | | | | |
| DC-ID 002 | RATE 125 | DMS-PORT 2 | DES-SITE NGT | | | | | | |
| STRM 2 | TYPE 1 | STEAM-START 102:13:59:56 | STEAM-STOP 102:14:55:38 | SC-ID 041 | DS-ID OE | | | | |
| BLKSRC N | MODHDR N | TIMOUT Y | TIMTAG N | BLKDST Y | INTCLK Y | CLKCLP N | CLKTRK N | CABENA Y | |
| ITU CLK RATE 512 | OTU CLK RATE 9600 | PORT ADDR 0120 | SRC-SITE NGT | DMS-SW RTN | | | | | |
| DMS-IN-PORT 20 | SM-PORT 0 | MODE-SW N/A | CIRCUIT-SW A | | | | | | |
| DC-ID S52 | RATE 512 | DMS-PORT 50 | DES-SITE GSFC | | | | | | |

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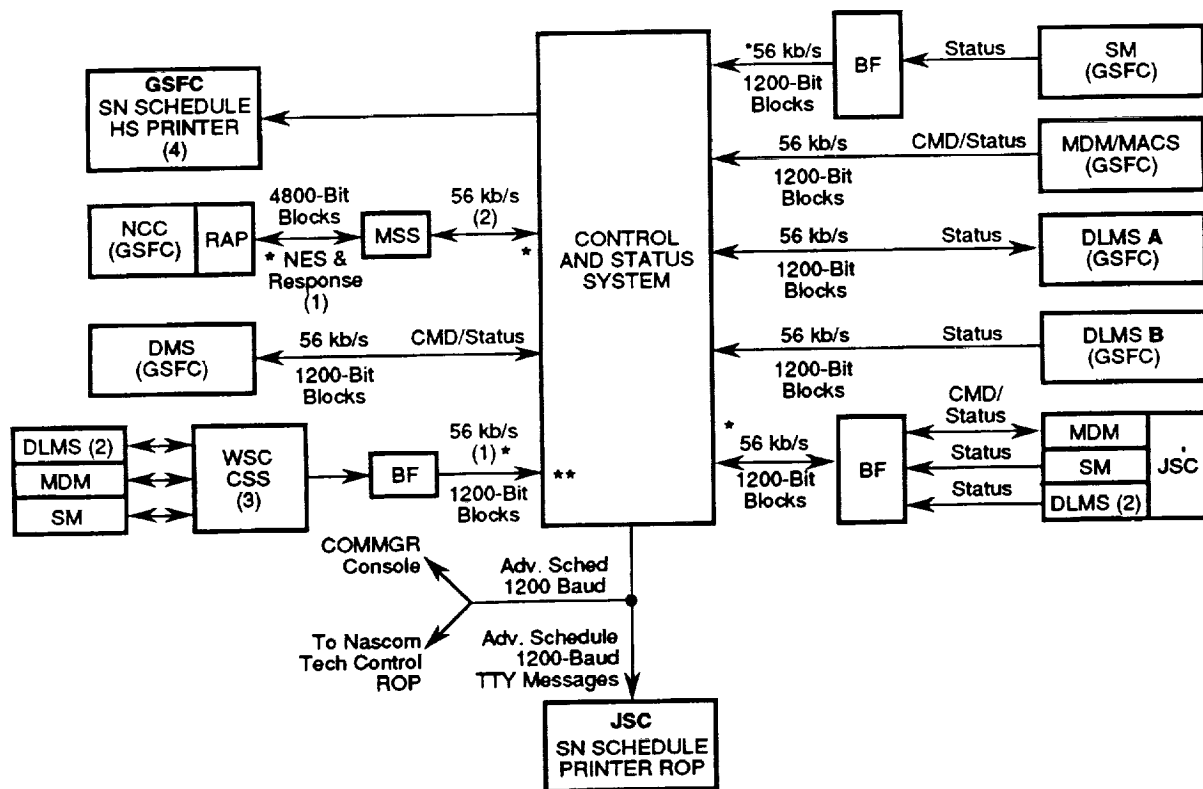
Figure 11-10. Typical CSS-Generated Advance Schedule TTY Message

- b. Provide acknowledge and accept/reject response messages to the NCC.
- c. Establish and store a 24-hour TCTS.
- d. Transmit an advance schedule by TTY to local operating positions as a backup to the TCTS.
- e. Execute the TCTS in real time by transmitting commands to the respective Nascom SN subsystems (MDM, and DMS).
- f. Receive, store, and display to operators, the Nascom subsystem status and performance information.
- g. Provide the NCC with certain status and performance messages.

11.6.3.2 CSS/BDS System Interfaces Overview

A functional overview of the CSS and its interfaces with Nascom Network subsystem elements are shown in Figure 11-11. All interfaces shown are Nascom control and status interfaces, except for the interface with the NCC.

- a. **NCC Interface.** The interface with the NCC is local PDS with redundant 56-kb/s circuits. Message interchange between the NCC and the CSS is in standard 4800-bit blocks. The NCC is constrained by ICD agreement to a maximum transmission rate of eight blocks per second. NES messages may be multiblock messages. The definition of messages by type, class, content, and protocol for interchange between the NCC and CSS is contained in 530-ICD-NCCDS/Nascom (formerly STDN No. 220.9), "Interface Control Document between the Network Control Center and the Nascom Control and Status System," November 1992.
- b. **Subsystem Interfaces.** On the basis of NES messages received from the NCC, the CSS performs a resource allocation, produces a TCTS, and issues TCTS time-driven command blocks to subsystem control elements. The CSS also maintains a data base of available Nascom System resources that it updates from status data received from subsystems.
- c. **Block Formatter Interface.** The following describes the Block Formatter (BF) interface:
 - 1. The BF is a Nascom subsystem element that was developed for four installations (WSC, JSC, and two GSFC SM locations). It multiplexes block status information from the MDM, SM, and DLMS at WSC and JSC for transmission to the CSS, and distributes schedule-driven control messages from the CSS to the MDM. The BF is capable of block multiplexing/demultiplexing 6 channels, and handles 1200-bit blocks. The BF is required in conjunction with the CSS, for implementation of automated scheduling and control of the Nascom SN elements. Inhouse fabrication, assembly, and tests were completed in March 1985; installations were completed in conjunction with CSS Phase I at the end of the second quarter 1987.



LEGEND:

- (1) Via Protected Wire Distributed System (PWDS)
- (2) Quantity two
- (3) Advanced schedule furnished to WSC by NCC via another 56 kb/s circuit to the NSS
- (4) Delivers advance schedule locally to tech control for all locations

* Indicates Block Error Detector (BED) in series with data flow

** CSS control of MDM and SM at WSC replaced by the WSC Control and Status System (NCSS) capability implemented at WSC. NCSS will continue to return status information to the CSS via the BF.

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Figure 11-11. CSS/Functional Network Interface Block Diagram

2. A total of eight BFs plus supporting equipment are installed (two each) at the following locations.
 - (a) Landsat Data Acquisition Facility located near Building 25 at GSFC.
 - (b) Spacelab Data Processing Facility in Building 23, GSFC.
 - (c) Communications Circuit Technical Control Facility in Building 30, JSC (Mission Operations Wing).
 - (d) WSC, White Sands, New Mexico.
3. The BFs are arranged in a hot-standby, redundant configuration. Each BF is capable of interfacing two SMs, one MDM MACS, and three DLMS units to the CSS. The BF select switch, which is part of the installation, provides switching functions of their BF serial, RS-422 interfaces. These functions include a 2x2 switch to route two communication links to/from the two BFs as well as a 2x1 switch to route the MACS and DLMS to and from either of the two BFs. The SM switch switches the interface of two SMs to and from the two BFs.

4. The CSS communicates with Nascom subsystem control elements in 1200-bit blocks over 56-kb/s interfaces. For CSS communication with the WSC and JSC locations, the BF performs a block multiplexing function for efficient utilization of 56-kb/s circuits established between GSFC and the remote locations. These 56-kb/s control circuits are established external to the MDM system for normal operational diversity configuration, but may use channels within the MDM system (serial data mode) as an alternate path.
- d. **DLMS Interface.** Each of the three BDS locations, WSC, JSC, and GSFC, have two DLMSs – one for each alternate downlink (A and B system), which will periodically send link status to the CSS. The DLMS provides status only, and requires no CSS commanding function. At GSFC, the DLMS interfaces directly with the CSS to provide link status. At WSC and JSC they interface via the BF.
- e. **MDM Interface.** The MDM system is interfaced directly to the CSS at GSFC, and through the BF at WSC and JSC for control and status functions.



Section 12. High Data Rate System

12.1 General

12.1.1 System Definition

The ground transport system referred to as "High Data Rate System" (HDRS) is a one-way, multimode/multichannel system designed to operate on a full C-band (36 MHz) transponder on a domestic communications satellite. It extends the TDRSS return link, single-access user digital data services in the relatively high data rate ranges, and Shuttle/Spacelab-unique analog and TV interfaces from White Sands, NM, to user facilities at GSFC, ARC, JSC, and MSFC.

12.1.2 Background Information

Nascom originally designed the HDRS to match the Shuttle/Spacelab, Ku-band, Channel 3 (modes 1 or 2), unique return link services capabilities, i.e., alternate digital or analog data handling capabilities. The Landsat program was also considered, and its high rate digital imaging data transport requirements were planned to be fully accommodated by the HDRS between shuttle missions. During shuttle missions it would be accommodated through scheduled time sharing of the HDRS. Although the HDRS was provided as a full-period dedicated service, it proved to be too constraining to both programs, and Nascom eventually supplemented the HDRS with an access to the shared-service NVTS. This provided the WSC with a capability for simultaneous off-site transmission of both high-rate digital data and commercial-grade analog TV signals. A description of the complete service arrangement is provided in the following paragraphs.

12.1.3 System Capabilities

The functional capabilities overview of the HDRS as a Nascom data transport system is illustrated in Figure 12-1. The HDRS is designed by Nascom to provide the following capabilities:

- a. Extend higher-rate TDRSS user's digital baseband data return link service (2 Mb/s and greater) from WSC direct to user installations at GSFC, JSC, MSFC, and ARC.
- b. Extend Shuttle/Spacelab video or analog data (Ku-band Channel 3, mode 2) TDRSS interfaces to JSC, GSFC, and MSFC users, either as an alternate or supplemental capability.
- c. Provide a 50-Mb/s data transport service with up to 48-Mb/s composite data throughput capability.
- d. Provide a time division multiplexing/demultiplexing capability with one to four channels, each with up to a 48-Mb/s composite limit.
- e. Provide a commercial-grade TV service or 4.2-MHz baseband analog data channel.

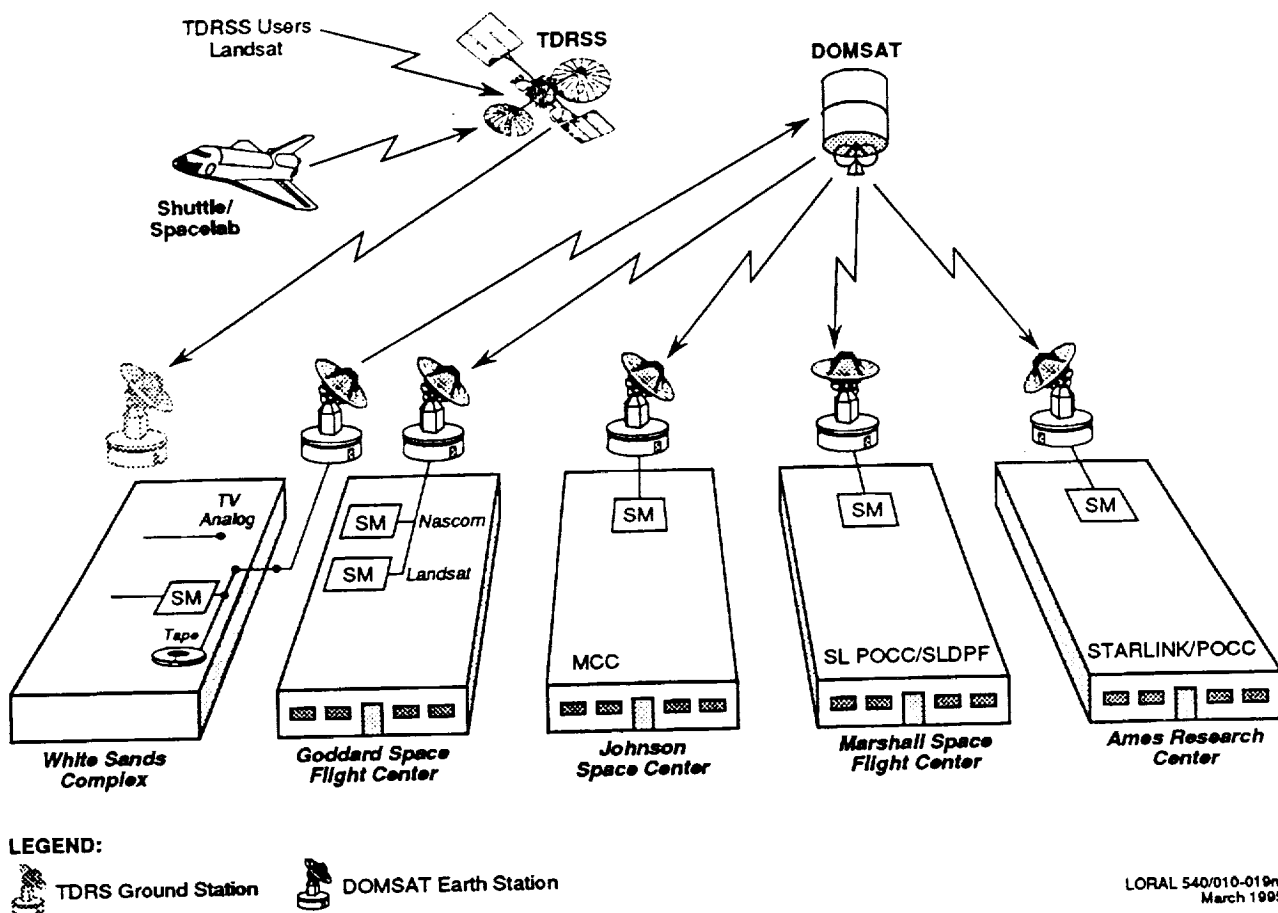


Figure 12-1. Functional Configuration of HDRS as a Nascom Data Transport System

12.2 HDRS System Description

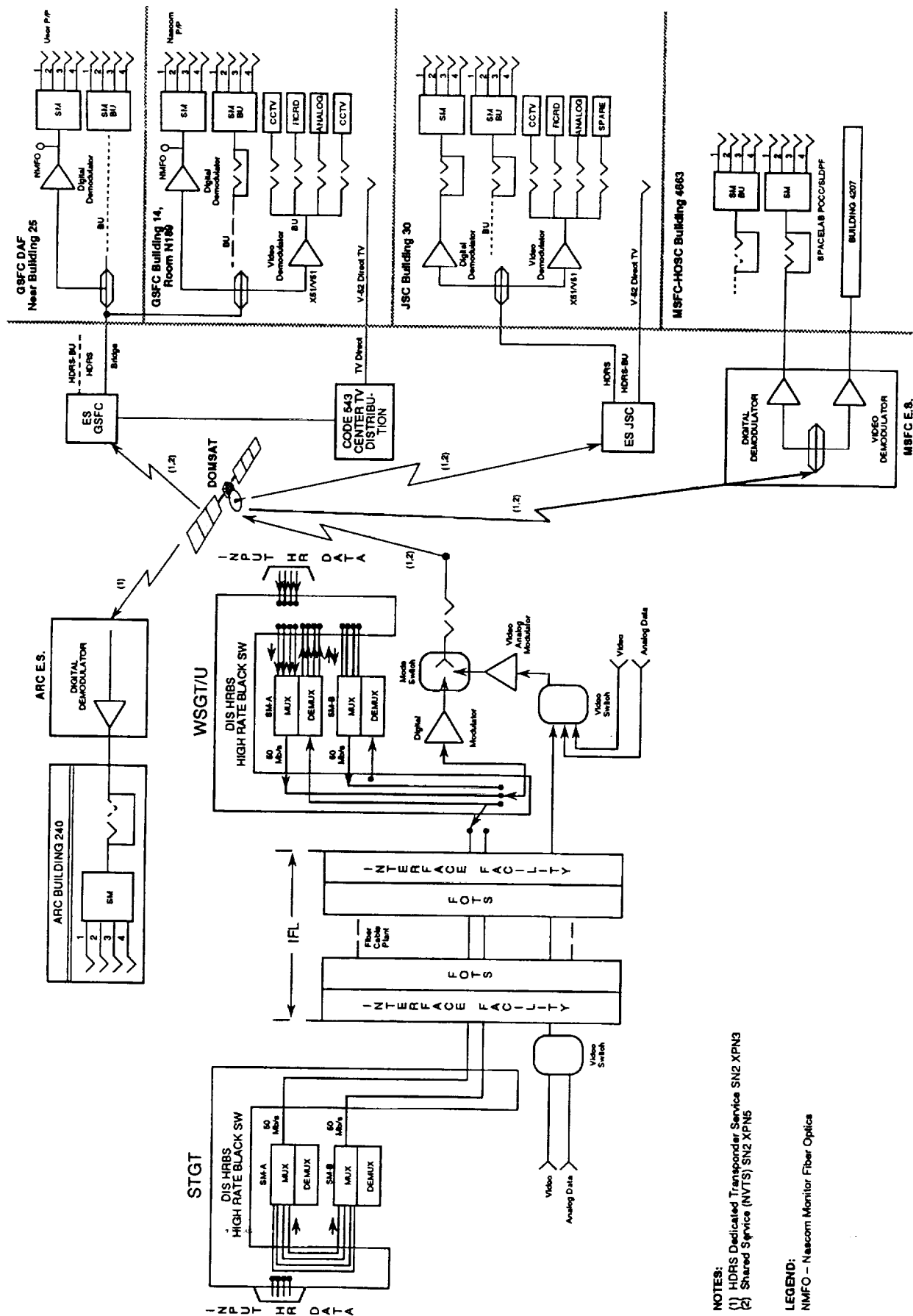
12.2.1 System Configuration

The system configuration of the HDRS is illustrated in Figure 12-2. The HDRS provides an SM system interposed with a leased common carrier (50-Mb/s) high data rate digital service provided in a full-period Domsat transponder. The SM system provides a return link broadcast transmission capability from WSC to user ground data capture and processing facilities. The SM is designed to effectively use the leased digital transmission resource (50 Mb/s) on the domestic communication satellite as the SMDS creates discrete channels that time share the total bandwidth in the digital mode with alternate analog and video services provided by the common carrier.

12.2.2 System Elements

The HDRS consists of three main system elements as follows:

- A Nascom-leased Common Carrier Domestic Satellite Transponder Service (CCDTS), including collocated Earth stations, DCE, and baseband service extension facilities to user SM installations.
- A Nascom-provided SMDS at each user interface.
- A supplemental leased common carrier NVTS.



NOTES:
 (1) HDRS Dedicated Transponder Service SN2 XPN3
 (2) Shared Service (NVTS) SN2 XPN5

LEGEND:
 NMFO - Nascom Monitor Fiber Optics

Figure 12-2. System Configuration of the High Data Rate System

12.2.3 System Interfaces

The system interfaces of the HDRS are as follows:

- a. The WSC handles the Shuttle, Landsat 4/5, Spacelab, and Starlink user service interfaces.
- b. Spacelab/Shuttle data monitoring facilities at JSC Building 30.
- c. Starlink data processing facilities at ARC Building 240.
- d. Landsat DAF near GSFC Building 25.
- e. Nascom tech control for carrier signal monitoring at GSFC Building 14.
- f. Spacelab POCC/SLDPF facility at MSFC.

12.3 SMDS Description

12.3.1 Role of SMDS in HDRS

For the high-rate (50 Mb/s) synchronous digital data mode of the CCDTS, Nascom provides a special four-channel SMDS system capable of multiplexing individual user data streams (up to four) with individual user data rates between 125-kb/s and 48 Mb/s into a composite data rate of up to 48 Mb/s. The SM reserves 2.0 Mb/s of bandwidth for system overhead. The capacity of the system for user data is constrained to 48.0 Mb/s. The system is designed to adapt to data rate changes and to track data rate variations from nominal rates indicated due to oscillator variation and system Doppler effects within specific tolerances, with the maximum increase above 48 Mb/s not to exceed 48.024 Mb/s.

12.3.1.1 Role of SMDS at WSC

The SN has provided cabling and distribution switching at WSC to integrate the switching of the KSA return link channel interfaces. NCC directed operations to configure the High Rate Black Switch (HRBS) to provide up to four digital signals from the HRBS to four input channels of the SM. The SM multiplexes the input channels and outputs a composite serial data stream to the 50-Mb/s synchronous data transmission service. A service switch interfaces the digital modulator (see Figure 12-2), while the digital modulator interfaces a mode switch before the multiplexed data is uplinked to the domestic satellite. The mode switching of these system functions, SM channel enabling, and data rate selection are under control of the Nascom CSS.

12.3.1.2 Role of SMDS at User Locations

The demultiplexers at user locations, demultiplex the composite data stream and deliver the data to each of its assigned channels. Each stream at this point is a synthesized replica of the bit synchronized clock and data stream originated at the input of the SM at White Sands. The SM uses its own data formatting and multiplexing technique that is germane to Nascom and transparent to users of the system. Redundancy is provided in the system with a backup SM at each location. The SM equipment is provided in full duplex for local loopback test capabilities.

12.4 CCDTS System Description

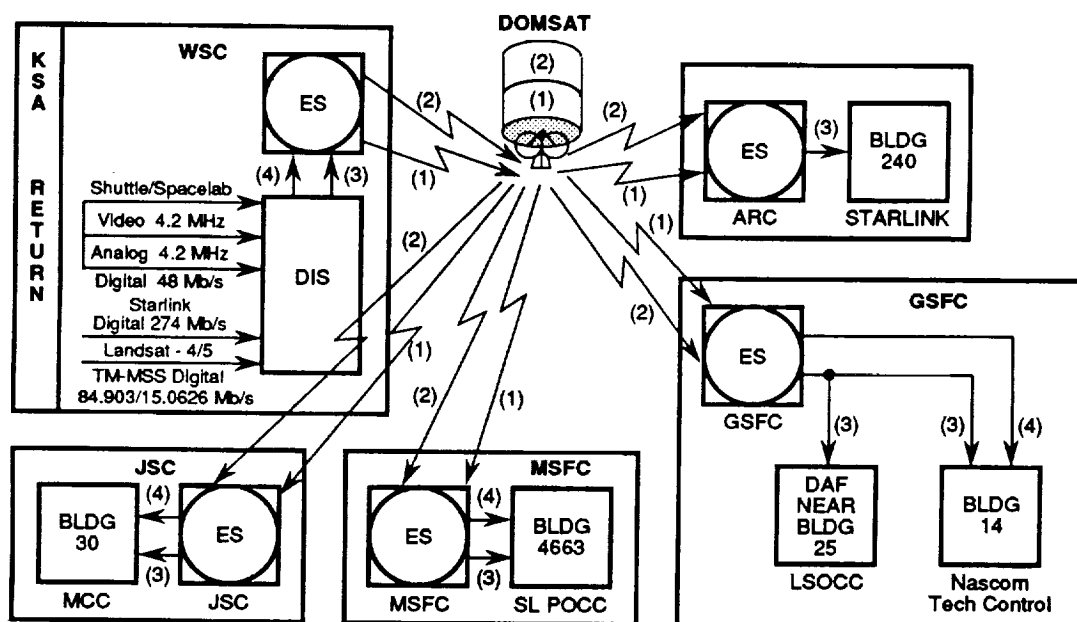
12.4.1 System Configuration

The system configuration of the CCDTS is illustrated in Figure 12-3. The hub of the CCDTS configuration is the NASA-leased, C-band transponder (36 MHz), with alternate digital/analog/video service capability. Similar to the BDS, the HDRS is configured to transmit the uplink from White Sands in "broadcast" to JSC, GSFC, MSFC, and ARC. Identical signals are provided at each location. The leased transponder service uses the collocated Earth station facilities at these locations. Although redundant transponders are not leased, long-term service availability performance of 99.95 percent is specified to the common carrier. This performance goal requires the common carrier to provide dual-string ground station equipment with remotely controlled switchover and attended maintenance operations.

12.4.2 CCDTS Services

The Nascom-leased Domsat transponder service provides the following elements for the CCDTS:

- a. Synchronous, binary digital data service at 50 Mb/s extended to user DTE/SM installations.



NOTES:

- (1) Full transponder, full period, shared service for digital and analog video data
- (2) Dedicated no-simultaneous video/analog 4.2 MHz or 50 Mb/s digital data services
- (3) 50 Mb/s digital data services only
- (4) TV/analog data service only

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Figure 12-3. System Configuration of the Leased Common Carrier Domsat Transponder Service

- b. Analog data channel service at 20 Hz to 4.2 MHz extended to user installations.
- c. TV (video) channel service compatible with Electronic Industries Association (EIA) standard RS-170 and RS-250. TV channel service mode includes capability to transport a 50-Hz to 15-kHz audio signal.
- d. Analog/digital mode switch with remote control interface provided.
- e. Supplemental access to the NVTs.

12.4.2.1 50-Mb/s Digital Data Service

The system provides direct delivery of digital data services via the Earth stations located at WSC, GSFC, JSC, ARC, and MSFC. Common carrier Intermediate Frequency (IF) modulator and demodulator terminals and 50-Mb/s data modem equipment are collocated with WSC and user data processing and data capture facilities in JSC MCC (Building 30), MSFC Spacelab POCC (Building 4663), ARC Building 240 (Starlink Data Processing Facility), and Landsat DAF near Building 25. This data service is also extended to Building 14 for monitoring at the Nascom technical control facility. Mode selection switching capability is provided by the carrier at WSC, where it is available for local Nascom operational control.

The SMDS, whose aggregate output to the carrier's modem is 50 Mb/s, is provided with a stat mux bypass feature. This feature enables a 50 Mb/s serial clock and data signal, from a source other than the stat mux, to be directly interfaced to the digital side of the carrier's modem. Theoretically, this bypass feature enables transport, on a scheduled basis, of a 50 Mb/s TDRSS Ku-band return link serial data stream for transport (on a bent-pipe basis) from WSC to one or more receiving stations. Receiving stations which are already configured as part of SMDS should be able to receive and operate upon the 50 Mb/s serial clock and data digital output of the carrier's modem by patching around (or otherwise by-passing) their stat demux equipment. An engineering test of this feature was performed by Nascom in 1991. This test is documented in Nascom High Data Rate System 50 MBPS Service Engineering Test Report September 3 Through 6 1991, 541-153, dated December 1991. In practical terms, use of this bypass feature might enable a mission or program whose requirement is for 50 Mb/s serial clock and data to receive that data, on a scheduled basis, using existing Nascom capabilities. If the mission's requirement can accommodate shared use of an institutional resource on a scheduled basis (e.g., if the bandwidth of the signal were such that a direct interface to one of the stat mux ports was technically feasible, and the mission could then accept service via the stat mux), use of this institutional capability might forestall having to (1) provide a rate buffering capability for its data at the WSC, or (2) procure a new 50 Mb/s data service from a commercial carrier.

12.4.2.2 Video/Analog Services

A second service available in the CCDTS consists of nonsimultaneous, one-way transmission of video or analog data. WSC provides return link, 4.2-MHz interfaces that can be used for either video or analog data service. The SN has provided cabling from the WSC interface to the DIS TV processing area. At the TV processing area, operations personnel select, configure, and route either the video or analog service to the mode switch for transmission to

GSFC, MSFC, and JSC. Also available, as shown in Figure 12-2, is the direct Shuttle transmission system that provides for video service capability.

12.5 HDRS Operation

12.5.1 Service Protection

The service class originally provided by the common carrier is "non-preemptible protected," which obligates the carrier not to allow preemption of the transponder for other users and to allocate a protection transponder in either the same or another satellite, in the event of a catastrophic transponder or satellite failure. Transponder restoration is required, contractually, within two hours of detection. However, the service currently utilized (NVTS) is not in this service class. As additional protection for digital data loss, high data rate digital recorders are available at WSC for backup recording of the TDRSS transmission.

12.5.2 HDRS Transmission Path

Service provided by the common carrier extends the intermediate-frequency or baseband signals from the receiving Earth station down-converters into demodulator terminals that are collocated with user data processing/capture facilities in JSC Building 30, MSFC Building 4663, ARC Building 240, and Landsat DAF. The carrier also extends signals to Building 14 at GSFC for monitoring at the Nascom technical control facility. Mode selection switching capability is provided by the carrier at WSC, where it is available for local NASA operational control. Control of mode selection is also extended back to the GSFC Nascom technical control facility through separate control circuits, where it can be controlled by the CSS automated scheduling system and/or the NCC.

12.5.3 HDRS Switching and Interface Operations

Information concerning HDRS switching and interface operations, as used in SN support of Shuttle/Spacelab and Landsat Missions, is provided in Section 14.



Section 13. Remote Site Circuit and NASA Center Support Arrangements

13.1 General

This section presents information concerning the two following areas:

- a. Special arrangements that Nascom has provided for reliable and diverse routing via common carrier's circuits. These arrangements are for the remote STDN and DSN tracking stations, for the intermediate Nascom switching center and for the NIFs.
- b. General allocation of responsibilities for operational communications support arrangements at various NASA field centers.

13.2 Background on Remote Station Circuit Arrangements

13.2.1 Approach to Specific Provisions

Prior to the implementation of Nascom-2000, specific provisions were made locally at GSFC, at station locations, and in long-haul routing to enhance reliability of communications to the extent possible through diversification of facilities. Where possible, circuits were divided between routes, allowing "graceful" reduction of capacity to minimum essential communications in the event of circuit outages. This enabled Nascom facility controllers, in coordination with Network and mission personnel, to restore the most critical functions on the remaining circuits while restoration activities of the communications carriers on the failed circuits were in progress. In all cases, control of options and reconfiguration actions were exercised from the Nascom switching center at GSFC.

With the implementation of Nascom-2000 for domestic communications and NOCS for principle overseas interfaces, a change has occurred in their accomplishment. Nascom-2000 (refer to Section 5 for a description) relies upon one carrier for the transmission of its circuits provided they do not exceed T-1 rates. This carrier is the GSA's FTS2000 Network A carrier (AT&T) to which NASA is assigned. Normal Nascom-2000 carrier services should be viewed as occurring within a T-1 cloud and afforded the specific features provided by the Network Service Assurance Plan contract modification. For circuits provided by Nascom-2000 that require a diverse route between their source and the sink, special routing provisions of the FTS2000 contract (as modified to accommodate Nascom requirements) are implemented. In those instances where the Network A vendor may not have the required infrastructure, Alternate Network Connectivity provisions may be implemented. In any event, the goals and objectives in the preceding paragraph are retained. Circuit requirements that are beyond the range of Nascom-2000's service capability are stated in the previous paragraph.

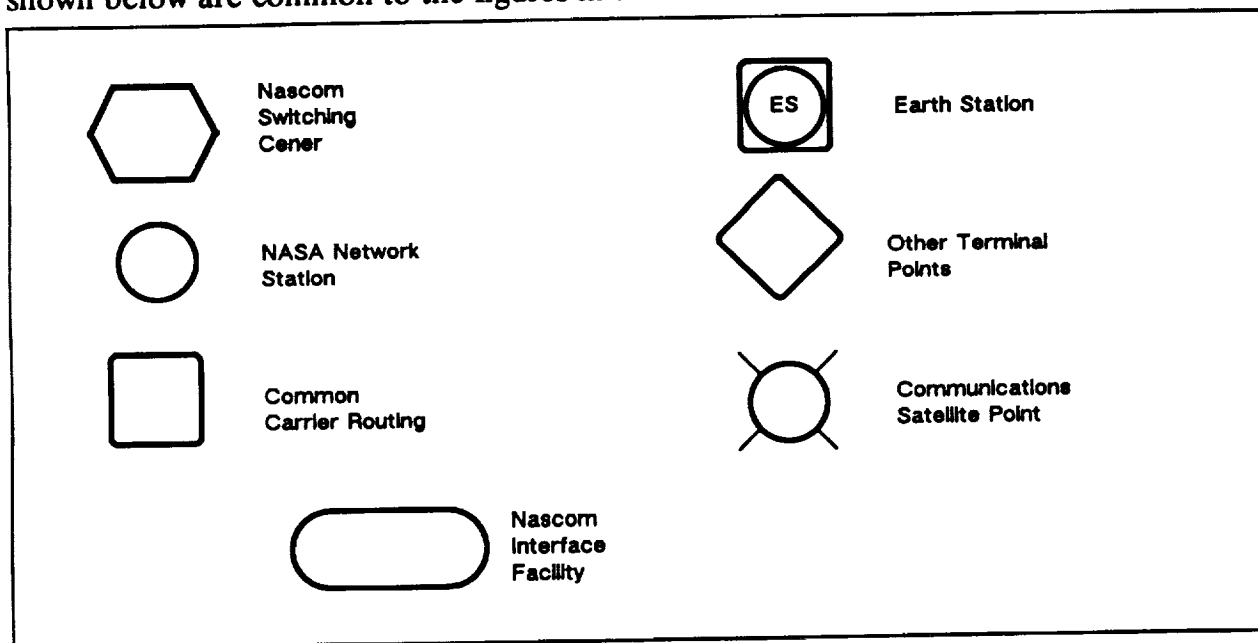
13.2.2 Common Carrier Services

Nascom-2000 services are terrestrial unless Alternate Network Connectivity provisions are invoked. In those cases, the routing is via domestic satellite. Wideband services for which the

data rates exceed T-1 (the upper limit for Nascom-2000 services) and overseas voice and data circuits, are generally implemented using satellite (Domsat or Intelsat, as appropriate) services procured through a competitive process. Intelsat, a consortium of international carriers, a variety of international record carriers, and foreign governments provide worldwide international satellite communications. Domestic satellite services are obtained primarily from three domestic satellite carriers. AT&T and GEAM provide services through their communications satellites. GTE's Federal Services Division provides services via their SpaceNet II and IV communications satellites. Some of the circuits leased from GEAM use SpaceNet II transponders which GEAM leases from GTE. Intelsat services are provided using, in particular, the following Intelsat communication satellites: Intelsat VA F-11, F-13, and F-15; Intelsat VI F-5; and Intelsat VII F-1.

13.2.3 Routing Information

The routing information that follows gives generalized representations and should not be regarded as complete or precise. Remote locations are in alphabetical order. The symbols shown below are common to the figures in this section:



13.3 NASA Network Stations Circuit Routings

13.3.1 Review of NASA Network Stations

Information concerning communications routing arrangements with the common carriers for nine NASA station facility locations is contained in the following paragraphs. These network facility locations are:

- a. Goddard Space Flight Center (GSFC).
- b. Bermuda (BDA).
- c. Canberra Complex (CDSCC).
- d. Dakar (DKR).

- e. Goldstone Complex (GDSCC).
- f. Madrid Complex (MDSCC).
- g. Merritt Island/KSC Launch Complex (MIL/KSC).
- h. Wallops (WFF).
- i. White Sands Complex.

13.3.2 Ground Network (GN) Phasedown

With TDRSS becoming operational, the Santiago (AGO) station terminated support September 30, 1989 as a GN station and was turned over to the University of Chile. However, AGO is still providing GSFC some limited support (approximately two hours per day), which is scheduled by the NCC. All Nascom circuits have been terminated. AGO support to GSFC is via a 64 kb/s service arranged and funded by the University of Chile.

13.3.3 Goddard Space Flight Center

13.3.3.1 GSFC Communications Routing Configuration

GSFC is located in Greenbelt, MD, approximately 10 miles northeast of Washington, DC. Diverse communications routing is achieved with four separate cable facilities to the Washington, D.C. interconnect center; Nascom is also directly connected to three on-site common carrier operated domestic satellite Earth stations with a total of five antennas between them.

13.3.3.2 Local Circuit Arrangement

The underground and aerial cables of the Bell Atlantic Telephone Company are diversely routed between GSFC and Washington, through Berwyn and Hyattsville, MD. In addition, the carrier achieves circuit diversity on these links by splitting circuit assignments to separated cables in isolated ducts along the common cable route. AT&T Federal Systems provides separate fiber optic cable routes from GSFC to their Washington, D.C. toll center; one cable is directly routed and the other is routed through their facility in Silver Spring, Maryland. Circuits derived from these cables are extended to the toll test centers at Washington. A fiber optic cable facility from Washington to GSFC is provided by ICC Inc. for use by record carrier access links.

13.3.3.3 Communications Satellite Circuit Arrangement

Five on-site satellite antennae, GTE-1 and -2, AT&T, and GEAM-2 and -3 provide GSFC with direct communications via satellite routes to domestic locations. In addition, GTE provides domestic satellite links to the Intelsat system through a collocated Earth station at Etam, WV.

13.3.4 Bermuda

13.3.4.1 BDA Communications Routing Configuration

As illustrated in Figure 13-1, communications circuits from the Bermuda (BDA) GN station located on Coopers Island are routed to the CWL facilities at Devonshire Flatts by two

routes. The prime route is via a NASA-provided, 24-channel microwave system. Alternate route voice grade channels are available via Kindley AFB, extended to the CWL submarine cable terminal at Devonshire Flatts through DoD submarine and buried cables. Switching of circuits is controlled by personnel at the GN station. BDA site long-haul circuit requirements are divided among the following three diverse routes linking Bermuda and the U.S.

- From CWL facilities at Devonshire, Bermuda via fiber optic submarine cable (PTAT) to New York, (Manasquan, NJ) and then to Washington, D.C. and GSFC.
- Via fiber optic submarine cable (CARAC) from Ojus, FL, St. Thomas, VI, and Tortolla to Devonshire.
- Via a CWL/Intelsat satellite path to the Etam, WV, Earth station, then to GSFC by coaxial/microwave systems via Washington, DC.

13.3.5 Canberra Complex

13.3.5.1 CDSCC Communications Routing Configuration

CDSCC is located at Tidbinbilla, southwest of Canberra, Australia, in the Australian Capital Territory (ACT). This complex accesses the Nascom Network through the Nascom interface

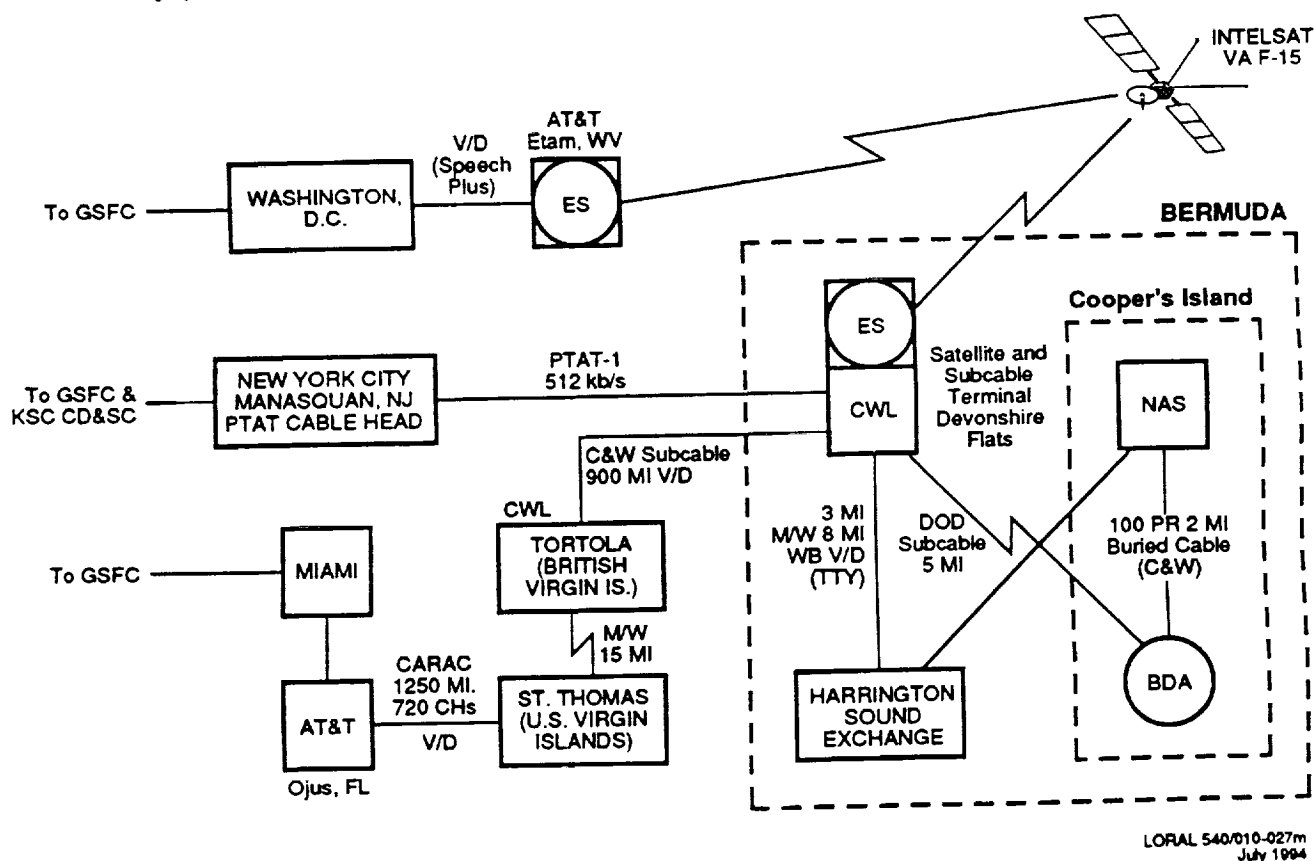


Figure 13-1. Bermuda (BDA) - Communications Routing

facility function located with the signal processing center of the CDSCC. Figure 13-2 portrays carrier infrastructure in the area.

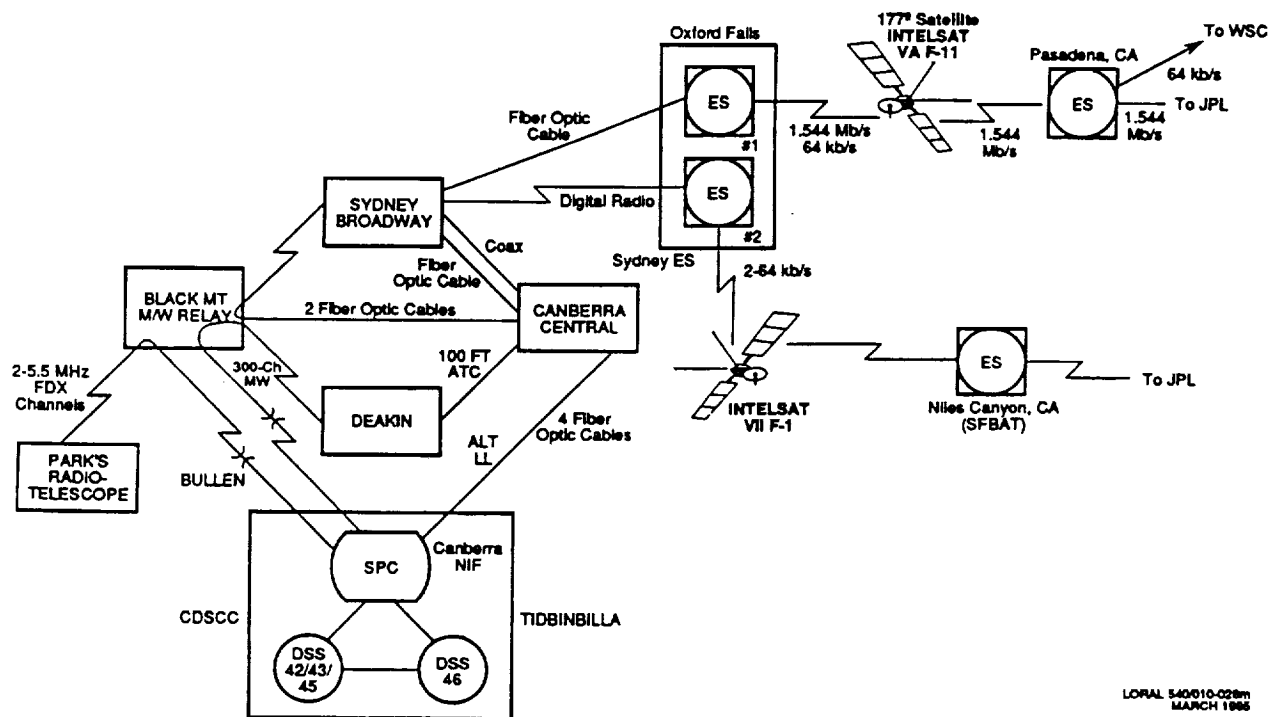
13.3.5.2 Common Carrier Circuit Arrangement

A mix of common carrier services is used in communications routing. These are described in items a through d:

- NASA trunk circuits into and out of the CNIF are routed between Tidbinbilla and Sydney via diverse analog and digital microwave and wire line, coaxial, and optical fiber cable facilities.
- An ATC-maintained, 300-channel microwave system, routed via Black Mountain to Deakin, provides a path for direct voice/data circuits, plus the NASA office TTY, some voice/data patch circuits, and some commercial phone circuits.

A four fiber optic cable connects CDSCC to Canberra central. One pair of fibers is terminated in Canberra central while the second pair is extended to Black Mountain for electronic diversity. Each fiber pair has an 8 Mb/s MUX connected which provide four 2 Mb/s channels.

The Canberra central system carries the prime 2 Mb/s system which is routed via the Sydney/Canberra/Melbourne Fiber Optic Route to Sydney. Also on the Canberra central system is a patchable 2 Mb/s channel which terminates on patch panels at Nascom Canberra and Canberra central. A third 2 Mb/s channel carries a 30-channel PCM digital system which



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Figure 13-2. Canberra Complex - Communications Routing

has voice/data patches, in the event of an outage on the 300-channel microwave, plus some commercial phone services.

The Black Mountain fiber system carries the backup 2 Mb/s system which is extended to Sydney via a microwave system using Digital Above Video (DAVID) system. One of the 2 Mb/s channels is also patched between Nascom Canberra and Black Mountain as required.

The two 2 Mb/s systems are diversely routed to OTC Broadway even to the extent of separate ducts within Broadway until they come together in the Nascom rack in Broadway.

Also, the Parkes microwave link between CDSCC and Black Mountain may be used to provide a 2 Mb/s path if the optical fiber cable between CDSCC and Canberra central was broken.

The wideband circuits and half the voice/data circuits are muxed onto the 2 Mb/s system. The MUX equipment will automatically switch to the alternate 2 Mb/s path in the event of the on-line patch failing.

- c. A full duplex 1.544 Mb/s circuit for wideband service between Canberra and JPL is routed via Intelsat VA F-11. The primary carrier is GEAM with COMSAT acting as the US agent for the Intelsat access. A 64 kb/s multiplexed data circuit is diversely routed, using Intelsat VII F-1, between JPL and CDSCC. MCI is the primary carrier for this service.
- d. A low-speed network TDM system is extended from GSFC to Canberra through a 9.6-kb/s data circuit. This low-speed TDM system has the capability to transport 15 low-speed data channels.

13.3.6 Dakar

The NASA tracking station at Dakar (DKR), West African Republic of Senegal, has been closed. However, NASA retains a UHF space-to-ground capability that is collocated with the Intelsat earth station; the station is approximately 20 miles northeast of the capital city of Dakar. Nascom retains two AVD circuits to the UHF ground station; the circuits are routed via Intelsat from Etam to Dakar. One of the circuits is a site-coordinated voice loop; the other extends the Shuttle's UHF A-G voice circuit to GSFC and on to JSC.

13.3.7 Goldstone Complex

13.3.7.1 GDSCC Communications Routing Configuration

The Goldstone complex is a NASA-leased section of Fort Irwin Military Reservation in the Mojave Desert, CA, approximately 100 square miles in area and located 120 miles northeast of Pasadena, CA. The communications routing configurations for GDSCC are illustrated in Figure 13-3. Facilities provided by JPL interconnect five DSN antennas with JPL via two T-1 services between the Pasadena GCF-20 and Goldstone GCF-10 control centers and between GCF-20 and Goldstone DSS-14.

13.3.7.2 Common Carrier Circuit Arrangement

This arrangement is described in the following paragraphs:

- a. A full-duplex 56-kb/s circuit; a full duplex 224-kb/s circuit; and two full-period, full-duplex AVD circuits are routed via direct satellite link to GSFC through a

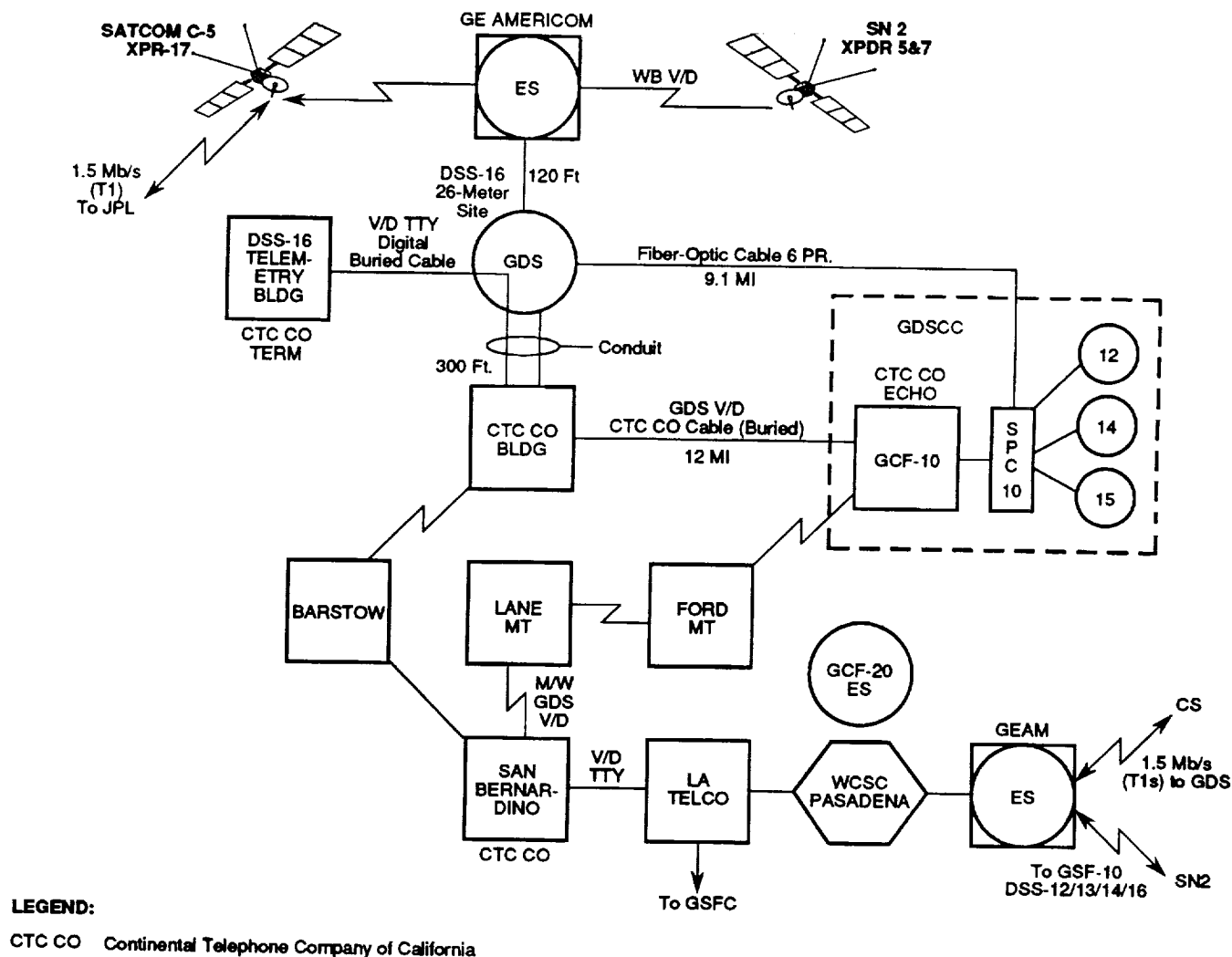


Figure 13-3. Goldstone Complex - Communications Routing

GEAM Earth station collocated at the 26-meter site. Two additional AVD and one TTY circuit to the 26-meter site are routed from GSFC by the AT&T terrestrial longlines system and the Continental Telephone of California Company (CTC Co) facilities. The CTC Co facilities consist of a microwave routed via Lane Mountain, then open wire and buried cable to the site through the CTC Co building at the GCF-10 center. Four full-period AVD interconnect circuits are also in service to the 26-meter site from the WCSC at JPL, via these facilities, as well as two full-period, full-duplex TTY circuits.

- b. A fiber-optic cable system (six pairs) has been installed between SPC-10 and the DSS-16 (26-meter site) for cross support requirements.

13.3.8 Madrid Deep Space Communications Complex

JPL's MDSCC is located near Robledo, Spain, approximately 30 miles west of Madrid. The MNIF and the MDSCC are located across a road from each other and are connected via

buried cables. The MDSCC's role as a switching and relay center for Nascom in Southern Europe has been terminated. However, the MNIF retains the NOCS TDM and serves as the carrier interface location for the site. Network connectivity to the DSN station is provided by a 1.544 Mb/s multiplexed digital trunk circuit, a segment of NOCS (refer to Section 9 and Figures 9-13A and B) that is directly routed between MDSCC and JPL's WCSC via Intelsat VA F-13. Alternate path connectivity with MDSCC is provided by two 64 kb/s digitally multiplexed circuits. These circuits are routed, via TAT-9 submarine cable, to GSFC where the circuits are extended on to JPL.

13.3.9 Merrit Island/KSC Launch Complex

13.3.9.1 MIL Communications

The MIL GN station is located on KSC, Merrit Island, Florida. With the implementation of Nascom-2000 for intercenter communication services, MIL interfaces are at the KSC CD&SC building (refer to Section 5 for a discussion of Nascom-2000, and Section 3 for changes in circuit routings to the KSC launch complex). This GN station operates and maintains the DSN compatibility test station (MIL-71) for JPL. The station principally serves as a tracking and acquisition station during launches. However, it also provides support services for spacecraft and payloads during the prelaunch phases at various KSC locations on Merrit Island, and for Air Force facilities at Cape Canaveral. MIL's external communications are very complex. Figure 13-4 provides a high-level overview of launch complex interfaces.

13.3.9.2 Circuit Routings and Demarcations

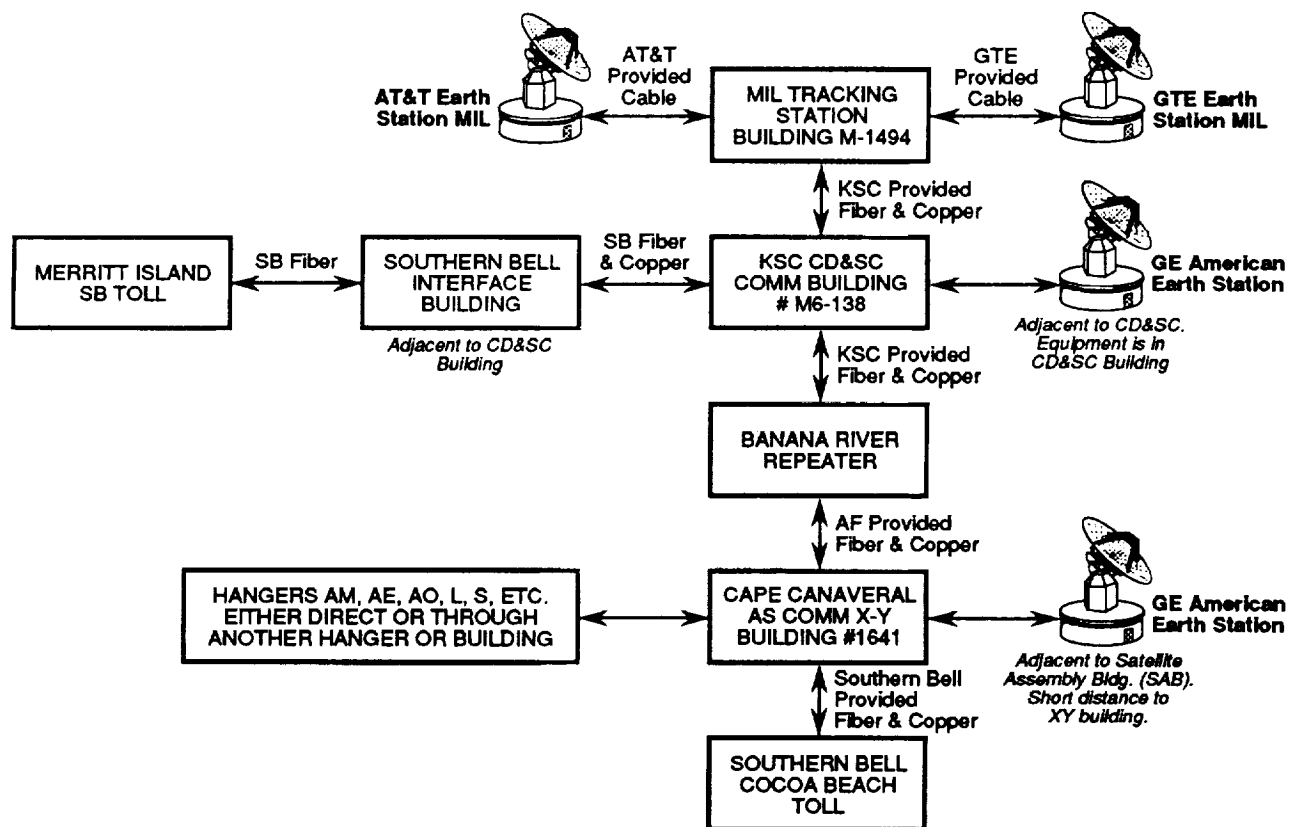
As shown in Figure 13-5, voice and data circuits are brought into and out of the KSC launch complex by Nascom-2000 services. Nascom-2000 services terminate in the CD&SC building at which point KSC's Voice (and data) Distribution Management System (KSC VDMS) takes on the role of the local carrier and distributes the tail segments of the Nascom-2000 circuits to the various source/sink locations in the area. In particular, KSC distributes Nascom-2000 circuit tail segments to the Launch Control Center, MIL, the Air Force's XY facility, Hanger AE, and to payload communications.

13.3.10 Wallops Flight Facility (WFF) and Range

13.3.10.1 WFF Responsibility

The following summarizes the WFF responsibility.

- a. WFF, on the eastern shore of VA and approximately 40 miles southeast of Salisbury, MD, comprises three separate pieces of real property. The main base, formerly Chincoteague Naval Air Station, is the location of the administrative offices, engineering offices, technical support shops, and facilities such as the range control center, research airport, and the main telemetry building. Also located at the Main Base is the National Environmental Satellite Service (NESS) Command and Data Acquisition (CDA) station and the relocated GN orbital tracking station (formerly BLT). Wallops Island launch area comprises the launch sites, assembly shops,

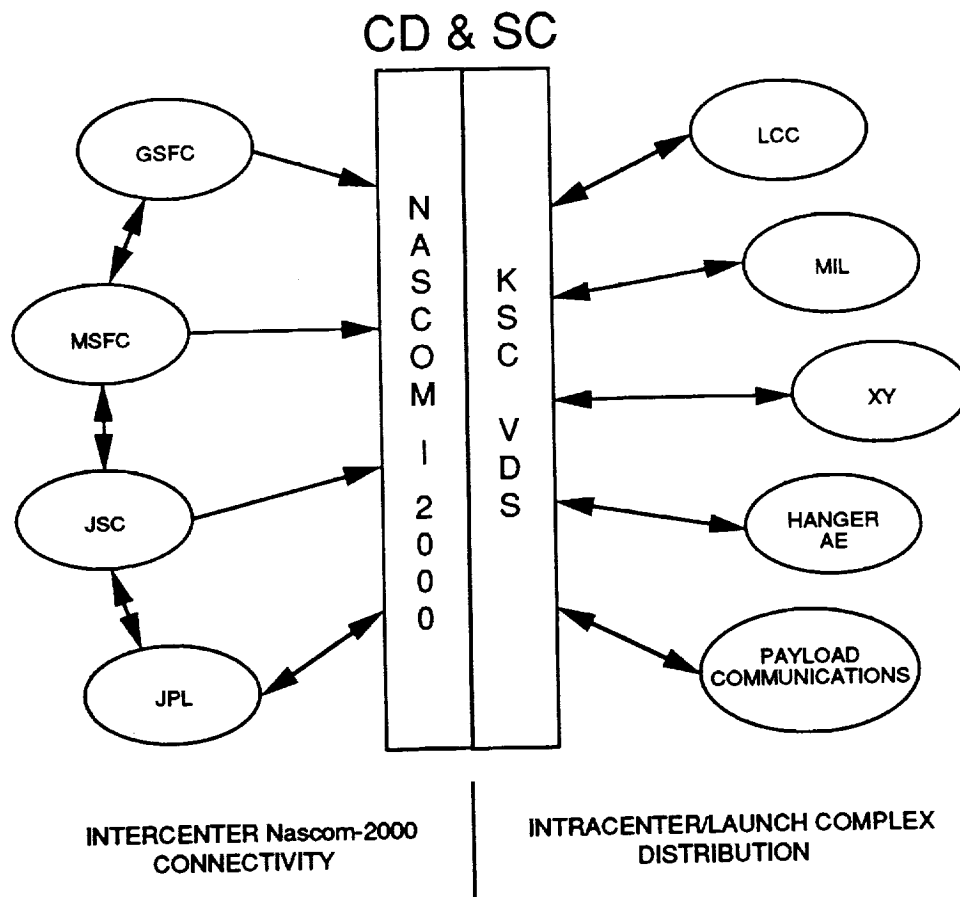


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Figure 13-4. KSC/MIL/CCAFS Transport Media

blockhouses, rocket storage building, and related facilities. Long-range radars, the command-destroy and transmitter building, and optical tracking sites are located on the Wallops mainland.

- b. These facilities are used to provide support for the satellite, reentry, sounding rocket, aircraft flight, and international research programs carried on at WFF. Much of the Wallops research effort is in support of the Sounding Rocket Program. These sounding rockets fly in a nearly vertical trajectory, carrying packages of scientific instruments 40 to several hundred miles high. Their lifetime is usually only a few minutes, terminating when they drop back to Earth. Most of the data is collected and disseminated by WFF.
- c. A project control center at WFF's main base is located on the third floor of the airport tower and is used to control various aeronautical flight projects. Multiple aeronautical projects can be conducted simultaneously using the project control center.
- d. The National Oceanic and Atmospheric Administration (NOAA) has a lease arrangement with NASA for its NESS CDA site at WFF main base. The NESS station is linked by a NOAA-provided 48-kHz wideband circuit with the Satellite Operations Control Center (SOCC) that operates the NESS at Suitland, MD. This service relays information obtained from weather observation satellites and spacecraft.



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Figure 13-5. Nascom-2000 and KSC VDS Demarcation

- e. WFF obtains weather forecasting support from NOAA through NOAA-provided facsimile and TTY circuits to Suitland, MD. Other long-haul circuits for gathering and disseminating meteorological information are funded and administered by WFF. WFF also provides temporary circuits to NASA and non-NASA range users on a reimbursable basis.

13.3.10.2 WPS Communications Routing Configuration

A NASA network station on Wallops Island (WPS) that functions as a GN station is located at the WFF main base, supporting orbital spacecraft telemetry and command operations.

13.3.10.3 Nascom Support Arrangement

The WFF range control center and the radars are linked by Nascom-provided voice, and low- and high-speed data circuits with GSFC and CCAS for launch support activities. Launch support communications include range safety voice coordination, command control, inter-range radar tracking, and acquisition data flow. The range safety officer at Wallops uses a voice/data circuit through GSFC to Bermuda to provide for a down-range command-destruct capability for WFF launches that Bermuda supports. These Nascom circuits are

terminated at a Nascom-provided patch facility in Building N159 at the main base, from which flexible distribution and access to Wallops radar facilities, control center, and computer facilities are made.

With the exception of three wideband circuits (one analog and two digital) and four high-speed data circuits, Nascom circuits supporting WFF and WPS are now provided by Nascom-2000. Since terrestrial infrastructure into and out of the Wallops area that may be used by Nascom-2000 T-1s is somewhat limited, Nascom-2000 service also employs alternate network connectivity. Transponder 15B of GTE's Space Net II domestic satellite carries the Nascom circuits, regardless of whether the carrier is FTS (Nascom-2000) or GEAM (non-Nascom-2000 circuits). Figure 13-6 depicts communications routing for Wallops Island facilities.

- Primary voice, data, 224 kb/s and a 56-kb/s wideband circuit for the WPS station are provided by Nascom via Nascom-2000 alternate network connectivity, and a GEAM Earth station that is located on the main base, extending them to GSFC via SATCOM SN2 Transponder 15B, to the GE Earth station at GSFC.
- Radar facilities on Wallops Island, the mainland, and on the main base, which provide launch tracking support for STS and other mission, and range safety command functions at the main base, are supported by Nascom voice/data land line circuits leased from AT&T. These are interfaced through a Nascom patch facility in Building N-159 at the main base.

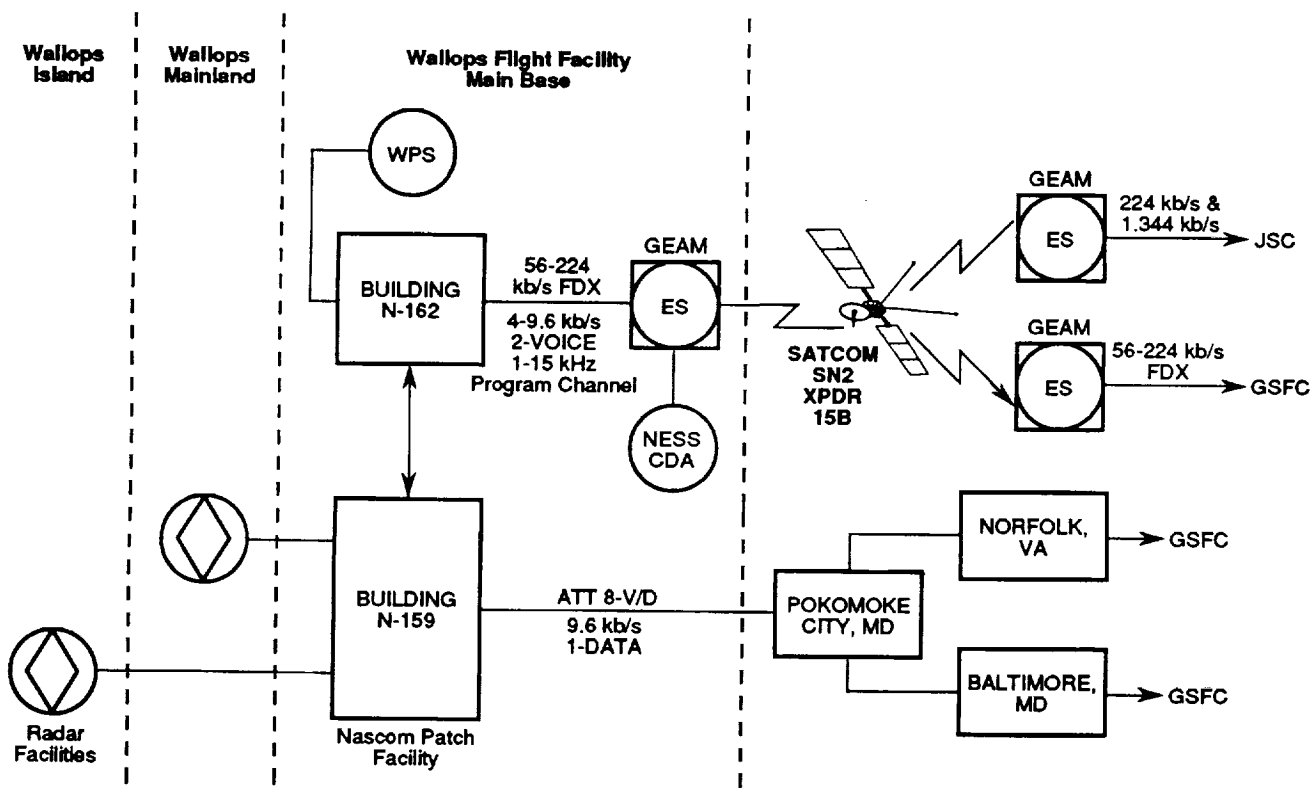


Figure 13-6. Wallops (WPS)-Communications Routing

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13.3.11 White Sands Complex

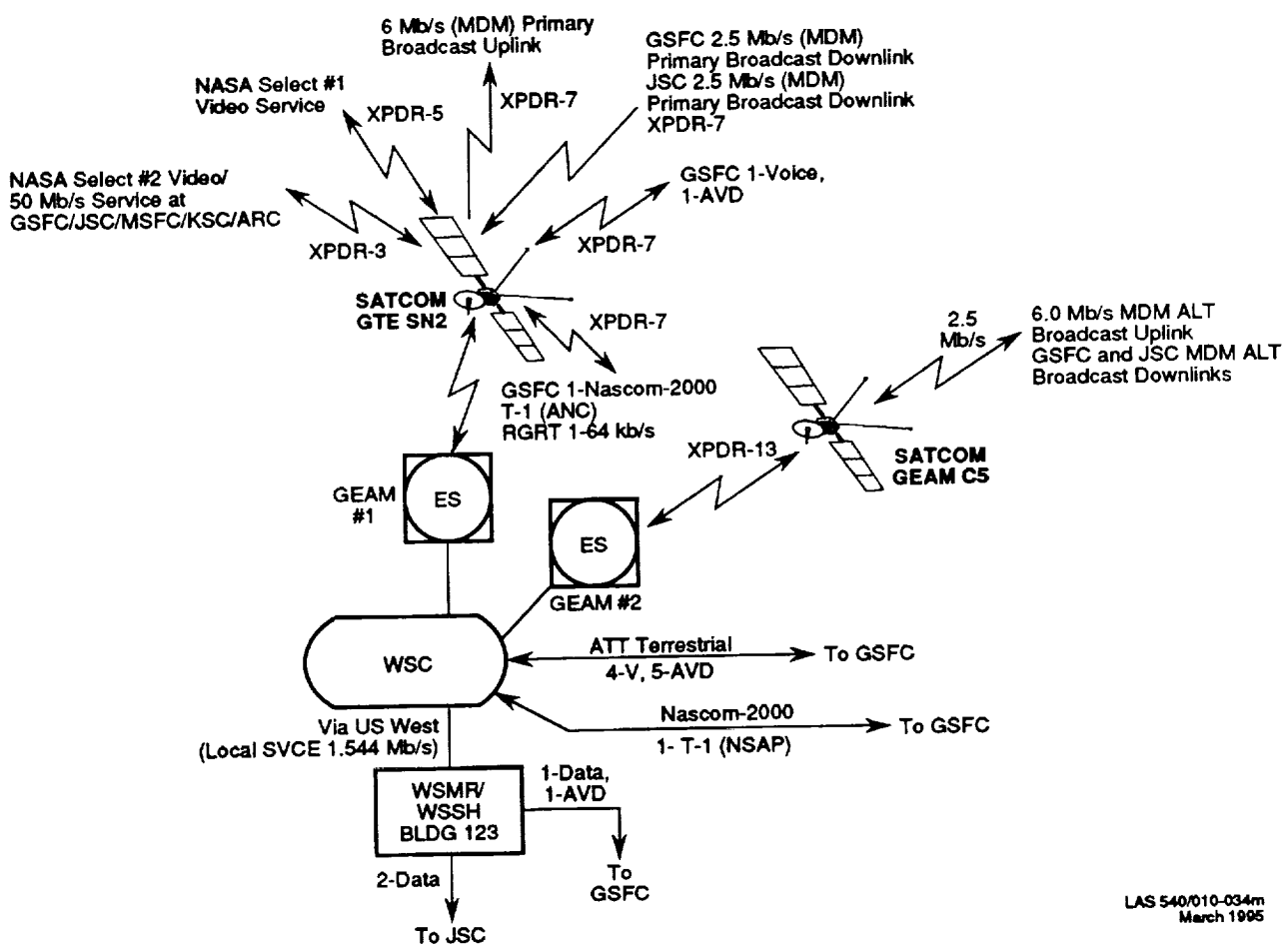
13.3.11.1 WSC Communications Routing Configuration

This is a major network station that functions as the NASA ground terminal interface between the TDRSS and the users/controllers of the SN. The communications routing configuration for WSC is illustrated in Figure 13-7. This station is located on the White Sands Test Facility administered by JSC, which is hosted by the DoD's White Sands Missile Range (WSMR). Nascom provides various common carrier interface facilities in the WSC for diversely routed off-site ground communications transport services – as indicated in the following paragraphs.

13.3.11.2 Common Carrier Circuit Arrangement

The following paragraphs describe the services provided by communication common carriers at the White Sands Complex.

- a. The first GEAM earth station at WSC provides the broadcast service for the baseline data system (MDM): a 6 Mb/s uplink and two 2.5 Mb/s downlinks via GTE's SN2 Domsat, transponder 7. This station also provides up and downlink support for



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Figure 13-7. NASA White Sands Complex-Communications Routing

NASA Select Two, and the 50 Mb/s high data rate system's statistical multiplexer using Domsat SN2, transponder 3. NASA Select One service provides up and downlink services through this earth station using transponder 5 of the SN2 Domsat. Other services provided by this earth station, using transponder 7 of the SN2 Domsat, include a Nascom-2000 T-1 (ANC) circuit to GSFC, a 64 kb/s circuit to the TDRS Remote Ground Relay Terminal (RGRT) near Canberra, Australia, and a voice and data circuit to GSFC.

- b. The second GEAM earth station at WSC provides the alternate broadcast service for the baseline data system: a 6 Mb/s uplink and two 2.5 Mb/s downlinks via transponder 13 of GEAM's Domsat C5.
- c. Terrestrial services are provided by AT&T (four voice and five data), Nascom-2000 (one NSAP T-1 service), and by the local carrier, U.S. West (a 1.544 Mb/s data circuit to the White Sands Missile Range).

13.4 U.S. International Record Carrier Gateways

All of the Nascom services extending into foreign countries are leased from U.S. based common carriers which are licensed by the FCC for such service. These common carriers are referred to as International Record Carriers (IRC). The IRCs provide services via U.S. gateway facilities. Most Nascom wideband circuits to foreign locations are routed by their respective IRCs via Intelsat satellite Earth station gateways. These are:

- a. Etam, WV, Earth station.
- b. Roaring Creek, PA, Earth station.
- c. Sunset Beach, HI, Earth station.
- d. San Francisco Teleport, Niles Canyon, CA.
- e. Vallejo, CA Earth station.
- f. New York Teleport, Carteret, NJ.
- g. Washington, D.C. (IRC locations)
- h. Andover, ME Earth station.

Nascom circuits may also be provided by transoceanic cables, both fiber optic and copper. Some of these cables now used by Nascom IRCs include the following:

To Bermuda and Europe
- Private Trans-Atlantic
- Trans-Atlantic 6-9

To Asia and the Pacific Islands
- Mainland 4
- Transpac 3, 4

To Bermuda and the Caribbean
- Caribbean-Atlantic

13.5 NASA Field Centers and Facilities

13.5.1 Review of Nascom Communications System Arrangements

13.5.1.1 Background Information

For reasons of economy, work-load, and responsiveness to project requirements, the Director, GSFC, may request the cognizant field installation to implement the required operational long-line communications facilities and services. There are major elements of NASA operational communications systems that are managed by other NASA field activities under such delegation of authority. Individual operational communications support arrangements are described for the following NASA Field Centers in the order indicated:

- a. JSC.
- b. KSC.
- c. MSFC.
- d. Langley Research Center (LaRC).
- e. Ames Research Center (ARC) and the Naval Auxiliary Landing Field at Crows Landing.
- f. Lewis Research Center (LeRC).
- g. DFRF.
- h. JPL and the DSS station at Goldstone, CA.

13.5.1.2 Common Nascom Support

Nascom-2000 transmission services, described in Section 5, are provided to each of the NASA field centers. Additional services may be obtained by following the provisions of NMI 2510.1().

13.5.2 Johnson Space Center

13.5.2.1 JSC Responsibility

JSC is located at Clear Lake near Houston, TX. Communications technical control facilities and DTE in the MCC and communications within JSC are under JSC responsibility, and as such are funded and arranged for by JSC.

13.5.2.2 Nascom Support Arrangements

All long-haul operational communications circuits terminating in the MCC and associated DCE are provided by GSFC as part of the Nascom Network. All operational long-haul circuits requiring termination in JSC are documented in the UDS. Approved and validated requirements are funded by Nascom through the OSC, and implemented by Nascom either through Nascom-2000 services or by lease from the common carriers. Engineering interface

coordination is accomplished between the Systems Development Division and Nascom. Operational maintenance coordination with the common carriers is accomplished in accordance with NASCOP and managed by GSFC.

13.5.2.3 Mission Control Center (MCC)

The MCC is located in the Mission Operations Wing (MOW) of JSC, Building 30, and provides centralized control of NASA manned space missions from launch through recovery. The MCC consists of three basic systems: Communications Interface System (CIS), Data Computation Complex (DCC), and Display and Control Systems (DCS). These systems are designed to provide the Flight Operations Team (FOT) with the necessary real-time data and associated reference data for quick assessment of mission progress and rapid decisions in the event of abnormal or emergency situations. The following paragraphs describe the systems and facilities of the previously listed areas, currently implemented for the STS.

- a. **Communications Interface System.** The CIS provides voice and data communications within the MCC and between the MCC and external circuits. The functions allocated to the CIS subsystems are described as follows:
 1. **The Communications Circuit Technical Control Facility (CCTCF).** The CCTCF provides terminations and configuration for all external voice, data, and TTY circuits entering and leaving the MCC, and termination/configuration for all MCC systems requiring access to these external circuits. It has the capability to interface and reconfigure the circuits and provide measurement of circuit performance.
 2. **The Network Interface Processor (NIP).** The NIP provides processing of incoming network data to the extent of determining data validity and quality; extracting tracking data, site-originated data (command history, site status, etc.), and telemetry data; and preprocessing individual vehicle data for transmission to the Shuttle Data Processing Complex (SDPC) and the Analog Event Distribution (AED) subsystem.
 3. **The Network Output Multiplexer (NOM).** NOM provides the output function for transmission of SDPC data, including spacecraft commands, and digital voice data to the network. SDPC data is output in block format when transmitted to the GN. Digital voice and SDPC data interleaving is accomplished when output to TDRSS. Interleaving is not performed for network management commands that are output to GN.
 4. **The Dump Data Handling Subsystem (DDHS).** DDHS provides reverse-to-forward and rate correction for dump operational downlink data and temporary storage of dump and real-time operational downlink data for quick access playbacks.
 5. **The Air/Ground Voice Subsystem (AGVS).** AGVS provides air-ground communications with the Orbiter – both analog or digital through GN, and digital through SN.
 6. **Digital Voice Intercom System (DVIS).** DVIS provides voice communications among MCC operational positions, and between these operating positions and

other external ground support locations. It also provides Public Affairs (PA) coverage in the MCC.

7. **Consolidated Communications Recording Facility (CCRF).** The CCRF provides historical recording of all data and selected voice communications entering or leaving MCC.
- b. **Data Computation Complex.** The DCC provides computational, peripheral, and switching capability supporting the requirements of the Shuttle program. The DCC is a distributed processing complex consisting of the following elements:
 1. **Multibus Interface (MBI).** MBI provides a common data bus, enabling multiple paths to be established dynamically on a demand basis among the SDPC, Telemetry Preprocessing Computer (TPC), Network Communications Interface Common (NCIC), and NOM.
 2. **Shuttle Data Processing Complex (SDPC).** SDPC provides the processing of command, trajectory, and telemetry functions.
 3. **Configuration and Switching Equipment (CSE).** The CSE provides interface equipment necessary to configure the DCC computer systems with communications, display and control systems, and select over for Mission Operations Computer/Dynamic Standby Computer (MOC/DSC) systems.
- c. **Display and Control System.** In conjunction with the DCC and CIS, the Display and Control System (DCS) provides mission and support personnel the capability to request and monitor computer data in several media. In this capacity the system can detect, encode, and transmit operator requests in the form of either display requests, configuration control messages, command requests, or data management information to the DCC. In response to functional requests, the DCC provides information in the proper media format to the DSC for use by such devices as Strip Chart Recorders (SCR), TV monitors, group displays, and event monitors, or sends the information to its proper destination (i.e., network or other JSC facilities). Other related DCS capabilities include providing the MCC with timing standards, hardcopy information in several media, switching and routing of display information, and conversion and taping of video information.
 1. **Digital Television Subsystem (DTS).** The DTS converts Shuttle computer data into video displays selectable by the user.
 2. **Television and Video Switching Subsystem (TVSS).** The TVSS provides video switching and synch for distribution to 3200 console monitors and group displays.
 3. **Command History Printer (CHP) Subsystem.** The CHP provides selectable hard copies of messages routed to the SDPC from the DSCIM, CCIM, and Digital Display Driver/Subchannel Data Distributor (DDD/SDD).
 4. **Group Display Subsystem (GDS).** The GDS provides large screen displays suitable for group viewing.

5. Discrete Display Subsystem (DDS). The DDS displays event data from Orbiter data and DCC computer-generated data for 250–300 lamp driver events per console.
6. Analog Event Distributor Subsystem (AED). The AED receives analog and bilevel event data from the NIP and distributes this data to SCRs.
7. Console Subsystem (CONS). The CONS provides the physical housing for the display and control devices required for operator interface with the DCC.
8. Timing Subsystem (TS). The TS provides the master timing source for all Orbital Flight Test Data System (OFTDS) subsystems
9. Display Select Computer Input Multiplexer (DSCIM). The DSCIM allows access to display-related information from the DCC computers as a result of a user console request.
10. Command Computer Input Multiplexer (CCIM). The CCIM accepts input data (pushbutton switch closures) from the CONS and converts this into binary codes for transfer to the SDPC command processor.
11. Computer Output Microfilm (COM). The COM provides offline generation of high-resolution film images of alphanumeric and graphic information for both mission-related and Earth resources data.
12. Pneumatic Tube Subsystem (PTS). The PTS provides hardcopy message transportation of video hardcopy to flight control from the various message centers located in Building 30, MOW.

13.5.3 Kennedy Space Center

13.5.3.1 KSC Responsibility

KSC on Merritt Island, FL, retains responsibility for providing operational intrasite communications facilities (which are funded by KSC), for all NASA facilities located at either KSC or CCAS. KSC communications consist of a variety of local networks and switching systems linking the KSC/CCAS area to other centers by means of the Nascom Network provided by GSFC. KSC communications facilities include local wideband carrier systems (4.5 MHz) and local voiceband Digital Operations Intercommunications System (DOIS) wideband and fiber-optic circuits. The Communications Distribution and Switching Center (CD&SC), located on KSC, is the hub of all communications circuits on KSC including wire pairs and optic fibers provided for the MIL/STDN and MIL/71/DSN sites. The CD&SC interconnects with the adjacent Southern Bell toll office, the "XY" Building at CCAS, and the GEAM Earth station. All KSC intrasite cabling and transmission systems are government owned. Other operational communications facilities at KSC include launch complex television, intercom, and mobile radio that are government owned.

13.5.3.2 Nascom Support Arrangement

Off-site circuits are all leased and provided by one of the Office of Space Communications networks. For operations support, Nascom-2000 services are used; where Nascom-2000

capabilities are exceeded, a competitively negotiated lease is obtained from one of the communications common carriers. For administrative and logistics support, services of the PSCN are provided.

13.5.4 Marshall Space Flight Center

13.5.4.1 MSFC Responsibility

MSFC is located at Redstone Arsenal, AL, an Army installation near Huntsville, AL. MSFC administrative and program support communications consist of a variety of networks and switching systems linking its facilities with NASA Headquarters, other NASA centers, the Slidell computer complex, and with various MSFC contractors on a nationwide basis for NASA administrative support of ongoing programs. The MSFC, Huntsville Operations Support Center (HOSC), located in Building 4663, is also used to terminate and operate both administrative and Nascom circuits.

13.5.4.2 Nascom Support Arrangement

Long-haul operational communications circuits required between the HOSC and other locations for prelaunch, launch, and flight phase support of all missions are provided through Nascom via existing landline and domestic satellite facilities. Nascom has established a Point-of-Presence facility in Building 4207, Room 107. Here, Nascom circuits (and selected systems) are interfaced by Nascom to the commercial carrier facilities on the one side and to the appropriate local Marshall signal distribution and/or switching function on the other side. See Section 3 for further details of this arrangement.

13.5.5 Langley Research Center

13.5.5.1 LaRC Responsibility

The Langley Research Center (LaRC) is located at Hampton, VA. Local communications facilities are under LaRC responsibility and as such, are funded by LaRC. The existing Nascom Network satisfies the communications needs for LaRC flight projects. Voice circuits are required between the Scout Project Office and Scout launch sites from the VAFB, WFF, and the Italian San Marco Range off the coast of Equatorial Africa.

13.5.5.2 Nascom Support Arrangement

External circuits connecting LaRC to the GSFC Nascom Switching Center are provided by Nascom-2000 services.

13.5.6 Ames Research Center

13.5.6.1 ARC Responsibility

The Ames Research Center (ARC) at Moffett Field, CA, has program responsibilities for the Pioneer, Tilt Rotor, and ARC Earth Resources Aircraft Projects. ARC is also involved in other projects such as Spacelab Life Sciences and Galileo. Local facilities include a multimis-

sion control facility for the Pioneer and Galileo projects and a satellite communications facility containing a technical control facility through which all network circuits are routed. TTY traffic and facsimile services are handled by the Ames Communication Center, with R/O units located in the Ames Stripchart Recorder (ASCR) and multimission control facility. The satellite communication facility provides all circuit patching and monitoring functions on the Nascom lines terminating at ARC.

13.5.6.2 Nascom Support Arrangement

OSC communication services are provided by both Nascom and PSCN. Nascom-2000 services interface ARC with the WCSC at JPL and with the Nascom switching center at GSFC. Additional Nascom services, e.g., video and SMDS, are also supplied.

13.5.7 Lewis Research Center

The Lewis Research Center (LeRC) is located at Cleveland, OH. Launch base communications and on-orbit data requirements for the Nascom Network are stated in respective MRR/DMR documentation and provided as part of the existing network. The funding and provisioning of longlines and ancillary equipment for voice and data circuits between LeRC and GSFC are Nascom responsibilities. The funding and furnishing of local communications and equipment at LeRC are LeRC responsibilities. Nascom-2000 services interface LeRC with the Nascom switching center at GSFC.

13.5.8 Dryden Flight Research Facility

13.5.8.1 DFRF Responsibility

Items a through d summarize DFRF responsibility in managing DFRF NASA field activities.

- a. DFRF located at Edwards Air Force Base (EAFB), CA, provides its own operational communications, tracking, and control facilities. These are under the technical management and administration of DFRF, including OSC budgetary provision.
- b. The DFRF operates and maintains a tracking and data acquisition range for the purpose of supporting manned or remotely piloted aerodynamic flight test programs such as the X-29, HiMat, Tilt Rotor, and various other research flight projects. The sites are located at Edwards for the purpose of acquisition, processing, display, or transfer of radar data, telemetry data, and audio/visual communications.
- c. Telephone communications are provided through Pacific Bell [dial services within the DFRF perimeter, commercial services, and Federal Telecommunications System (FTS) circuits] and through tie-lines between the Air Force base and DFRF equipment rooms. DFRF also provides the majority of required analog and video cabling between Building 4800 and DFRF.
- d. DFRF will continue to support Shuttle landings at EAFB. The S-band facility at DFRF has been upgraded to support Shuttle uplink during the landing phase through rollout and postlanding operations.

13.5.8.2 Nascom Support Arrangement

Nascom-2000 services for DFRF include T-1 spans to GSFC's Nascom switching center, ARC, JSC, and LaRC. Other Nascom services include shuttle video (both up and downlinks),

some high-speed services to the WCSC and Goldstone, and a low data rate circuit to the WCSC for shuttle support.

13.5.9 Jet Propulsion Laboratory to Goldstone Circuits

13.5.9.1 JPL Responsibility

DSN tracking circuits are interconnected to the GCF-10 Area Communications Center located adjacent to DSS-12, Goldstone, CA. The primary communications between the GCF-10 Communications Center and the GCF-20 Communications Center at JPL are two T-1 Nascom services. Of these, one is a Nascom-2000 NSAP service and the other is a Nascom-2000 Alternate Network Connectivity service. In addition, there are miscellaneous AVD circuits between JPL's Central Voice Terminal and GDS's Station Voice Terminal.

13.5.9.2 Nascom Support Arrangement

External circuits connecting JPL to the Nascom switching center at GSFC are provided by Nascom. There are no direct Nascom GSFC interfaces with GDS.

Section 14. Nascom Support for NASA Networks

14.1 General

14.1.1 NASA Network Definition

For the purpose of this document, a NASA network is a generic term referring to a communications network established by any of the NASA field centers under the auspices of NASA HQ, OSC, Code O, for the purpose of accomplishing the goals of NASA missions or programs. The Nascom Network, as well as the PSCN, is a NASA Network. In the context of this section, the NASA Network is quasi-defined, referring to the spacecraft tracking and data acquisition communication networks and their users. Networks supported by Nascom systems include DSN, STDN and any unique configuration of elements for these NASA networks. For major users, a unique configuration (e.g., Shuttle) may be referred to as a support network.

14.1.2 Extent of Nascom Support

14.1.2.1 Traditional Support Arrangement

Nascom provides a wide range of support services for the NASA networks. Traditional Nascom services include systems engineering, equipment and leased procurement, logistics support, facility installations, technical control services, and administrative services. Nascom systems such as LSN, HSDS, Voice System, WBDS, HRDS, BDS, etc., are used by NASA networks as operating components. Specific support provided by Nascom for a given network is described in its respective section.

14.1.2.2 Special Support Arrangement

In addition to traditional support services for NASA networks, Nascom has special communications support arrangements for the Space Shuttle Program that include facilities of other cooperating agency systems such as those under the DoD and NOAA. With the advent of Space Station Program Phase I, Nascom services to Russia have been established. For later phases, Russian space-ground communication sites may be located in the United States and require Nascom interfaces. The NOCS (refer to Section 9) project has now provided multiplexed data links to ESA sites where the Nascom data links terminate in ESA multiplexers. These same ESA multiplexers also support ESA's OPSNET providing a capability for each network to provide direct support to each other; e.g., as in the alternate routing of circuits by the simple expedient of entering some keystrokes at the network management terminals.

14.2 Deep Space Network

14.2.1 DSN System Description

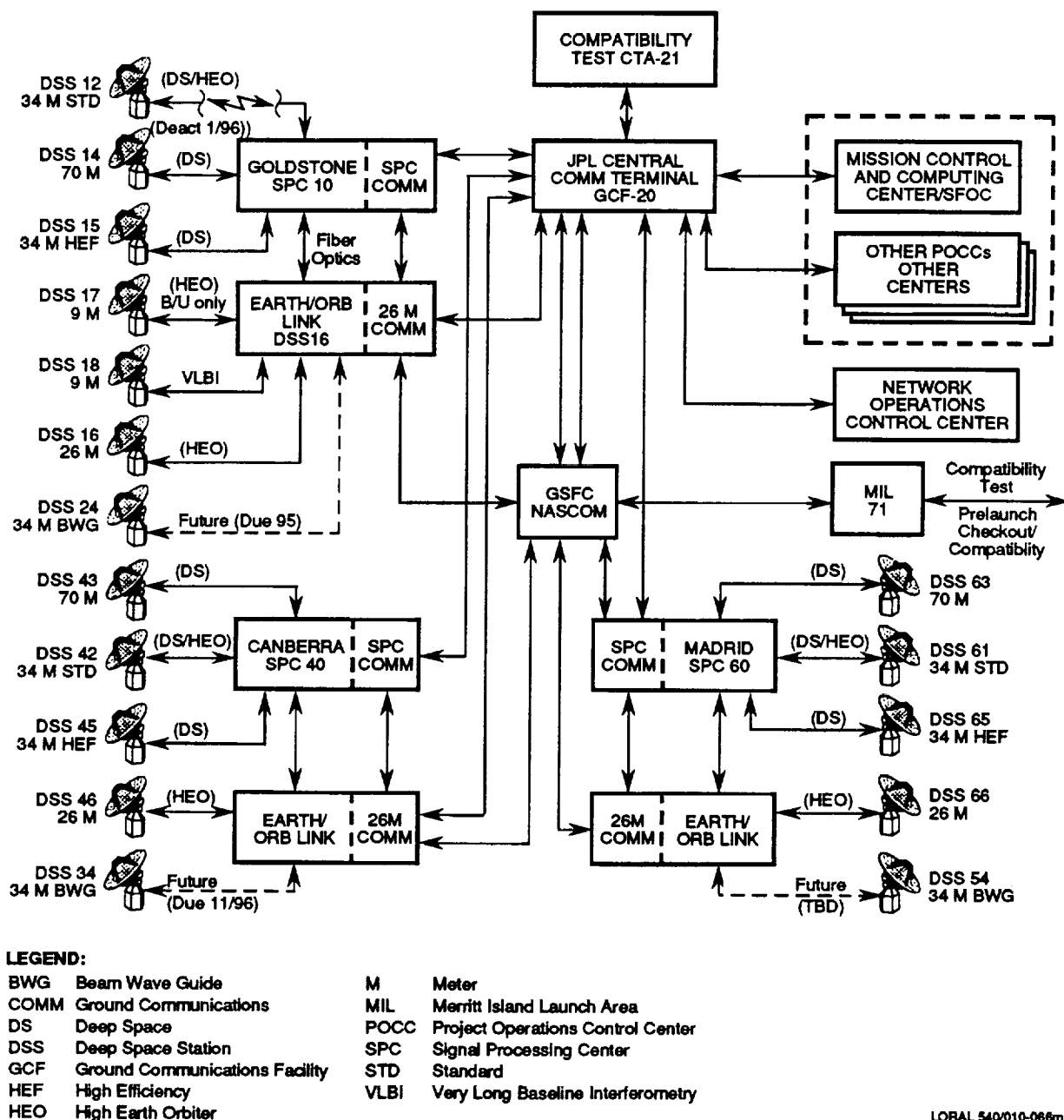
DSN is under the system management and technical direction of JPL. JPL is staffed and managed by the California Institute of Technology under operating and facilities contracts

with NASA's Office of Space Communications. JPL has the primary responsibility for unmanned planetary projects. The DSN is designed for two-way communications with unmanned spacecraft traveling approximately 16,000 km (10,000 miles) from Earth to—and beyond the outermost planets. The configuration of the DSN is illustrated in Figure 14-1. The DSN tracks, controls, and acquires data from various interplanetary spacecraft and is composed of three elements: the Deep Space Communications Complexes (DSCC), Network Operations Control Center (NOCC), and the Ground Communications Facility (GCF). The DSN is a separate, autonomous network supporting deep space interplanetary missions such as Pioneer, Voyager, etc. The 26-meter stations support high-Earth orbiters and non-TDRSS compatible Earth-orbital missions. The DSN also supports joint international planetary and Earth orbital missions primarily in cooperation with European and Japanese networks. Elements of the DSN are described in the following paragraphs.

14.2.1.1 Deep Space Network Stations

The DSN station element is composed of the Deep Space Communications Complexes (DSCC), the Compatibility Test Area (CTA)-21 at JPL, and the launch compatibility test station (MIL-71) at the MIL STDN station, KSC. Table 14-1 is a listing and facility description of the DSN stations. The following items (a through c) describe the components of the DSN station element.

- a. **Deep Space Communications Complexes.** The DSN includes worldwide subnetworks of DSSs with large antennas (9-, 26-, 34-, and 70-meter diameter); low-noise, phase-locked receiving systems; and high-power transmitters. These subnetworks provide radio communications with spacecraft traveling to the planets and beyond, and high elliptical orbiters. The DSCCs are grouped into complexes located at Goldstone, CA; Canberra (Tidbinbilla), Australia; and Madrid (Robledo), Spain. The DSN has been developed to simultaneously support multiple complex missions, hence the development of the 34- and 70-meter subnets. The deep space phase begins with the acquisition of the spacecraft and radio signal by one of the deep space stations. Two-way radio telecommunications between the DSN and the spacecraft are then established. This is followed by continuous DSCC tracking, providing two-way radio communications between the spacecraft and ground to the mission's end. To enable continuous radio contact with spacecraft, the DSCCs are located approximately 120 degrees apart in longitude; thus, a spacecraft on deep space flight is always within the field of view of at least one DSCC, and for several hours each day will be seen by two DSCCs. Furthermore, since spacecraft on deep space missions travel in the ecliptic plane, the DSCCs are located within latitudes of 45 degrees north or south of the equator. All DSCCs operate at S-band frequencies: 2110-2120 MHz for Earth-to-spacecraft transmission and 2290-2300 MHz for spacecraft-to-Earth transmission. All DSCCs are equipped with X-band downlink capability.
- b. **Compatibility Test Area.** CTA-21 at JPL has all the essential characteristics of the standard deep space stations adaptable to a 34- or 70-meter configuration except that CTA-21 has no tracking antenna. CTA-21 is used during spacecraft system tests to establish compatibility with the DSN of the proof test model and development



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Figure 14-1. JPL/DSN Configuration

models. CTA-21 has real-time data interfaces with the GCF-20 communications center via voice and data communications. CTA-21 is also used by mission operations for DSN ground data system compatibility testing and training. Also available for use in ground data system compatibility testing is the Goddard Compatibility Test Van.

- c. Merritt Island Station. The DSN facility at STDN MIL is identified as MIL-71. This station provides selected spacecraft telemetry and command capability during certain preflight testing at KSC. In addition, the facility is used for DSN compatibility testing with the spacecraft to be supported by the DSN.

Table 14-1. DSN Station List

| Location | Identification/DSS | Antenna Diameters (meters) | Remarks |
|-----------------------------|--------------------|----------------------------|-----------------------------------|
| Goldstone, CA (GDSCC) | GCF-10 | -- | Area Comm Center |
| | SPC-10 | -- | Signal Processing Center |
| | DSS-12 | 34 | |
| | DSS-13 | 34 | R&D Station |
| | DSS-14 | 70 | |
| | DSS-15 | 34 | |
| | DSS-16 | 26 | |
| | DSS-17 | 9 | |
| | DSS-24 | 34 | Future BWG |
| Canberra, Australia (CDSCC) | SPC-40 | -- | Processing Center |
| | DSS-42 | 34 | |
| | DSS-43 | 70 | |
| | DSS-45 | 34 | |
| | DSS-46 | 26 | |
| | DSS-34 | 34 | Future BWG |
| Madrid, Spain (MDSCC) | SPC-60 | -- | Processing Center |
| | DSS-61 | 34 | |
| | DSS-63 | 70 | |
| | DSS-65 | 34 | |
| | DSS-66 | 26 | |
| | DSS-54 | 34 | Future BWG |
| Merritt Island, FL | MIL-71 | 9 | Prelaunch Station |
| Pasadena, CA | NOCC | -- | Network Operations Control Center |
| | GCF-20 | -- | |
| | CTA-21 | -- | |

14.2.1.2 Network Operations Control Center

The NOCC provides centralized operational and configuration control of the DSN and monitors and analyzes DSN real-time performance. The NOCC interfaces operationally with various deep space projects and their respective mission control and computing centers at JPL and Remote Mission Operations Centers (RMOC) located elsewhere. The Network Operations Control Area (NOCA), Network Data Processing Area (NDPA) and GCF-20 of the NOCC are located in Building 230. The NOCC computers are not in series with the flow of data between the DSS and the JPL Mission Control and Computing Center (MCCC)/RMOC, but rather the NOCC accepts a parallel feed of the DSS data. The NOCC electrical interface is with the GCF-20 Central Communications Terminal (CCT).

14.2.1.3 Ground Communications Facility

The following paragraphs describe the GCF.

- a. **GCF Capability.** The GCF of the DSN provides ground communications capabilities necessary for support of spaceflight operations. The GCF consists of long-haul leased circuits; terminal equipments; switching facilities; and personnel required for the ground transmission, reception of data, recording, and control signals between the DSCCs, the NOCC, and the project mission control and data analysis locations (POCCs/RMOCs).
- b. **GCF Design and Engineering.** The GCF is designed and engineered to function as a multimission entity and is configured and operated to meet DSN and mission-dependent requirements. The DSN arranges with Nascom to provide all operational long-haul circuits and associated switching and data transmission facilities (refer to paragraph 14.2.5). The GCF is controlled by the GCF-20 CCT, a portion of which is allocated to, and functions as, the Nascom West Coast Switching Center (WCSC). The CCT is located at JPL in Building 230 and includes communications terminal equipment, technical control, patch, test, switching, and monitoring capabilities.
- c. **Digital Communications Subsystem.** This system in the JPL/GCF performs internal routing of data blocks in the CCT at JPL via the Error Correction and Switching (ECS) computer and/or the CCP/EUG computers.

14.2.2 JPL Flight Project Support Office/MCCC Interface

Using the MCCC at JPL, project personnel command and control spacecraft in deep space and receive telemetry and radio metric data via the DSN GCF. The facilities of the MCCC are organizationally under the Flight Project Support Office (FPSO). Data flow interfaces also exist between MCCC and the TDRSS at White Sands, as well as between JSC and MCCC. TDRSS and STS interfaces will nominally be via the Nascom WCSC at JPL. JPL also provides management and support (tracking and data acquisition) for non-DSN space flight projects. This support is accomplished by the DSN 26-meter station or the TDRSS. The CCT accommodates both the DSN interface (GCF-20) and the Nascom WCSC interface to the MCCC, RMOCs, and RICs - as well as the WCSC interface with the WR launch facilities at VAFB.

14.2.3 Missions Supported on the DSN/GCF

The DSN currently supports tracking and data acquisition operations related to Earth orbiting and deep space satellites. Table 14-2, Emergency Support Mission Set, Table 14-3, Deep Space Missions, and Table 14-4, Near-Earth Mission Set summarize DSN support to these spacecraft. Task RTOP-60, Very Long Baseline Interferometry (VLBI) is also being supported. The DSN/GCF and its Nascom-furnished ground communications facility elements, described later in this document, have an ongoing support requirement for these missions. Future DSN mission support commitments and requirements are summarized in Table 15-8.

Table 14-2. Emergency Support for SN

| Spacecraft | Command Rate (kb/s) | Telemetry Rate (kb/s) |
|------------------------|---------------------|------------------------------|
| Landsat-4 and 5 | .125 | 1.0 Real-time, 24.0 Playback |
| Shuttle | 32 or 72 | 96, 192, 1024 |
| TDRS-1, 3, 4, 5, and 6 | .125 | 2.0 |
| ERBS | 1.0 | 1, 1.6, 12.8, 32, 128 |
| HST | 1.0 | .5, 4, 32, 1024 |
| GRO | .125 or 1.0 | 1, 32 |
| UARS | .125 or 1.0 | 1, 32, 512 |
| EUVE | 2.0 | 1, 32, 256, 512, 1024 |
| TOPEX/Poseidon | 2.0 | 16, 512, 768, 1024 |

Table 14-3. Deep Space Missions

| Spacecraft | Command Rate | Telemetry Rate |
|---------------------------------------|--------------|--------------------------|
| International Cometary Explorer (ICE) | 256 b/s | 16, 32, 64, 128, 256 b/s |
| Pioneer 6, 7, 8 | 1b/s | 8, 16, 64, 256, 512 b/s |
| Pioneer 10, 11 | 1b/s | 16 to 1024 b/s |
| Voyager 1, 2 | 16 b/s | 40 b/s to 7.2 kb/s |
| Galileo | 32 b/s | 10 b/s to 134.4 kb/s |
| Ulysses | 15.6 b/s | 64 b/s to 8.1 kb/s |

Table 14-4. Non-TDRS Compatible Near-Earth Missions

| Spacecraft | Command Rate (kb/s) | Telemetry Rate (kb/s) |
|---|---------------------|---|
| Advance Satellite for Cosmology & Astrophysics (ASCA) | N/A | 1.024, 4.096, 32.768 Real-time, 262.144 Playback |
| GEOTAIL | N/A | 16.4 or 65.5 Real-time, 65.5 or 131 Playback |
| SAMPEX | 2.0 | 4, 16, 900 |
| Solar-A | N/A | 1.024, 4.096, 32.768 Real-time, 131.072, 262.144 Playback |

14.2.4 Deep Space Mission Low Rate Digital Television Coverage

During the periods of encounter, landing, and on-surface activities, images are transmitted digitally on a real-time or delayed basis from the planetary spacecraft to the DSCCs. It is anticipated that during these periods, as was done for the Viking and Voyager-Jupiter/Saturn and other missions, Nascom will provide slow-scan TV channels (9.6 kb/s) from JPL to NASA HQ, GSFC, and the cognizant research center for relay and distribution of processed image material to meet the high interest in events at that time. Requirements will be established for TV coverage of these phases during Mission encounters.

14.2.5 Nascom Support for DSN

Nascom supports the DSN by providing dedicated circuits from each DSCC to the JPL GCF. In addition to the Nascom support services described in paragraph 14.1.2, other Nascom-provided support services are described in the following subparagraphs.

14.2.5.1 Support for DSSs

DSCCs at Canberra, Australia, and Madrid, Spain, have real-time data interfaces with the Nascom Network and are connected with JPL's GCF-20 CCT via voice, TTY, and data communications circuits. These circuits are now transported via NOCS 1.544 Mb/s multiplexed data link circuits between the offshore DSCCs and JPL. Additionally, a separate 64 kb/s multiplexed data circuit provides an alternate route for critical circuitry in the event of a failure along the primary path. The Goldstone GCF-10 communications center has TTY, voice, high-speed data, and wideband ties with GCF-20 via one GEAM 1.544 Mb/s T-1, one Nascom-2000 (NSAP) T-1, and one backup alternate voice/data circuit via Continental Telephone of California Company (CTCC) and PT&T facilities. From the GCF-10 communications center, the circuits are switched to the DSSs.

14.2.5.2 DSN Circuit-switched Network

All Nascom-provided data circuits used to support the DSN are circuit switched. Wideband and high-speed data channels are switched at the WCSC and GSFC technical control by patch panel facilities. JPL schedules Nascom circuitry directly with Nascom on a weekly basis. There are limited message-switching requirements for DSN data routed through GSFC technical control. The central communications terminal operated by the DSN/GCF at JPL extends and distributes channels locally at JPL. The wideband data circuits are configured as shown in Figures 9-8 (GSFC-JPL), 9-12 (CDSCC-JPL), and 9-13 (MDSCC-JPL).

14.2.5.3 Nascom Monitoring Support

The data monitoring support provided by Nascom to DSN on GSFC routed data circuits is described in the following paragraphs.

- a. **DSN Standard Transmission Format.** The DSN/GCF uses a standard 1200 or 4800-bit block format similar to the standard Nascom block on its data circuits, with the same sync code and 22-bit polynomial trailer.
- b. **DSN Encoder/Decoder.** The DSN/GCF supplied encoder functions with 1200-, 2400-, or 4800-bit block sizes, and 22- or 33-bit polynomial codes. The equipment

performs online encoding and decoding for the users. Nascom switching center and technical control at GSFC is equipped to selectively monitor and test both types of data streams. When used as monitors, the Nascom BEDs do not modify the user's data blocks. Nascom can monitor the 22-bit polynomials with a modified 547-548 error detection encoder and the GSFC Performance Monitoring System (PMS). The DSN/GCF monitors all high-speed and wideband circuit performance via the GCF Monitor and Control Assembly at the JPL/CCT. The nomenclature used by the DSN/GCF for this equipment is Network Encoder/Decoder (NED).

14.2.5.4 MIL-71 Interface

MIL-71 has real-time data interfaces with the Nascom Network and is connected with the GCF-20 communications center via voice, TTY, and data. Temporary Nascom circuits are brought up when needed between GSFC and the MIL station for MIL-71 during periods of required prelaunch and launch support of DSN-supported missions.

14.2.5.5 DSN/Nascom Requirement Interface

The DSN GCF Engineering Manager acts as the general coordinating interface for all space mission ground communications requirements at JPL. The DSN GCF Engineering Manager also acts as agent for Nascom with respect to circuit requirements for project spacecraft checkout, and ground communications requirements for supporting contractors and project Remote Information Centers (RIC) interfacing with the Nascom WCSC. The DSN operations organization coordinates project-network support requirements and has the responsibility of operating all elements of the GCF.

14.2.5.6 DSN/Nascom Circuit and Equipment Funding, and Facility Interfaces

The DSN arranges for Nascom to fund and provide all long-haul operational circuits required to support spaceflight projects except those extending between the JPL CCT and the DSCC. With the consolidation of individual voice and data circuits onto the multiplexed data link trunk circuits provided by Nascom NOCS project (refer to Section 9), the Nascom points of demarcation with each offshore DSCC, and with JPL, are at the channel access points for each type of circuit: voice and data. Normal practice is for the demarcation to be at the bulkhead connector interface panel in the bottom of the Nascom equipment rack (for digital data), and on the punchdown (or wire wrap) block in the back of the rack for analog and voice. The DSN GCF provides all communications terminal cabinet equipment for the high-speed and wideband data transmission and test equipment. The Nascom-provided equipment is operated and maintained by DSN. Any equipment provided by DSN directly interfacing Nascom channels requires the compatibility approval of Nascom. Agreements between Nascom and DSN organizations provide that Nascom will design, fabricate, and furnish complete data transmission terminal assemblies with engineering documentation. These data transmission terminals will include cabinets with internal wiring, modems, data sets, channel test equipment, jackfields, switching matrices, power supplies, and any other ancillary equipment necessary for the establishment and maintenance of data transmission service. DSN installs, modifies, or relocates the Nascom-provided terminal equipment in accordance with Nascom engineering instructions, and maintains and operates the terminals. DSN assumes custodial responsibility/property accountability for these terminals.

14.2.5.7 Circuit Requirements

The DSCC interface with the NOCC is provided in the CCT. Voice circuits and TTY message capability are required by the DSN GCF for operational coordination. Voice circuit design for the GCF permits shared use of voice circuits between the CCT and each DSCC. Separate voice circuits for each station are normally required during critical periods. Design of the GCF requires an independent full-duplex TTY capability between the CCT and each DSCC. The GCF requires full-duplex, high-speed data circuits or channels between the CCT and each DSCC for the transmission of spacecraft telemetry, command, metric, radio science, monitor and control, simulation, and other operational data. Wideband data capability at each DSCC is needed to satisfy project requirements for transmission of high-rate science and engineering data to the CCT. Nascom arranges for discrete data, voice, and TTY circuits connecting project-associated RICs and RMOCs with GCF-20 or WCSC. Funding for these circuits is normally project provided. Multiple-mission support circuit requirements are normally provided in the Nascom Network. The total number of channels that must be connected through GCF-20 and WCSC depends on the type of operation and number of missions in progress at the time. Circuits to project locations (RICs and RMOCs) also interface from the CCT or WCSC. DSN circuit requirements from DSCCs to the CCT are included in the DSN forecast of requirements submitted biannually by JPL.

14.2.5.8 Circuit Implementation

Except for the CCT to GCF-10 circuits, the circuits used by the DSN GCF are supplied by Nascom. Nascom also specifies circuit routing. Circuits between the CCT and overseas DSCCs are routed through the appropriate remote Nascom switching center and NIFs. Now that NOCS provides the transport service between JPL and the offshore DSCCs, the basic configuration between JPL and each DSCC is a 1.544 Mb/s data link and a diversely routed 64 kb/s "little pipe" multiplexed data circuit. As new mission requirements occur, the channel configuration of the 1.544 Mb/s data link multiplexer may be changed to accommodate those requirements.

14.2.5.9 Control of the Circuits

GSFC has responsibility for the technical control of the Nascom circuits used by DSN. JPL has responsibility for mission control of the circuits. In fulfillment of the responsibility for technical control, GSFC informs JPL of the availability and condition of diversely routed circuits during periods when circuits in use are marginal, but will not perform the actual switching without prior concurrence of JPL. In such cases of marginal circuit operations, the DSN will do inhouse checking first, and then report the condition to Nascom. GSFC takes immediate action to provide make-good circuits when it is evident that complete communications failure has occurred and circuits for restoration are available. GSFC then notifies JPL Communications Control after circuit restoration. JPL has responsibility for control of all circuits between GCF-20 and the DSCCs and for all circuits between the WCSC and west coast users.

14.2.5.10 Communications Circuit Performance

The DSN GCF performs end-to-end circuit measurements of data performance on high-speed data and wideband circuits by real-time monitoring of its operational traffic and by

conducting special tests. Nascom furnishes JPL with copies of periodic reports detailing Nascom-scheduled (nonoperational) error rate performance tests on high-speed and wide-band data circuits. Both the DSN and Nascom record circuit outages of all types. Daily Communications Reports (DCR) showing outages on circuits up for the DSN GCF are sent by JPL to the Nascom Communications Services Section for use in Nascom Network availability reports and for review with the common carrier. Nascom is responsible for the daily operational technical control functions and circuit restoration actions with the common carrier on the long-haul circuits, and for overall maintenance of the service within reliability and performance criteria. JPL is responsible for performance of all circuits between GCF-20 and the Goldstone DSCC, except for Nascom-2000 service, and local WCSC users.

14.2.5.11 Terminal Equipment

At each DSCC the GCF provides the switching and distribution equipment necessary to interconnect the transmission circuits to the multiple station computers and users. A Local Area Network (LAN) allows digital time-division block multiplexing such that several DSS computers can access the same digital transmission path via the SPC Area Routing Assembly (ARA) computers. ARA/SCP data transmissions are accomplished using the Nascom/DSN 4800-bit block format and 22-bit polynomial for error detection. High-speed data, 1200-bit blocks are packed into 4800-bit blocks for ARA transmissions. The SPC ARA accommodates these functions. The GCF-20 CCT at JPL is the hub of the GCF. It provides digital data block multiplexing/demultiplexing, encoding, decoding, and error correction capability compatible with the DSS equipment. The GCF-20 CCT switches and routes data to JPL MCCC, to RMOCs such as ARC and the German Space Operations Center (GSOC), and to RICs at the experimenter locations. The interface for the NOCC is also at GCF-20.

14.3 Spaceflight Tracking and Data Network (STDN) Overview

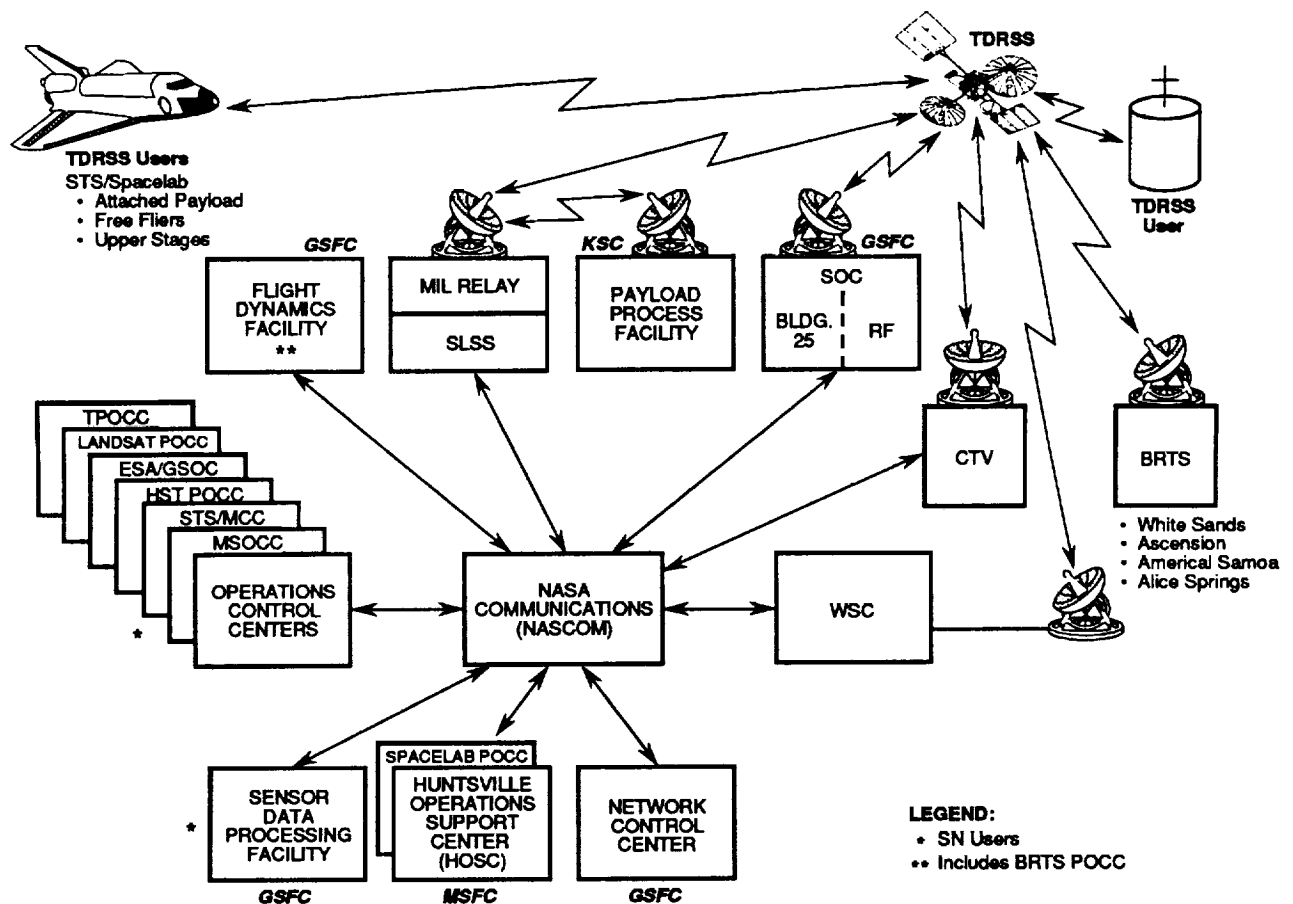
14.3.1 STDN System Description

The STDN is under the control of the GSFC NCC and consists of Space Network (SN) elements and the Ground Network (GN). The SN became operational in June 1989 when the full TDRSS configuration was established. This event signaled a new era in tracking and data relay support to NASA's Earth-orbiting satellite programs. The following paragraphs further describe the SN and GN.

14.3.1.1 Space Network

The SN is composed of the following elements (see Figure 14-2):

- a. Tracking and Data Relay Satellites: TDRS East (F4) at 41° West; TDRS (F6) at 46° West; TDRS Spare (F3) at 171° West; TDRS West (F5) at 174° West; and TDRS (F1) at 275° West.
- b. The WSC [Second TDRSS Ground Terminal (STGT) while the WSGT is being upgraded.] (TT&C and data transport interface between the spacecraft and the common carrier).



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Figure 14-2. Overview of Major (SN/TDRSS) Network Supporting Elements and Users

Closely associated with the SN in the control or support that they provide are the following:

- NCC, FDF at GSFC, and the Bilateral Ranging Transponder System (BRTS).
- A TDRSS-compatible relay facility at MIL/KSC (MIL relay).
- A TDRSS-compatible ground station at Tidbinbilla, Australia for support of GRO.
- The Radio Frequency Simulation Operations Center (RF SOC) facility at GSFC and TDRS Compatibility Test Van (CTV), a transportable facility.
- Nascom systems that provide the data transport resources or capability to link the above-mentioned elements with the ground-located users of the TDRSS.

14.3.1.2 Ground Network

The GN is made up of two GSFC managed ground stations: Merritt Island (MIL)/Ponce de Leon (PDL), and Bermuda (BDA). To supplement the resources of the GN and provide worldwide coverage, GSFC has agreements with JPL for use of DSN facilities and with DoD

for use of its T&DA sites. Within MO&DSD, the focal point for scheduling of the GN or requesting support from supporting stations is the Networks Division, Code 530. The NASA Communications Division, Code 540, and the Nascom Network, provide operational communications circuits to the GN and DSN stations and to Nascom Interface Facilities at designated DoD stations for service extension over DoD communication systems. Table 14-5 lists the Goddard GN stations, the NASA Wallops Flight Facility, and the three DSN DSCCs and summarizes their current operational configuration. The following paragraphs further describe the GN and the stations augmenting its capabilities.

Table 14-5. Non-TDRSS Tracking Stations List

| Station | Antennas | | | | | Comments |
|---|----------------|--------|------|-----------|-------|---|
| | Unified S-band | | | Multiband | VHF | |
| | 4.3 M | 9 M | 26 M | 18 M | SATAN | |
| BDA | | 2 | | | | Operates 8 Hr/Day, Mon-Fri, C-Band Radar Available |
| + CAN | | | 1 | | | Operates 160 out of 168 hours per week |
| + GDS | | * 1 | 1 | | | Operates 160 out of 168 hours per week |
| + RID | | | 1 | | | Operates one link full time |
| MIL/PDL | 1 | 2 | | | | Pad and Orbital Support; One Link 160 out of 168 hours per week. Second Link available 0800L-1600L, Mon-Fri with prior negotiated concurrence |
| WPS | | 1 | | 1 | 1 | One Link Full Time, IUE Only (18M); 2nd Link Operates 8 Hr/Day, Mon-Fri; 3rd Link, IMP-8 In-view Coverage Mon-Sun |
| Notes: | | | | | | |
| * Provide backup support for STS missions only. | | | | | | |
| + Stations under JPL management, but GSFC retains operational responsibility for TDRSS-compatible satellites. | | | | | | |

- a. The GN supports various scientific and manned missions in Earth orbit. Primary communications with spacecraft are provided via 9-meter and 26-meter S-band antenna systems. Three 26-meter sites are managed by JPL/DSN but with GSFC retaining operational responsibility for TDRS compatible satellite support. Table 14-5 also lists a T&DA Earth orbital mission support site at Wallops Island, Virginia. Though not a GSFC/Code 530 managed/controlled facility, responsibility for its operation and maintenance has been assigned to GSFC, Code 800.
- b. The GN is scheduled, configured, and controlled from the NCC at GSFC. The NCC and GN receive tracking systems analysis and acquisition data computational support from the FDF, Code 553. The GSFC MO&DSD establishes POCCs at GSFC for the various GSFC-managed and non-GSFC-managed Earth-orbital scientific satellite missions. The Mission Planning Center (MPC) of the Directorate consolidates the scheduling requirements and acts as the schedule coordinating interface with the NCC for GSFC-controlled missions. The NCC merges this with other

scheduling requirements, then schedules, controls, and coordinates the GN via Nascom voice, LSN, and data circuits.

14.4 SN System Support

14.4.1 Mission Support Transition

The Space Network provides prime support to the STS Orbiter, attached orbiter payloads (including Spacelab), and to most of the future planned NASA Earth orbital free flier missions. It is presently supporting low Earth-orbiting missions within TDRS coverage. Although Landsat and the Earth Radiation Budget Satellite (ERBS) were not designed for support by TDRSS, these missions are currently receiving prime orbital coverage from the TDRSS and contingency support from the GN. The TDRSS began limited operations in late 1983, and is now providing full-coverage operation support on a routine basis. TDRSS was declared fully operational in June 1989. The constellation currently includes five TDRS satellites, one of which is an inorbit spare satellite and another designated for closure of the TDRS ZOE for the GRO spacecraft. The MIL station with its TDRS interface continues as a launch support and payload checkout station. Payload checkout functions of the MIL station include a TDRSS-compatible relay capability, which allows the Shuttle and TDRSS-supportable payloads to communicate with their POCCs during payload preparation and the pre-launch phases at KSC. The MIL station is also capable of communicating with the Shuttle operating in the TDRSS mode during its postlaunch ascent phase. The BDA GN station continues to provide launch and range safety support functions.

14.4.2 SN Support Configuration

The TDRSS element of the SN system currently consists of four geo-stationary relay satellites, an inorbit spare, and the White Sands ground facility complex. Together, the satellites and ground complex provide a near-global, real-time, bent-pipe relay network for transmission of command, telemetry, and tracking data between low-altitude, Earth-orbiting user spacecraft and user control and data processing facilities that have coverage for at least 85 percent of the user spacecraft's orbit. Figure 14-3 illustrates the TDRSS system configuration and coverage limits. The TDRSS is further described in the following paragraphs.

14.4.2.1 TDRS Configuration

Two relay satellites which are normally located at 41 and 174 degrees west longitude, an inorbit spare satellite at 171 degrees west longitude. A stored satellite located at 46 degrees west longitude, and a ZOE closure satellite at 275° west longitude, for GRO support only, constitute the satellite system. WSC operates the TDRS spacecraft and provides a relay interface between the space element and the ground elements (i.e., the WSC's Nascom facilities, the ground-located users, and operators of the TDRSS).

14.4.2.2 Zone of Exclusion

A communication Zone of Exclusion (ZOE) straddles the equator at about 73 degrees east longitude and varies in area as the altitude of the user spacecraft varies. This geographic zone

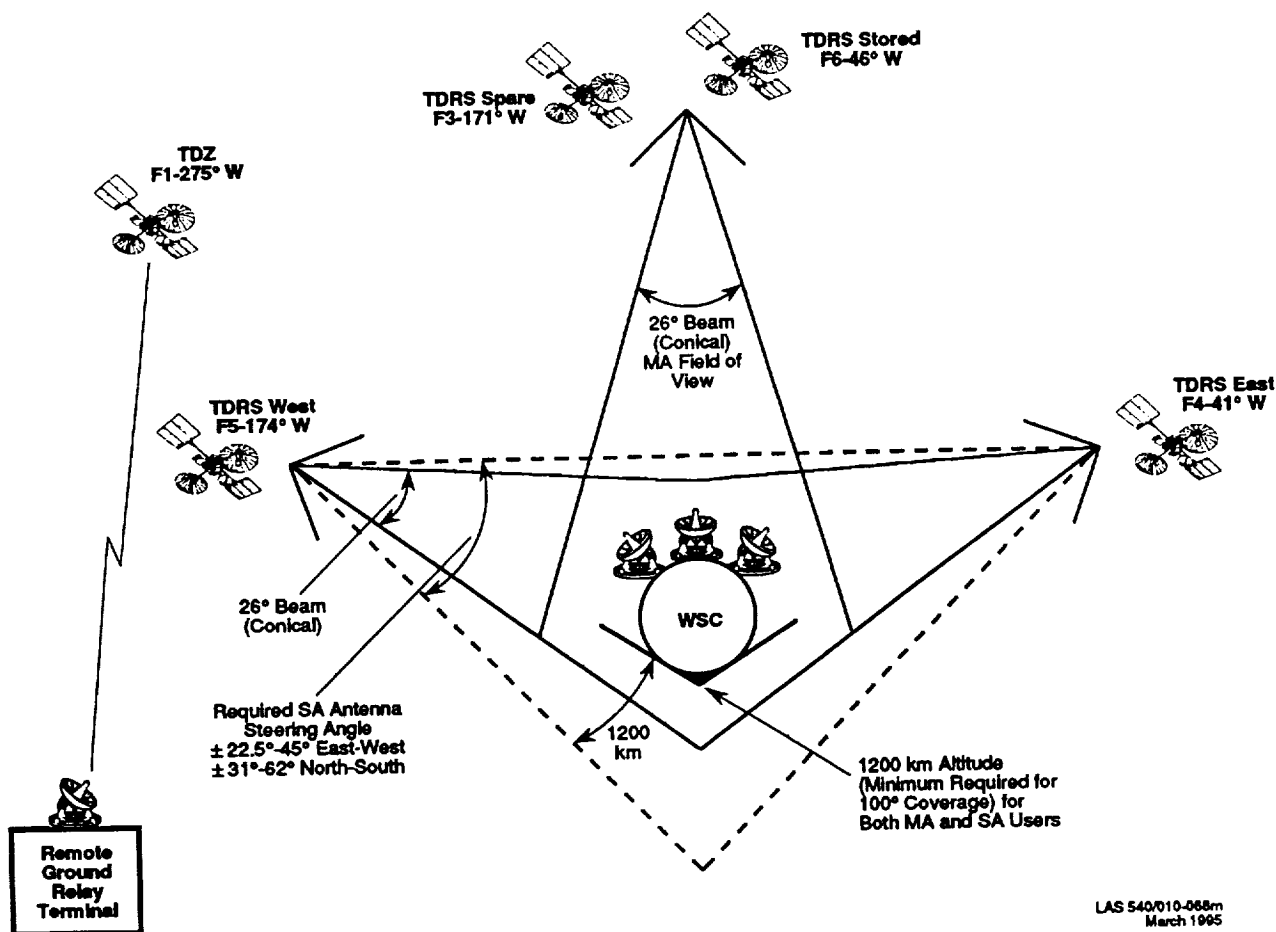


Figure 14-3. TDRSS System Configuration and Coverage Limits

limits communication coverage of low-flying orbiting spacecraft by up to 15 percent. For spacecraft orbiting at altitudes between 1200 to 10,000 kilometers coverage is virtually unrestricted. When the GRO spacecraft experienced a failure of its onboard data recorders that precluded it from storing data for transmission to the ground in high-rate bursts, a need arose to provide dedicated TDRS coverage so that data could be transmitted to the ground while in its view. TDRS F1 was moved to 275° west and a Remote Ground Relay Terminal was established at the Canberra DSN station, Australia, to manage the satellite and receive its telemetry. Ground communication links have been established with the Extended TDRS Ground Terminal (ETGT) at the WSC. The F1 satellite in its 275° west position has also been used by the Shuttle and the Hubble Space Telescope to demonstrate the TDRS ZOE closure application of a "healthy" TDRS in this orbital position. TDRS F1 function failures, over time, have reduced the satellite's operational support capability to the point that NASA is now moving the F3 satellite into position as a replacement for the F1. Disposition of the F1 is still to be determined.

14.4.2.3 GSFC Support Facilities

Scheduling, configuration control, and status monitoring of the SN is performed by the NCC at GSFC. These functions are almost completely automated, and are conducted via a data link between the NCC at GSFC and WSGT. NCC responds to the SN schedule requests and ground configuration requests from POCCs, and provides confirmed schedules and status to user POCCs and data processing facilities. A computing facility at GSFC provides orbit computation, scheduling, and acquisition aids to the NCC for the TDRS and user spacecraft. A system of TDRS bilateration ranging transponders, maintained at dispersed ground locations, is utilized by this support computer facility to define the TDRS orbits.

14.4.2.4 WSC Fault Isolation and Simulation

WSC performs interface fault isolation monitoring, interface relay and switching, and data recording and playback functions also under the scheduling control of the NCC. A simulation operations facility at GSFC and a transportable compatibility test facility provide flexible payload and POCC simulation and TDRSS-compatible communication relay capability for premission compatibility testing of user spacecraft and control centers on the SN.

14.4.2.5 Reference Documentation

For additional information concerning TDRSS, refer to STDN No. 101.2, TDRSS User's Guide. For an overall configuration guide to the SN, refer to STDN No. 117, Tracking and Data Relay Satellite System (TDRSS) Network Functional Description.

14.4.3 Nascom Extension of TDRSS Interfaces

14.4.3.1 General

The Nascom Network has extended the TDRSS forward link and return link services by providing data transport systems between the White Sands Complex, the NCC, and major user spacecraft control centers and data processing facilities. Nascom provides basic service entry points to the data transport systems at GSFC and JSC locations for all ground-located TDRSS users. The BDS data transport systems provide the users individual access interfaces for command and telemetry via digital matrix switching systems at GSFC and JSC. This allows individual users to have discrete channel interfaces with Nascom for the forward and return link services to and from the spacecraft, on a scheduled, time-shared basis. Users at locations other than these access points must coordinate with Nascom for ground communication access links. In the case of Shuttle attached payloads using the Orbiter OI/TDRSS communication relay link, the user control center, if remotely located, must communicate with their payloads via the JSC/MCC for commanding and receiving telemetry. These users may employ the services of the Nascom data transport system elements between GSFC and JSC, also used by the SN. The HDRS data transport system provides return link extension directly to high-rate science data users at GSFC, MSFC, JSC, and ARC.

14.4.3.2 Uplink and Downlink Function

The terms uplink and downlink normally refer to the data signals to and from the user spacecraft when tracked by a ground station. Uplink refers to transmitting command signals

to the spacecraft, while downlink refers to receiving telemetry signals from the spacecraft. With the advent of the TDRSS system, the TDRS relays signals in each direction. Command signals are transmitted up to the TDRS (relay satellite) and then down to the orbiting spacecraft; for the SN this end-to-end flow is referred to as the forward link. Telemetry signals are transmitted from the orbiting spacecraft up to the relay satellite and relayed down to the ground station. In the SN, this is referred to as the return link. The details of the forward and return link services are discussed in STDN No. 101.2. How Nascom extends these SN interfaces through the ground communication system is discussed in the following paragraphs.

14.4.3.3 Nascom Domsat

“Uplink and downlink” terminology has been used in previous sections with respect to the common carrier Earth stations transmission (uplink) to the Domsat, and reception (downlink) from the Domsat. This reference conveys no relation to command and telemetry nor to forward and return links.

14.4.3.4 Nascom BDS and HDRS Support

As described in Sections 5, 11, and 12, Nascom has implemented two distinct major multi-channel transport systems for ground segment extension of operational data relayed by TDRS or associated with TDRS TT&C. The characteristics of each are unique to the TDRS forward and return link service interfaces it supports, with Type 1 data (10 b/s to 2 Mb/s) transported by the BDS, and Type 1 and Type 2 data (2 Mb/s and greater) transported by the HDRS. Figures 11-2 and 12-2 illustrate the functional overview of the BDS and HDRS data transport systems, respectively. Ancillary systems and CSS automated scheduling control of these systems are described in Section 11.

14.4.3.5 Type 1 and Type 2 TDRSS Service Interfaces

Type 1 service interfaces accommodated on the BDS are all of the TDRS Multiple Access (MA), Ku-band Single Access (KSA), and S-band Single Access (SSA) services to users requiring command, housekeeping telemetry, and science data transport services with data rates in the relatively lower ranges. Type 1 and Type 2 service interfaces accommodated on the HDRS are all TDRS SSA and KSA return link services to users requiring high-rate science and image data transport services.

NOTE

Even though the WSGT/NGT wall interfaces and the DSS-1 and DSS-2 switches associated with NGT are no longer operating, retention of the terms “SN Type 1” and “SN Type 2” maintains a useful distinction; namely, to categorize by data rate that data which will be routed to the MDM (BDS) and data which will be routed to the SM (HDRS). These two types of SN interfaces are defined in the following paragraphs.

14.4.4 Categories of SN Interfaces

Nascom data transport services supporting the SN accommodate the extension of these Type 1 and Type 2 interfaces to users requiring command (forward link) and telemetry (return link)

support. The Nascom data transport systems provide forward and return services that are divided into three broad categories of transmission interfaces: (1) Type 1 data, (2) Type 2 data, and (3) video or analog data. These categories are defined in the following paragraphs.

14.4.4.1 Type 1 Interface

SN Type 1 interfaces are specified to accommodate a range from 0.1 kb/s to 12 Mb/s. The highest (user) data rate currently planned to be handled by the BDS is 2.0 Mb/s; this is a policy restraint, not a technical one.

14.4.4.2 Type 2 Interface

SN Type 2 interfaces accommodate high data rate services up to 48 Mb/s. The maximum Type 2 user spacecraft data rate for known planned users of the TDRSS at this time is 84.9 Mb/s, which will be slowed to half this rate through use of tape recorders at NGT and then played back at a rate within the capability of the Nascom HDRS (SM).

14.4.4.3 Video or Analog Data Interface

The video or analog data, 20 Hz to 4.2 MHz, is used to transport Spacelab and Shuttle video, using the HDRS transponder, from WSC to JSC, MSFC, and GSFC.

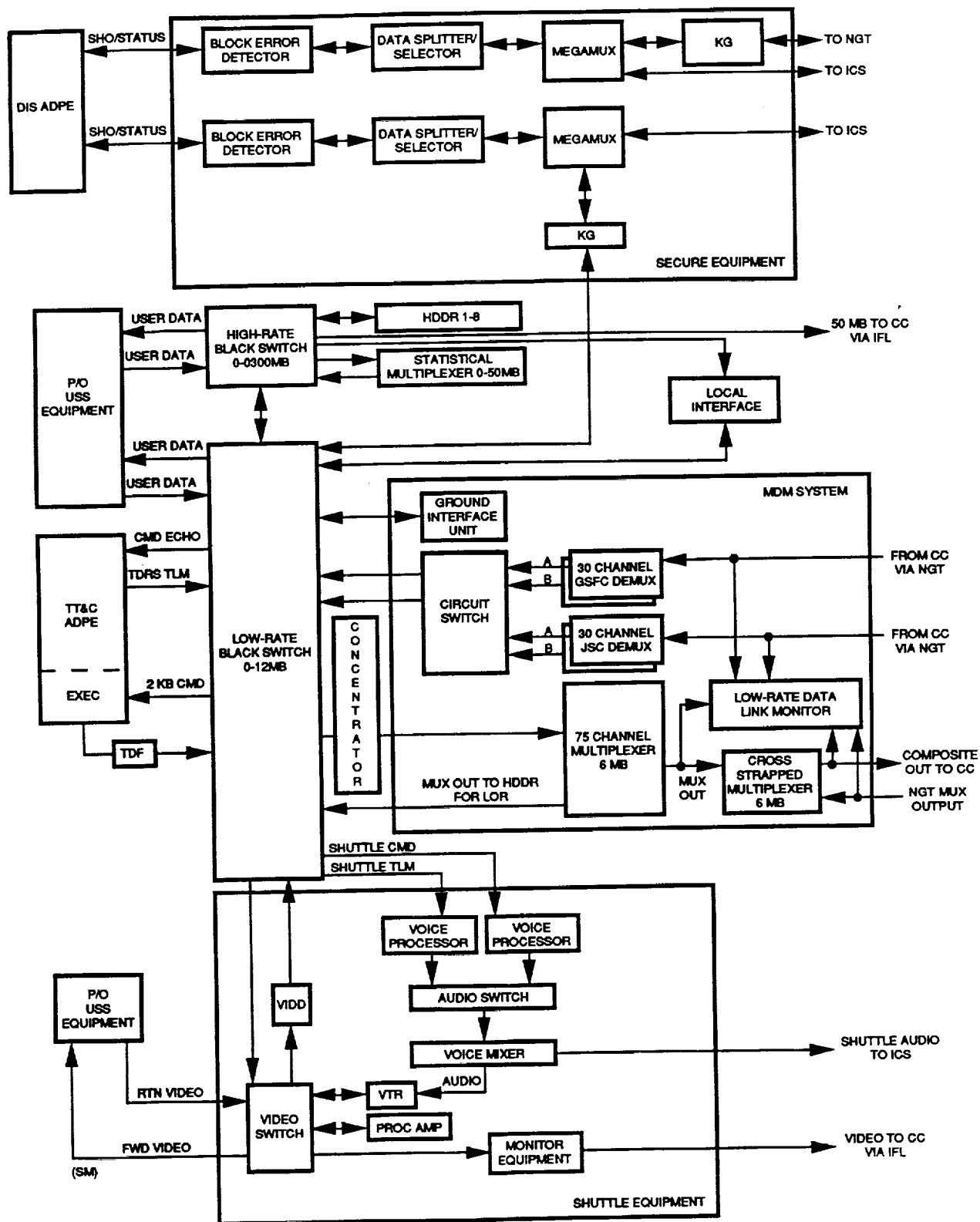
14.4.5 SN Interfaces

In March of 1995, the WSGT was decommissioned so that its upgrade might commence. This action leaves only the STGT to provide the SN's TDRS interfaces. With the decommissioning of the WSGT, terms such as "wall interfaces" and "Digital Switching System 1 and 2" became obsolete. Instead, terms such as "Low-rate Black Switch," "High-rate Black Switch," and "Data Interface System" are in use. The following paragraphs address the interfaces of the SN now that the STGT has assumed full ground station responsibility. In describing these interfaces, extensive use of figures is required. A principle source for this information is the *Second TDRSS Ground Terminal (STGT) Systems Handbook*, 534-SHB-STGT, April 1994. The Data Interface System (DIS) is presented in this section, while the Interfacility Link (IFL) is described in Section 16 of this document.

14.4.5.1 Data Interface System

The DIS at the STGT provides both internal and external interfaces for data (and voice) communications between the Space-to-Ground Link Terminals (SGLT), S-band Tracking, Telemetry, and Command System (STTCS), common carrier communications facilities, the IFL, and Nascom. Included within the DIS are the STGT MDMs, statistical multiplexer equipment for the HDRS, the Low-rate Black Switch (LRBS), and the High-rate Black Switch (HRBS). At STGT, this equipment is controlled and monitored by the DIS ADPE. A simplified block diagram of the DIS is presented in Figure 14-4.

- a. MDM. Low-rate data (formerly Type 1) is transported via the MDMs. Included in the STGT complement is a two-channel Cross Strapped Multiplexer (XSM). The XSM permits acceptance of two composite streams, one from the STGT's GSFC/



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Figure 14-4. DIS Simplified Block Diagram

JSC multiplexers and the other from the NGT's GSFC/JSC multiplexer. The XSM combines the two composites into one for demultiplexing by the GSFC and JSC demultiplexers. Simplified block diagrams of the demultiplexing and multiplexing processes associated with the DIS are depicted in Figures 14-5 and 14-6, respectively.

- b. **Statistical Multiplexer.** High-rate data (formerly Type 2) is interfaced to the STGT SM. The composite signal is then interfaced to the IFL for transport to NGT where it is interfaced to the common carrier's 50 Mb/s modem for uplink and broadcast. Figure 14-7 shows the relationship of the SM to the HRBS.
- c. **Low-rate Black Switch.** The LRBS provides the interface between the SGLTs and the transport elements of the DIS for data rates within the range of 100 b/s to 12 Mb/s. The MDM (BDS) is the principle Nascom system transporting data associated with this switch. Figure 14-8 shows the LRBS from the SGLT on the left side to ground communications on the right side.
- d. **High-rate Black Switch.** The HRBS provides the interface between the SGLTs and the transport elements of the DIS for data rates up to and including 300 Mb/s. The SM (HDRS) is the principle Nascom system transporting data associated with this switch. The HRBS is shown in Figure 14-7.

NOTE

The term "Black", as used in this context, refers to the fact that this switch is restricted to processing/switching only unclassified-data. The opposite term to "Black" is "Red."

14.4.5.2 Interfacility Link

Information on the IFL is presented in paragraph 16.4.2 of Section 16.

14.5 GN System Support

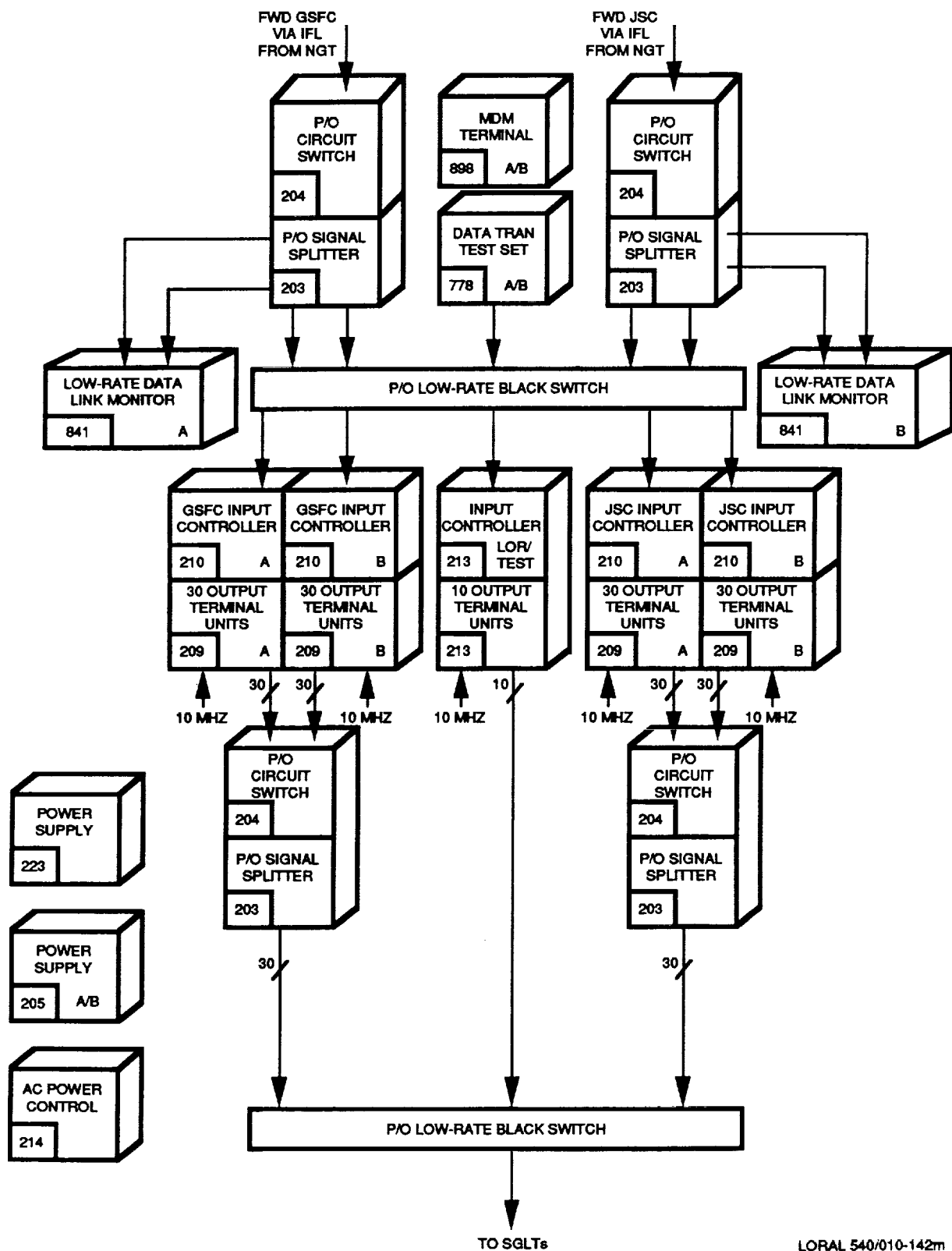
Paragraph 14.3.1.2 provided an overview of the GN. The following paragraphs describe key features of the GN and general Nascom support.

14.5.1 GN Data Formatting and Outputs

The GN is capable of formatting spacecraft data for transmission in the throughput format used for TDRSS-compatible spacecraft. It can also support the PDF throughput format (equivalent to the DSN or DGIB format). Appendix B provides detailed information regarding the different 4800-bit blocks and their formats.

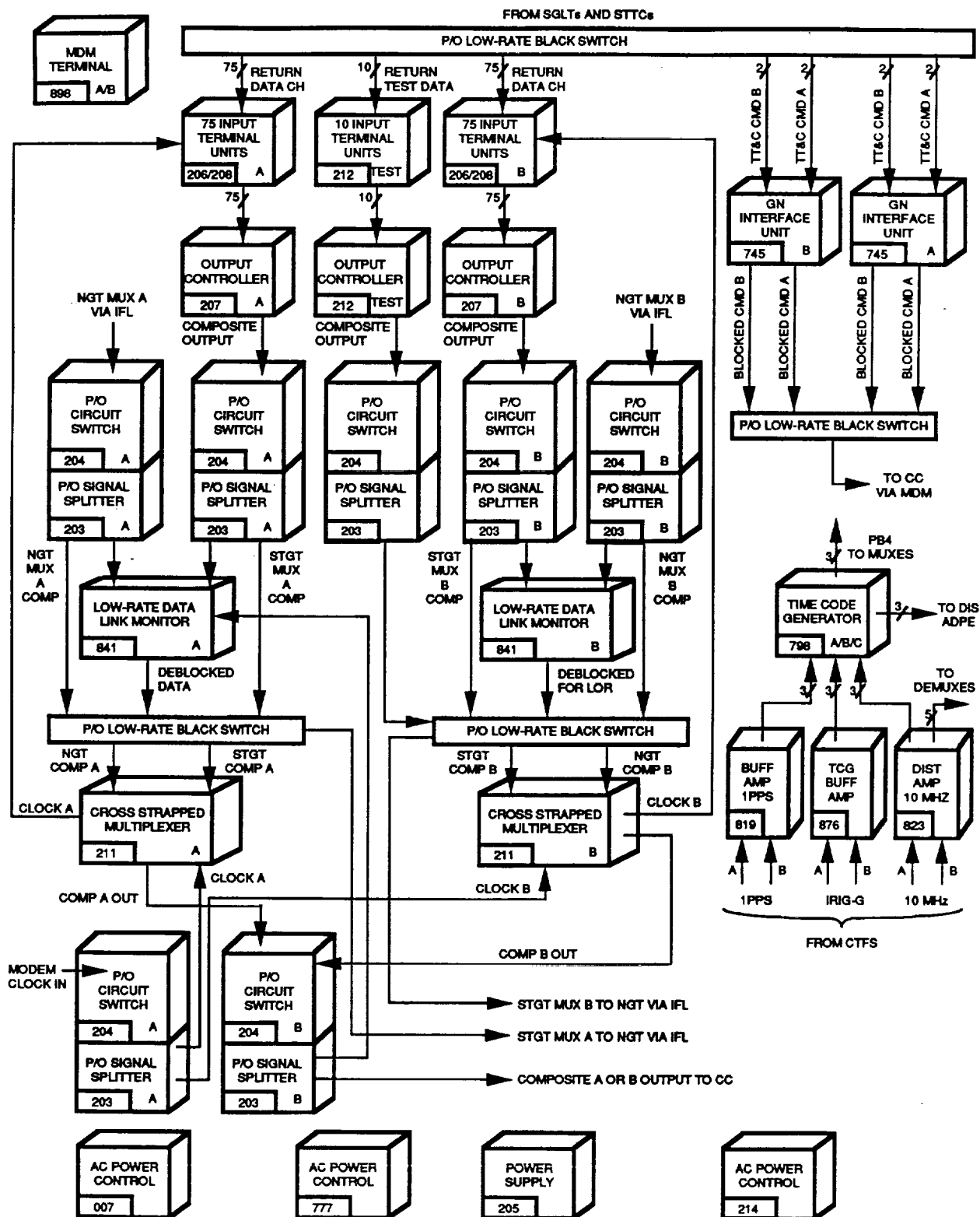
The GN can output data in the following manners:

- a. **Minimum Delay.** Real-time data or stripped high bit rate data can be output at the bandwidth of the Nascom communications line with a maximum delay of one second.
- b. **Store and Forward.** High data rates are recorded then played back post-pass at a reduced rate.



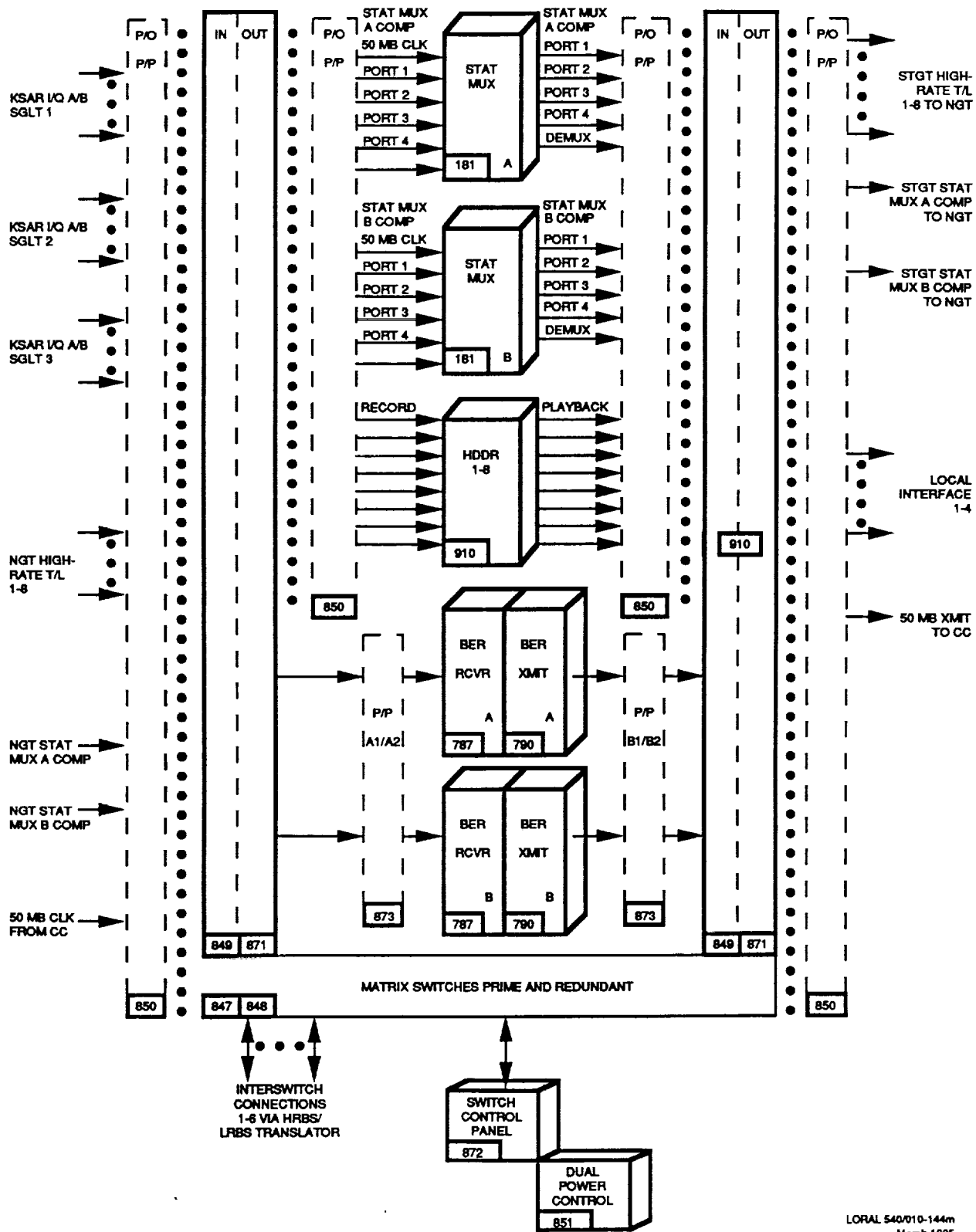
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Figure 14-5. DIS Demultiplexer System



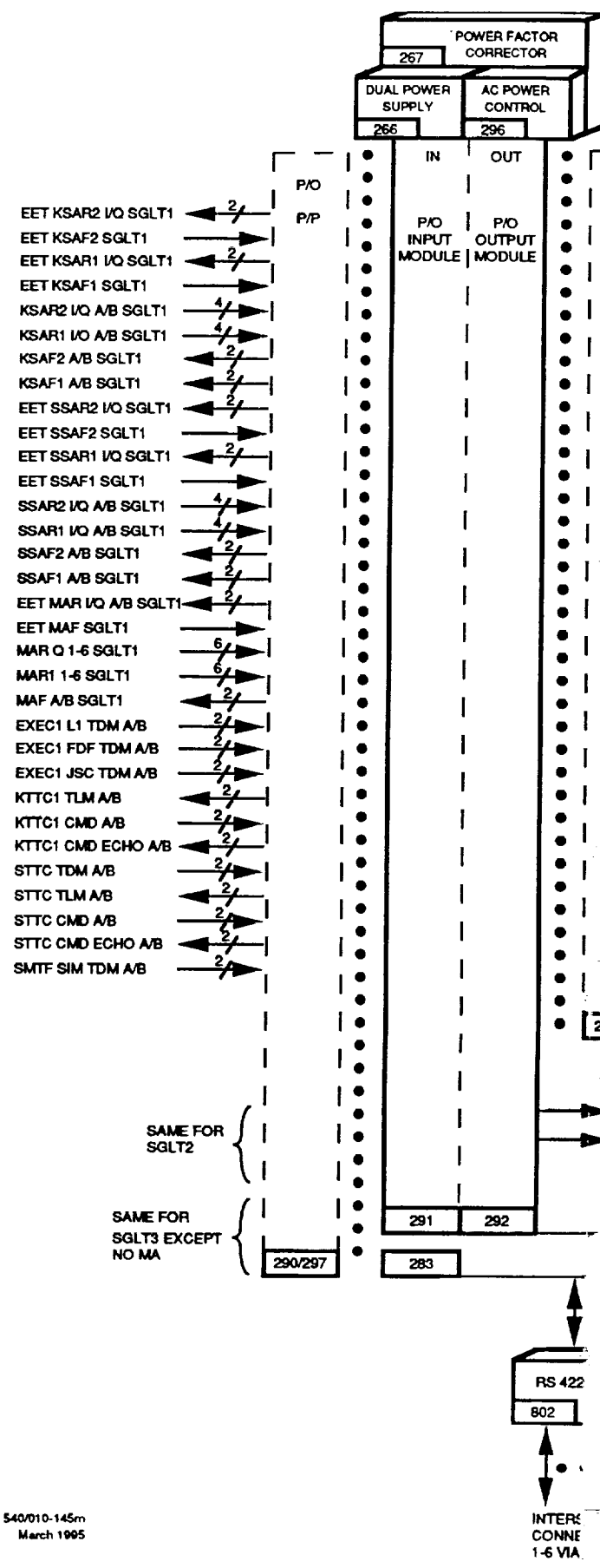
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Figure 14-6. DIS Multiplexer System



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Figure 14-7. DIS High-Rate Black Switch



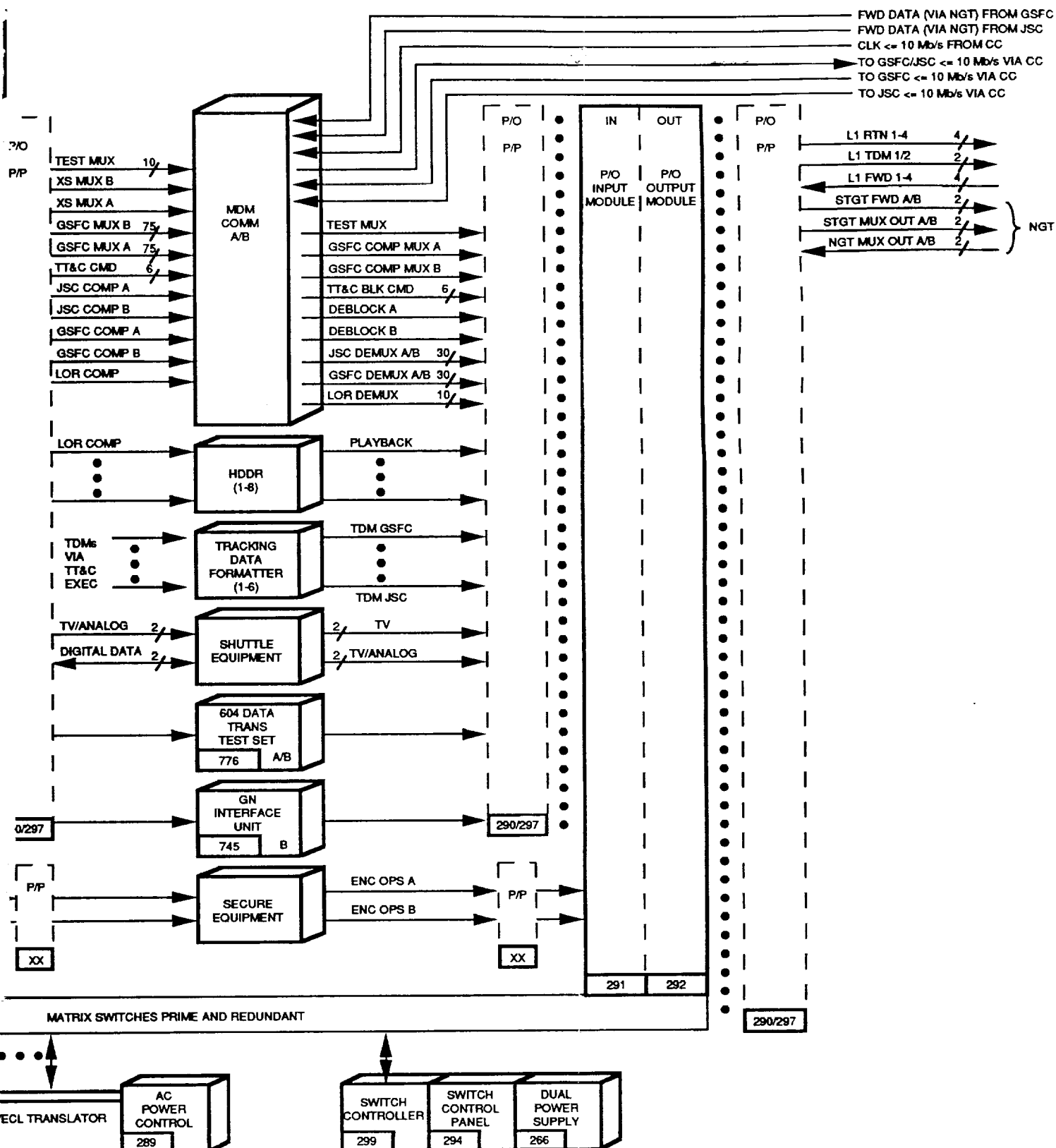


Figure 14-8. DIS Low-Rate Black Switch

Data from up to four links can be multiplexed over wideband channels back to GSFC. At GSFC, the Nascom Message Switching System Upgrade (MSU) switches data to users over wideband channels. Various types of data are multiplexed on these user wideband lines (e.g., real-time, playback, handshaking, status, etc.). The MSU reacts to the network header for message block detection, switching, and routing functions.

Figure 14-9 provides a representation of the GN stations at MIL and BDA.

14.5.2 Bermuda, Mila/Ponce De Leon Throughput Mode

Ground station capabilities are described in the following paragraphs. In the throughput block, bit synchronized data is packed into the data field of the block without frame synchronization, or asynchronously. This block format is referred to as the "4800 A" block.

14.5.2.1 Programmable Modem Interface

There are four Programmable Modem Interfaces (PMI) located at MIL and BDA. They act as the interface between the station computing equipment and the Nascom data transmission terminal. The Nascom data transmission terminal processes serial data; the station computing equipment interfaces with a parallel data stream. The PMI is essentially a serial-parallel converter; PMIs are now programmed for 22-kb/s operation but can be modified to work at data rates between 56 kb/s and 1.544 Mb/s.

14.5.2.2 Network Command Process System

Forward link command data received from GSFC over a Nascom interface is routed to the Network Command Process System (NCPS) for uplink to the spacecraft.

14.5.3 Nascom Support Responsibility for the GN

The NASA Communications Division provides and technically manages all ground communications to the GN sites. The GSFC Networks Division provides main distribution frames, on-site cabling, intercom systems, data handling, recording, and monitoring systems. Nascom provides LSN and data transmission terminals to all the GN sites. The following paragraphs further describe Nascom's responsibilities.

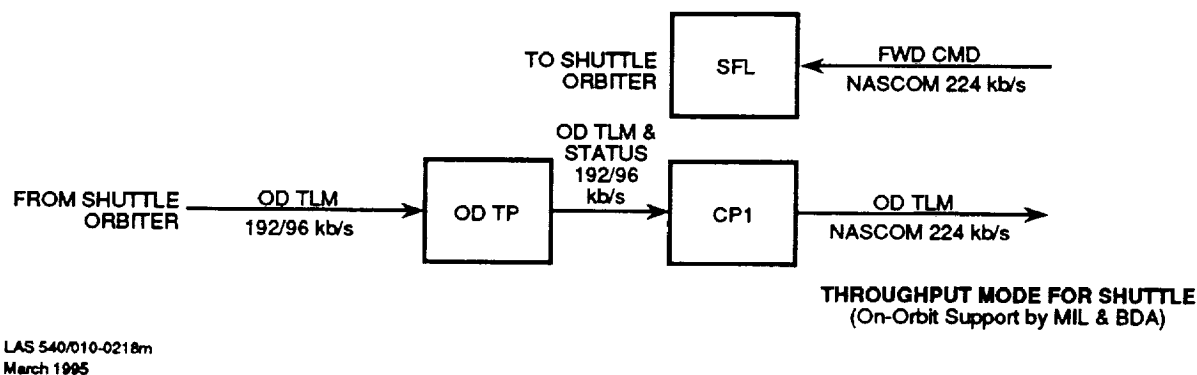


Figure 14-9. GN Station Wideband Data Facilities Interface

14.5.3.1 Design and Engineering Demarcation

The demarcation point of design and engineering responsibility for voice systems between Nascom and the GSFC Networks Division is at the main distribution frame at the GN sites. For digital data services the demarcation point of responsibility is the DC side of the Nascom-provided data transmission terminal. For LSN systems, Nascom responsibility includes the terminal equipment and the DC interface at the site TDPS interfaces, where they exist.

14.5.3.2 Nascom-provided Data Transmission Terminal

Nascom's responsibilities are specified in the following:

- a. The Nascom data transmission terminal is engineered and procured by Nascom Systems Engineering, Code 541, and is maintained and operated by station personnel. This terminal provides a matrix switch, BED, and DCE for either wideband or high-speed data lines. The interface to the commercial carrier facility is established with this terminal. The BED encodes the last 24 bits of the block on return-link data from the station to GSFC. The forward-link block from GSFC is decoded and an error status bit is set to binary "0" if the block is error free.
- b. The data transmission terminal is considered an integral part of the data transmission channel and includes cabinets, internal wiring, modems, data sets, coding equipment, jackfield, switching matrices (in wideband data terminals), power supplies, channel test equipment, and other auxiliary equipment necessary for establishment and maintenance of the Nascom long-haul digital data services.

14.5.3.3 System Engineering

Nascom designs, fabricates or procures, and furnishes these facilities – together with engineering documentation – to GN sites. The GN sites install, modify, maintain, and operate these facilities in accordance with the documentation, under direction of their respective GSFC network engineering, facilities service, and operations organizations.

14.5.3.4 Nascom Voice Circuits

Nascom voice circuits terminate in the site four-wire key system equipment. Some sites have standardized four-wire systems based on an original Nascom-provided design, which are used as the operational intercom. These sites also generally have a two-wire PABX system. Both the operational intercom and the two-wire PABX are capable of being interfaced with Nascom's long-haul four-wire voice channels, the latter via a built-in four-wire-to-two-wire conversion feature. Transport is via Nascom-2000 circuitry or NOCS.

14.5.4 Nascom Support for STDN

The support provided by Nascom is described in the following paragraphs.

14.5.4.1 Support for Remaining GN Stations

The GN continues to support the non-TDRSS-compatible extended missions and those missions that are TDRSS compatible as required. It also supports those missions that are not

considered in the 26-meter station mission subset. Since TDRSS became fully operational, several GN stations have been closed and the two remaining perform only launch and test support. The SN has assumed the role of supporting NASA's Earth-orbiting science applications and manned space missions that are TDRSS compatible. The DSN 26-meter stations are responsible for all non-TDRSS-compatible missions. Nascom support of the currently remaining GN stations is described in items a and b:

- a. **Circuit-switched Network Support.** In the GN, wideband data channels are circuit switched when used for nonstandard data transmissions (i.e., analog, asynchronous, special block formats, etc). Otherwise, all wideband channels are normally dedicated to a message-switched environment but may be circuit switched if required. Nascom has assigned the following abbreviations for circuit identification and scheduling purposes. They appear in STDN No. 502.16, paragraph 5.3.

Circuit Switched

| <u>Designator</u> | <u>Rate</u> | <u>Configuration</u> |
|-------------------|--------------|----------------------|
| WC1-X | 6 kb/s | 1200-bit block |
| WC1, WC2, WC3 | 56 kb/s | 4800-bit block |
| WC7, WC8, WC9 | 168/224 kb/s | 4800-bit block |
| ACIS | 800 kb/s | ANALOG |

- b. **Message-switched Network Support.** The DDPS network configuration and missions supported, require Nascom 4800-bit block transmission from each of the GN stations. At least one 56-kb/s wideband circuit is provided. These circuits are dedicated on a full-time basis to the Nascom MSU; therefore, they are not required to be scheduled. (See Figures 14-9 and 14-10 for GN capabilities.) All GN users gain access through the Nascom MSU. Nascom has assigned the following abbreviations for circuit identifications and scheduling purposes. They appear in STDN No. 502.16, paragraph 5.3.

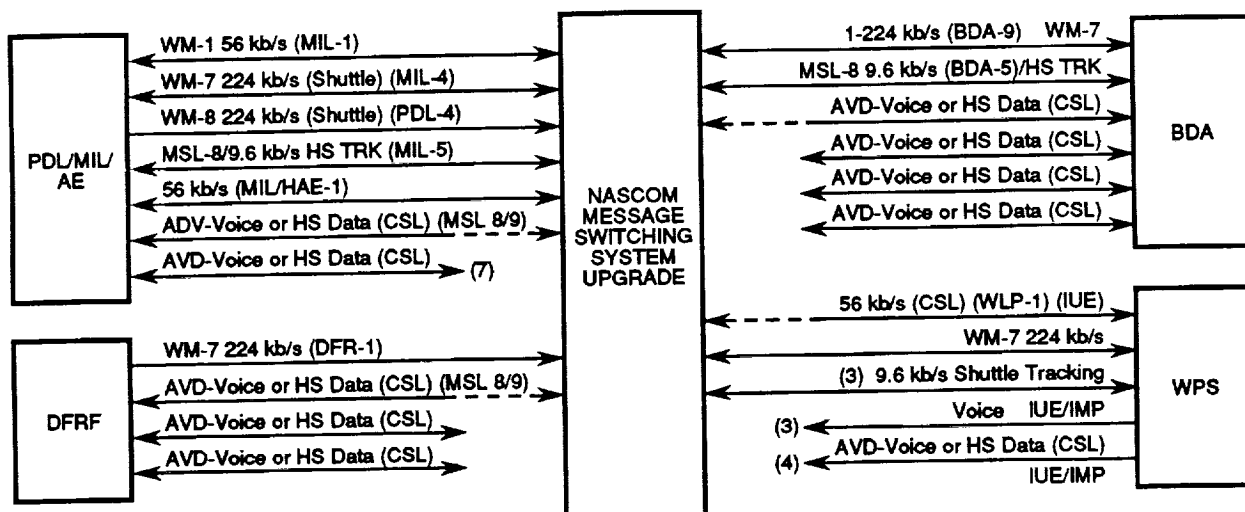
Message Switched

| <u>Designator</u> | <u>Rate</u> | <u>Configuration</u> |
|-------------------|--------------|----------------------|
| WM1, WM2, WM3 | 56 kb/s | 4800-bit block |
| WM7, WM8, WM9 | 168/224 kb/s | 4800-bit block |
| SM1B | 1.544 Mb/s | 4800-bit block |

14.5.4.2 GSFC MSS Support

At GSFC, circuit interfaces from GN and GSFC users are connected to the MSU for data interchange between the users and the network. The support provided by the GSFC Nascom MSS is described in items a through g:

- a. **Data Circuit Technical Control Interfaces.** The wideband and high-speed data circuits are routed from the DCE through patch panels located in Data Technical



LEGEND:

WM Wideband Message-Switched Lines
 CSL Circuit Switched Lines
 MSL MSU Backup TLM (MSL-9) and
 CMD (MSL-8)-9.6 kb/s
 (N) Quantity Circuits

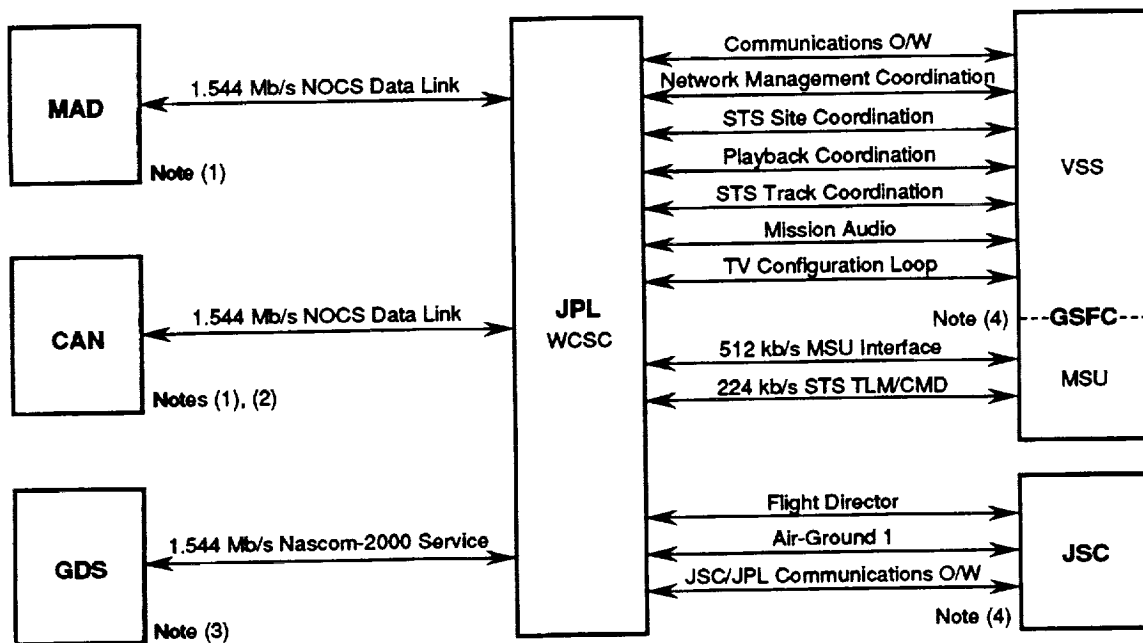
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Figure 14-10. GN Station-Communications Line Switching Orientation at GSFC

Control to the MSU. Patching, switching, and quality control of these interfaces are performed by Nascom technical control.

- b. MSU Input/Output and Network Header Processing. The MSU uses the network header of the incoming block to process and switch data. The network header is processed as follows:
 1. Synchronization Code. The first 24 bits are examined to determine if a valid synchronization code was received. If the synchronization code is not perfect, the block is rejected.
 2. Source Code. The next eight bits, the source code, are read and stored for display, if required.
 3. Destination Code. The next eight bits, the destination code, are read to determine the ultimate routing of the block. A destination code may represent single or multiple destinations. Nascom has limited multiaddressing to six destinations.
 4. Block Sequence Number. This three-bit number identifies the sequence in which blocks are transmitted by the source. This sequence number will be used to check the order in which blocks are received at GSFC.
 5. Format Code. This five-bit code identifies the general type of data contained in the block (i.e., telemetry, tracking, or commands).

- c. **Nascom-provided Communication Line Capability.** The Nascom MSU provides communications line switching capabilities for both GN stations and JPL/DSN stations as described below:
1. **GN Stations.** The configuration of the Nascom MSU at GSFC for GN communications line switching is shown in Figure 14-10. Nascom also provides a high-speed data capability (9.6 kb/s) at each station for backup purposes. Such circuits are operationally designated MSL-8 (command) and MSL-9 (telemetry) when set into the message switching system (refer to STDN No. 506.16, paragraph 5.3). Each GN station is provided at least a 168 kb/s data transmission capability. GN sites have additional capacities (i.e., 224 kb/s). Such message-switched circuits are designated WM-7 or WM-8. These wideband services are not subject to the NCC scheduling system. They are "set-in" from the GN station to Nascom on a 24-hour basis as dedicated lines.
 2. **JPL/DSN Stations.** The configuration of the MSU for JPL/DSN switching is shown in Figure 14-11. From each of the DSCCs, Nascom provides a primary path 1.544 Mb/s multiplexed data link to the JPL WCSC. JPL demultiplexes the data and switches it to its end destination, e.g., MAD, CAN, GDS, JPL, or GSFC.
- d. **User Telemetry/Command Interface.** User interfaces to the MSU are established on a case-by-case basis by Nascom in planning coordination with the individual projects intending to use the GN. The MSU output data rates to user POCCs and processing facilities, principally for telemetry data, are selected to accommodate higher than maximum simultaneous incoming data rates expected from all sources; for GSFC POCCs, generally 224 kb/s. For data rates from GSFC POCCs to the MSU, principally for command data, 56 kb/s has been generally adopted as a standard to minimize transmission delays. Since the effective command data rates are relatively low, POCCs remote from GSFC will usually use 9.6-kb/s circuits for economy. Certain ports will handle multiple block data formats, which is a function of the user's data handling capability.
- e. **User Data Interfaces.** For data support from GN sites via GSFC, user return link interfaces are established on a case-by-case basis for each project. The MSU is capable of functioning as a multiplexer transmitting data to a user, effectively interleaving 4800-bit blocks from more than one source or line. The output data rates to users (e.g., POCCs) are selected to accommodate something higher than the maximum simultaneous incoming data rate expected from all sources. These high output rates serve to reduce queuing of data in the MSU and conserve its buffer pool. Most of these rates are set at the standard network service rates (i.e., 9.6, 56, 224, and 1,544 kb/s). For 4800 D block data handling, the SDPF has been able to accept composite data from all sites supporting 4800 D format-type operation into its single TELOPS interface. This interface is set at 600 kb/s to accommodate this function. Likewise, the POCCs in the past have been able to accept interleaved data from multiple sources and this has conserved the number of interfaces required in the MSU.



NOTES:

- (1) The 1.544 Mb/s data links from MAD and CAN to JPL each provide:
 - (a) 768 kb/s "Big Pipe"
 - (b) 256 kb/s DSN slow scan TV
 - (c) 64 kb/s DSN administration
 - (d) 9.6 kb/s tracking data
 - (e) 32 kb/s voice (7 lines)
- (2) In addition, the 1.544 Mb/s data link from CAN to JPL transports data flowing between WSC and the TDRS Remote Ground Relay Terminal
- (3) The 1.544 Mb/s Nascom-2000 service between JPL and GDS provides:
 - (a) 224 kb/s for command and telemetry
 - (b) Voice circuits for Shuttle support (DSN 26M Track Loop, STS Site Coordination Loop, and Playback Coordination Loop).
- (4) JPL extends Shuttle support circuits to GSFC via Nascom-2000 services, and TDRS RGRT support circuits to the WSC. GSFC then switches these circuits to their end destinations.

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Figure 14-11. DSN Station-Communications Line Switching Orientation at GSFC and JPL

- f. **Throughput Data Interfaces.** With the advent of throughput (4800 A block) data handling from the GN and the 26-meter sites, there has been a move away from multiplexed data interfaces, to a greater number of discrete interfaces capable of handling only single-stream(non interleaved, single source at a time) data. Such interfaces are usually dedicated to a respective mission and data type. The use of throughput data interfaces has increased the required number of MSU dedicated interface requirements into the Control Centers (e.g., Multisat) and into the Sensor Data Processing Facility (e.g., the Telemetry Interface Preprocessor-into-TELOPS, or TIPIT), a throughput data handling facility.
- g. **GN/SN Throughput Data Time-sharing of Interfaces.** Certain user throughput interfaces are time shared between the GN message switched sources and the SN source (i.e., the WSC/MDM system). The user interfaces are manually switched in the DMS [i.e., shifted between the MSU source, or an SN (MDM channel) source].

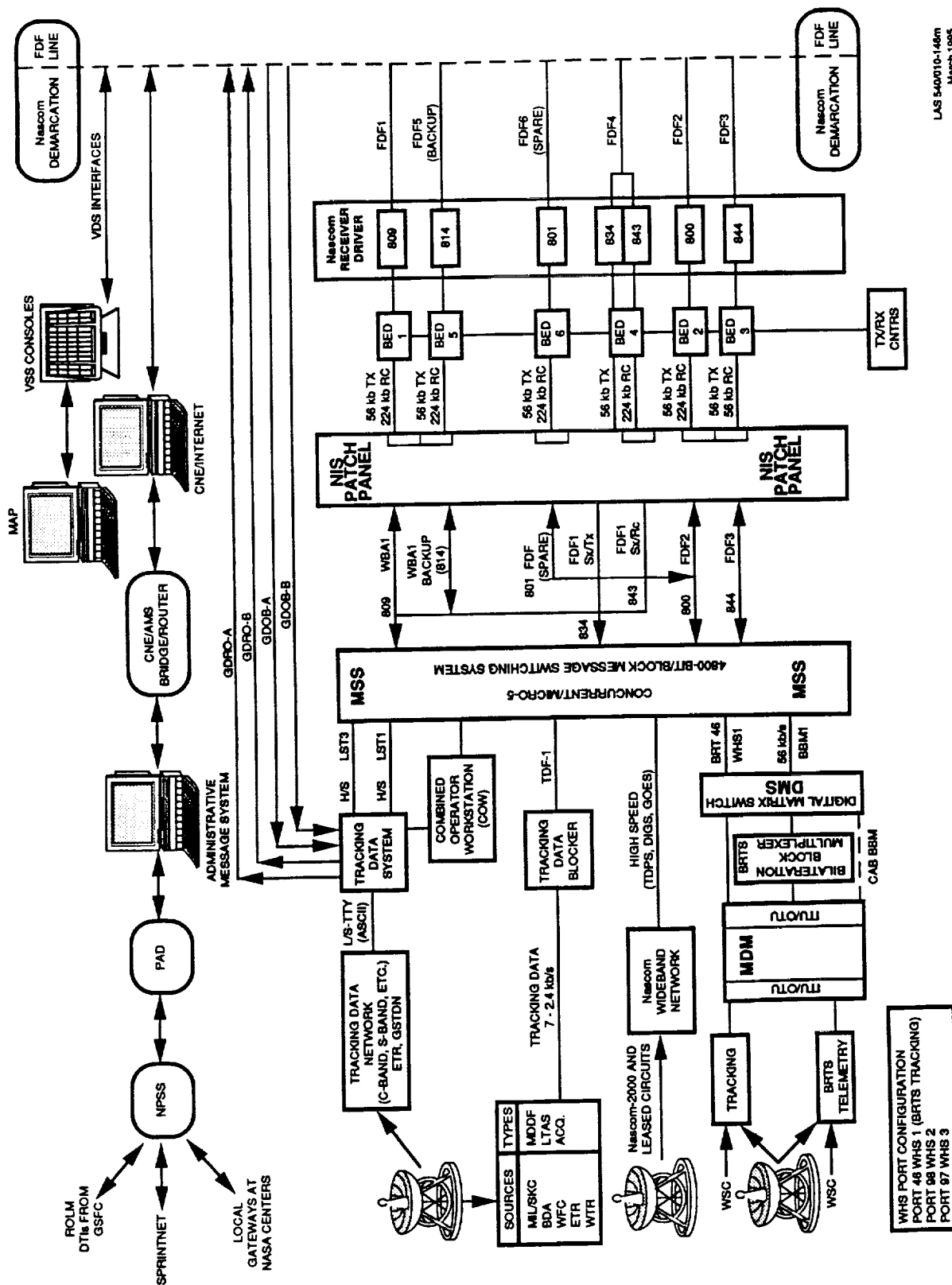
14.5.5 Other Major STDN User Interfaces at GSFC

Various other major STDN user and network support facilities route their data via the MSU. This includes the network scheduling and status data for the NCC, network and spacecraft checkout data to and from simulators, contractor locations, etc. However, the GSFC Flight Dynamics Facility interfaces with the MSU designed for handling metric data are unique. These interfaces are portrayed in Figures 14-12A and 14-12B, and are described in the following paragraphs.

- a. **Data Received.** The FDF receives orbital tracking data for spacecraft supported by the GN. The FDF also receives data from other NASA and DoD/ER and -WR trackers to provide launch and landing trajectory data for the STS and other missions. FDF also receives Delta and Centaur launch vehicle guidance data from the GN and vectors from orbit computation facilities at other centers (i.e., JSC and JPL). Tracking data from the SN for spacecraft supported by the SN and for TDRSS spacecraft from the BRTS, are also received in the FDF. Additionally, the FDF receives BRTS telemetry data from WSC, as it performs a housekeeping function for the BRTS.
- b. **Data Generated and Transmitted.** FDF functions include the generation and transmission of acquisition data to the GN and SN- and also the supply of scheduling aids to STDN controllers and the payload controllers using the GN and SN. It also transmits ephemeris data to its correspondents, vector data to other centers and networks, and BRTS scheduling requests and acquisition status data to the SN/NCC.
- c. **Received Data Interface.** Figure 14-12A illustrates the complex interface that exists between the Nascom MSU and interfacing elements of the FDF, for the receipt and transmission of the various types of data. The following describes each FDF-Nascom element interface.

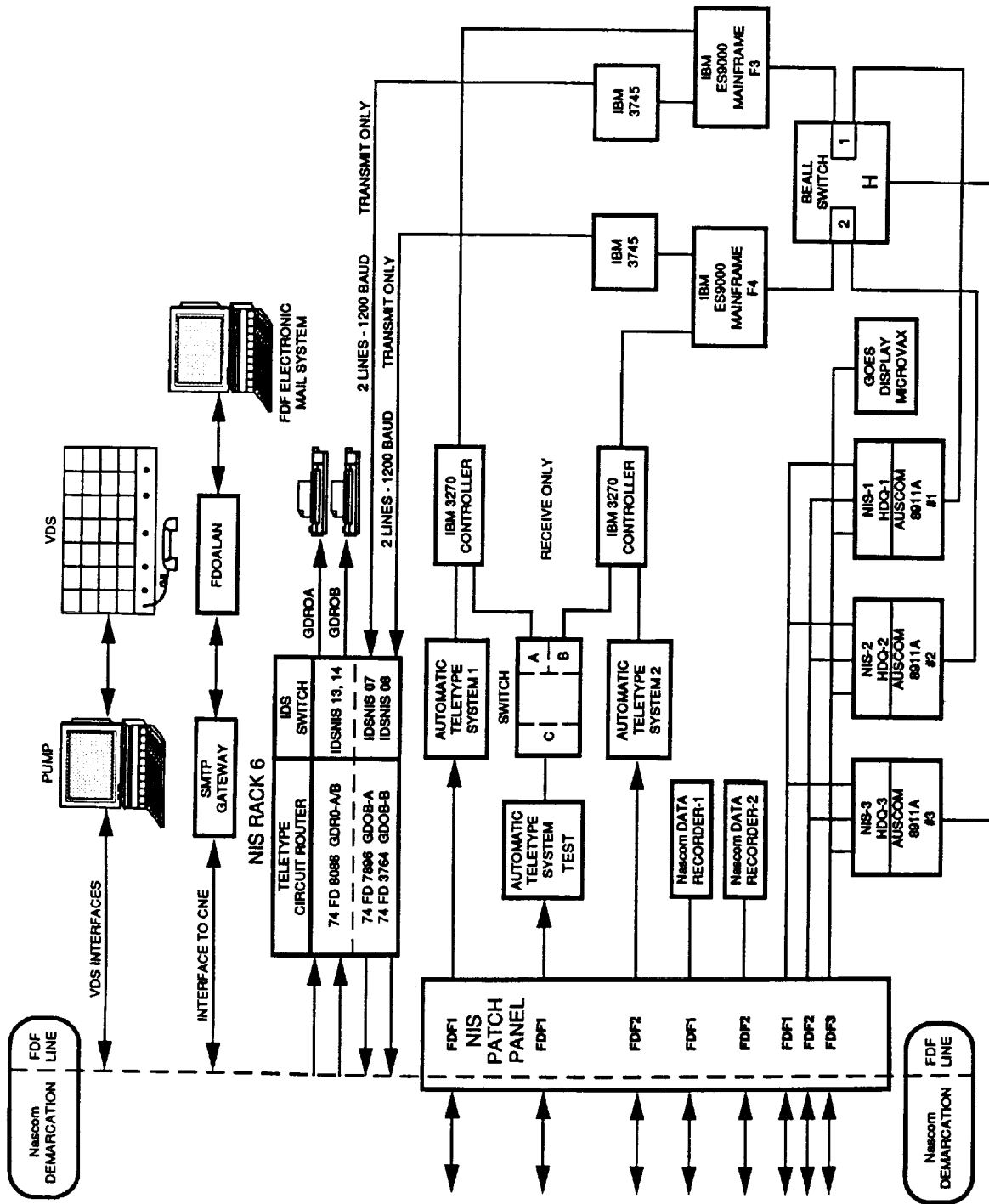
High-speed launch and landing trajectory data received on 2.4 kb/s circuits is routed through a Tracking Data Blocker, then to the MSU, and to the FDF over 224 and 56 kb/s lines for real-time processing. All data received by the Nascom MSS in 4800-bit blocks is delivered via the MSU 224 kb/s interface to the Nascom Interface Systems (NIS) elements of the FDF. These include high-speed Tracking Data Processor System (TDPS) data, launch vehicle guidance data, TDRS/BRTS tracking data, BRTS telemetry data, Intercenter Vector (ICV) data, and NCC scheduling data.

- d. **Transmit Data Interface.** On the transmit side (Figure 14-12B), the FDF transmits acquisition data for the following:
 1. Nonreal-time operations via 300-baud ASCII interfaces to the Nascom LSN system for store and forward distribution.
 2. For real-time operations, the FDF interface also includes transmission of FDF-generated 4800-bit blocks with implanted ASCII Coded TTY acquisition data messages, via 56 kb/s interfaces directly to the MSU from the NIS system.
 3. FDF - generated 4800-bit blocks for SN operations are transferred via these same interfaces to the MSU system, for routing to FDF correspondents. These



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Figure 14-12A. Nascom Functional Circuit Configuration Block Diagram



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Figure 14-12B. FDF Functional Circuit Configuration Block Diagram

include SN scheduling aids, SN acquisition data, BRTS scheduling requests, payload state vectors, and ICVs.

14.5.6 Interbuilding Communication Link Upgrade (ICLU)

The ICLU replaces the Interbuilding Data Transmission System (IBDTS) consisting of a coaxial-cable-based system supporting rates equal to or greater than 1.544 Mb/s, and in some cases special rates less than 1.544 Mb/s. ICLU also replaces the Interbuilding Data Dissemination Resource System (IBDDR), a fiber optic based system terminated with T-3 (44.736 Mb/s) fiber optic terminal equipment which, in turn, is interfaced with hierarchical T-1 multiplexers. For more specific information, refer to the *System Implementation Plan for Interbuilding Communications Link Upgrade (ICLU)*, 541-207, December 1994, and the *Operator's Manual for Model 2200 High Speed Fiber Optic Equipment*, Rev 2.0, January 1995.

14.5.6.1 System Description

The central node of the ICLU is the Nascom Technical Control Center located in Building 14. ICLU transports digital data between the control center and other buildings on the GSFC grounds. ICLU interfaces with Nascom switching center equipment such as the MSU and the DMS. It also interfaces directly with local common carrier equipment in the several common carrier points of presence in the GSFC facilities.

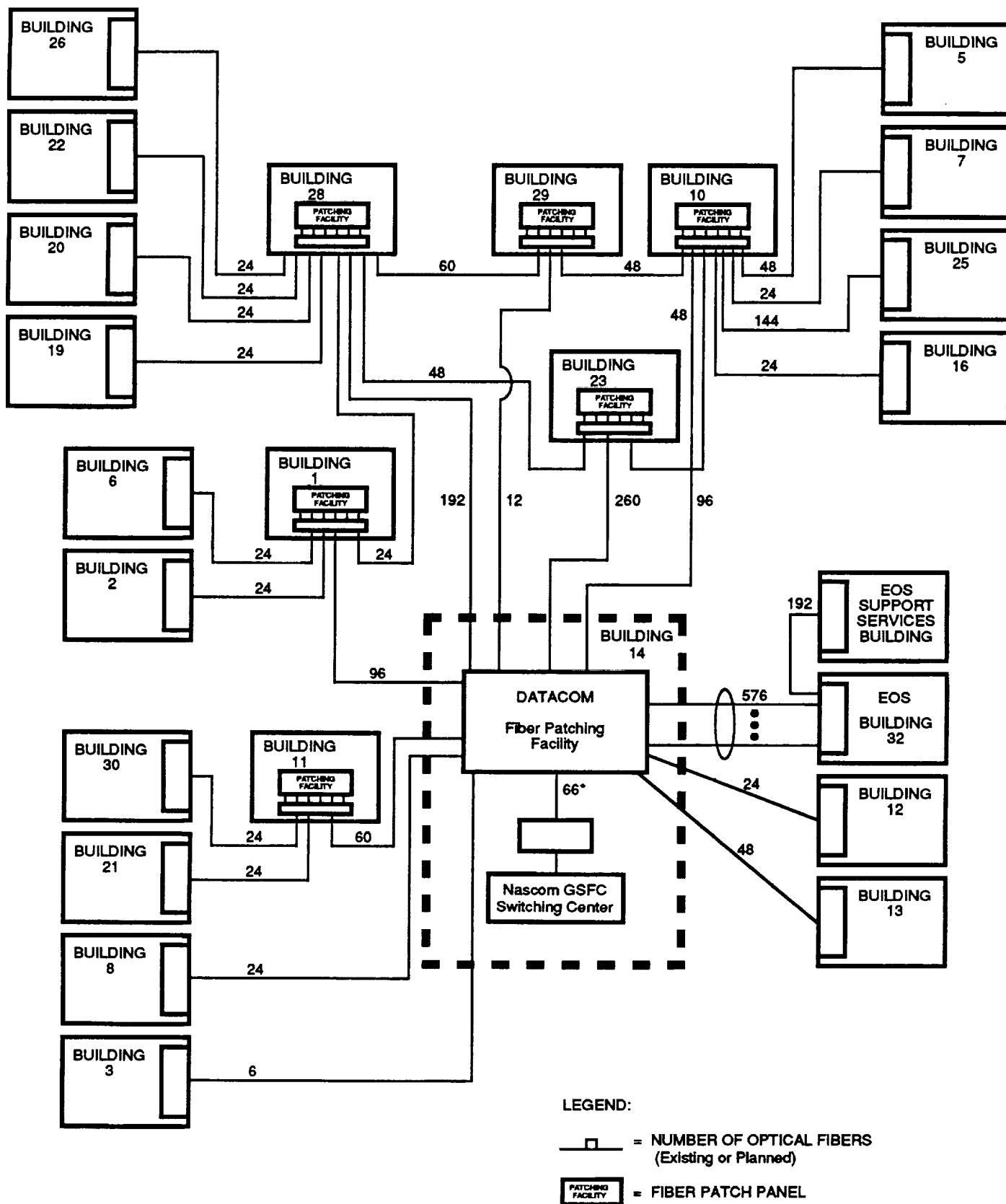
To meet GSFC requirements, Nascom has purchased 356 Fiber Optic Transceivers (FOT), or modems as they are called in vendor literature. Up to 322 FOTs are allocated for use on the fiber cable plant shown in Figure 14-13. Note that only a small portion of the GSFC fiber cable plant will be terminated by ICLU equipment. Twelve of the fiber optic transceivers have been designated as spares and are consigned to the GSFC Logistics Depot. The remaining 24 are held for future requirements.

Nascom provides patch and input/output panels as required. For example, a fiber patch panel in Building 14 serves as the test point and the demarcation point between the Nascom switching center and the ICLU. User interfaces to the ICLU in the various GSFC buildings are electrical (EIA RS-422). The user interface is plenum-rated, shielded, twisted pair cable terminating on connector interface panels populated with RS-449, 37-pin connectors. If the number of channels to a user's building is very small (four or less), the electrical interface may be physically direct, using PLC75-terminated, 125-ohm twinaxial cable from the fiber optic transceiver to the user. A typical (generic) diagram of ICLU and its interfaces with GSFC buildings and other Nascom systems is provided in Figure 14-14.

14.5.6.2 Equipment Description

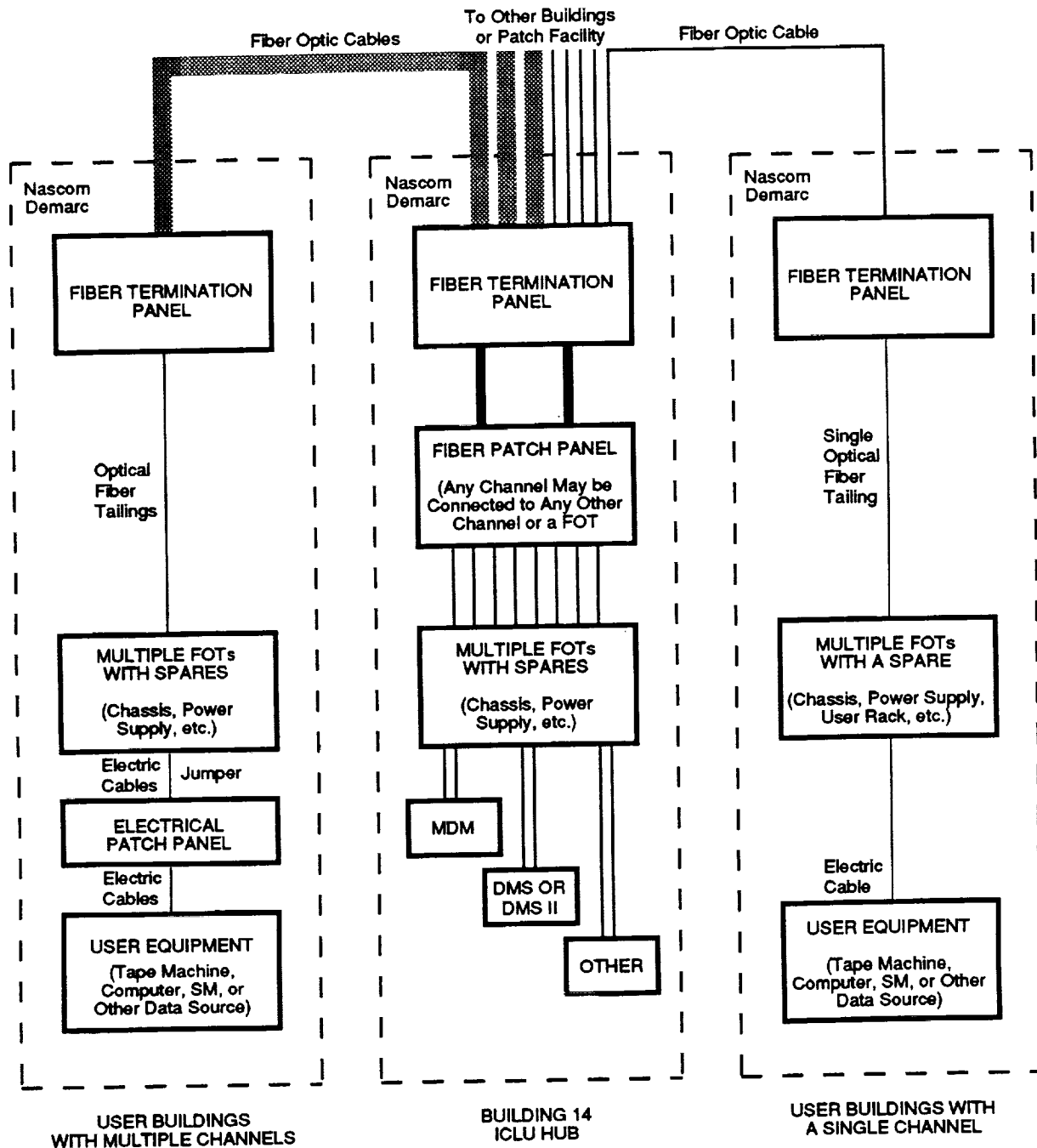
The ICLU provides high-speed fiber optic modem equipment, where each modem is capable of transporting synchronous data at rates between 1 kb/s and 10 Mb/s. Asynchronous data may also be directly interfaced to the modem provided that the data rate does not exceed 1.25 Mb/s.

Nascom has procured the Model 2200 Variable Rate Fiber Optic Modem from Broadband Communications Products, Inc., of Melbourne, Florida. Each modem is contained on a



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Figure 14-13. Nascom Available and Planned Fiber Cable Plant



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Figure 14-14. Typical ICLU Inter and Intra Building Connections

single card. Up to 12 modems (transmitter/receiver cards) may be installed in a chassis. Redundant power supplies are included with each chassis. Each modem is full duplex, supporting both the send and receive directions. Each chassis may support up to 12 independent, mixed rate data flows. Individual chassis are stacked within standard 19-inch racks until the required number of fiber lines at a given location have been terminated.

Not only is each modem card independent, but each chassis is independent of every other chassis in a rack. This permits maximum flexibility to transport a broad range of individual interbuilding data flows within the GSFC facilities. Figure 14-15 shows a typical "fully loaded" rack as installed in Nascom's Building 14. In the figure, the left elevation is the front panel view, the right elevation is a view of the back of the rack. Figure 14-16 shows a generic Nascom rack as installed in a user's building. Figure 14-17 illustrates a typical elevation where ICLU terminal equipment is installed in user-provided rack space.

On the electrical (input and output) modem interfaces, the standard is EIA RS-422 with a NRZ-L data format. On the optical interfaces, the link loss budget is typically 19 dB. The optical transmitter is a 1300 nm Class 1 laser diode that is designed to input a minimum of -7 dBm into a 9/125 μ m single mode fiber, or an average minimum power of -10 dBm into a 50/125 μ m or 62.5/125 μ m multimode fiber. The optical receiver is an InGaAs PIN photodiode that has a -31 dBm sensitivity across the 1 kb/s to 10 Mb/s band. On the modem card, optical loss detection is set at -28 dBm.

14.5.7 Buildings 13 and 14 Complex Fiber Optics

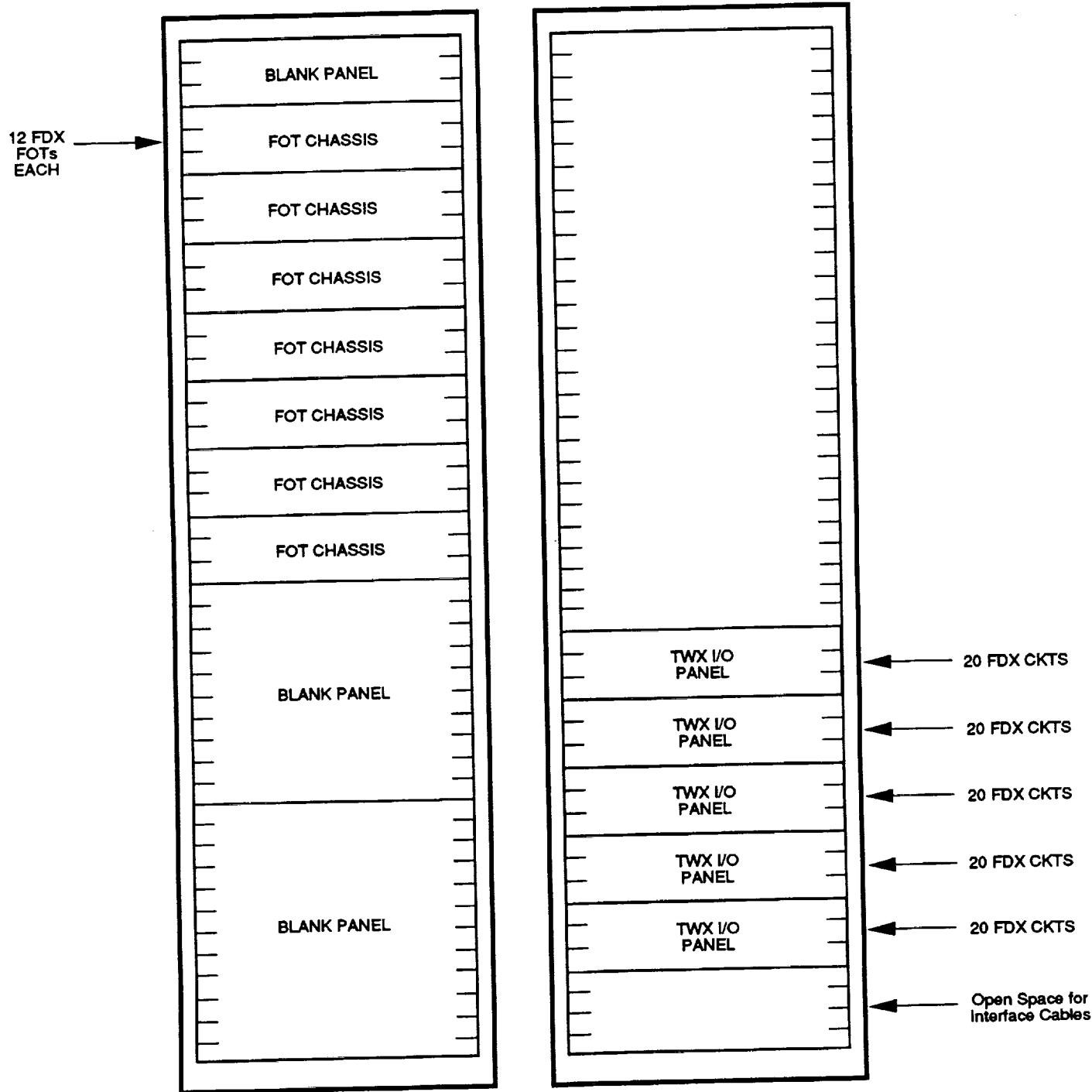
Several systems are related to the enhanced security development in the Building 13-13A-13B-14 complex serving the NCC and Nascom systems. Elements of these systems include the following:

14.5.7.1 MSU/CSS-related Security Enhancement

This system provides a fiber-optic link at 56 kb/s between the NCC (Building 13, Room 141) and the MSU/CSS Distribution Bay (Building 14, Room E171). Also implemented are internal CSS-related Nascom links between: (1) the Communications Terminal Modular Controller (CTMC) interface and the Operator Interface Console, (2) the MSU/CSS and the DMS Control System, and (3) the MSU/CSS and the MACS. In addition, a STU-III (secure telephone unit) wall phone is being installed in Room E-125A of Building 14.

14.5.7.2 Building 13 Complex Fiber Optic Distribution System

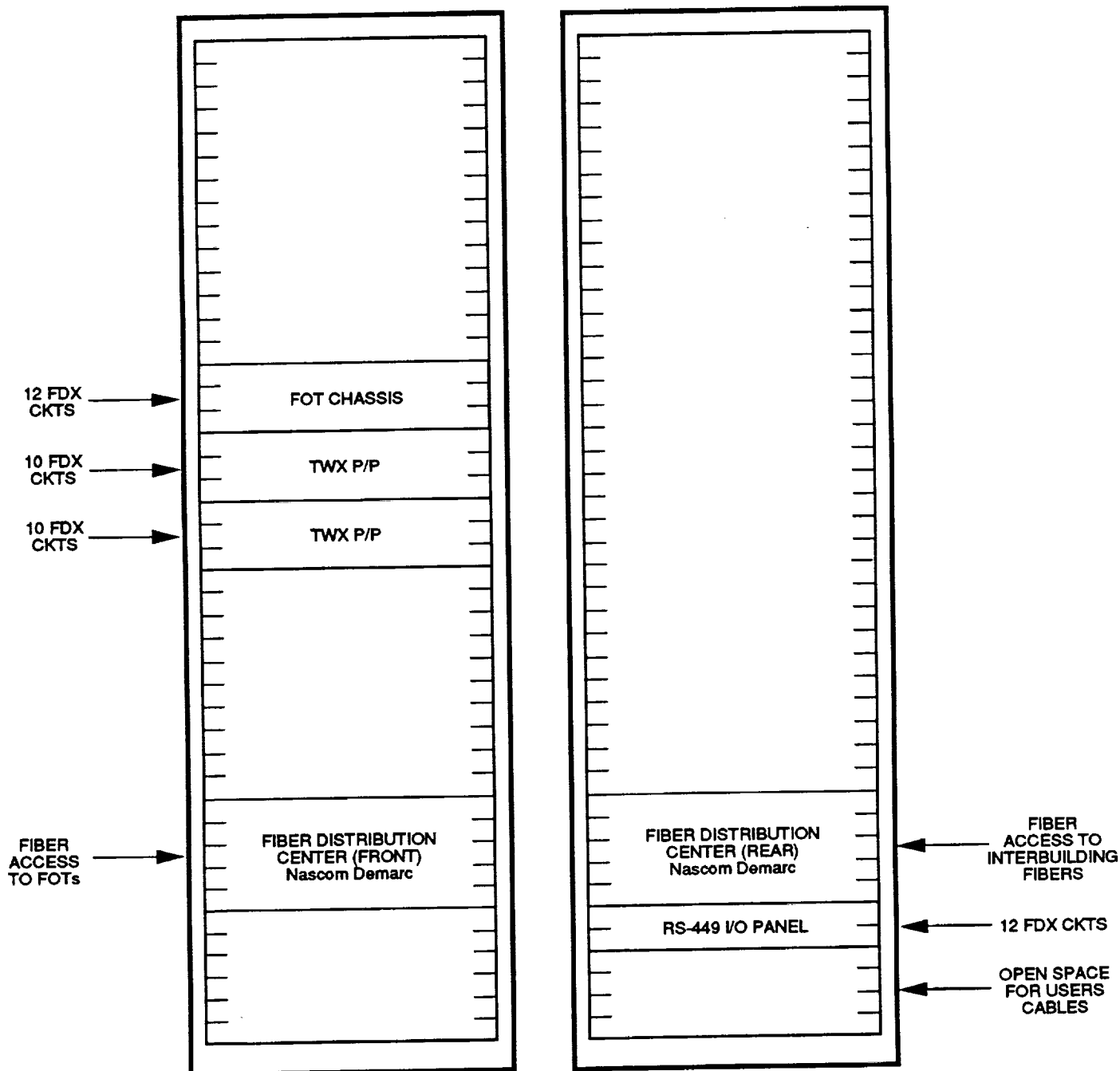
This system provides a fiber-optic distribution system between Building 14 and the Building 13 complex, and distribution within the Building 13 complex. The FO configuration is illustrated in Figure 14-18. The system was implemented in two parts: part one for the installation of the fiber-optic cables; part two for the installation of the fiber-optic/copper conversion, patch, test, and interface systems. Passive Fiber-Optic Racks (PFOR) and the interconnecting fiber-optic cables between the PFORs are included in the baseline system. The installation specifies the use of 50/125 μ m fiber cable type with bulkhead feed through SMA-type connector termination. In the fiber-optic link between Buildings 14 and 13, transmit/receive circuits are implemented using duplex fiber cables. Forty-eight duplex



NOTE: Each Cabinet Supports 84 FDX Circuits

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Figure 14-15. Typical ICLU Rack Elevation for Nascom Technical Control



LORAL 540/010-136m
March 1995

Figure 14-17. Typical ICLU Configuration for User-Provided Rack Space

14.5.7.3 Building 13 PFOR Installation

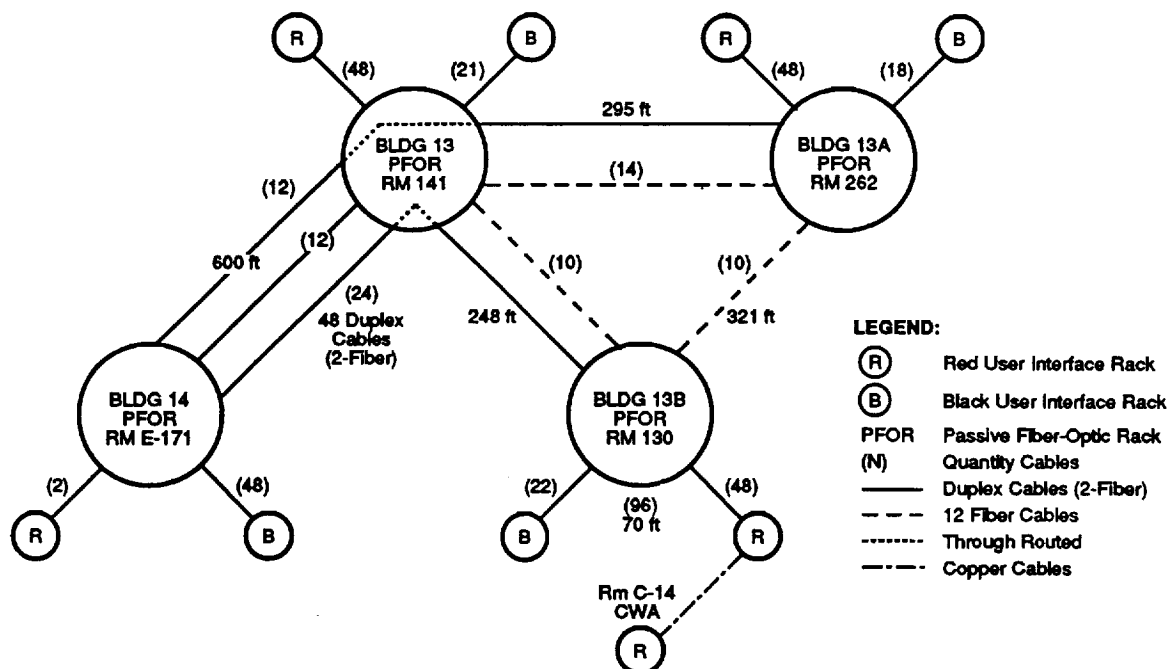
Additional PFORs in Buildings 13A and 13B and the Building 13 PFOR form a three-node configuration interconnected by 12-fiber cable links. Each PFOR is provided with both Black and Red separate user interfaces.

14.5.8 MODNET and NOLAN

14.5.8.1 Background

The MO&DSD Operational/Development Network (MODNET) provides a unified Directorate-wide operational network linking various operational MO&DSD computers using Transmission Control Protocol/Internet Protocol (TCP/IP), DECnet, and HYPERchannel protocol. Nascom Code 541.2 is responsible for network expansion, network security, continuing engineering, maintenance and operation of MODNET.

MODNET has been an operational network since 1988. Various processed orbit, attitude, and telemetry data are transported between more than 200 host computer systems via MODNET. There is no direct interface between MODNET and any other Nascom Network, but there is a connection to the Center Network Environment (CNE).



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Figure 14-18. Building 13 Complex Fiber Optic Distribution System Configuration

14.5.8.2 NOLAN, Expanding MODNET Beyond Code 500 Systems

MODNET connects to non-MO&DSD computers through the Nascom Operational LAN (NOLAN). NOLAN provides an operational FDDI LAN on-center and a Wide Area Network (WAN) capability for off-center data transport. Given formal requests for service, expansion of connectivity to new or additional buildings on GSFC for support of non-MO&DSD host systems will be considered for implementation through NOLAN. NOLAN currently connects (or is about to connect) the projects listed in Table 14-6.

14.5.8.3 System Configuration

The MODNET/NOLAN network is based on an interbuilding FDDI backbone with Ethernet, FDDI, and serial wide-area network extensions to users. The backbone ring is composed of redundant FDDI concentrators connected via optical bypass switches. IP routers support isolation, filtering, and media translation for TCP/IP-based data transfers. HYPERchannel adapters support hosts utilizing NETEX/BFX. A diagram of the IP portion of the network is shown in Figure 14-19; the HYPERchannel portion of the network is depicted in Figure 14-20. Although IP and HYPERchannel protocols share the same FDDI backbone, there is no gateway connection between them.

MODNET/NOLAN provides sufficient flexibility to satisfy the service requirements of a wide variety of users. This is accomplished by providing two levels of security, and permitting users to choose that level which best meets their requirements. The two levels of security are furnished by segmenting the system into an Open Segment and a Closed Segment with a Secure Gateway sitting between the open and closed segments. Whereas the Closed Segment lies behind (is protected by) the Secure Gateway (the Secure Gateway is based on DEC's Firewall Services System), the Open Segment lies only behind a filtering router. The Closed Segment is typically used by critical elements such as control centers. The Open Segment is more widely used and provides connectivity to both the CNE and the Internet.

Two real-time Network Management Systems (NMS) continuously monitor the network for faults. The IP NMS, running HP Open View, is located in Nascom Technical Control, Room E171, Building 14. The HYPERchannel NMS, running proprietary software, is located in the Data Distribution Facility (DDF), Room N308, Building 23. Both NMSs provide graphical and analytical indications of the health and status of MODNET/NOLAN.

A Domain Name Service (DNS) translates host names and aliases to IP addresses uniquely identifying each host. The DNS is split into both open and closed segments associated with the Open Segment and Closed Segment, respectively. Each DNS resolves addresses within its segment. However, the DNS for the Open Segment also sends requests for Closed Segment user address information to the Gatekeeper for resolution by the Closed Segment's DNS. The MODNET/NOLAN name service is compliant with the hierarchical Internet name service system convention: `nascom.nasa.gov` for the Open Segment and `ops.nascom.gov` for the Closed Segment. Each segment has both a primary and a backup name server.

14.5.8.4 MODNET HYPERchannel Connections

Network Systems Corporation Network Executive (NETEX) is the common network operating system for the MODNET. Bulk File Transfer (BFX) software and User Access software

Table 14-6. NOLAN Connections

| Requirements Source | Data Link | Protocol | Bandwidth (Mb/s, Maximum) | Number of Hosts of Workstations | Location of Hosts or Workstations | Connect Date |
|--------------------------|------------------------------|----------|---------------------------|---------------------------------|-----------------------------------|---------------|
| FAST/Berkeley, CA | Berkeley: V35 GSFC: RS422 | TCP/IP | 1.536 | 2 | Berkeley, CA | November 1993 |
| SOHO ECS | Ethernet | TCP/IP | 10 | 2 | Building 3 | November 1993 |
| SOHO | Ethernet | TCP/IP | 10 | 3-4 | Building 25, Room N171 | February 1994 |
| XTE | Ethernet | TCP/IP | 10 | 1 | Building 29, Room 150 | February 1994 |
| XTE | Ethernet | TCP/IP | 10 | 2 | Building 20, Room 80 | February 1994 |
| XTE | 2 Ethernet | TCP/IP | 10 | 10-20 | Building 3, Room S38E | December 1994 |
| FAST/Poker Flats, Alaska | RS422 | TCP/IP | .0086 | 2 | Poker Flats, Alaska | April 1994 |
| XTE | RS422 | TCP/IP | .056 | 1 | San Diego, CA | May 1994 |
| XTE | RS422 | TCP/IP | .056 | 1 | Boston, MA | May 1994 |
| Nascom | Ethernet | TCP/IP | 10 | 1 | Building 12 | May 1994 |
| XTE | Ethernet | TCP/IP | 10 | 1 | Building 7/10 | April 1995 |
| SWAS | RS422 | TCP/IP | .224 | 1 | Boston, MA | June 1994 |
| HST | 2-RS422 | TCP/IP | 1.536 | 10 | Baltimore, MD | |
| XTE | Ethernet | TCP/IP | 10 | 1 | Building 2, Room 256 | March 1995 |
| TRMM | Ethernet | TCP/IP | 10 | 5 (TBD) | Building 32, Room W251 | June 1995 |
| TRMM | 2 Ethernet | TCP/IP | .336 | 20 (TBD) | MSFC | July 1995 |
| TRMM | 1 Ethernet | TCP/IP | .336 | 1 | LaRC | July 1995 |

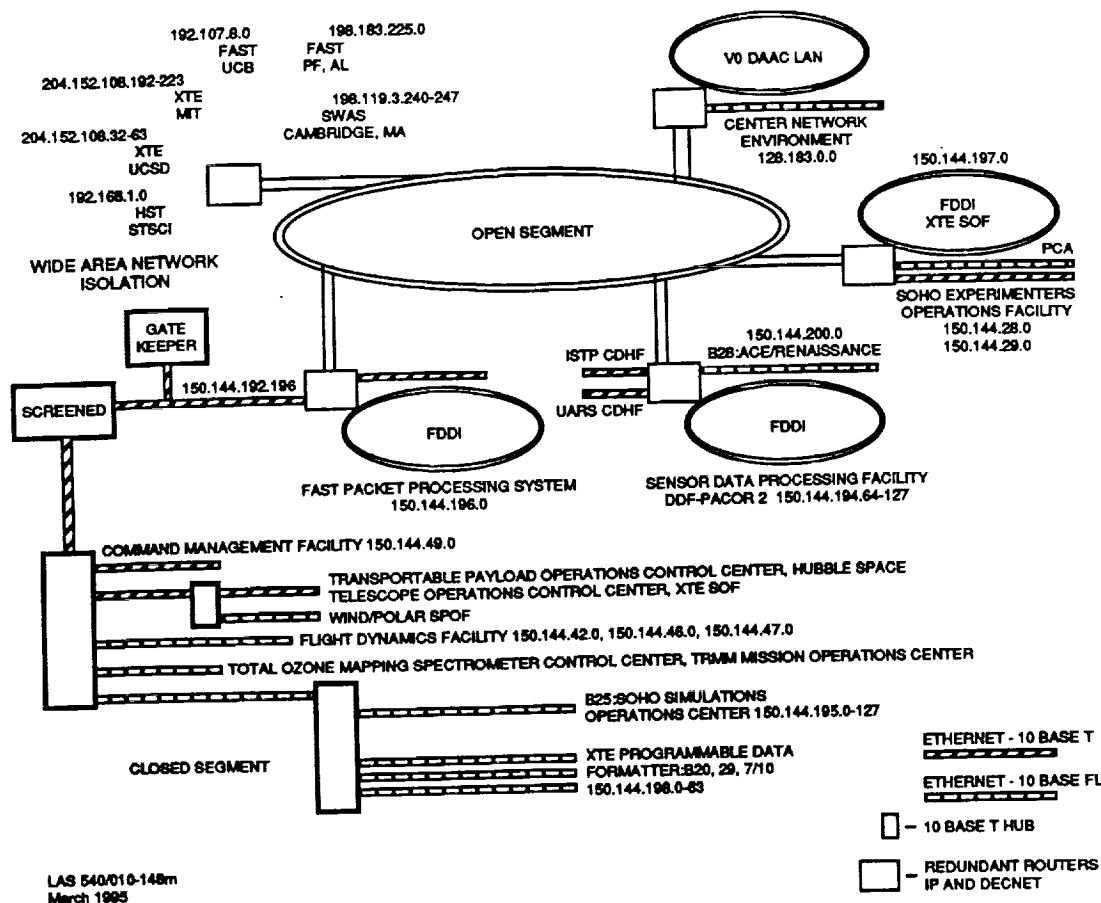
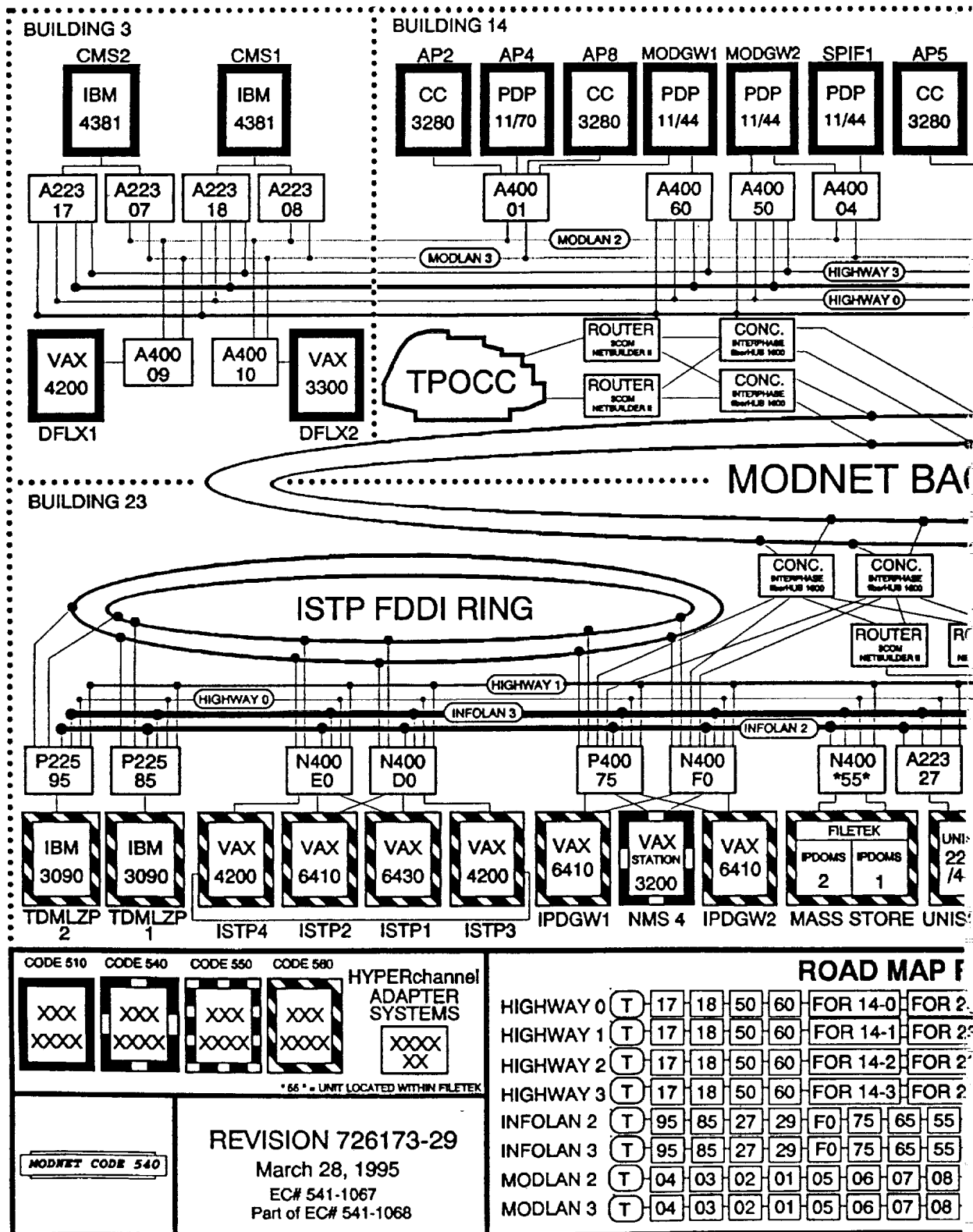


Figure 14-19. MODNET/NOLAN System Diagram

are utilities that allow file transfers between hosts. They are not Government Open System Interconnection Profile (GOSIP)-compliant protocols.

The following systems are connected to the MODNET:

| | | |
|----------|--------------|---|
| Code 510 | CMS 1, 2 | Command Management System |
| Code 510 | DFLX 1, 2 | Command Management System |
| Code 510 | DOCS 1, 2 | Data Operations Control System |
| Code 510 | MODGW 1, 2 | MODLAN Gateway provides isolation to the MSOCC MODLAN trunks |
| Code 510 | SPIF 1, 2 | Shuttle/POCC Interface Facility |
| Code 510 | AP 1-8 | Applications Processor |
| Code 550 | FDF 3, 4, | Flight Dynamics Facility |
| Code 560 | IPDGW1, 2 | InfoLAN Gateway |
| Code 560 | IPDOMS 1 & 2 | Mass Storage System |
| Code 560 | UNIS 2200 | Telemetry Facility |
| Code 560 | UARS 1, 2 | Upper Atmosphere Research Satellite Central Data Handling Facility |





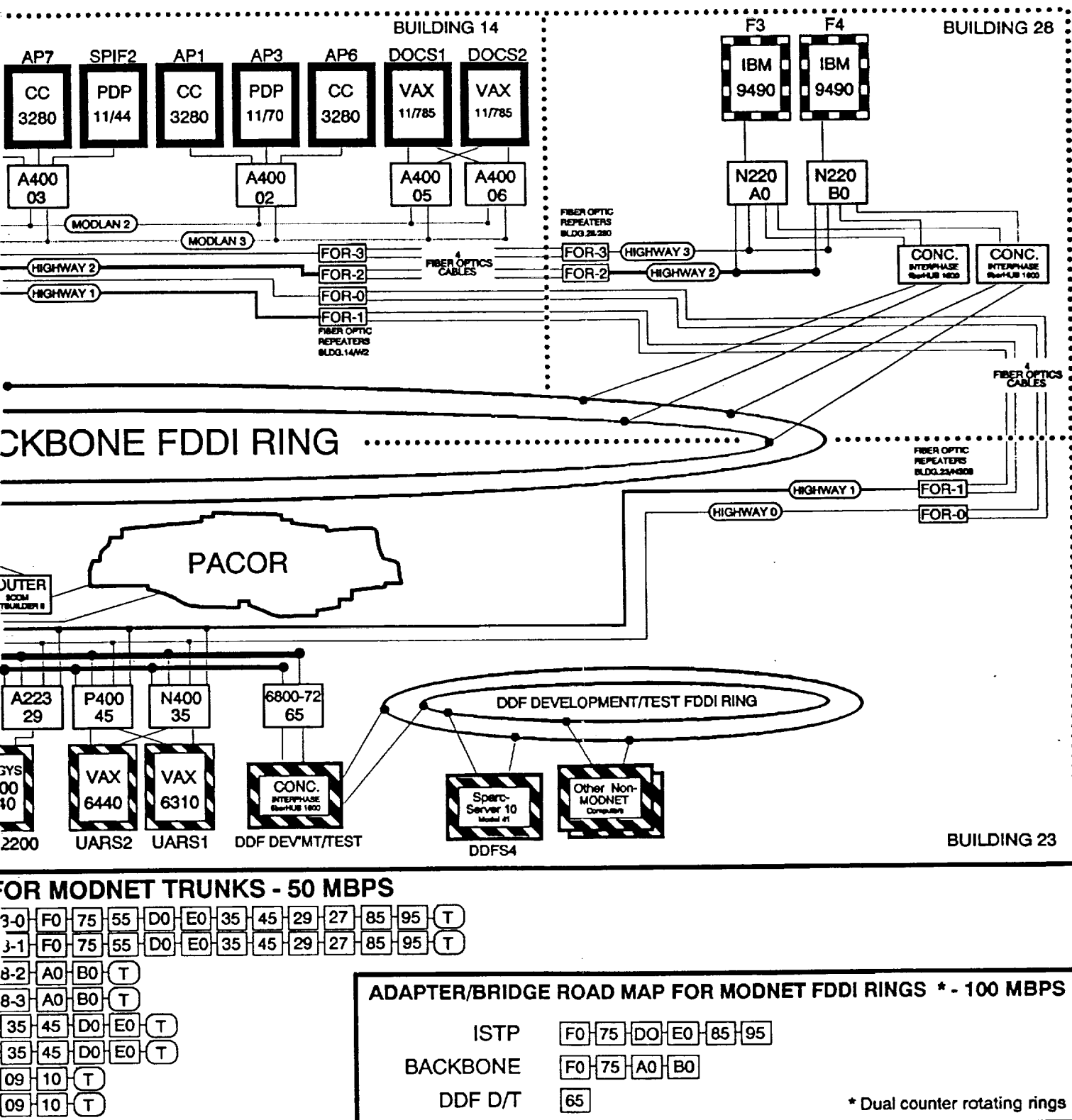


Figure 14-20. MODNET Operational Baseline Configuration

| | | |
|----------|-----------------|--|
| Code 560 | TDMLZP 1 & 2 | Time Division Multiplex Level Zero Processor. Up- grade to Telemetry Online Processing System |
| Code 560 | ISTP 1-4 | International Solar Terrestrial Physics Program |

14.5.8.5 MODNET IP Connections

TCP/IP has been selected for use as users migrate to GOSIP-compliant protocols. TCP/IP is used on both MODNET and NOLAN. As there is currently no requirement for a gateway between TCP/IP and NETEX, none will be provided.

The following systems are connected to MODNET using IP:

| | | |
|----------|-----------|---|
| Code 510 | CMF | Command Management Facility |
| Code 510 | SOHO | Solar and Heliospheric Observatory |
| Code 510 | TPOCC LAN | Transportable Payload Operations Control Center Local Area Network |
| Code 513 | TOMS-EP | Total Ozone Mapping Spectrometer - Earth Probe |
| Code 520 | FAST LZP | Level Zero Processor |
| Code 550 | FDF | Flight Dynamics Facility |
| Code 560 | PACOR II | Packet Processor |
| Code 560 | DDF II | Data Distribution Facility |

14.6 Space Shuttle Program Network Support

14.6.1 Space Shuttle Program Support Overview

The forms of support provided by the STDN Ground and Space Networks and by many other special Space Shuttle supporting ground stations, including the Nascom special support arrangement with the Space Shuttle Program (SSP), are described in this paragraph. It should be mentioned that GSFC, Code 500 has the responsibility to act as the "lead range" for the SSP, i.e., to arrange all of the T&DA support required by JSC for the SSP. Nascom provides most of the operational communication interconnections as part of that responsibility. The Space Shuttle Program is conducted by JSC using the launch facilities at KSC. Tracking stations operated by ER, WR, WSMR, United States Electronic Proving Ground (USAEPG), DFRF, GSFC managed ground stations, and JPL's DSN provide T&DA functions for the Shuttle. In addition, several stations and facilities of the DOD, various off-net remote sites and contractor locations are used.

NOTE

The circuits mentioned throughout the following paragraphs are mostly provided using Nascom-2000 services. Refer to Section 5 for a discussion of the Nascom-2000 services.

14.6.2 STDN GN Support for SSP

The communications support provided or sponsored by GSFC via the STDN/ground stations for Space Shuttle operations is described in the following paragraphs.

14.6.2.1 GN S-band Station Support

The following GN S-band stations support the Space Shuttle Program:

- a. Bermuda – BDA.
- b. Wallops Flight Facility – WFF.
- c. Merritt Island – MIL.
- d. Ponce De Leon – PDL.

14.6.2.2 GN Augmented Support

The GN is augmented by the 26-meter stations of the DSN located at Canberra, Australia (CAN), Goldstone, California (GDS), and Madrid, Spain (RID). These stations provide S-band support. Unless otherwise indicated, the following stations, mostly DoD, provide C-band radar tracking support:

- a. Edwards AFB, CA AFFTC – Tracking (Air Force Flight Support Test Center).
- b. Antigua Island ANT – Tracking support.
- c. Ascension Island ASC – Tracking support.
- d. Bermuda BDA – C-band tracking support and range safety command.
- e. Cape Canaveral, FL CNV – Tracking support.
- f. Dryden Flight Research Facility, CA DRF – S- and C-band support tracking.
- g. Jonathan Dickinson, FL JDI – Tracking support.
- h. Kwajalein Island KWJ – Tracking support.
- i. Kaena Point, HI KPT – Tracking support.
- j. Mount Lemmon, AZ MTL – Tracking support.
- k. Patrick AFB, FL PAT – Tracking support.
- l. Point Mugu, CA PMT – Tracking support.
- m. Point Pillar, CA PTP – Tracking support.
- n. San Nicholas Island, CA SNI – Tracking support.
- o. Vandenberg AFB, CA VNB – Tracking support.
- p. Scott Peak, AZ SPK – Tracking support.
- q. White Sands Missile Range, NM WHS – Tracking support.

14.6.2.3 GN Downlink Processing

The Space Shuttle Phase Modulated (PM) real-time, unencrypted, high data rate downlink is 192 kb/s; this 192 kb/s downlink is comprised of two digital voice channels at 32 kb/s per channel and Shuttle telemetry data at 128 kb/s. An alternate low data rate of 96 kb/s is comprised of a single digital voice channel at 32 kb/s, plus Shuttle telemetry data at 64 kb/s. The Shuttle also has an FM downlink which may be used (1) by the Orbiter operations recorders or the payload recorders to dump data at various rates up to 1.024 Mb/s, or (2) for downlink of Orbiter television to MIL, GDS or VAFB.

Because the Dakar station no longer supports Shuttle S-band downlink data, the one basic mode of operation for the remaining GN stations is the throughput mode. The throughput mode of operation is made possible by use of 224 kb/s data circuits between the ground stations and the Nascom switching center.

- a. **Real-time Telemetry/Voice.** The 192 kb/s downlink is bent-piped through the ground station and transmitted to the GSFC Nascom Switching Center via a 224 kb/s circuit. Nascom then message switches the data blocks for transport via the MDM system to JSC. JSC demultiplexes the voice and telemetry and converts the voice signals from digital to analog form. MIL/PDL, GDS, BDA, WFF, and DFRF can support both the 96-kb/s or 192 kb/s downlinks and transmit the data to GSFC on 224 kb/s circuits.
- b. **Dump Data Telemetry.** Orbiter operations recorder data and payload recorder playback data are telemetered to the ground station at 960 kb/s or 1.024-Mb/s. The dump data is analog recorded on-site, rate reduced, and transmitted at a 128 kb/s rate over the 224 kb/s circuit to the GSFC Nascom Switching Center where it is message switched to JSC. Data is output by the ground station in a store-and-forward mode, post-pass.

14.6.2.4 GN Uplink Processing

There are two schemes for uplinking data: (1) High Data Rate (HDR) at 72 kb/s with the composite uplink comprised of two digital voice channels at 32 kb/s each and one command channel at 8 kb/s; and (2) Low Data Rate (LDR) at 32 kb/s with the composite uplink comprised of one digital voice channel at 24 kb/s and one command channel at 8 kb/s. In either case, the uplink is composed by JSC and encrypted there prior to transmission to the GN sites for uplink to the Orbiter.

As with the S-band downlink, there is only one mode for the S-band uplink now that Dakar no longer provides support; namely, the throughput mode.

- a. **Command/Voice.** JSC outputs a stream of 72 kb/s (the HDR) to the GSFC Nascom Switching Center on the MDM system. At GSFC, the 72 kb/s uplink data is circuit switched to BDA, MIL/PDL, GDS, WFF, and DFRF via 224 kb/s circuits. The sites in turn uplink the data stream to the Orbiter. In the case of MIL, both the 32 kb/s and 72 kb/s data streams are switched to the station. JSC instructs MIL which of the two streams is to be uplinked. It should also be noted that MIL, BDA, and DFRF are capable of directly receiving Shuttle return link S-band data in the TDRS mode.

This feature provides a backup capability during Shuttle landings, but only for that period of time when the Shuttle is in RF line-of-sight view of one of these stations.

- b. **Command Echo.** Each station has the capability to echo the command/voice uplink data to JSC. Command echo is used as a troubleshooting and prepass verification tool. Since command echo data is transmitted from the station to GSFC on the telemetry lines, echo cannot be enabled while telemetry data is being transmitted. At GSFC, command echo data is message switched to a discrete MDM channel and transmitted to JSC. Only one station at a time may transmit command echo data.

14.6.3 Special Space Shuttle Ground Stations

The special Space Shuttle ground station is a NASA designation of NASA field centers or cooperating agencies that directly support SSP mission operations. These ground stations are described in the following paragraphs.

14.6.3.1 Dryden Flight Research Facility, CA

DFRF is an S-band landing support station. Telemetry, command, and UHF A-G are transmitted between JSC and DFRF during the landing phase. Also, after the Shuttle lands and the crew leaves the vehicle, DFRF transmits telemetry data to KSC via GSFC and MIL until Orbiter power down (a period that may last up to 105 hours). Some postlanding telemetry is also transmitted to JSC. DFRF also transmits tape recorder dumps to JSC post STS landing. DFRF has been provided with Communications Data Formatters (CDF) by GSFC to block this data.

14.6.3.2 Kennedy Space Center

The KSC Launch Control Center (LCC) provides launch control functions. It also receives all Shuttle real-time telemetry from supporting ground stations via GSFC/MIL. The MIL station deblocks the data received from the JSC SKR and transmits it to KSC/LCC via the KSC wideband system in serial form. This data is also transmitted from the KSC/LCC area to Rockwell International at Downey, CA, via JSC. JSC, in turn, forwards the data to Rockwell Downey.

14.6.4 Nascom Special Support Arrangement for SSP

14.6.4.1 Overview of Nascom Support

Nascom is providing a Shuttle-unique configuration of communications circuits between JSC and the various support stations, centers, and ranges via the GSFC switching center, remote switching facilities at both KSC/CD&SC, and the West Coast Switching Center (WCSC) at JPL, Pasadena, CA, and other switching and patching arrangements. Except for a few DoD-provided circuits, Nascom provides all necessary ground communications facilities to link these supporting elements for exchange of data and information. The JSC interfaces with the GSFC MSS over MDM channels of an independent Nascom-provided JSC/GSFC 2.5 Mb/s and GSFC/JSC 2.5 Mb/s wideband system (BDS). The White Sands Complex, in return, broadcasts a 6 Mb/s wideband composite data stream to both JSC and GSFC.

14.6.4.2 GSFC MSU Support

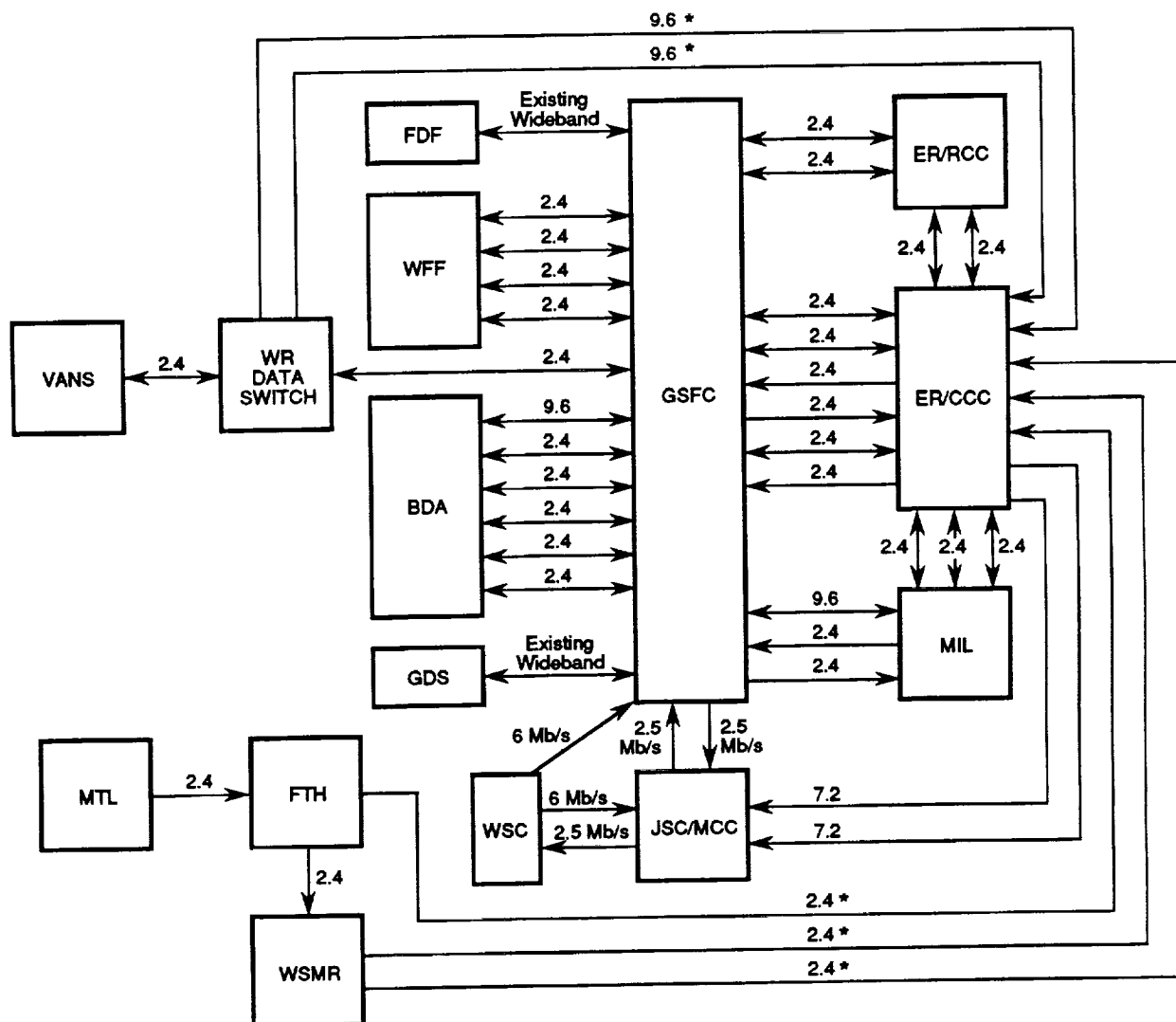
The MSU essentially performs the same function for Shuttle-type data as it does for all blocked data.

The MSU outputs blocks (received from the ground stations over their 224 kb/s lines) to JSC. In addition, all telemetry blocks (including postlanding data) are sent to KSC via MIL, using the GSFC/MIL 224 kb/s circuit and the KSC-provided wideband circuit from MIL to KSC/LCC. This telemetry data is also transmitted from the KSC/LCC to Rockwell International in Downey, CA, via JSC.

14.6.4.3 Nascom HSDS Support

The configuration of the HSDS data circuit provided by Nascom for the Space Shuttle Program is illustrated in Figure 14-21. Nascom and DoD provide various high-speed data communications channels operating at rates of 2.4, 7.2, and 9.6 kb/s for transmission of C-band and S-band tracking data, launch and landing acquisition data, telemetry parameters, and range safety command data to support Space Shuttle launches, landings, orbital operations, and range safety functions. The high-speed data circuits implemented for Shuttle support are described in items a through e.

- a. **S-band Tracking Data.** One full-duplex 9.6 kb/s tracking data circuit is provided between GSFC and ground stations MIL, BDA, and GDS (via JPL). Data received on these circuits is switched by GSFC to JSC/MCC via the wideband circuit and to FDF via existing wideband circuits. These circuits are used for launch and landing support. One simplex 2.4 kb/s S-band tracking data circuit each from BDA and MIL to ER Central Computer Complex (CCC) at CCAFS are provided for range safety support during all KSC launches. The BDA circuit is routed through GSFC to CCC. The MIL circuit is routed directly to CCC, but the data is also transmitted to GSFC/FDF.
- b. **C-band Tracking Data.** One full-duplex 2.4 kb/s C-band tracking data circuit between BDA and ER/CCC and two full duplex 2.4-kb/s C-band tracking data circuits between WFF and ER/CCC are routed via GSFC and provided for range safety support. The backside of the BDA-to-GSFC circuit and the backside of one of the WFF-to-GSFC circuits are used by Nascom to transmit ER/CCC-originated Launch Trajectory Acquisition System (LTAS) 2.4 kb/s data to BDA and WFF. The following items further describe the high-speed data circuits provided by Nascom to accommodate the C-band tracking data.
 1. Two simplex 9.6 kb/s data circuits from WR data switch to ER/CCC are provided by DoD for transmission of high sample rate C-band tracking data. Data from up to four radars can be multiplexed and transmitted over each circuit.
 2. Two simplex 2.4 kb/s data circuits from WSMR computers to ER/CCC are provided by DoD for transmission of high sample rate C-band tracking data. Data from two radars is reformatted, multiplexed, and transmitted on each of the two 2.4 kb/s circuits.
 3. One simplex 2.4 kb/s data circuit from Fort Huachuca (FTH), AZ, to ER/CCC is provided by DoD for transmission of high sample rate C-band tracking data.



LEGEND:

* DoD-provided

NOTE:

All data transmission rates are in kb/s unless otherwise noted

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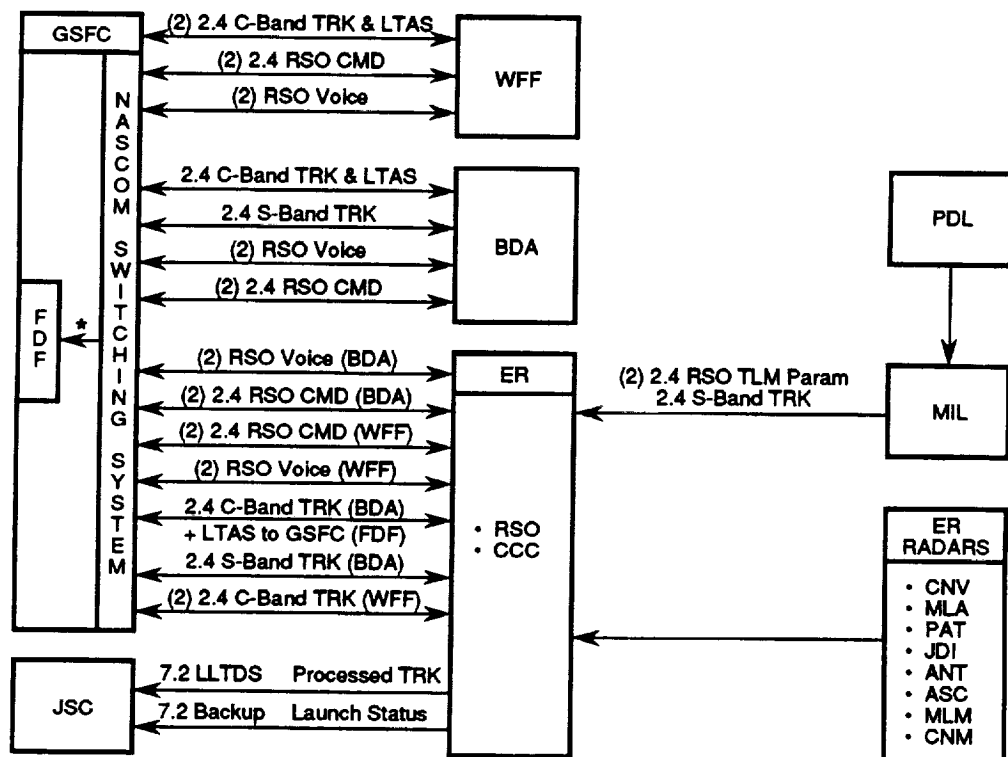
Figure 14-21. Space Shuttle High-speed Data Circuit Configuration

Data from both the SPK and MTL radars are multiplexed and transmitted on the 2.4 kb/s circuit.

- c. Launch and Landing Trajectory Data System Tracking Data. Two full-duplex 7.2 kb/s circuits are provided between ER/CCC and JSC/MCC. These circuits are used for simultaneous transmission of Launch and Landing Trajectory Data System (LLTDS) 7.2 kb/s data to JSC/MCC during all launches and landings.
- d. Launch and Landing Acquisition Data. One simplex 2.4 kb/s LTAS (Launch Trajectory Acquisition System) data circuit is provided between ER/CCC and GSFC. This data is also extended directly to MIL (not via GSFC). The LTAS data received at

GSFC on this circuit is extended to BDA and WFF for all KSC launches. The data is also extended to DFRF on existing circuitry. One simplex 2.4 kb/s LTAS acquisition data circuit is provided from ER/CCC to Nascom for all EAFB landings. This circuit is extended from GSFC to GDS and DFRF. The data is used by GDS as an acquisition aid during Shuttle landings at EAFB.

- e. **Range Safety Officer Launch, Telemetry, and Command Data.** The configuration of the Space Shuttle Range Safety Officer (RSO) launch circuitry is illustrated in Figure 14-22. The ER RSO monitors and coordinates the launch of the Shuttle via Nascom and DoD-provided 2.4 kb/s data circuits. These circuits carry C-band and S-band tracking data, RSO telemetry parameters, command data, and LTAS data. Designated NASA and DoD stations provide the ER/CCC with C-band and S-band tracking data and S-band RSO telemetry parameters which are processed by the CCC and transmitted to the RSO for use in range safety coverage of the Shuttle launches. Two 2.4 kb/s range safety command circuits between BDA/WFF and ER/Range Control Center (RCC), provide the RSO with the capability to activate the command equipment at those two locations. The following describes the Nascom-provided high-speed data circuits.



LEGEND:
 * C-band + LTAS from CCC (WFF, BDA, ER)

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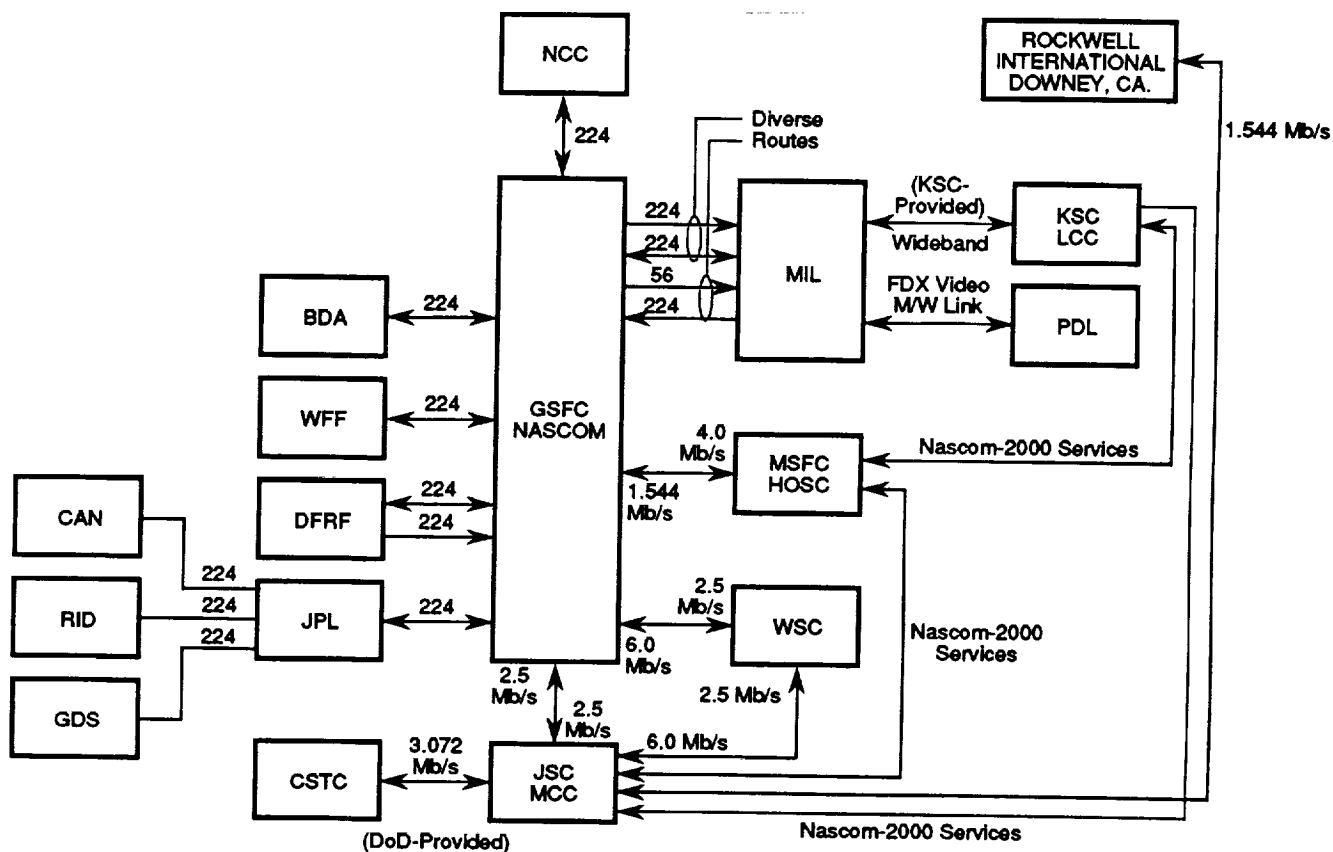
Figure 14-22. Space Shuttle RSO Launch Circuitry

1. Two full-duplex 2.4 kb/s command data circuits are provided from ER/RCC at CCAS to BDA and WFF via Nascom. Command data is routed to each station on two circuits: one prime, and one backup. The two circuits to each location are diversely routed where that capability exists.
2. Three simplex 2.4 kb/s circuits are provided from MIL to ER/CCC. During the Shuttle launch phase, MIL selects two of the four RSO telemetry parameter data streams from PDL, BDA, WFF, and MIL and transmits them to ER/CCC for processing and further transmission to RSO.

14.6.4.4 Nascom WBDS Support

The configuration of the Space Shuttle wideband data circuitry is illustrated in Figure 14-23. Wideband data circuits are provided by Nascom for transmission of telemetry, command, and other Shuttle-related data. These circuits support GN stations, various special ground stations, GSFC NCC and FDF in support of the Space Shuttle Program.

- a. GSFC-JSC. Two full-duplex MDM-terminated data circuits, a prime and an alternate, are provided between GSFC and JSC. These circuits are used for transmission of all Shuttle-related data from the GN and NCC to JSC, and for JSC transmission of all Shuttle-related data to the GN. Restoration-diversity is available between GSFC and JSC.
- b. GSFC-STDN. Wideband service to Space Shuttle supporting ground stations is accomplished in the following manner. The 224 kb/s circuits are extended between the GSFC Nascom Switching Center and the following STS ground support stations: MIL/PDL, DFRF, BDA, and WFF. These circuits are used to transport Shuttle downlink (multiplexed voice and telemetry) and other Shuttle-related data to GSFC for further transmission to JSC, and for transmission of the uplink (multiplexed commands and voice) and other Shuttle-related data to these stations. Further detail on these circuits is provided on a site-by-site basis.
 1. GSFC-MIL/PDL. One full-duplex 224 kb/s MIL to GSFC wideband circuit is provided for MIL transmission of Shuttle telemetry and other Shuttle-related data through GSFC to JSC. One 56 kb/s GSFC to MIL wideband circuit is provided for GSFC transmission of JSC-originated 32 kb/s commands and other Shuttle-related data to MIL. Additional 224-56 kb/s wideband circuits are implemented between GSFC and MIL for the transmission of PDL telemetry data via GSFC to JSC, and for the GSFC transmission of JSC-originated 72 kb/s commands to MIL/PDL. The backside (GSFC to MIL) of the full-duplex 224 kb/s circuit referenced above is used for the transmission of all real-time and postlanding Shuttle telemetry [Serial KG Recombiner (SKR)] data to KSC/LCC via GSFC and MIL. This telemetry data is transmitted from JSC SKR to GSFC via the MDM and from GSFC to MIL via the previously referenced 224 kb/s circuit, and from MIL to KSC/LCC via existing KSC wideband circuits. The wideband circuits provided for MIL and PDL data transmissions between MIL and GSFC are diversely routed. All telemetry (including postlanding data) is transmitted from the KSC/LCC area to Rockwell in Downey, CA via JSC.



NOTE:

All transmission rates are in kb/s unless otherwise noted

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Figure 14-23. Space Shuttle Wideband Data Circuit Configuration

2. GSFC-DFRF. One full-duplex 224 kb/s circuit is provided by Nascom-2000. DFRF transmits Shuttle 192 kb/s return link multiplexed voice and telemetry data to GSFC on the 224 kb/s circuit for further transmission to JSC via the MDM. This 224 kb/s circuit is also used by DFRF to receive multiplexed command and voice uplink data from JSC via GSFC. A second Nascom-2000, 224 kb/s circuit allows DFRF to play back the operations recorder dump data to GSFC for relay to JSC concurrent with real-time telemetry support during postlanding operations. The first 224 kb/s circuit is also used for DFRF to transmit postlanding Shuttle telemetry to KSC via GSFC. This requirement is for all EAFB landings and is required for up to 105 hours after landing.
3. GSFC-BDA, GSFC-GDS, and GSFC-WFF. One full-duplex Nascom-2000 224 kb/s wideband circuit is provided to each of these stations for support of the Orbiter. BDA, GDS, and WFF each transmit Shuttle 192 kb/s telemetry data to GSFC for further transmission to JSC via the MDM system. The GSFC-to-BDA, GSFC-to-GDS, and GSFC-to-WFF side of the 224 kb/s circuit is used for transmission of 32 or 72 kb/s uplink data from JSC.

NOTE

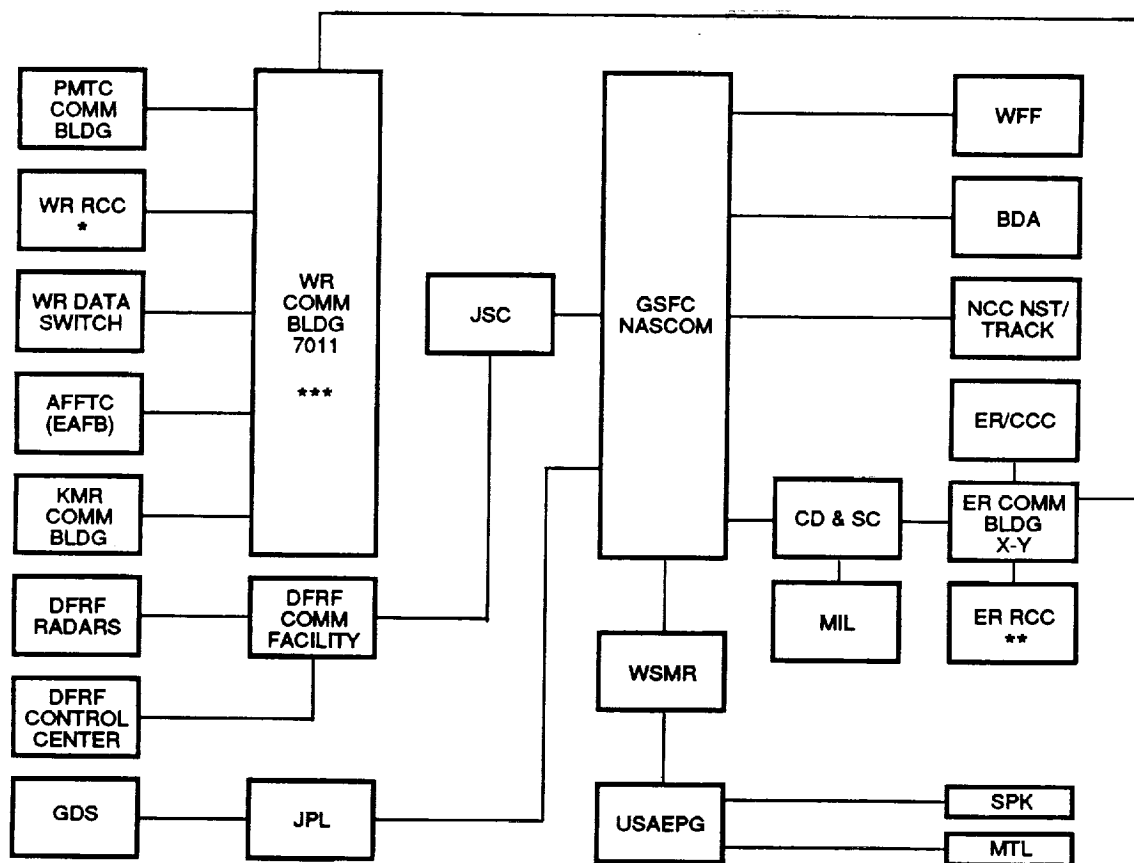
Data to and from Goldstone is routed through JPL using Nascom-2000 services. Nascom no longer provides direct connectivity (a one-hop path) to GDS from GSFC.

- c. JSC-750 SGL. The Air Force Consolidated Satellite Test Center (CSTC) also supports Shuttle/Orbiter flights. CSTC provides a directly routed wideband multiplexed link (3.072 Mb/s) extending Orbiter uplink/downlink data support between its Network Control Facility at Onizuka AFS, CA, and the JSC/MCC. (NOTE: neither the circuit nor the equipment on which the circuit terminates is a Nascom resource; the MDM equipment is Air Force property and the circuit is Air Force leased.)

14.6.4.5 Nascom Voice System Support

Voice circuits for site coordination, video conferences, air-ground communications, and communications technical coordination are provided by Nascom and DoD. JSC is linked by voice circuitry with GSFC, KSC, MSFC, DFRF, Northrop Strip (NS), VAFB, and Rockwell International at Downey, CA. Shuttle-unique voice circuits are also provided between GSFC and all ground stations, ER, WR, and the NCC at GSFC. Dedicated voice circuits are furnished for voice commentary to accompany the video channels supporting Shuttle missions. These voice circuits are routed directly between JSC and DFRF, KSC, GSFC, NS, and ground video-support stations. The routing distance of each video-accompanying voice circuit must be the same as for its companion video circuit to assure sight-sound synchronization (lip sync). Figure 14-24 illustrates the Space Shuttle tracking coordination voice circuit configuration.

- a. Switching and Conferencing. Switching and conferencing of these voice circuits is accomplished by GSFC voice control under the direction of flight control personnel at MCC. An exception is that two A-G circuits between JSC and DFRF are routed directly between the two locations rather than via GSFC. The following voice network circuit designations are used for the Shuttle program.
- b. Site Coordination. Site coordination voice circuits are provided to the supporting stations and centers. These circuits support two distinct functions: (1) coordination among MCC, NCC, and ground stations, and (2) the Nascom orderwire to supporting stations.
- c. Air-to-Ground Circuits. The following items describe the A-G circuits:
 - 1. A-G1. The A-G1 circuit is provided between GSFC and all supporting ground stations. These circuits are extended from GSFC voice control to MCC via voice-data quality channels and are used primarily by flight crew members for S-band and UHF A-G communications with MCC. S-band A-G communications are generally via digital voice in the MCC uplink command stream (32 kb/s or 72 kb/s) and the telemetry downlink (192 kb/s or 96 kb/s).
 - 2. A-G2. The A-G2 circuit fulfills the same basic functions as A-G1. When a Mission Specialist is aboard the Shuttle, the A-G2 circuit is normally used by this



LEGEND:

- * Coordination with PTP, VDB, KPT, and KMR is through WR RCC
- ** Coordination with CNV, MLA, PAT, JDI, ANT, and ACS radars is through ER RCC
- *** WR COMM extends circuit to AFFTC, PMTC, and KMR COMM building for further extensions as required

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Figure 14-24. Space Shuttle Tracking Coordination Voice Circuit Configuration

person for S-band A-G communications with POCCs, MCC, and other personnel involved in payloads. During launches and landings, the A-G2 circuit is normally used for UHF A-G communications. Only five ground stations have UHF A-G capability in addition to S-band capability. S-band A-G communications are generally via digital voice in the MCC uplink command stream (32 kb/s or 72 kb/s) and the telemetry downlink (192 kb/s or 96 kb/s). Dakar now has a UHF A-G only capability.

3. A-G Longline. The MIL station is provided additional A-G longline circuits directly to JSC for prelaunch checkout of the Space Shuttle and for extension of UHF A-G service to JSC. [NOTE: JSC digitizes and encrypts both the 32-72 kb/s (A-G voice and commands) prior to transmission to Shuttle via TDRSS or GN.]

- d. **Tracking Coordination.** DoD and Nascom voice circuits are used to join BDA, DFRF, GDS, MIL, WFF, and the GSFC/Network Engineering Support Team (NEST) Track; JSC/MCC; the WR RCC responsible for coordination of VNB, PTP, KWJ, and KPT radars; Pacific Missile Test Center (PMTTC) responsible for coordination of the three SNI radars; the Dryden Radar Controller responsible for coordination of DFRF radar; the ER RCC responsible for coordination of CNV, MLA, PAT, JDI, ANT and ASC radars; the WSMR Controller responsible for coordination of White Sands radars; and the FTH Controller responsible for coordination of SPK and MTL radars. (See Figure 14-24.)
- e. **Range Safety Officer.** Two four-wire voice circuits are configured on launch days directly between BDA, WFF, and ER RSO. These circuits are diversely routed and function as primary and backup. They are extended by GSFC voice control to KSC CD&SC where KSC extends them to the ER XY Building for conferencing to RSO primary and backup circuits.
- f. **TV Conference Voice Circuits.** Television conference voice circuits are for TV coordination between video support locations at JSC, GSFC, NGT, KSC, MSFC, DFRF, GDS and MIL. The circuits are also extended to individual GEAM domestic satellite earth stations (JSC, GSFC, KSC/MIL, MSFC, DFRF and GDS) for voice coordination when these Earth stations are participating in Shuttle TV transmissions.

NOTE

Control of the uplink, including switching it from station to station, is exercised from GSFC. By the simple act of entering the proper code via a touch tone pad, the GSFC TV controller can automatically and remotely switch the uplink to and from any one of the uplink equipped stations: GSFC, JSC, KSC/MIL, DFRF, GDS, and MSFC. The GSFC TV controller announces when the uplink is about to be switched by saying, "On my mark, switch the uplink from ... to Mark." At that point, the command to switch the uplink is transmitted and the uplink is automatically switched.

- g. **Contingency Landing Sites.** Voice circuits are provided between JSC/MCC and contingency landing sites using existing DoD and NASA resources.

14.6.4.6 Nascom Video System Support

The Space Shuttle video circuit configuration is illustrated in Figure 14-25. Commercial-grade color television support of the Shuttle Program is provided by Nascom for all flight phases (prelaunch, launch, orbital, and landing). These video circuits link the JSC to KSC, GSFC, MSFC, DFRF, and selected GN/DSN Shuttle-supporting stations largely through the use of the Nascom Video Transponder Service (NVTS) operating on GTE SATCOM SN2 Transponders 5/3 on a full-period basis. SN2-5 is designated as "NASA Select One" and SN2-3 is designated as "NASA Select Two." Video circuits also link the key supporting

stations (GDS, MIL and NGT) with JSC mission control for in-flight video transmissions. A video circuit from NS to JSC will be provided as soon as possible after determination that an AOA or EOM landing will take place at NS. A program voice channel accompanies each video circuit to allow appropriate support voice commentary, coordination and conferencing as needed. The NASA administrator has indicated that coverage of Shuttle and other NASA events should be given the widest possible dissemination; however, the first priority for use of SN2-5/SN2-3 transponders is to cover operational support of Shuttle and other NASA spacecraft. Scheduling of these two transponders is done by the Nascom Scheduling Office in accordance with the following priority system:

- a. Shuttle operational support.
- b. Other NASA spacecraft operational support.
- c. Public Affairs Office.
- d. Systems and engineering testing.

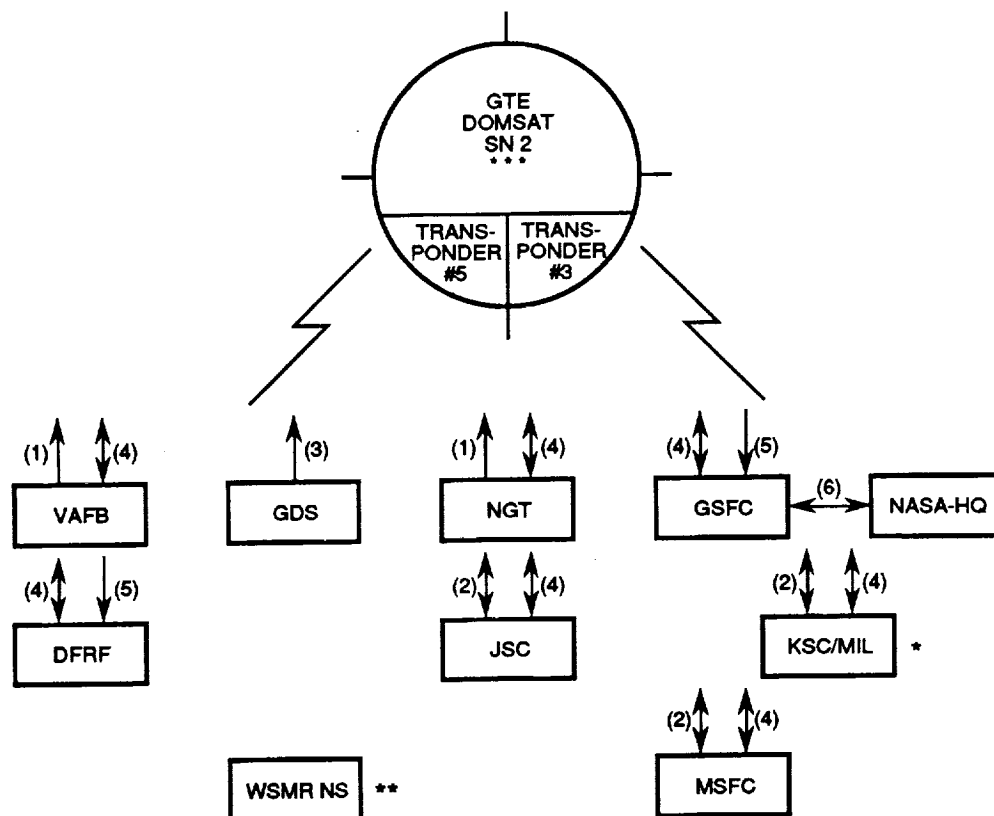
Specific support provided by the Nascom Video System is described as follows:

a. NASA Select One (Transponder SN2-5).

1. The KSC uplinks launch support scenes and information from approximately launch minus 5 hours through lift off sequences. When shuttle is out of view of KSC controlled cameras and all playbacks have been accomplished, uplink is transferred from the KSC to the JSC.
2. JSC normally will maintain uplink capability throughout orbital support periods. This allows JSC to uplink the color converted Shuttle video which is normally not available until after payload bay door opening. Since video communications via TDRSS cannot be established prior to payload bay door opening, any required video transmissions are by the FM downlink (received by either MIL, or GDS). In such cases, the SN2-5 uplink is made available to the station receiving the video for transmission to JSC. JSC then color converts this video, records it on tape and waits until video receiving ground station has LOS. SN2-5 uplink is then transferred to JSC for transmission of the color converted video. JSC normally maintains uplink capability on SN2-5 until payload bay door closing (prior to reentry phase) at which time uplink is transferred to DFRF or KSC, as appropriate, to cover the landing phase of the mission. For an Edwards AFB landing, VAFB's long range optical cameras are normally the first to receive pictures of Shuttle during reentry. When VAFB reports the Shuttle in view of their optical cameras, the SN2-5 uplink is transferred to VAFB and remains with them until acquisition of Shuttle via DFRF optical cameras at which time uplink is transferred back to DFRF. The uplink remains with DFRF through landing, crew egress, crew welcome and any other crew activity at DFRF. For a KSC landing, the uplink remains with KSC for the duration of landing activities.

b. NASA Select Two (Transponder SN2-3)

1. KSC uplinks on the multiplexed JSC mission evaluation room (MER) and MSFC HOSC ice team selected pad camera video SN2-3 commencing early in



LEGEND:

- (1) Uplink only, Transponder 5
- (2) Uplink/downlink, Transponder 5
- (3) Uplink only, Transponder 3
- (4) Uplink/downlink, Transponder 3
- (5) Downlink only, Transponder 5
- (6) NASA-leased fiber optic circuit. GSFC can extend any video signal received on Transponders 5/3 to NASA HQ

* GE Earth station located at KSC services both KSC and MIL. MIL has the capability to receive Shuttle downlink video and extend it to KSC via cable for uplink on Transponder 3.

** WSMR (NS) currently has no capability to transmit video to JSC or other NASA locations. Should it be determined during a Shuttle mission that the Shuttle will make an AOA or EOM landing at the NS, then Nascom will arrange for temporary Earth station service at the NS to uplink video on Transponder 5 or 3.

*** GEAM leases transponders from GTE.

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Figure 14-25. Space Shuttle Video Circuit Configuration

the minus count (approximately L minus 12 hours) through liftoff and subsequent tape playbacks.

2. After payload bay doors are opened, the SN2-3 uplink is transferred to NGT. This allows NGT to transmit either K-band Shuttle field sequential video, up to 4.2 MHz analog, or the 48 Mb/s STAT MUX data to GSFC, JSC, and MSFC. The SN2-3 uplink normally remains with NGT throughout the mission.
- c. White Sands Space Harbor (Northrup Strip). There is no in-place video service capability from the WSSH NS to JSC and GSFC for AOA or EOM landing support.

After a determination has been made that the NS will be used for either an AOA or EOM landing, an arrangement with a commercial carrier is made for a temporary video uplink service from NS.

- d. All video transmitted via the GEAM video circuit is received by all users in the Nascom video network. Launch, landing and certain orbital video is extended to Washington TVOC for release to the commercial networks. Video validation testing from GDS, MIL, NGT, MSFC, KSC, VAFB and DFRF to JSC is conducted prior to each launch. All video engineering, implementation, scheduling, procedures and operational control for the use of the video systems are accomplished by the Nascom Division, Operations Management Branch, Code 542.

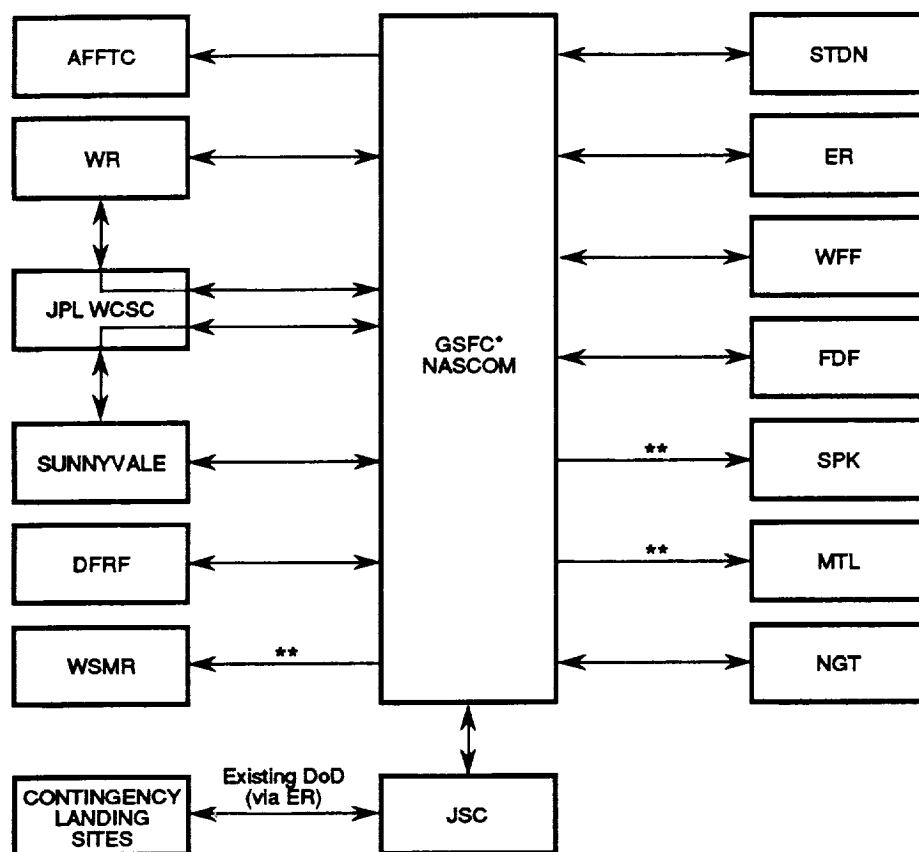
14.6.4.7 Nascom LSN System Support

The Space Shuttle LSN circuit configuration is illustrated in Figure 14-26. Nascom provides LSN circuits to the Shuttle-supporting ground stations, CSTC, and the DoD locations involved in the Shuttle Program. LSN circuits are provided between the GSFC Nascom Switching Center and the ground stations, WFF, and CSTC. Simplex LSN circuits link the GSFC switching center to MTL and SPK. A simplex, 1200-baud circuit is provided from GSFC to the WSMR Operations Center. LSN services are described as follows:

- a. GSFC-GN Circuit. Full-duplex LSN circuits are provided between GSFC and all Shuttle-supporting ground stations. One circuit to each site is used for acquisition and tracking data.
- b. GSFC-WR Circuit. A full-duplex, 1200 baud LSN circuit is provided between GSFC and WR for transmitting FDF-originated acquisition data to WR and receiving C-band tracking data from WR for distribution to FDF and JSC. The WR communication switch extends this circuit to the WR supporting C-band tracking stations.
- c. GSFC-ER Circuit. A 1200 baud LSN full-duplex circuit is provided between GSFC and ER for transmitting FDF-originated acquisition data to ER and receiving C-band tracking data from ER for distribution to FDF and JSC. ER extends this circuit to its supporting C-band tracking stations.

14.6.4.8 Meteorology Interactive Data Display System

JSC developed a centralized weather support system capable of processing various types of weather data to aid in the preparation of weather forecasts. This system also permits distribution of weather forecast products to users of the information. The Meteorological Interactive Data Display System (MIDDS) is a complex, highly interactive hardware and software system based on an embedded computer designed to acquire, monitor, store, retrieve, reformat, manipulate and display weather-related data. It enables a forecaster to build a display base by blending satellite and conventional data obtained from a variety of sources into a visual format through interactive manipulation.



LEGEND:

- * 8-level (ASCII) employed throughout
- ** Simplex LSN circuits from GSFC directly to WSMR, SPK, and MTL for GSFC transmission of acquisition data.

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Figure 14-26. Space Shuttle TTY Circuit Configuration

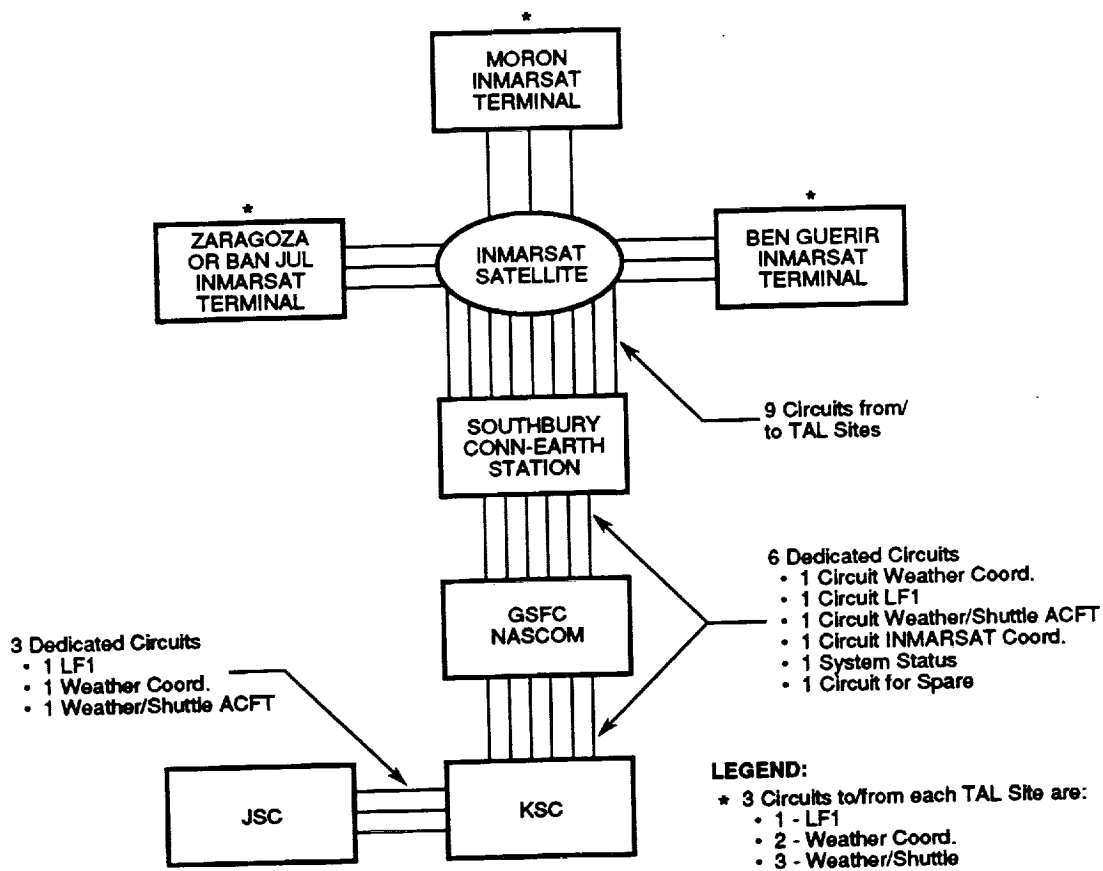
Nascom provides the communications circuits with various locations interacting with the MIDDS. Dedicated common carrier services support the MIDDS network. Services currently available are:

- a. 1-56 kb/s FDX CCAS RCC to JSC.
- b. 1-224 kb/s SPX Wallops Building N162 to JSC.
- c. 1-56 kb/s FDX Suitland National Meteorological Center to JSC.
- d. 1-9.6 kb/s FDX JSC - EAFB Weather Station Building 1200.
- e. 1-4.8 kb/s FDX JSC - EAFB Rocket Propulsion Lab, Building 8255.
- f. 1-9.6 kb/s FDX JSC - MSFC Building 4663.
- g. 1-56 kb/s FDX CCAS - MSFC Building 4663.
- h. 1-4.8 kb/s FDX JSC/Daytona Weather Radar.

- i. 1-4.8 kb/s FDX Tinker AFB to CCAS MIDDs.
- j. 1-1.33 Mb/s SPX Wallops CDA (NOAA) to JSC.
- k. 1-1.33 Mb/s SPX Gilmore Creek CDA (NOAA) to JSC.
- l. 1-9.6 kb/s FDX WSMR to JSC.
- m. 0.4 kb/s FDX WSMR to JSC.
- n. 2-9.6 kb/s FDX CCAS to JSC.
- o. 1-4.8 kb/s FDX Tinker AFB to JSC.
- p. 1-166.67 kb/s SPX METEOSAT III data from WPS to JSC.
- q. 1-9.6 kb/s FDX Melbourne Weather Service to JSC (NEXRAD) .

14.6.4.9 Transoceanic Abort Landing (TAL) Site Communications

NASA has arranged for the use of landing fields at Moron and Zaragoza, Spain; Ben Guerir, Morocco; and Banjul, The Gambia, in the event that a transoceanic abort landing is required. Nascom has arranged for use of the International Maritime Satellite Organization (INMARSAT) system services for communications to these remote locations. KSC provides the transportable INMARSAT communications terminals at the TAL sites. The INMARSAT Earth Station in Southbury, CT, is the Nascom interface for these INMARSAT services. Each TAL site has three INMARSAT voice circuits to the Southbury Earth Station: WeatherCoord, LF1 and Weather/Shuttle. Southbury conferences these lines and interfaces them to Nascom over three circuits. An additional three voice circuits between Nascom and Southbury are provided for System Status, INMARSAT Coord, and Spare. GSFC Nascom extends these six circuits to KSC. In turn, KSC extends the conferenced TAL site circuits to JSC. The configuration for TAL site communications using the INMARSAT system is shown in Figure 14-27.



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Figure 14-27. TAL Site Communications

Section 15. Nascom Planning for NASA Missions

15.1 General

15.1.1 NASA Mission Definition

This section describes the mission and project-unique support planning Nascom provides for NASA missions. The term "NASA mission," as used in this document, refers to any NASA or cooperating agency spaceflight operation which is to be supported in any manner on the NASA Network(s) and/or by the Nascom System sponsored by NASA HQ, Code O.

15.1.2 Categories of Nascom-supported Missions

The NASA missions that involve Nascom support can generally be categorized as follows:

- a. SN-supported missions.
- b. GN-supported expendable launch vehicle missions.
- c. STDN/Nascom support of STS payloads.
- d. DSN-supported missions.

MO&DSD Document 501-803, "Mission Requirements and Data Systems Support Forecast," provides a compilation of summarized mission descriptions as well as STDN link support coverage requirements for categories a, b and c. Missions of the d category are summarized in the DSN 870-14, "Deep Space Network Mission Support Requirements." Missions that involve committed STDN support for near-Earth phases of deep space missions are also listed in 501-803.

15.1.3 Mission Support Planning

15.1.3.1 General

Normally, Nascom will support missions institutionally on existing systems, and will attempt to share circuits and interfaces to the extent possible. However, Nascom will plan to provide mission-unique services and interfaces when necessary. Nascom cognizance of each planned NASA mission is maintained by a cadre of individually assigned specialists to ascertain as early as possible the imminence of a communications requirement impact. With this awareness imparted to the Division, Nascom can plan and budget support services and enlist engineering and operations planning resources in a timely, economical, and effective fashion. For the same reasons, and in the same manner, Nascom maintains cognizance of ongoing missions and their extended support requirements, commitments, and/or support termination dates.

15.1.3.2 Nascom Planning Support

Nascom planning for support of individual projects (e.g., TDRSS users) will involve: (1) defining the local or remote control center or data capture facility, the interfaces required to

the BDS or HDRS, and the data rates and required extension of local and remote circuits for data distribution; (2) developing coordinated planning configuration codes for simplified scheduling and configuration of required data flows; and (3) defining circuit requirements that may be required for payloads in the prelaunch phases for compatibility testing and verification at contractor plants or at payload preparation and integration facilities at the launch complex.

15.1.3.3 External Planning Coordination Interface

The Nascom mission planning specialists maintain close coordination with counterparts in the Flight Mission Support Office (Code 501) of GSFC MO&DSD; GSFC Flight Project Directorate (Code 400) personnel; and with counterparts in JSC, MSFC, JPL, and other NASA centers; and in other agencies (e.g., DoD and NOAA). The Nascom Mission Planning Section undertakes to sponsor a continuing mission-oriented Intercenter Communications Working Group (ICCWG), and participates in other mission planning working groups (i.e., Shuttle Operations Intercenter Working Group, and Mission Operations Working Group). For the interplanetary and deep space missions, Nascom undertakes continuing close coordination with JPL's DSN/GCF network and mission planners, including semiannual inter-divisional conferences for information interchange on DSN mission support requirements, and network support development activities.

15.1.3.4 Requirements Documentation

Nascom Mission Support Planners provide input to communications requirements placed in official requirements documentation (UDS, MRR/DMR, PIP, etc.), and maintain detailed cognizance of such requirements documentation for the Division (refer to paragraph 1.7.1).

15.1.3.5 Division Long-range Mission Planning

High-level, long-range development planning for support of such major NASA missions as International Space Station or Earth Observing System (EOS) is accomplished at Division management levels through participation in Directorate planning activities. More directly, the Engineering Branch and the Advanced Development Section of Code 541 sponsor and conduct R&D and development planning studies related to such missions (refer to Section 16). These activities are conducted in coordination with the MO&DSD's Advanced Data Systems Study Manager, the Code 502 Systems Management Office and its respective Data Systems Managers (DSM); coordination is also maintained with NASA HQ Level III Program planning offices and with appropriate Code O planning offices.

15.1.3.6 Nascom Mission-unique Support Services

Nascom will provide, on an as needed basis, mission-unique communication support services in the form of engineering study and design, new interfaces, new circuit procurement (leasing) and equipment procurement and installation, provision for testing and monitoring, and technical and administrative services. Mission-related Nascom-provided support (institutional and unique) for specific missions is described in the following paragraphs.

15.2 Space Network-supported Missions

15.2.1 Overview of SN-supported Missions

Table 15-1 summarizes the future approved missions through approximately 1998 to be supported by the TDRSS. Table 15-2 summarizes the current TDRS-supported ongoing missions. The TDRSS-supported missions are considered in the context that Nascom provides support to these missions as an element of the SN. The table information has been extracted from 501-803. 501-803 provides additional information such as support coverages required, when known, for each identified mission. Unique Nascom launch and landing, and on-orbit contingency support configurations for the STS/Orbiter have been described in Section 14. STS on-orbit TDRSS support is included in Table 15-2.

15.2.2 Review of Selected TDRSS-supported Missions

The TDRSS-supported missions selected for description in this paragraph are the following:

- a. Landsat-4/5 (Nascom HDRS-supported). On-going mission-unique arrangements described.
- b. Spacelab (Nascom HDRS-supported) generic support described.
- c. Hubble Space Telescope (HST). On-going support, STS servicing mission planning.
- d. Gamma Ray Observatory (GRO). On-going support, mission-unique ground systems extensions.
- e. Upper Atmosphere Research Satellite (UARS). On-going TDRSS support.
- f. International Space Station (ISS).
- g. Earth Observation System (EOS).
- h. Large Explorer Missions.

15.2.3 Landsat - 4/5 Mission

15.2.3.1 Landsat Mission Description

The on-orbit spacecraft are currently being supported on the SN system with contingency support provided by the DSN. Two Landsat-4 solar panels have failed, requiring optimum power management operations and limited daily support to provide Thematic Mapper (TM) data.

- a. Thematic Mapper. The TM downlinked data will be received on a KSA "I" channel at the full 84.903-Mb/s data rate and configured through the HRBS to a tape recorder (record mode). When scheduled by the NCC, the recorder output will be connected to channel 1 of the SM for playback of the TM data at half speed to produce a 42.4515-Mb/s data rate. The digital data output of the SM will be routed through the HRBS switches for transmission directly back to the Landsat DAF.
- b. Multiple Spectral Scanner (MSS) Data. The MSS downlinked data will be received on a KSA "Q" channel at 15.06 Mb/s. It may be connected through the HRBS to

Table 15-1. TDRSS-supported Missions Planned (Note 1) (1 of 2)

| MISSION (ACRONYM) | MISSION TITLE (APPROVAL STATUS) DOCUMENTATION | LAUNCH VEHICLE/ SITE/DATE/ LANDING SITE | SUPPORT PERIOD/ ORBIT | ON-ORBIT MAXIMUM DATA RATES (KB/S) BY SERVICE TYPE | | | | | | | |
|--|---|--|---|--|----------------|------------|------------|---------------------|------------|------------|------------|
| | | | | SMA FWD | SSA/KSA FWD | MA RTN | SSA RTN | KSA RTN (Note 2) | | | |
| | | | | | | | | | | | |
| AXAF-S | ADVANCED X-RAY ASTROPHYSICS FACILITY SPECTROSCOPY (APPROVED) AXAF AMO-2000 REQUIREMENTS FOR THE MRR AND DMR AXAF-101 PROGRAM REQUIREMENTS DOCUMENT (10/82) AXAF OPERATIONS PANEL MEETING MINUTES NASA/MSFC (6/22-23/83) | STS-92 KSC 7/98 | 3 YEARS 97.9 DEG 850 KM CIRCULAR | 1.0 | .125, 1.0 | 16 (RT) | 16 (RT) | 16 (RT) | 16 (RT) | 16 (RT) | 16 (RT) |
| EOS | EARTH OBSERVING SYSTEM (MULTI-MISSION OBSERVING SYSTEM) PROJECT PLAN FOR THE EOS (9/94) EOS MISSION OPERATIONS CONCEPT DOCUMENT (3/93) EOS AMT MRR (11/82) EOS PMT MRR (4/93) | ATLAS II VAFB 8/08 ATLAS II VAFB 8/04 ATLAS II VAFB 8/10 TBD VAFB 12/00 TBD VAFB 12/08 TBD VAFB 12/12 TBD TBD 8/99 TBD TBD 8/03 TBD TBD 8/11 | 6 YEARS (EACH) 98.2 DEG 708/708 KM CIRCULAR 6 YEARS (EACH) 98.2 DEG 708/708 KM CIRCULAR 6 YEARS (EACH) ORBIT TBD | 1.0 | RNG | 16 (RT) | 16 (RT) | 16 (RT) | 16 (RT) | 16 (RT) | 16 (RT) |
| AMT, 2, 3 | | | | | | | | | | | |
| PMT, 2, 3 | | | | | | | | | | | |
| PA/TI, 2, 3 | | | | | | | | | | | |
| LALT, 2, 3 | | | | | | | | | | | |
| CHEM, 2, 3 | | | | | | | | | | | |
| EURECA (UP TO 5 MISSIONS) | EUROPEAN RETRIEVABLE CARRIER (LAUNCH/ RETRIEVE) NSTS EURECA PIP JSC-14088, REV D | STS-47 KSC 10/87 EAFB STS-92 KSC 7/98 EAFB | 10 YEARS (PROGRAM) 10 DAYS 28.5 DEG 350 KM 9 DAYS 28.5 DEG 296 KM | | | | | | | | |
| 2R | | | | | | | | | | | |
| ISS | INTERNATIONAL SPACE STATION ALPHA STATION - ADDENDUM TO PIP (11/93), SSP 60017 (3/94) SEQ. UPDATE (7/94) RUSSIA AS THE PRIMARY DEVELOPER U.S. AS THE PRIMARY DEVELOPER JAPAN AS THE PRIMARY DEVELOPER EUROPEAN SPACE AGENCY AS THE PRIMARY DEVELOPER | (LAUNCH VEHICLE, LAUNCH SITE, AND LANDING SITE - TBD FOR ALL LAUNCHES 4/92, 5/98, 6/98, 7/98, 11/98, 2/99, 5/99, 9/99, 10/00, 8/00, 10/00, 11/00, 5/01, 10/01 11/97, 12/97, 6/98, 9/98, 11/98, 12/98, 3/99, 4/99, 7/99, 9/99, 11/99, 12/99, 8/00, 10/01, 12/01, 2/02, 5/02, 8/02, 8/02 | TBD 61.6 DEG 444 KM CIRCULAR | | | | | | | | |
| 1R, 2R, 3R, 4R, 5R, 6R, 7R, 8R, 9R, 10R, 11R, 12R, 13R, 14R 1A, 2A, 3A, 4A, 5A, 6A, 7A, 8A, 9A, 10A, 11A, 12A, 13A, 14A, 15A, 16A, 17A, 18A, 19A 1A, 1A, 1A, 2A, 2A 1E, 2E | | | | | | | | | | | |

Note 1: Source documents STON 803 Dec 1993/Jen 1994
 Note 2: Orbiter/Specialist Capabilities - Rates on Ch. 2: 25, 40, 1.0, or 2.0 Mb/s (HRM), or 960/1024 orbiter recorder dumps.
 Note 3: Orbiter/Specialist Capabilities - Rates on Ch. 3: mode 1: 2, 16, 32 Mb/s (HRM), or 48 Mb/s (direct access channel)
 Note 4: Shuttle unique services for payload or attached payload data
 Note 5: PL data via STS KSA RET Link Chan 1 (192 kba) via JSC/MCC PDIS
 Note 6: PL data via STS KSA RET Link Chan 2 (up to 2.0 Mb/s) via HRM or orbiter recorder (1024 kba)
 Note 7: PL data via STS KSA RET Link Chan 3 (up to 48.0 Mb/s) via HRM mode 1
 Note 8: PL video or analog data via STS KSA RET Link Chan 3 mode 2
 Note 9: POCC CMDS via JSC/MCC via SSA forward service, 32 or 72 kba/s

LEGEND:
 () Contingency

LORAL 540010-258/ajm
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Table 15-1. TDRSS-supported Missions Planned (Note 1) (2 of 2)

| MISSION (ACRONYM) | MISSION TITLE (APPROVAL STATUS) DOCUMENTATION | LAUNCH VEHICLE/ SITE/DATE LANDING SITE | SUPPORT PERIOD/ ORBIT | ON-ORBIT MAXIMUM DATA RATES (KB/S) BY SERVICE TYPE | | | | | | | |
|-------------------------|--|--|---|--|------------------------|----------------------|---------|---|--|--------------------------|---|
| | | | | 8MA FWD | SSA/KSA FWD | MA RTN | SSA RTN | KSA RTN (Note 2) | | | |
| | | | | Q | Q | Q | Q | Q | Q | Q | Q |
| LANDSAT-7 | LANDSAT-7 (APPROVED) LANDSAT-7 DMR, SDR DRAFT, 11/93 | DELTA II VAFB 5/98 | 5 YEARS 705-4-5 KM | 1.2 | 11.5 (144 OMBII) | 11.5 | 11.5 | 6.0 (RT) 300 (PB) (1.2 OMBII) | 6.0 (RT) 300 (PB) | 300 MB/s | |
| LDBP (SERIES) | LONG DURATION BALLOON PROGRAM (APPROVED) LDB SIRD, REV 1 (5/91) | BALLOONS FROM MCMAURDO 12/94 | 10-90 DAYS (EACH) 78 DEG SOUTH (4-5) 40 KM | TBD | TBD | 1-10 (2 BALLOONS) | TBD | TBD | TBD | | |
| SL-M | SPACELAB-MIR MISSION INTEGRATION PLAN JSC 21277 CH3 JUNE 1994, PIP ANNEX 5, JUNE 1994 | STS-71 KSC 5/24/95 KSC STS-74 KSC 10/28/95 STS-77 KSC 3/20/96 STS-80 KSC 7/31/96 | 10 DAYS 51.6 DEG 314-381 KM TBD TBD | | [5] MSFC POCC | [5] MSFC POCC | | | | [2] 48 MB/s or (4) | |
| STARLINK | STARLINK MIR, MAY 1994 DMR (DRAFT), AUGUST 1994 | ER-2 ARC 8/95 | 6-8 FLIGHTS/YEAR 1-10 HOURS DURATION | | 400 ARC POCC | | | | | <150 MB/s | |
| TRMM | TROPICAL RAINFALL MEASURING MISSION TRMM MRR (1/93) TRMM DMR (7/94) | H-II TANEGASHIMA, JPN 8/97 | 3 YEARS 35 DEG 350 KM CIRCULAR | | 5 1.0 RING | | | 32 (RT) | 128 (PB) or 2 MB/s (PB) 1.0 (RT) | | |
| USML-2 (SPACELAB) | SPACELAB UNITED STATES MICROGRAVITY LABORATORY (APPROVED) STS USML-2 PIP JSC-21115, BASIC (9/91) THRU CHANGE NO. 13 | STS-73 KSC 9/95 EAFB | 16 DAYS 28.5 DEG 286 KM | | [5] MSFC POCC | | | | | [4] VIDEO | (1) & (2) 125, 250, 500, or 1000 |
| USMP-3, 4 (SPACELAB) | SPACELAB UNITED STATES MICROGRAVITY PAYLOAD (APPROVED) STS USMP-3 PIP NSTS-21248, BASIC (4/94) THRU CHANGE NO. 1 | STS-75 KSC 2/08 STS-87 KSC 8/97 | 16 DAYS 28.5 DEG 286 KM | | [5] MSFC POCC | | | | | | |
| XTE | X-RAY TIMING EXPLORER XTE DMR (9/93) | DELTA II ER 8/95 | 2-6 YEARS 23 DEG 600 KM | 1.0 | RING | 1.0 | RING | 32 (RT) (2) | 32 (RT) (2) | 512 1024 (PB) | |

Note 1: Source documents STDN 803 Dec 1992/Jen 1994
Note 2: Orbiter/Spacelab Capabilities - Rates on Ch. 2: 25, 50, 1.0, or 2.0 Mbit/s (HRM), or 960/1024 orbital recorder dumps.
Rates on Ch. 3: mode 1-2, 18, 32 Mbit/s (HFM), or 48 Mbit/s (direct access channel)

LEGEND:
() Contingency

Notes for shuttle unique services for payloads or attached payloads data
(1) PL data via STS KSA RET Link Chan 1 (192 Kbit/s) via JSC/MCC PDIS
(2) PL data via STS KSA RET Link Chan 2 (up to 10 Mbit/s) via HRM or orbital recorder (1024 kbit/s)
(3) PL data via STS KSA RET Link Chan 3 (up to 10 Mbit/s) via HRM or orbital recorder (1024 kbit/s)
(4) PL video or analog data via STS KSA RET Link Chan 3, mode 2
(5) POCC GMS via JSC/MCC via SSA forward service, 32 or 72 kbit/s

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Table 15-2. TDRSS--supported On-Orbit Missions (1 of 2)

| Mission (Acronym) | Mission Title Documentation | Launch Date Orbit Inclination (I) | Support Period | Maximum Data Rates (Kb/s) by Service Type | | | | | | | | | | | | | | | | | |
|----------------------|---|--|--|---|-----|-----------------------|-----|----------------------|---------------------|-----|-----|--------------|--------------|-----|-----|-------------------|---|-----|---|-----|--|
| | | | | MA | | FWD | | SSA/KSA | | MA | | RTN | | SSA | | RTN | | KSA | | RTN | |
| | | | | I | Q | I | Q | I | Q | I | Q | I | Q | I | Q | I | Q | I | Q | | |
| BRTS | Bilateration Ranging Transponder System, 6 transponders (GSFC/FDF BRTS MOC) (Note 9) | NA | Life of TDRSS | - | RNG | - | RNG | .64 | .64 | .64 | .64 | .64 | .64 | .64 | .64 | - | - | - | - | | |
| ERBS | Earth Radiation Budget Satellite SIRD 5/82 | 10/05/84 575x592KM 1 = 57 | Thru 9/30/85 | 1.0 | RNG | | | 1.6 | 12.8/ 32 | | | 1.6 | 32/128 | | | - | - | - | - | | |
| EUVE/EP | Extreme Ultraviolet Explorer on Explorer Platform (new MMS) (GSFC MOC/PACOR) (SIRD REVISION 10/88/SORD 08/89) | 6/07/82 507x521KM 1 = 28 | Thru 6/30/86 | 1.0 | RNG | 1.0/ .125 | RNG | 1.0/32 | 1.0/32 | | | 1/32 | 1/32/ 512 | | | - | - | - | - | | |
| GRO | Gamma Ray Observatory SIRD 7/83 (GSFC MOC) | 4/05/81 450x450KM 1 = 28 | Thru 4/30/89 4/30/01 potential | 1.0 | RNG | 1.0 .125 | RNG | 1.0 32 | 1.0 32 | | | 1.0 32 | 1.0 32 | | | - | - | - | - | | |
| HST Note 1 | Hubble Space Telescope servicing missions baseline SORD 3/90 SM-2 7/97 STS-88 | 4/24/90 566x604 1 = 28 | Thru 4/30/05 | .125 | RNG | 1.0 (SSA) | RNG | 4.0 500 | 4.0 or 32 500 | | | 1.024 b/x | - | | | - | - | - | - | | |
| LANDSAT | Land Satellite-4 Land Satellite-5 | 7/16/82 697x708 1 = 98 3/01/84 699x706 1 = 98 | Indefinite- contingency/ emergency support only | 1.0 | RNG | 1.0 | RNG | 8 | 32 | | | 8 | 32/ 128 | | | 15 & 84.9 Mb/s | | | | | |
| TOPEX/ POSEIDON | Ocean topography experiment Joint US/French Mission (JPL POCC) JPL D-601 Rev.B 12/85 Prel SIRD 5/92 | 8/10/82 1336x1336 1 = 66 | Thru 8/31/85 7/31/97 potential | 1.0 | RNG | 1.0/ .125 (SSA) | RNG | 1.0 or 16.0 RT | 32 or 48.0 PB | | | 16.0 RT | 512 PB | | | - | - | - | - | | |

Table 15-2. TDRSS--supported On-Orbit Missions (2 of 2)

| Mission (Acronym) | Mission Title Documentation | Launch Date Orbit Inclination (I) | Support Period | Maximum Data Rates (kb/s) by Service Type | | | | | | | | | | | | | | | | | | | |
|-----------------------------------|--|---|--------------------------------------|--|---|-------------|-----|--|----|--------------|---|----|---|-----|---|-----|--------------|--------------|---|-------------------------------|---|---|--|
| | | | | MA | | FWD | | SSA/KSA | | FWD | | MA | | RTN | | SSA | | RTN | | KSA | | RTN | |
| | | | | I | Q | I | Q | I | Q | I | Q | I | Q | I | Q | I | Q | I | Q | I | Q | | |
| STS Note 2 | Space Transportation System Launch and Landing and Flight Operations PRDs, on file in ASRS, periodically up- dated | See STDN 803 | Up to 16 days per flight | | | | | SSA 32 or 72 (Note 3 KSA 72 or 216) (Note 4) | | | | | | | | | 96 or 192 | | | 4.2 MHz video (ch.3) | | 192 (ch.1) Note 6 960/ 1024 (ch.2) Note 7 | |
| UARS | Upper Atmosphere Research Satellite SIRD 2/85 (GSFC MOC/DCF/CDHF) | 9/12/91 575x591KM 1 = 57 | Thru 9/30/95 9/30/98 potential | 1.0 | RNG | 1.0 .250 | RNG | 32 or 1.0 | 32 | 32 or 1.0 | | | | | | | Note 5 | 32 or 1.0 | - | | | - | |
| Note 1: Note 2: Note 3: | Requirements indicated are for orbital support. SM require- ments are TBS Orbiter No. 102 Columbia Orbiter No. 103 Discovery Orbiter No. 104 Atlantis Orbiter No. 105 Endeavor SSA low rate TDM 8 kb/s plus 1 voice digital 24 kb/s (32 kb/s) SSA high rate TDM and 8 kb/s CMD plus 2 voice digital 32 kb/s each (72 kb/s) | | | Note 4: Note 5: Note 6: Note 7: Note 8: Note 9: | KSA low rate TDM and 8 kb/s CMD plus 2 voice digital 32 kb/s each (72 kb/s) KSA high rate TDM 72 kb/s CMD/voice plus 144 kb/s text and graphics (216 kb/s) (1 or 2) 32 kb/s digital voice plus orbiter and payload TLM (TDM) 2-32 kb/s digital voice plus orbiter and payload TLM (TDM) STS OPS recorder, time shared with payload data STS video time shared with payload video, analog, or digital data Transponder locations: Alice Springs (1) TDRSW Ascension (2) TDRSE American Samoa (1) TDRSW White Sands (2) TDRS EW | | | | | | | | | | | | | | | | | | |

channel 2 of the SM and transmitted back in real-time. An optional method of data handling will be to record and play back as described above for TM data, except that the recorded data rate of 15.06 Mb/s will be played back through the SM on channel 1 at either the real-time data rate of 15.0625 Mb/s or at twice the real-time data rate (30.125 Mb/s).

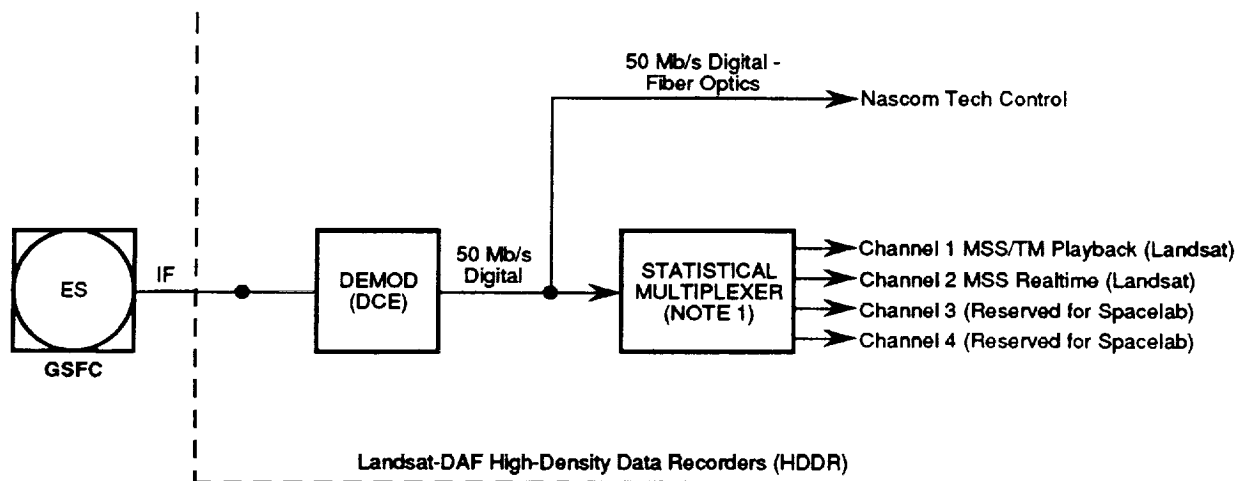
- c. **HDRS Load Consideration.** Present capacity of the HDRS is constrained (the Landsat-4/5 TM data rate exceeds current HDRS capacity), requiring store and forward operation. Contention for the SM system will occur when STS/Spacelab missions operate concurrently with Landsat. Increased high data rate communications services have received planning consideration in Nascom. In the immediate future, however, Nascom plans to support Landsat, Spacelab, and Space Shuttle video via the HDRS and STS video interfaces.

15.2.3.2 Landsat POCC

The Landsat 4/5 POCC Control and Simulation Facility (CSF) is located at 4300 Forbes Boulevard, Lanham, MD. In addition to the Lanham facility, a temporary building known as the Data Acquisition Facility (DAF) is located in the vicinity of Building 25 at GSFC. The DAF houses the High Density Data Recorders (HDDR) used to record the Multiple Spectral Scanner (MSS) and the Thematic Mapper (TM) payload data. The DAF also houses the Statistical Multiplexers (SM). All Nascom communications to the POCC and the DAF provide for tracking, telemetry, command, data transmission, and voice coordination services.

When operating via the SN, the Landsat POCC will transmit commands and receive spacecraft housekeeping telemetry, Real-time Clock (RTC) information and engineering data via the Nascom MDM/DMS baseline data transport system. The POCC will use a 56-kb/s circuit routed via the MSS for interaction with the NCC for arrangement of SN schedules. Both interfaces are provided within the Control and Simulation Facility (CSF) of the POCC.

- a. **Data Acquisition Facility.** The DAF functions as the Data Capture System for image data. The communications system is completely redundant. The incoming TM and MSS data is recorded for processing at a later time. The GSFC Domsat Earth station receives the downlink and transmits the data to the DAF at the Intermediate Frequency (IF). The Nascom common carrier-provided demodulator processes the signal to a composite baseband binary data stream for input to the SM. The SM outputs unblocked serial data to an assigned multiplexer output channel. The unblocked serial data is switched to the proper tape recorder in the DAF. MSS/TM playback data is assigned to channel 1. Channel 2 transports MSS data in real-time.
- b. **Nascom Responsibility.** Nascom is responsible for equipment maintenance and for ensuring that the equipment is operated in a manner to meet all performance specifications. Nascom technical control monitors the signals and assists the users in troubleshooting and fault isolation. The configuration for this arrangement is illustrated in Figure 15-1.



Landsat Data Rates from White Sands (TDRSS)

1. 15.06 Mb/s
2. 30.12 Mb/s. Recorder playback at twice the recorded rate of Multiple Spectral Scanner (MSS)
3. 42.4515 Mb/s. One half recorded speed of real-time (84.903 Mb/s) Thematic Mapper (TM)

NOTE 1:

- Statistical MUX capacity, 4 channels (2 assigned to Landsat)
- Up to 48 Mb/s each channel
- Data may be connected to all four channels with a combined rate no greater than 48 Mb/s

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Figure 15-1. GSFC-Landsat-4/5 Configuration

15.2.3.3 Nascom-unique Support for Landsat-4/5 Mission

The configuration of Landsat DAF is illustrated in Figure 15-1. As indicated in this figure, the Nascom SM of the HDRS may be considered the heart of the HDRS supporting function. The status of the SM is monitored at the Nascom Technical Control Center via the 50-Mb/s optical fiber circuit. The Landsat command and housekeeping telemetry portions of the mission are also supported by the BDS and other elements of the Wideband Data System. The support provided by these two systems is described in the following paragraphs:

- a. **Baseline Data System Support.** The BDS is the transport system used for extending 2 Mb/s and lower rate data from the WSC to GSFC. The system includes all telemetry and command data. Data is exchanged between the TDRSS user spacecraft and the user data capture facilities via the BDS MDM Data System.
- b. **Wideband Data System Support.** The Landsat POCC interface with the DSN for spacecraft telemetry, engineering data, and command, is via two full-duplex 56-kb/s interfaces via the Nascom Message Switch.

15.2.4 Spacelab Mission

15.2.4.1 Spacelab Mission Description

An overview of the Spacelab (SL) mission is given in the following paragraphs:

- a. **SL General Information.** The following itemizes the general information about the SL mission.

1. Program management responsibility for Spacelab is at MSFC, conducted by the Spacelab Payload Project Office (SPPO) and Spacelab Program Office (SLPO). Responsibilities include: SL POCC planning missions and defining the payloads and their integration requirements; implementation; delivery; SL payload test, Ground Support Equipment (GSE) at KSC; and managing tests and checkouts at KSC. MSFC will perform these responsibilities from the MSFC SL POCC facilities by monitoring and coordinating tests, and evaluating Spacelab real-time data for any future Spacelab missions. These latter responsibilities also result in requirements for transmission of SL science and engineering data from KSC and JSC to MSFC via GSFC.
 2. Real-time operational control and conduct of most SL missions is from the SL POCC element of MSFC. Spacelab operations control requires real-time direct delivery of all Spacelab data transmitted via the Orbiter/TDRSS, Ku-band links, and relayed through WSC and the HDRS directly to the MSFC POCC.
 3. Science data capture for nonreal-time processing is at the SLDPF at MSFC. Science data capture at SLDPF also requires real-time direct relay of Spacelab data via the SN/Nascom data transport systems.
 4. The development of the Spacelab Payload Mission/NASA/ESA was a cooperative effort. The German Space Operations Center (GSOC) at Oberpfaffenhofen, West Germany, has been implemented with a Payload Operations Center that acted as a remote POCC to the SL POCC for the D-1 and D-2 Spacelab missions. The German Payload Operations Center (GPOC) is operated by the German Deutsche Forschungsanstalt fuer Luft-und Raumfahrt (DLR) organization, which would be used for any follow-on ESA Spacelab missions. DLR would have responsibility for any U.S.-to-GPOC communications required.
 5. Planned future Spacelab missions to be supported by the SL POCC at MSFC are indicated in Table 15-1.
- b. Spacelab/Orbiter/WSC Communication Configuration. The following is a description of this configuration.
1. Spacelab will be located in the cargo bay of the Space Shuttle and will use the Orbiter Ku-band Signal Processor (KuSP) for transmitting data through the TDRSS system. The primary source of data from the Spacelab is the High Rate Multiplexer (HRM), which is used to multiplex the output of up to 16 experiments, as well as experiment housekeeping (ECIO) and Spacelab engineering (SSIO) data, and High Data Rate Recorder (HDRR) dumps. The HRM is capable of operating at rates in binary steps between 125 kb/s to 32 Mb/s, and at 48 Mb/s. WSC will use the High Data Rate Interface for transmitting this data over the domestic satellite system to the SLDPF and the Spacelab POCC at MSFC.
 2. Figure 15-2 illustrates the Shuttle/Spacelab signal processing mode "1" communications. Onboard the Orbiter, in mode "1" the Spacelab HRM will output data at 2 to 48 Mb/s over KuSP channel 3 between the Shuttle and the TDRSS.

WSC will receive the data on a KSA "Q" channel. The data will be configured through the HRBS to channel 4 of the SM. The 2 to 48-Mb-s data will be transmitted to SLDPF and the MSFC Spacelab POCC over the domestic satellite system. Additional sources of data for direct access to KuSP channel 3 are individual high rate experiments (if included in the mission) and the HDRR.

- Figure 15-3 illustrates the Shuttle/Spacelab signal processing mode "2" communications. In Spacelab signal processing mode "2," either CCTV video or high data rate analog data will be transmitted over KuSP channel 3 between the Shuttle and the TDRSS. WSC will receive the downlinked data and transmit via the video switch. Either video processing or analog routing facilities will be selected and the signals transmitted in broadcast to both JSC and MSFC Spacelab POCC. (Note: KuSP channel 3 aboard the Orbiter will support either Spacelab or Shuttle video on a time-shared basis.) The configuration of the communications for either Shuttle or Spacelab will be controlled by the MCC. The Shuttle and Spacelab video are switched in exactly the same manner at White Sands. Only Spacelab video is described here. The video will normally be transmitted over the direct Shuttle video transmission system, access to which is also implemented at WSC. However, the HDRS full-transponder service must be used to transmit Spacelab analog data, because the direct Shuttle video transmission service is not specified to the response requirements of Spacelab analog data.

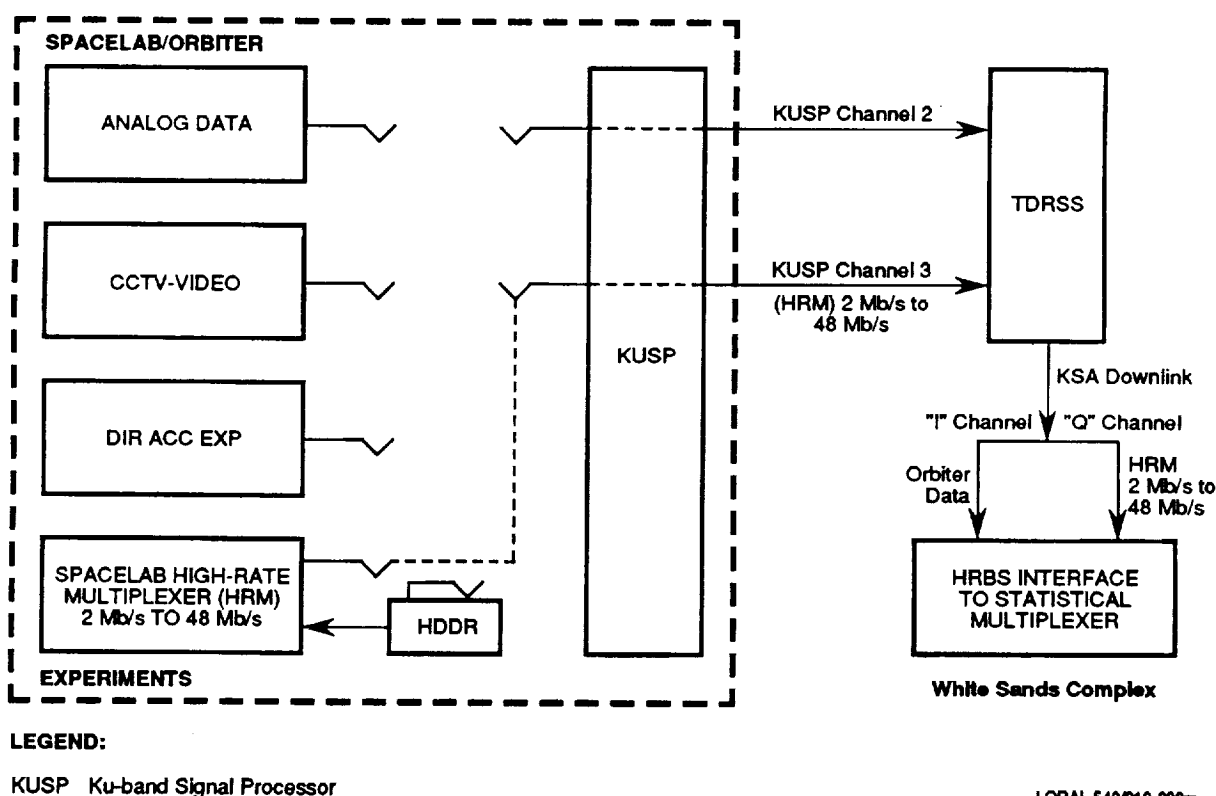


Figure 15-2. Shuttle/Spacelab Signal Processing Mode "1" Communications

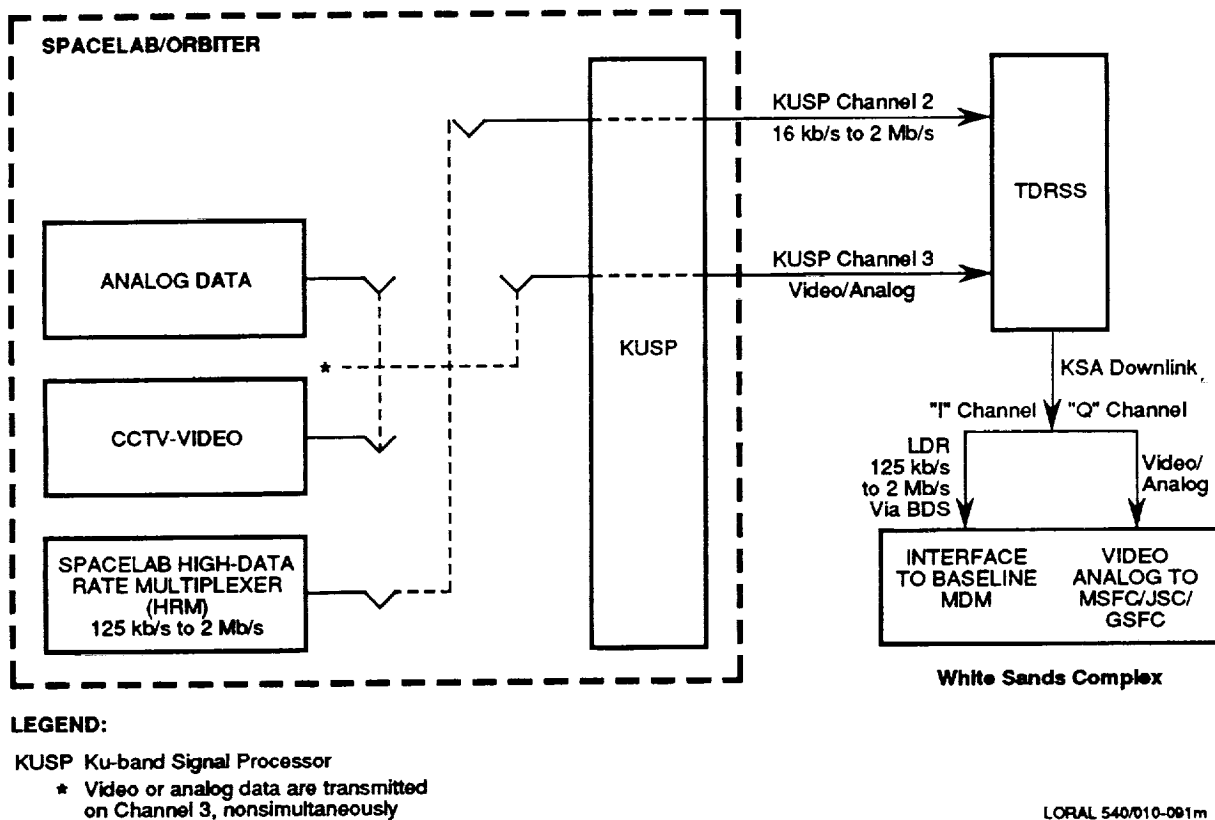


Figure 15-3. Shuttle/Spacelab Signal Processing Mode "2" Communications

4. Also in mode "2", the Spacelab HRM will be configured to output a relatively low data rate (2 Mb/s). The data is switched to KuSP channel 2 (which is capable of supporting data rates from 16 kb/s to 2.0 Mb/s) for transmission between the Shuttle and the TDRSS. WSC will receive the data on a KSA-I channel. Nascom transmits this Spacelab channel 2 data to both SLDPF and the Spacelab POCC over the baseline MDM system, or on SM channel 3 if the 2 Mb/s cannot be handled on the baseline MDM. It is also possible to tape record the data for playback over the SM at a later time.
- c. Spacelab POCC at MSFC. The following is a description of the Spacelab POCC at MSFC.
1. Figure 15-4 illustrates the MSFC/Spacelab data configuration. The Spacelab POCC at MSFC is the real-time control center for the Spacelab mission. Redundant IF signals are fed from a collocated Earth station to the POCC. The POCC has a backup SM, redundant communications equipment, test generators, bit error monitoring equipment and loopback facilities for self-checking the communications system. MSFC POCC personnel are responsible for oper-

ating all front panel controls and patch facilities, and for performing all local loopback tests for fault isolation.

2. A Nascom wideband link established between MSFC and GSFC is equipped with an MDM system for extending SL telemetry channels to the MSFC SL POCC. The MDM system provides 24 channels from GSFC to MSFC and 24 channels from MSFC to GSFC. The common carrier wideband data service is 4.0 Mb/s GSFC to MSFC, and 1.544 Mb/s MSFC to GSFC. The SL HRM data transmitted on Orbiter Ku-band channel 2, up to 2 Mb/s, is extended to the SL POCC and SLDPF from GSFC via an MDM channel. A MSFC to GSFC channel transports SL command data to GSFC for relay to JSC for integration into the Orbiter uplink. Other links are extended between MSFC and GSFC on this system for other programs. JSC has data-quality monitoring capability with the common carrier IF interface, video, Nascom-provided SM equipment, and FIMS data supplied by NCC. JSC is responsible to the NCC for scheduling links to both the MSFC POCC and SLDPF. The video/analog clusters are redundant and required patching is performed by local operators. The backup SM must be patched by operations personnel.
3. Nascom retains responsibility for MDM and SM equipment engineering, configuration, control, logistics support, and assuring that the equipment is operated in a manner to meet all performance specifications. JSC and MSFC provide field-level maintenance.

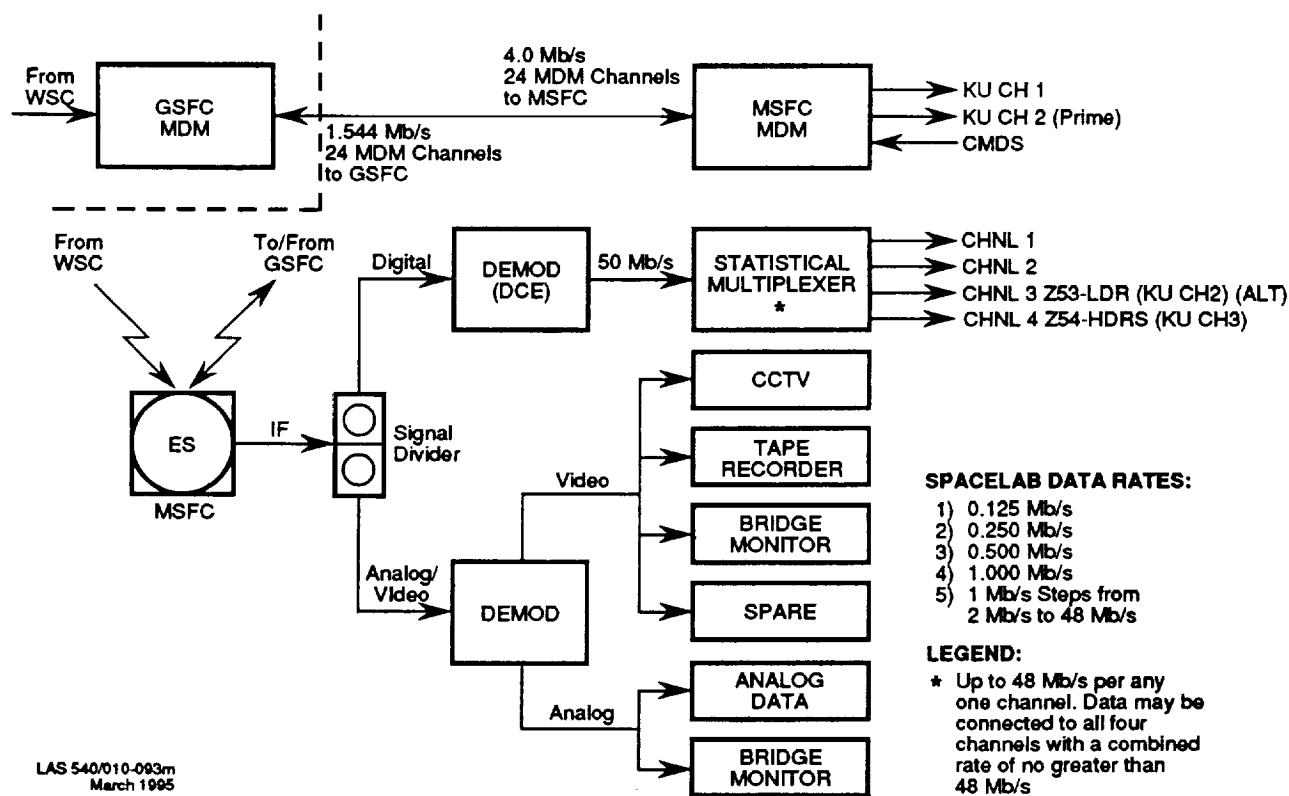


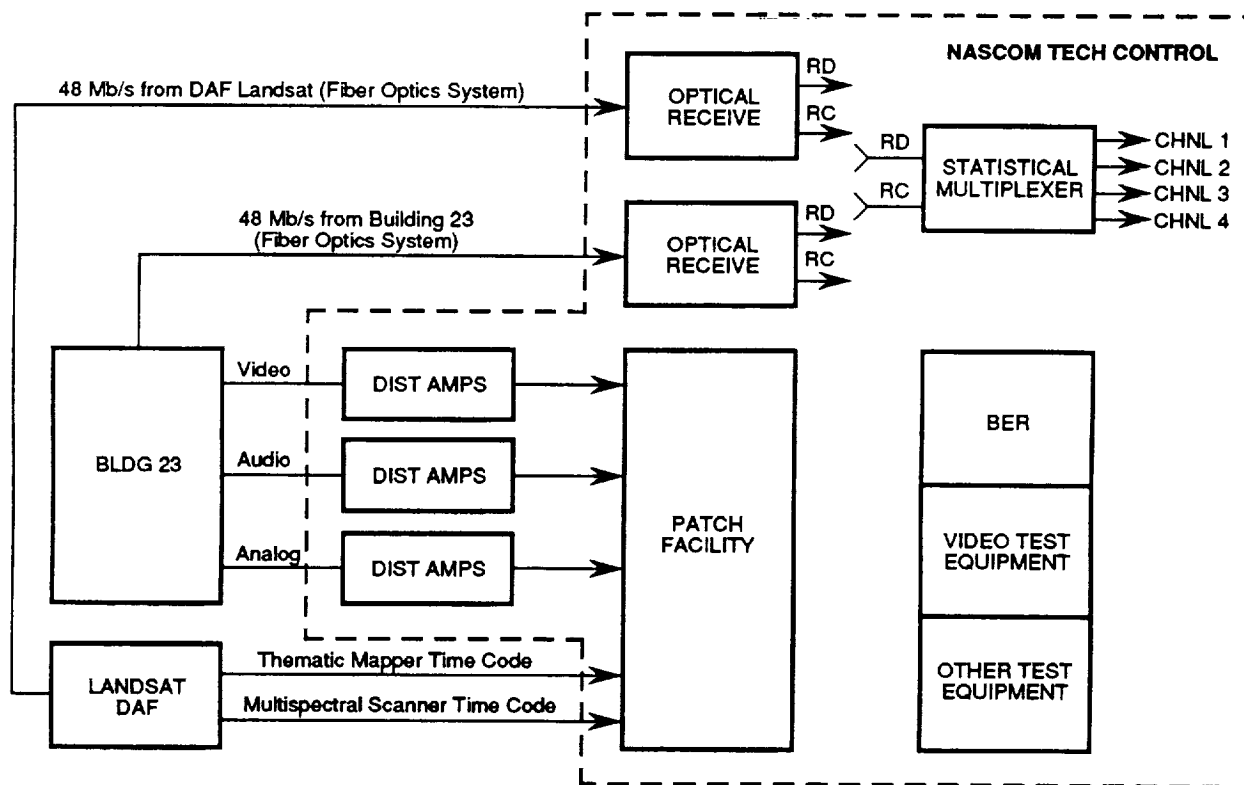
Figure 15-4. MSFC-Spacelab Data Configuration

d. **Spacelab Data Processing Facility at MSFC.** The following is a description of the SLDPF at MSFC.

1. As shown in Figure 15-4, the SLDPF receives downlink IF or baseband signals from the Earth Station. The IF signal is applied to a divider that bridges the signal to both the digital and video/analog interfaces. If the signal is digital, the demodulator equipment will deliver the baseband 50-Mb/s composite serial data and clock signal. The SM will demultiplex this data and output the Spacelab data on an assigned channel to the tape recorder in the Signal Input Processor System (SIPS) or the SLDPF. If the signal is either video or analog data, the demodulator will provide signals for up to four video ports and two analog data ports. The function of the SLDPF is experiment data capture and nonreal-time data processing.
 2. SLDPF personnel are responsible for operating all front panel controls and patch facilities, and for performing all local loopback tests for fault isolation. The SLDPF has a backup SM, redundant communications equipment, test generators, BER monitoring equipment, and loopback capabilities for self-testing the communications system. Also, the video and analog port cluster are redundant and the required patching is performed by operations personnel.
 3. Nascom retains the overall responsibility for equipment maintenance and for assuring that the equipment is operated in a manner to meet all performance specifications. Nascom technical control at GSFC monitors the signals and assists the users in troubleshooting and fault isolation. The configuration of the Nascom technical control segment (in GSFC, Building 14, room 191) that monitors the Landsat and SL HRDS is illustrated in Figure 15-5.
- e. **Ground Network Contingency Support.** In a TDRSS contingency, a Spacelab mission is provided with a GN contingency support configuration. In this configuration Spacelab data is transmitted via the Orbiter's FM downlink to GN stations at a 1.0-Mb/s data rate. This data may be recorded and played back at 8:1 slowdown at 125 kb/s via Nascom 224-kb/s GN wideband data lines. This contingency data is routed via the Nascom MSS and transported through the MDM system to MSFC, with the OTU at MSFC operating in the serial data mode. This contingency GN/Nascom configuration remains available.

15.2.4.2 Nascom Support for the Spacelab Mission

Like the Landsat mission, Nascom support for the Spacelab mission is primarily provided via the HDRS at several locations. The SMDS, a major Nascom ground communications support system and an element of the HDRS, is configured to provide a one-way 50-Mb/s aggregate-transmission between the WSC SM, the SL POCC at MSFC, and the JSC/MCC. As indicated in Figure 15-5, the status of the GSFC SM is monitored by the Nascom technical control via



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Figure 15-5. Nascom Technical Control-Building 14, Room 191 (Monitoring of Landsat-D and Spacelab High Data Rate System)

the 50-Mb/s fiber-optic circuit. The other forms of support provided by Nascom are summarized in the following paragraphs:

- Baseline Data System Support.** As indicated in Figure 15-3, Nascom transmits the Spacelab channel 2 data over the BDS MDM Data System. It is relayed to the SL POCC and SLDPF at MSFC via the MDM extension system.
- Video/Analog Service Support.** As indicated in Figure 15-5, the Spacelab video and analog signals are fed to Nascom technical control at GSFC, Building 14, for fault isolation purposes. The video is also monitored, quality checked, and distributed locally in the Building 8 Nascom TV control facility.
- MDM and SM Support.** Nascom is responsible for MDM and SM equipment engineering, configuration, control, and logistics support, and for assuring that the equipment is operated in a manner that meets all performance specifications.

15.2.5 Hubble Space Telescope

15.2.5.1 HST Mission Description

Hubble Space Telescope (HST) is a high-resolution optical telescope operated as a national facility. It consists of a 2.4-meter aperture Ritchey-Chretien cassegrain telescope weighing

approximately 9525 kg – with various energy detectors designed for the observation of infrared, visible, and ultraviolet wavelengths (0.12 to 1000 microns). HST was launched by the Space Shuttle from KSC on 24 April 1990, and deployed into a 28.5-degree inclination, circular orbit that permits an HST orbit lifetime of 15 years. HST is projected for 15 years in-orbit operation. HST servicing/maintenance missions are manifested on the Space Transportation System (STS) every 3 years (approximate) after launch.

- a. **Spacecraft Data Flow.** The data flow between the HST spacecraft and the HST ground facilities is described in the following paragraphs:
 1. All of the HST observatory science and engineering data received via TDRSS/Nascom is routed to the POCC and the GSFC Data Capture Facility. The DCF records all of the science data. This data is forwarded to the Science Institute Space Telescope (Sci) within 1 day.
 2. The POCC receives, records, processes, and displays all HST engineering data to monitor the health and safety of the science instruments and support systems. It also receives and transmits the science data to the Science Support Center (SSC) and the Sci for quicklook evaluation and target acquisition support. The POCC generates, transmits, verifies, and records all commands to the HST and produces the daily mission schedule. Either the SSC or the Sci may transmit (not simultaneously) real-time HST command requests, as scheduled to the POCC via the SSC command interface.
- b. **TDRSS Support Services.** The TDRSS provides approximately 320 minutes-per-day support on the SSA return link and 100 percent in-view support on the MA return link. All HST support is provided by TDRSS. DSN/GN is responsible for providing contingency support for the HST if TDRSS or SC failure prevents communications via that link. MA return services provides real-time science or engineering data at up to 4 kb/s on I-channel, and real-time engineering data up to 32 kb/s on Q-channel (on MA/SSA cross support when needed). SSA return link service on I-channel provides data at 1.024 Mb/s for real-time science, or engineering and science data playbacks, or for Onboard Computer (OBC) memory dumps.

15.2.5.2 Space Telescope Observatory Management System

The HST Observatory Management System (STOMS) consists of the HST Operations Control Center (STOCC), and the Data Capture Facility (DCF).

- a. **HST Operations Control Center.** The STOCC located in Building 3-14 areas at GSFC, and composed of the POCC and the Science Support Center (SSC), serves as the focal point of all orbital operations, including the monitoring and support of the spacecraft. The following describes the components of STOCC:
 1. The HST POCC performs all real-time health and status functions and offline spacecraft support functions for the HST mission. The HST POCC is composed of the Preliminary Operations Requirements and Test Support Section (PORTS), the POCC Applications Software Support (PASS), and the UPS.
 2. PORTS is that part of the HST POCC responsible for engineering design, hardware, online computer system payload operations, telemetry processing,

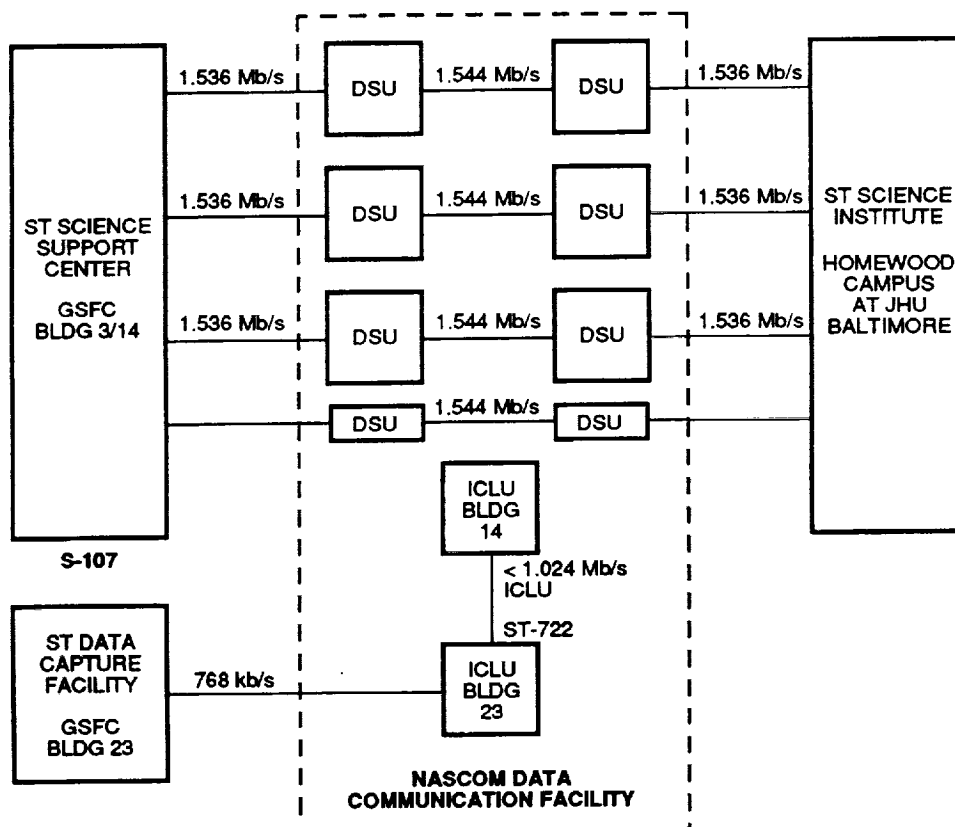
and supporting functions. Included are a High Rate Switch, Telemetry and Command Processors (TAC), three Applications Processors (AP), and two Virtual Interface Processors (VIP). The TACs and VIPs are DEC PDP-11/44s. The APs are DEC VAX 4000 computers. All external communications are through the high rate switch.

3. POCC Applications Software Support (PASS) is a collection of software systems responsible for implementing capabilities in the POCC offline computer system as provided through PORTS. PASS responsibilities include areas of mission scheduling, command loading, attitude and calibration computation, spacecraft subsystem monitoring, PASS data management, and PASS operations support.
 4. Support and Maintenance System (SAMS) is a separate facility located in Building 1 that provides resources for the development and staging of hardware, software, and network changes on a noninterference basis with the HST POCC. SAMS will also have the capability to serve as an emergency backup control center in the event of a requirement to evacuate the POCC facilities in Building 3-14.
 5. UPS is an intelligent terminal in the POCC that provides an NCC interface for scheduling tracking, telemetry, and command support via the TDRSS.
- b. Data Capture Facility. The DCF is a GSFC-managed and -operated element responsible for the capture and quality accounting of all received HST science data. It is a dedicated element of the Packet Data Processing Facility (PDPF) - one of the four major facilities making up the Information Processing Division located in Building 23, GSFC.

15.2.5.3 Nascom Support for HST Mission

Nascom support for the HST mission is as follows:

- a. Data Transmission Channels. The HST ScI, located on the Homewood campus of Johns Hopkins University, Baltimore, MD, is responsible for obtaining, reviewing, and prioritizing observation proposals. It provides long-range science planning, participates in real-time science operations, and performs science data calibration, data analysis, science instrument trend analysis, science data archiving, and data distribution. It has real-time science data display and monitor capability essentially identical to that in the SSC. The HST Science Operations Ground System (SOGS) performs specific functions crucial to the operation of the HST. The HST SOGS contains data processing equipment that is collocated at the HST ScI Facility and at the ST SSC at GSFC. There is a requirement for data to flow in both directions. Nascom provides five data transmission channels for SOGS: four Nascom-2000 services operating at 1.544 Mb/s between HST SSC and the HST ScI, and another local GSFC channel between the HST SSC and the HST DCF, at a lesser data rate not to exceed 1.024 Mb/s transported on the ICLU. These data transmission channels are all full-duplex and are configured as shown in Figure 15-6.
- b. Inorbit Operations. In-orbit operations are conducted from the POCC using Nascom voice and data interfaces to accommodate HST commands, engineering data,



NOTE: Source - ST SOGS ICD

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Figure 15-6. ST SOGS Data Transmission Channel Configuration

science planning and scheduling, onboard computer support, NCC/TDRSS ground control messages, and other HST GSFC institutional required data. The following describes the inorbit operations, the external data flow for which is configured as illustrated in Figure 15-7.

1. The POCC interfaces with the NCC and the FDF is via Nascom existing message switch interfaces. POCC interfaces with TDRSS are via Nascom MDM channels for telemetry and command data. DCF receives science data from WSC through the Nascom MDM system and existing interbuilding transmission facilities to GSFC, Building 23.
2. MA return service is used for backup coverage as required, at up to 32 kb/s.

15.2.6 Gamma Ray Observatory

15.2.6.1 GRO Mission Description

The Gamma Ray Observatory (GRO), was STS-launched on April 5, 1991. It consisted of one spacecraft carrying four instruments, providing comprehensive observations covering

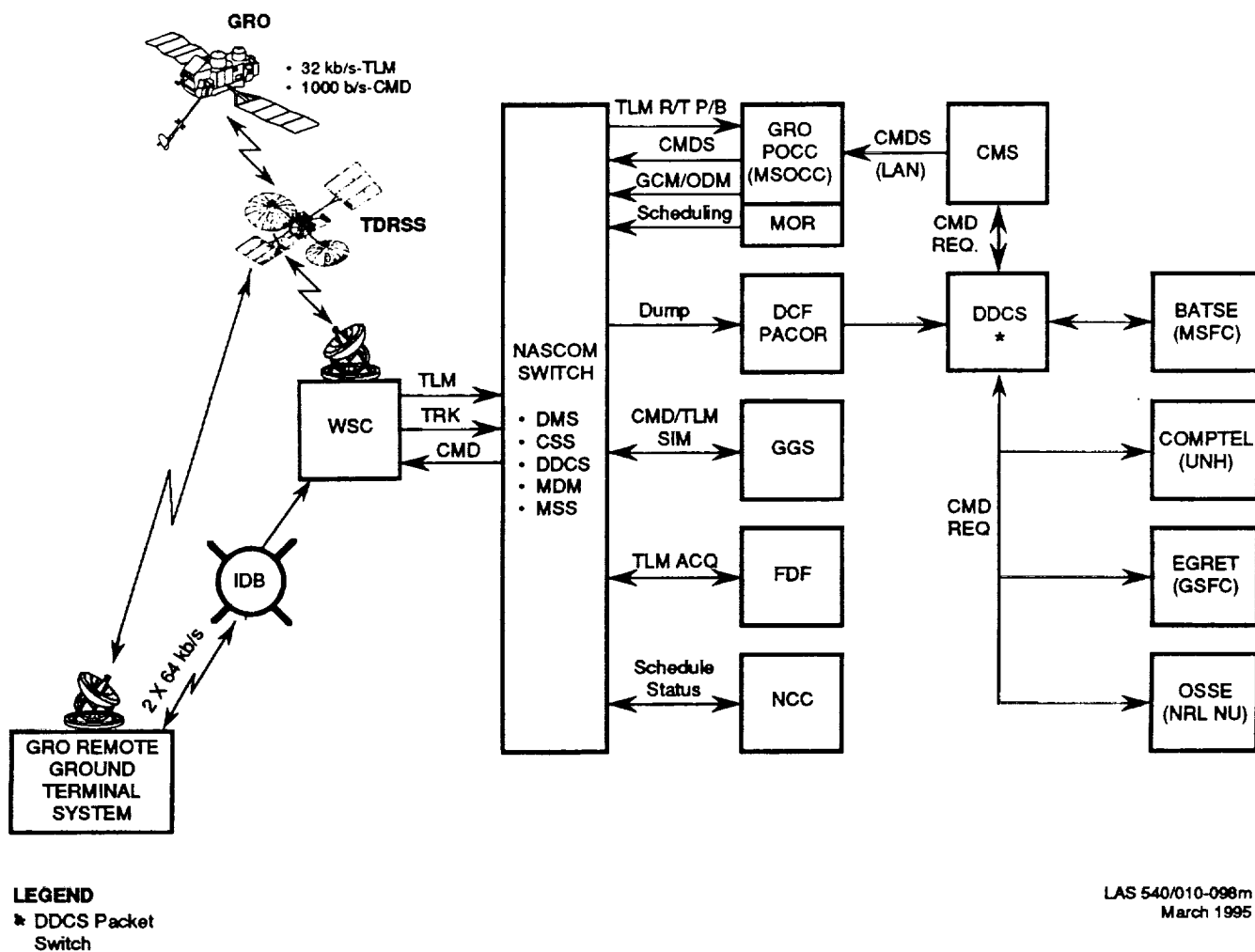


Figure 15-8. GRO Ground System Configuration and Interface Data Flow

GRO scientific users and investigators equipped with Instrument Ground Support Equipment (IGSE).

15.2.6.2 Nascom Support for GRO Mission

The support provided by Nascom for the GRO mission is primarily in the following areas: scheduled BDS data transmission for ground transport of GRO spacecraft command and telemetry data, GRO Remote Terminal System (GRTS) coverage for the GRO spacecraft when it is in the TDRSS zone of exclusion (ZOE), and interfaces to the GRO ground system elements.

- a. **Data Transmission Channel Provision.** The GRO POCC uses a 56-kb/s BDS circuit interface, circuit switched, for receiving spacecraft real-time data; a 9.6-kb/s BDS circuit, circuit switched, for spacecraft commanding, and voice coordination loops. The PACOR requires a 1.544-Mb/s circuit interface, circuit switched, for receiving spacecraft dump data, and a 224-kb/s FDX interface to the X.25 DDCS, and voice

loops. The CMS requires a 56-kb/s interface to the DDCS for interchange with experimenters for command generation and integration.

- b. Establishment of GRTS. A GRTS has been installed in Tidbinbilla, Australia to provide ground terminal coverage to the GRO spacecraft when it is in the TDRSS ZOE. Two 64 kb/s links (one primary, and one backup) are established between WSC and the Tidbinbilla GRTS. These links, terminating in T1 multiplexers, will provide the following signal paths:
 1. 9.6 kb/s / synchronous – control and status (enabling WSC to command the Tidbinbilla GRTS).
 2. 8 kb/s / digital / analog voice and fax.
 3. 2 kb/s simplex / isochronous / TDRSS command (WSC to GRTS).
 4. 1 kb/s simplex / isochronous / TDRSS telemetry (GRTS to WSC).
 5. 32 kb/s simplex / isochronous / GRO telemetry (GRTS to WSC).
 6. 110 b/s simplex / asynchronous / Tracking Data Messages.

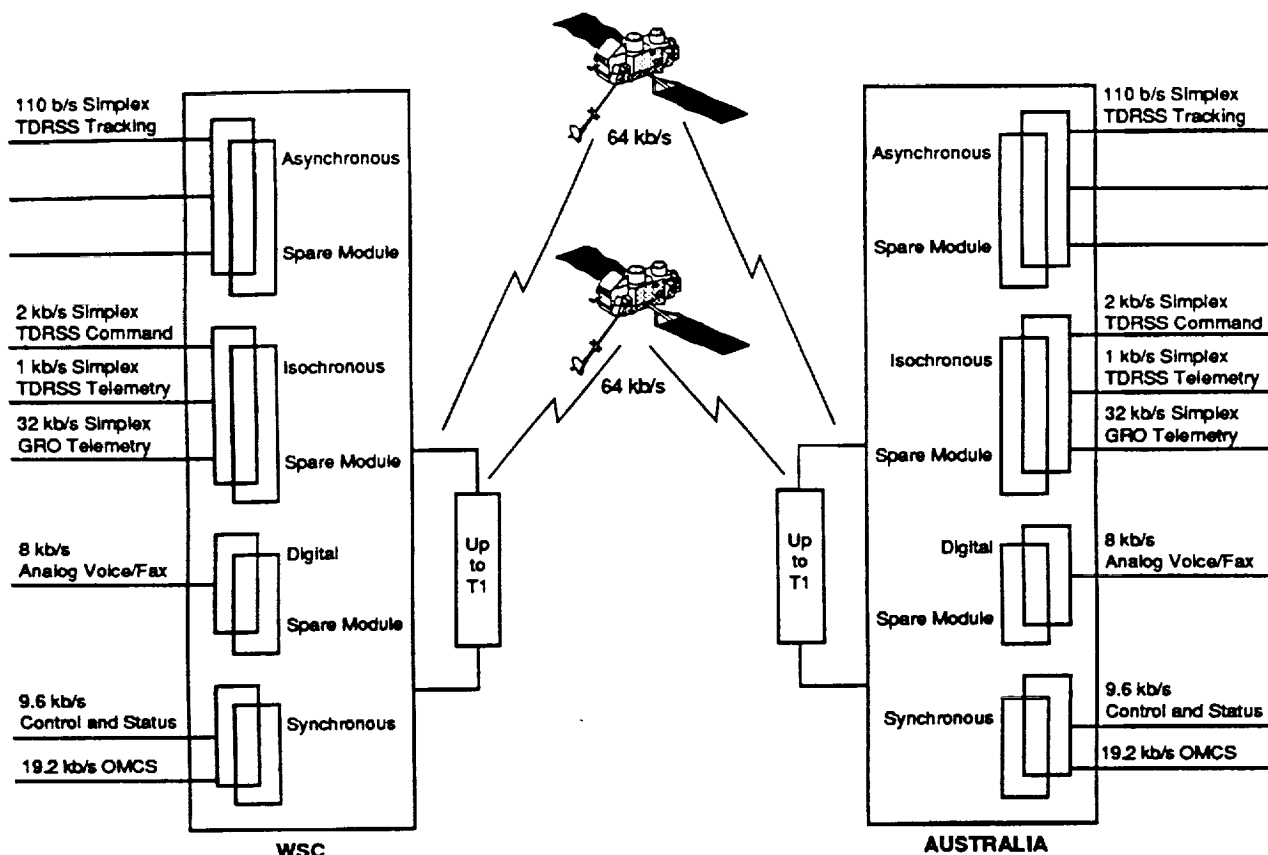
Figure 15-9 illustrates the GRTS Configuration.

- c. Establishment of DDCS. Nascom initially developed and implemented the DDCS for the GRO mission. This system provides a primary packet switching node at GSFC which is used as a concentrator for remote user traffic interfaces to the PACOR and CMS. A remote node has been integrated into the X.25 network at MSFC to interface the BATSE experimenter IGSE at that location. Nascom has also provided the wideband circuits for the GSFC DDCS and the remote DDCS. The following describes the support provided:

1. GSFC DDCS. The GSFC DDCS maintains communication with the IGSEs for distribution of packetized scientific data and packetized command requests between the IGSEs, CMS, OSTC, and the PACOR. The DDCS is configurable with up to 12 interface ports for user access links.

- (a) The remote-user external circuit interfaces are:

| | |
|---------|---|
| CMS | One 56 kb/s circuit. |
| BATSE | One 56 kb/s circuit to MSFC PDP 11/73 (via GSFC/MSFC MD system). |
| COMPTEL | One 56 kb/s circuit to UNH HP 1000F. |
| EGRET | One 56 kb/s circuit to GSFC PDP 11/44. |
| OSSE | One 56 kb/s circuit to NRL VAX 780. |
| PACOR | One 224 kb/s circuit to GSFC DCS. |



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Figure 15-9. GRTS Configuration

(b) The DDCS at GSFC is required to support:

- (1) A peak throughput of 107 packets per second from the PACOR to the IGSEs.
- (2) A peak throughput of 65 packets per second between the CMS and the IGSEs.
- (3) Variable packet sizes: 16, 32, 64, 128, and 256 octets/packet. Packet size for the GRO project is 256 octets/packet.

15.2.7 Upper Atmosphere Research Satellite

15.2.7.1 UARS Mission Description

The Upper Atmosphere Research Satellite (UARS) project is directed toward the study of the middle and upper atmosphere through the use of an Earth-orbiting observatory that operates at an altitude of 600 km and an inclination of 57 degrees. The observatory was launched in the fall of 1991 from KSC, using the STS. The configuration of the UARS

mission, including the supporting space and ground system elements, is illustrated in Figure 15-10. The following items a through c describe the primary system support elements.

- GSFC Institutional Support.** Flight operations are performed with the use of GSFC institutional mission support systems. These facilities provide for satellite command and control, definitive orbit and attitude computation, command management, and data capture (MSOCC, FDF, and DCF).
- GSFC Central Data Handling Facility.** Instrument data processing is accomplished in the CDHF at GSFC. Data analysis and theoretical studies are conducted by members of the UARS science team through the use of remote analysis computers located at the PI's facilities.
- TDRSS Support.** Communications between the observatory and ground facilities are provided by the TDRSS SSA system. The UARS is also compatible with the GN and the DSN. A 10-minute contact every orbit is baselined for tape recorder playbacks at 512 kb/s and real-time data transmission at 32 kb/s. These contacts are normally sufficient for ranging, command, OBC memory dumping, and monitoring the performance of the observatory. The forward SSA system is normally used for commanding at 1 kb/s. When SSA service is not available, command, real-time telemetry, and OBC dumping will be through the MA system. In addition, an SSA emergency mode and a ground station mode will be available.

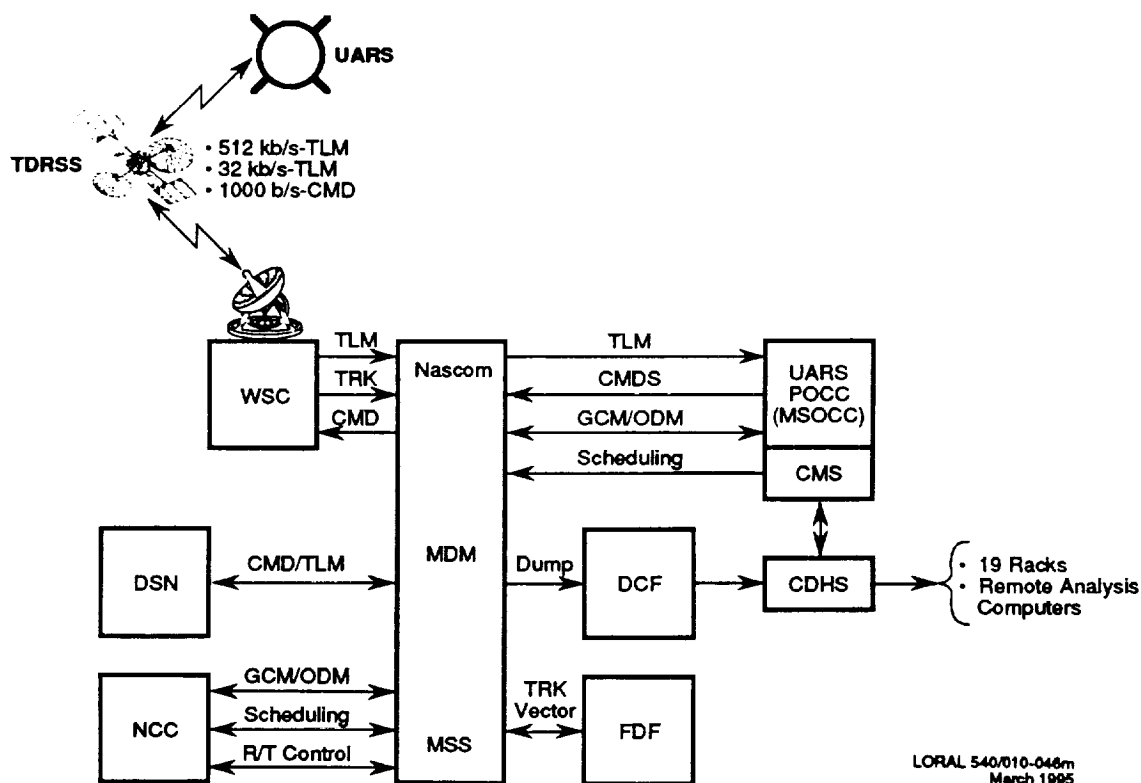


Figure 15-10. UARS Ground System Data Flow Interfaces

15.2.7.2 Nascom Support for UARS Mission

As illustrated in Figure 15-10, the primary support provided by Nascom for the UARS mission is the extension of the UARS/TDRSS transmission channels to GSFC UARS facilities via the BDS.

15.2.7.3 Remote Experimenter Network

Nineteen Remote Analysis Computer (RAC) locations are being served by the GSFC CDHF for data processing and analysis activities. The following table lists the location and type of service to be provided to these RACs. Secondary data distribution is via the Project Support Communications Network (PSCN).

| <u>Continental Locations</u> | |
|---|--------------------------------------|
| Ann Arbor, MI | *9.6 kb/s |
| Atlanta, GA | 9.6 kb/s |
| Boulder, CO (NCAR) | *9.6 kb/s |
| Boulder, CO (U of CO) | 9.6 kb/s |
| Greenbelt, MD #1 | 56.0 kb/s |
| Greenbelt, MD #2 | 56.0 kb/s |
| Hampton, VA | *9.6 kb/s |
| Livermore, CA | 9.6 kb/s |
| Palo Alto, CA | *9.6 kb/s |
| | 2 experimenters to share one line |
| Pasadena, CA | *9.6 kb/s |
| San Antonio, TX | *9.6 kb/s |
| Seattle, WA | 9.6 kb/s |
| Suitland, MD | 9.6 kb/s |
| Washington, DC | *9.6 kb/s |
| <u>Overseas Locations</u> | |
| Bracknell, England | *9.6 kb/s |
| | 2 experimenters to share one line |
| Paris, France | 9.6 kb/s |
| * Requires connection with the GSFC CMS | |

15.2.8 International Space Station (ISS)

15.2.8.1 ISS Mission Description

The ISS is an international facility to provide a permanent outpost to live and work productively in space. The unified station will combine components by the European Space Agency

(ESA), National Space Development Agency of Japan (NASDA), Canadian Space Agency (CSA) and the U. S. National Aeronautics and Space Administration (NASA) with the Russian Space Agency (RSA) Mir components. Some hardware will be jointly developed. Goals are to: (1) provide unique and extensive scientific and research opportunities for humans in space, (2) jointly develop and construct an international space station with permanent human capability, and (3) produce a capable and cost effective space station in a cooperative international effort.

The science program will include research activities in microgravity sciences, environmental health, biomedical science, and fundamental biology. Technology and systems validation studies will be conducted on station technologies and subsystems and crew support.

Overall Concept

The new international enterprise is planned to be accomplished in three phases. Phase One involves an expanded program combining the Shuttle-Mir program with additional Shuttle flights to Mir and U. S. crew onboard Mir.

Phase Two involves the use of U.S. and Russia-developed launch vehicles and station elements. During phase two, the station provides a human-tended research capability.

Phase Three begins with the delivery of the Soyuz as the first Crew Transfer Vehicle (CTV) and concludes when the station is ready for delivery of the U. S. -Russian jointly developed Solar Dynamic power element. During Phase Three, all of the International Partner components are delivered to the station.

15.2.8.2 Early Phase Requirements

This information is presented to illuminate some aspects of the current ISS from which Nascom support requirements may be expected:

- a. ISS Space-Ground Data Rates. The intended C&T data rates planned to be transmitted on the SN (TDRSS) Space-ground link user services are:
 1. S-band (SSA): 192 kb/s, return link, normal; or 12 kb/s, return link, contingency.
 2. S-band (SSA): 72 kb/s, forward link, normal; or 6 kb/s, forward link, contingency.
 3. Ku-band (KSA): 50 Mb/s, return link.

15.2.8.3 Preliminary Assembly Sequence

The new concept for the ISS includes three distinct phases. Phase One expands upon previously planned joint participation by U.S. and Russian crews in Mir and Shuttle operations. Phase Two combines previously planned Station and Russian hardware to create an advanced orbital research facility with a human tended capability. Phase Three completes construction of this research facility to support a permanent human presence. Table 15-3 depicts a preliminary assembly sequence and schedule for Phases Two and Three of the ISS.

**Table 15-3. International Space Station Assembly Sequence and Schedule
(1 of 2)**

| Flight* Designator | Launch** Vehicle | Element | Launch Date | |
|---|--|--|---|-------|
| P H A S E T W O | 1A | Proton | FGB (Launched on PROTON Launcher) | 11/97 |
| | 2A | Shuttle | Node 1, (2 Storage Racks), PMA1, PMA2 | 12/97 |
| | 1R | RSA ELV | Service Module | 04/98 |
| | 2R | RSA ELV | Soyuz | 05/98 |
| | 3 Person Permanent International Human Presence Capability | | | |
| | 3R | RSA ELV | Universal Docking Module (UDM) | 06/98 |
| | 3A | Shuttle | Z1 Truss, PMA3, Ku-Band, EVAS, CMGs (Spacelab Pallet) | 06/98 |
| | 4R | RSA ELV | Docking Compartment | 07/98 |
| | 4A | Shuttle | P6, PV Array (4 Battery Sets)/TCS Radiators S-Band **S-Band Activated** | 09/98 |
| | 5R | RSA ELV | SPP-1 w/Gyrodynes, Radiator | 11/98 |
| | 5A | Shuttle | Lab (4 Lab System Racks) | 11/98 |
| | 6A | Shuttle | 1 Storage, 7 Lab System Racks (on MPLM), UHF, SSRMS (on Slab Pallet) *K-Band Activated* | 12/98 |
| P H A S E T H R E E | 6R | RSA ELV | SSP-2 w/Autonomous Thruster Facility (ATF) | 02/99 |
| | UF-1 | Shuttle | ISPRs (on MPLM) | 02/99 |
| | 7A | Shuttle | Airlock, HP gas (on Spacelab Pallet) | 03/99 |
| | 8A | Shuttle | SO, MT, GPS, Umbilicals, A/L Spur | 04/99 |
| | 7R | RSA ELV | SPP Solar Arrays (4) | 05/99 |
| | UF-2 | Shuttle | ISPRs, 2 Storage Racks (on MPLM), MBS | 06/99 |
| | 9A | Shuttle | S1 (3 Rads), TCS, CETA (1), S-Band, Ext. Cameras | 07/99 |
| | 8R | RSA ELV | Research Module #1 (RM-1) | 09/99 |
| | 10A | Shuttle | Node 2 (4 DDCU Racks), Cupola, 1 O ₂ Tank | 09/99 |
| | 11A | Shuttle | P1 (3 Rads), TCS, CETA(1), UHF, Ext. Cameras | 11/99 |
| 12A | Shuttle | P3/4, PV Array (4 Battery Sets), 2 ULCAS | 12/99 | |
| * A = America, E = Europe, J = Japan, R = Russia, UF = User Outfitting ** RSA Launch Vehicle to be identified. | | | | |

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**Table 15-3. International Space Station Assembly Sequence and Schedule
(2 of 2)**

| Flight* Designator | | Launch** Vehicle | Element | Launch Date |
|---|---------|--|--|----------------|
| P H A S E T H R E E | 9R | RSA ELV | Docking and Stowage Module (DSM) | 01/00 |
| | 1J/A | Shuttle | JEM ELM PS (5 JEM Sys, 2 ISPR, 1 Storage Rack, SPDMS, 2 O ₂ Tanks) | 01/00 |
| | 1J | Shuttle | JEM PM (3 JEM Sys Racks), JEM RMS | 03/00 |
| | UF-3 | Shuttle | ISPRs, 1 Storage Rack (on MLPM), P5 | 06/00 |
| | 10R | Shuttle | Research Module #2 (RM-2) | 06/00 |
| | 13A | Shuttle | S3/4, PV Array (4 Battery Sets), 4 PAS | 08/00 |
| | 11R | RSA ELV | Life Support Module (LSM) | 10/00 |
| | 2J/A | Shuttle | JEM EF, ELM-ES, 4 PV Battery Sets (on ULC) | 10/00 |
| | 12R | RSA ELV | 2 SPP Autonomous Thruster Facilities (ATF) | 11/00 |
| | UF-4 | Shuttle | ISPRs, (on MPLM), 1 O ₂ Tank, AP (on ULC) | 01/01 |
| | 1E | Ariane | APM (5 Sys, 1 Storage, 5 ISPR Racks) (Launched on Ariane Launcher) | 02/01 |
| | 2E | Shuttle | 1 APM Rack, 3 U.S. Storage, 7 JEM Racks (on MPLM), 2 PV Battery Sets (on ULC) | 03/01 |
| | 13R | RSA ELV | Research Module #3 (RM-3) | 05/01 |
| | UF-5 | Shuttle | ISPRs, 1 Storage Rack (on MPLM) | 08/01 |
| | 14A | Shuttle | Centrifuge (24,000 lbs.), S5 | 10/01 |
| | 14R | RSA ELV | SSP Solar Arrays (2), 1 ATF | 10/01 |
| | 15A | Shuttle | S6, PV Arrays (4 Battery Sets), Port MT/CETA Rails | 12/01 |
| | UF-6 | Shuttle | ISPRs, (on MPLM), 1 O ₂ Tank, AP (on ULC) | 01/02 |
| | 16A | Shuttle | HAB (6 Hab Racks) | 02/02 |
| | 17A | Shuttle | 1 Lab Sys, 8 Hab Sys Racks (on MPLM) 2 PV Battery Sets (on ULC) | 05/02 |
| 18A | (TBD) | CTV #1 (Launch Vehicle TBD) | 06/02 | |
| 19A | Shuttle | 3 Hab Sys, 11 U.S. Storage Racks (on MPLM) | 06/02 | |
| 6 Person Permanent International Human Presence Capability | | | | |
| * A = America, E = Europe, J = Japan, R = Russia, UF = User Outfitting ** RSA Launch Vehicle to be identified. | | | | |

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15.2.9 Earth Observing System (EOS)

15.2.9.1 EOS Mission Description

The EOS is a multimission program with the objective of acquiring geophysical, chemical, and biological information necessary for intense study of planet Earth. The EOS information system will build up over 10 years and then function at least 15 more years to accurately model processes that control the environment. The program involves operation of numerous instruments on multiple spacecraft in both polar and non-polar orbit to support a large international user/scientific community. The U.S. is developing multiple series of spacecraft, beginning with the EOS-AM series in 1998. Other EOS series include EOS-PM, EOS-Chemistry, EOS-Aerosols, and EOS-Altimetry. Each spacecraft has a projected operational lifetime of 5 years, except for EOS-Aerosols which have an operational life of 3 years, with respective replacement spacecraft to provide observations of the Earth for not less than 15 years. Both ESA and NASDA are planning Earth observing missions which complement the NASA flights; both will also have instruments on selected EOS flights. The CSA is providing one of the instruments on EOS-AM1 and is sponsoring two interdisciplinary investigators. EOS will also encompass data from designated Earth Science Missions under the broad umbrella of "Mission to Planet Earth".

15.2.9.2 Flight Profile

EOS spacecraft are self contained free-flyers, operating in sun-synchronous polar orbits. EOS-AM and -PM series will be launched from Vandenberg AFB, CA by the ATLAS II launch vehicle into 705 km near circular orbits with 100 minute periods. The launch vehicles for the EOS-Aerosol, -Chemistry and -Altimetry series are still TBD. The mission flight schedule for EOS is depicted in Table 15-4.

Table 15-4. Schedule of EOS Missions

| Mission | Launch | Mission | Launch | Mission | Launch | Mission | Launch | Mission | Launch |
|---------|----------|---------|----------|-----------|----------|-----------|----------|-----------|----------|
| EOS-AM1 | Jun 1998 | EOS-PM1 | Dec 2000 | EOS-RALT1 | Mar 1999 | EOS-CHEM1 | Dec 2002 | EOS-LALT1 | Jun 2003 |
| EOS-AM2 | Jun 2004 | EOS-PM2 | Dec 2006 | EOS-RALT2 | Mar 2005 | EOS-CHEM2 | Dec 2008 | EOS-LALT2 | Jun 2009 |
| EOS-AM3 | Jun 2010 | EOS-PM3 | Dec 2012 | EOS-RALT3 | Mar 2011 | EOS-CHEM3 | Dec 2014 | EOS-LALT3 | Jun 2015 |

15.2.9.3 SN/DSN/GN Support

The EOS mission requires support equivalent to one TDRS/TDRSII KSA channel. During normal operations, each EOS flight will utilize a TDRS KSA channel for approximately 20 minutes per orbit for return link transmission of recorded science and engineering data. In addition, the capability exists for the spacecraft to transmit both real-time and recorded science and engineering data (selected data sets) via KSA. Real-time engineering and housekeeping data, and optionally dump data, will be transmitted via the corresponding SSA channel. Forward link command requirements include real-time commands and spacecraft

loads for handling by the spacecraft onboard computer. Normal operations will consist of scheduled daily command loads. A number of contingency modes involving KSA, SSA and SMA services will exist. Tracking services will be required during orbit acquisition and for verification of the TDRSS Onboard Navigation System (TONS). Specific forward and return link services are depicted in Tables 15-5 and 15-6.

Table 15-5. EOS: Forward Link Services*

| Service | Data Type and Rate (BPS) | | Support |
|--|--------------------------|-----------|--|
| | I Channel | Q Channel | |
| SSA | CMD at 10K | None | Available for normal commands and large uplink loads |
| SSA | CMD at 1000 | Ranging | Available for normal command operations |
| SSA | CMD at 125 | None | Initial contact and contingency |
| SMA | CMD at 1000 | Ranging | Contingency |
| *Forward link services as currently proposed and reflected in STDN No. 803, November 1994. | | | |

Table 15-6. EOS: Return Link Services*

| Service | Data Type and Rate (BPS) | | Support |
|--|---------------------------|---------------------------|--|
| | I Channel | Q Channel | |
| KSA | Sci/Engr RT at up to 75M | Sci/Engr RT at up to 75M | Early checkout and anomaly investigation |
| KSA | Sci/Engr PB at up to 75M | Sci/Engr at up to 75M | Thirty minutes per orbit |
| KSA | Sci/Engr PB at up to 75M | Sci/Engr RT at up to 75M | Selected EOS data sets |
| SSA | Engr/Hskg PB at up to 16k | Engr/Hskg RT at up to 16k | Routine operation; identical data on I and Q channels |
| SSA | Engr/Hskg RT at 16k | Engr/Hskg RT at 16k | As required: anomaly follow-up |
| SSA | Hskg RT at 1000 | PCP Dump at 1000 | Contingency (omni) |
| SMA | Engr/Hskg RT at 16k | Engr/Hskg RT at 16k | Real-time housekeeping; identical data on I and Q channels |
| *Return link services as currently proposed and reflected in STDN No. 803, November 1994. High-rate recorders playback at up to 150 Mb/s; low-rate telemetry recorders playback at 256 kb/s and are not downlinked on a regular basis. | | | |

15.2.9.4 Earth Science and Data Information System (ESDIS) Project Elements

The EOC at GSFC is responsible for mission control, mission planning and scheduling, instrument command support, and mission operations. All communications with the platforms and instruments go through the EOC. The EOC will interface with Instrument Control Centers (ICC) and their Instrument Support Terminals (IST). The ICCs are responsible for health and safety monitoring of the instrument and observatory, planning and scheduling instrument operations, generating, validating, forwarding or storing command sequences,

and providing instrument controllers with status for their instruments. ESDIS elements also include Distributed Active Archive Centers (DAAC).

15.2.10 Large Explorer Missions

15.2.10.1 Extreme Ultraviolet Explorer (EUVE) Mission Description

EUVE has completed a survey of the entire celestial sphere in the extreme ultraviolet spectrum. Spectroscopic observations of individual targets are now being conducted through the office of the EUVE guest observer program. Launched on June 7, 1992 by a Delta II, the spacecraft is currently in a 507 km circular orbit at 28 degrees inclination with a period of 95 minutes. Figure 15-11 shows the supporting space and ground elements and their interfaces.

15.2.10.2 X-ray Timing Explorer (XTE) Mission Description

XTE will study a variety of x-ray sources including white dwarfs, accreting neutron stars, black holes, and active galactic nuclei. Measurements will be made over a wide range of photon energies from 2 to 200 keV. The XTE consists of three instruments: the Proportional Counter Array (PCA), the All Sky Monitor (ASM), and the High Energy X-ray Timing Experiment (HEXTE). The XTE will be launched from CCAS on a Delta II 7920 launch vehicle into a circular orbit at an altitude of 580 km with a period of 96 minutes. The XTE ground system is illustrated in Figure 15-12.

15.2.10.3 Nascom Support

Both EUVE and XTE are TDRSS-compatible missions that make use of the SSA and MA services. Telemetry data rates range from 1 to 1024 kb/s while commanding is performed nominally at 1 kb/s with a contingency rate of 125 b/s. The DSN stations are available to provide emergency support to both missions should the need arise. The BDS provides all communications between the WSC and GSFC where data is switched to the applicable support elements. Communications support with the DSN, if necessary, would use existing capabilities that are shared with other missions.

15.3 Ground Network-supported Missions

This paragraph provides a description of selected missions or mission categories involving principally ground network tracking and data acquisition support and related unique Nascom ground communications support planning.

15.3.1 International Solar Terrestrial Physics Program (ISTP)

15.3.1.1 ISTP Mission Description

ISTP is a joint cooperative effort undertaken to study the solar-terrestrial physics of the near-earth space environment or the Geosphere. This effort involves the spacecraft of three international agencies: The National Aeronautic and Space Administration (NASA), The Japanese Institute of Space and Astronautical Science (ISAS), and The European Space Agency (ESA). It also includes one Russian experiment, KONUS, on the U.S. spacecraft

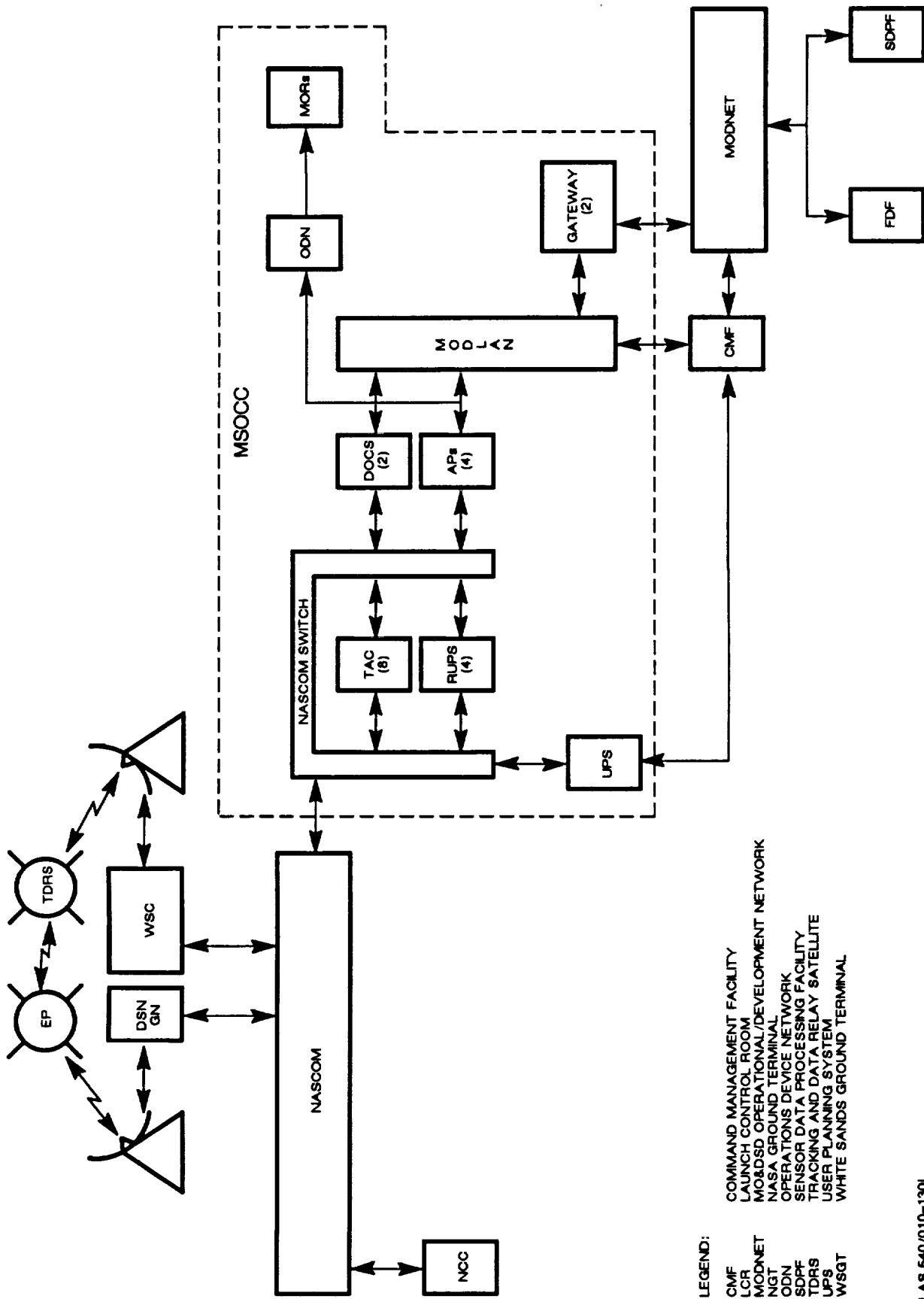


Figure 15-11. EUVE Ground Data System

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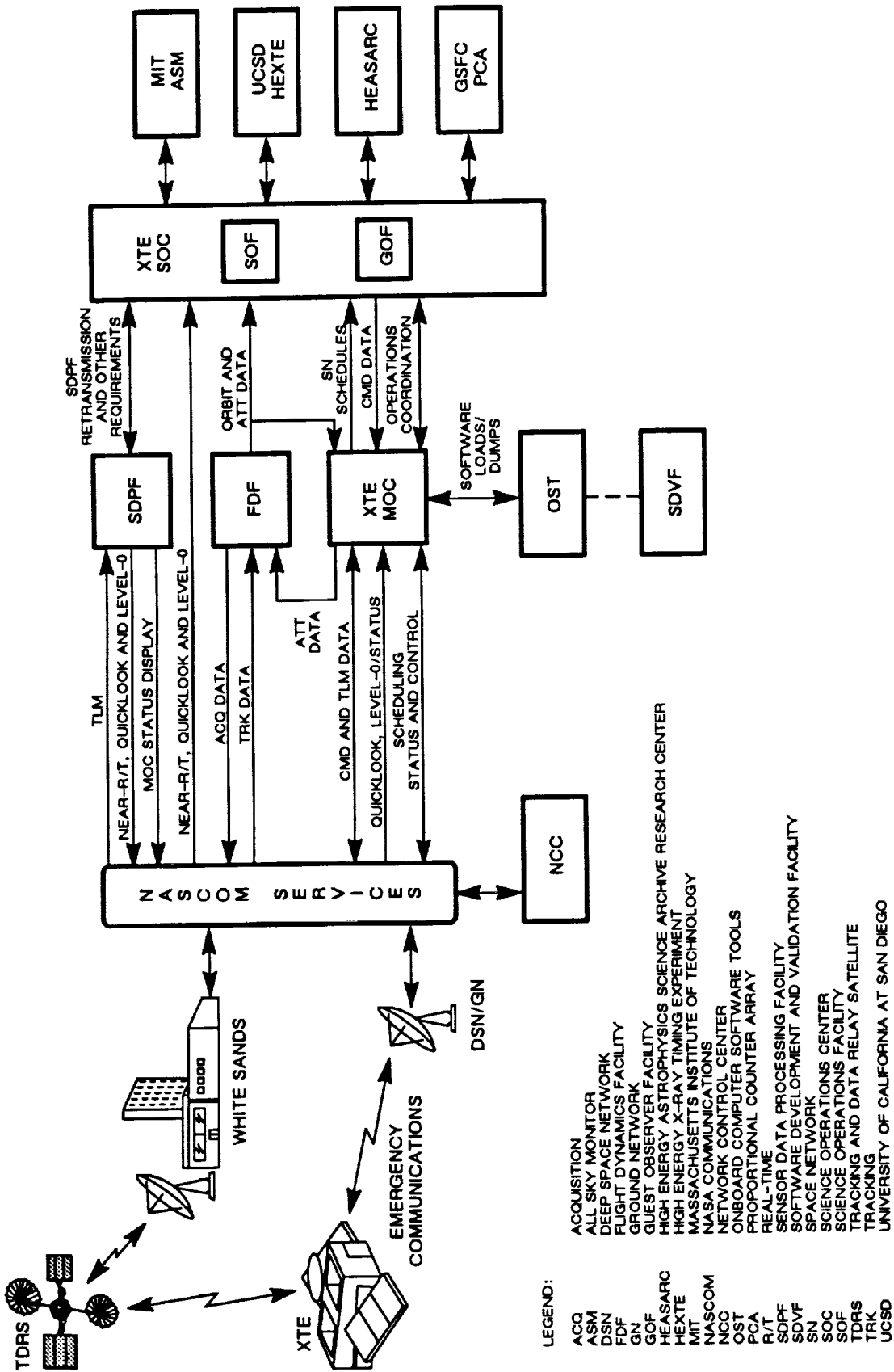


Figure 15-12. XTE Ground Data System

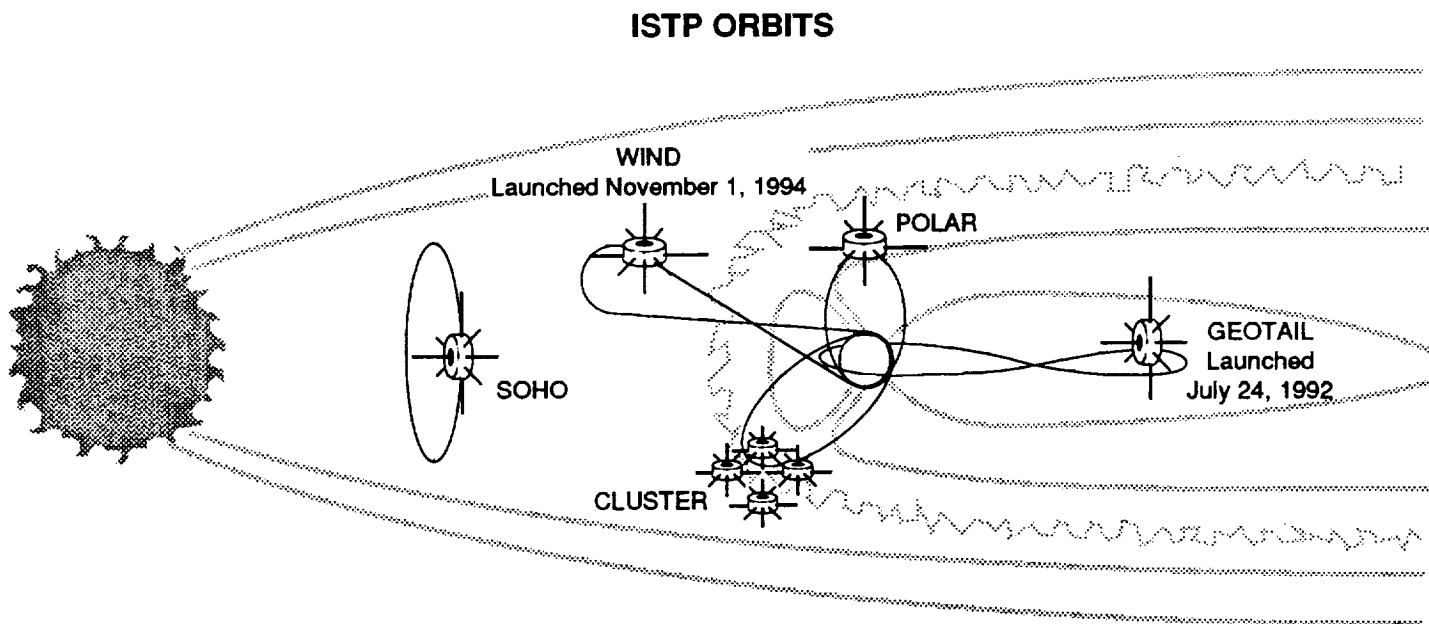
LAS 540/010-1311
March 1995

"WIND". The U.S. program is further subdivided into two programs, 1) The Global Geospace Science project which is the NASA portion with two spacecraft, WIND and POLAR; and 2) The Collaborative Solar-Terrestrial Research Initiative (COSTR) that provides for the development and operation of U.S. experiments on the ISAS spacecraft, GEOTAIL and the ESA spacecraft, SOHO and CLUSTER. CLUSTER is a group of four satellites that orbit together in a predetermined pattern within the geosphere. The spacecraft will be launched over a period of three and a half years and during the latter part of the program, all of the spacecraft will be in operation simultaneously to provide time correlated data on the energy exchange within the geosphere.

15.3.1.2 Flight Profile

The orbits of the spacecraft will be as follows and as shown in Figure 15-13.

- a. **GEOTAIL.** A nightside double lunar swingby orbit with an apogee of 80 to 220 Earth Radii (RE) and perigee of 5 to 10 RE for the first 2.3 years; GEOTAIL will then be placed in an Earth-centered 8 by 30 ellipse for another year with an anti-sunward June solstice apogee.
- b. **WIND.** A dayside double lunar swingby orbit with an apogee of 80 to 250 RE and perigee of 5 to 10 RE with a period of 2 to 6 months, then an optional Halo orbit about the sunward L1 libration point at a distance of 235 to 265 RE with a period of 6 months.



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Figure 15-13. ISTP Mission Configuration

- c. **POLAR.** An earth-centered, 2 by 9 RE ellipse with the apogee near the north pole and a period of 18 hours.
- d. **SOHO.** A Halo orbit about the L1 libration point approximately 1.5 million KM sunward from the earth with a nominal mission duration of 2 years and 4 months.
- e. **CLUSTER.** A group of four spacecraft in a 20 by 3 RE eccentric polar orbit with a northern apogee and a period of 54.9 hours.

15.3.1.3 DSN Support

Since all of the spacecraft orbits are beyond the nominal orbit of the TDRS, the DSN will provide the telemetry and tracking support for ISTP. The ground system data flow diagram for WIND and POLAR is shown in Figure 15-14; SOHO is shown in Figure 15-15.

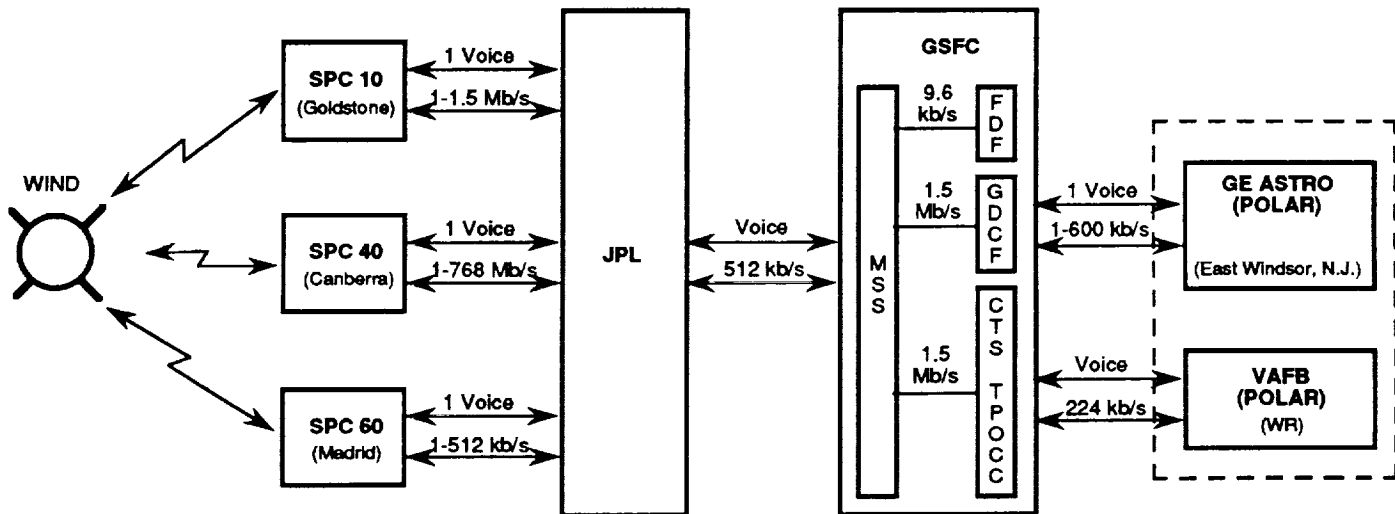
15.3.1.4 Assumptions for ISTP Bandwidth Requirements

The following are assumptions for ISTP bandwidth requirements and the bandwidth requirements for each spacecraft are shown in Table 15-7:

- a. **GEOTAIL.** The normal support is 65.54 kb/s, format 1, playback data; or 131.07 kb/s, format 1, playback data. The rate is determined essentially by the spacecraft's distance from earth and the antenna aperture, both of which determine the required BER.

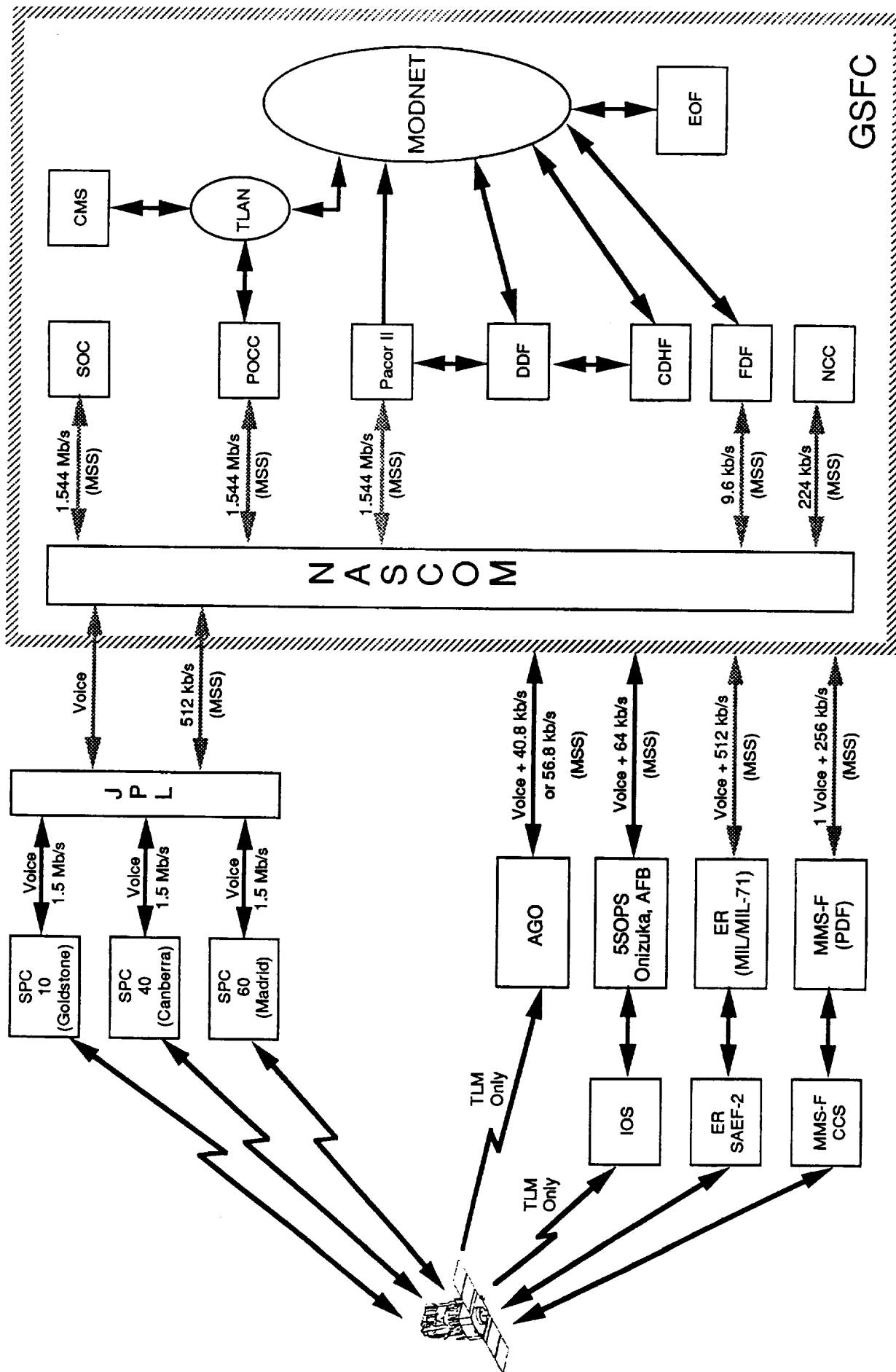
In the event of a data recorder or editor "B" failure on GEOTAIL, i.e., contingency mode operations, the 16.38 kb/s, format 1, real-time; or 65.54 kb/s, format 3, real-time data will be supported 24 hours/day.

- b. **WIND.** The normal support rates are 64 kb/s playback plus 5.56 kb/s real-time; or 128 kb/s playback plus 11.12 kb/s real-time, again based on the required BER.



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Figure 15-14. WIND/POLAR Ground System Data Flow Diagram



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Figure 15-15. SOHO Ground Data System Operational Configuration

Table 15-7. ISTP Communications Bandwidth Requirements

| Mission Spacecraft | DSN Support Required (Data Rates in kb/s) | Data Rates (kb/s)/Type | | Support Duration in Minutes | Total Data Volume/Day (MBITS) | Bandwidth Required (kb/s)/ Data Type | Worst Case Bandwidth Re- quirement (kb/s) | Total Composite Band- width Required | | Date Req. |
|-------------------------------------|--|--|-------------------------------|-----------------------------------|-------------------------------------|---|---|--|------------------|--------------|
| | | Low | High | | | | | Normal | Worst Case | |
| GEOTAIL Launched 7/24/92 | Contingency 24 hrs/day | 16.38/RT | | 1440 | 1415.7 | 16.38/RT | 65.54 | | | |
| | | | 65.54/RT | | | 65.54/RT | | | | |
| | Normal 3 or 4 passes/day 9 hrs @ 131.07 or 1.8 hrs @ 65.54 | 65.54/PB | | 432 | 1698.8 | 19.66/PB | | 19.66 | 65.54 | 7/92 |
| WIND Launched 11/01/94 | 24 hrs/day @ 64 PB + 5.56 RT or 1 hr/day @ 128 PB + 11.12 RT | 64 PB + | | 120 | 460.8 | 5.33/PB | | 24.99 | | |
| | | 5.56 RT | | | 40.03 | 5.56/RT | | | | |
| | | | 128 PB + 11.12 RT | 180 | 460.8 40.03 | 5.33/PB 11.12/RT | 5.33 11.12 | 30.55 | 70.87 81.99 | 11/94 |
| POLAR Launch date 12/95 | 4-3/4 hrs/day PB @ 512 kb/s + 55.6 kb/s RT | 512 PB + | | 180 | 5529.6 | 64/PS | 64 55.58 | 94.55 150.15 | 176.54 326.69 | |
| | | 55.6 RT | | | 600.5 | 55.56/RT | | | | |
| | 12 hrs/day Tot + 1, then 3.6 hrs/day | 256/RT PWI @ 3.6 hrs/day | 256/RT PWI @ 12 hrs/day | 720 216 | 11059.2 3317.8 | 128/PW1 38.4/PWI | 128 | 188.5 | 454.69 | 12/95 |
| SOHO Launch date 11/95 | 1-8 hrs RT/day + 3-1.33 hrs PB/day | 46 RT 8 hrs/ day + 160 PB 4 hrs/day | | 480 240 | 1324.8 2304 | 46/RT 26.7/PB | 46 160 | 234.55 | | |
| | | | | | | | | | | |
| | For 10 mos. then 1-24 hrs RT/day for 2 mos. | 46 RT + 160 MDI 24 hrs/day | | 1440 1440 | 3974.4 13824 | 46/RT 160/MDI | | 261.25 | 500.69 660.69 | 11/95 |
| CLUSTER Launch date 12/95 | 1-1/2 hrs/orbit for each of two S/C | 256/PW1 PB | 256/PW1 PB | 60 | 921.6 | 10.67/PW1 PB | 10.67 | 271.92 | 671.36 | 12/95 |
| (As of March 1995) | | | | | | | | | | |

- c. POLAR. The normal support is 512 kb/s playback plus 55.6 kb/s real-time for four, 3/4 hour passes/day. The wideband PWI support is 12 hours/day to L+ 1, then 3.6 hours/day thereafter.
- d. SOHO. The normal support is one, eight-hour pass per day for 46 kb/s, real-time telemetry plus 16 kb/s, real-time, wideband MDI data; and three, 1-1/3 hour passes per day of 46 kb/s, real-time telemetry plus 160 kb/s, playback data for a total support of 12 hours per day for ten months of the year; then continuous 24 hours daily of 46 kb/s, real-time telemetry plus 16 kb/s, real-time, wideband MDI data for two months of the year.
- e. CLUSTER. The normal support is one, 1/2-hour pass, each, for two of the four spacecraft per day for a total of one hour of 256 kb/s, playback data per day.

The normal maximums and the worst case data scenarios are totaled in separate columns under "Composite Bandwidth". These running totals are shown in Table 15-7 where the launch dates and the increases in Nascom requirements bandwidth can be seen at a glance.

It is assumed that the playback data is buffered and played back over a 24-hour period and real-time data is passed forward at the real-time rate, as received, to GSFC. This leaves no overhead available on the line for replays, etc. Therefore, these required bandwidths do not include any Nascom overhead.

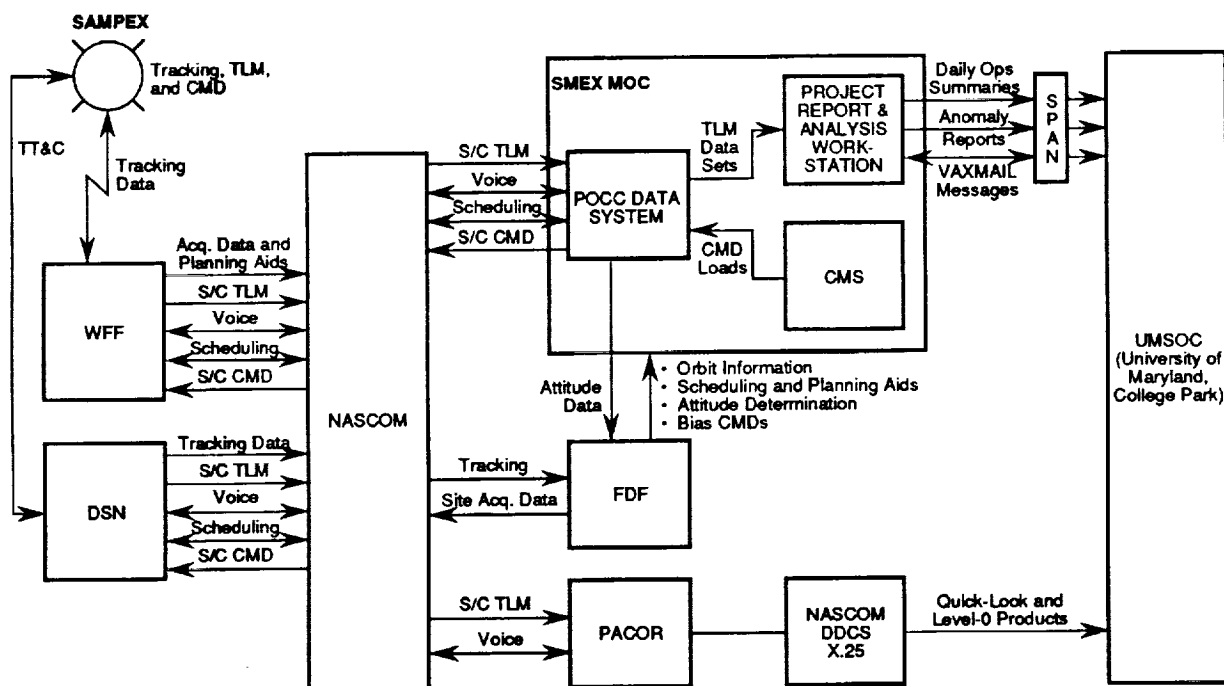
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It is assumed that the playback data is buffered and played back over a 24-hour period and real-time data is passed forward at the real-time rate, as received, to GSFC. This leaves no overhead available on the line for replays, etc. Therefore, these required bandwidths do not include any Nascom overhead.

15.3.2 Small Explorer (SMEX) Program

15.3.2.1 Solar, Anomalous and Magnetospheric Particle Explorer (SAMPEX) Mission Description

SAMPEX is the first mission in the SMEX program, a GSFC project employing a common spacecraft bus for flight research opportunities. The SMEX program concept is based upon small, quick turn-around, and relatively low cost missions. The SAMPEX mission will study solar energetic particles, anomalous cosmic rays, galactic rays, and magnetospheric particles. The University of Maryland at College Park provides the Science Operations Center (UM-SOC) function; the UMSOC has a non real-time operations role for this mission. SAMPEX was launched from Vandenberg Air Force Base on a four-stage Scout launch vehicle. The orbit is nominal circular at 580 kilometers, inclined at 82 degrees, and has a period of 96 minutes. Figure 15-16 provides a ground system data flow diagram for the SAMPEX mission.



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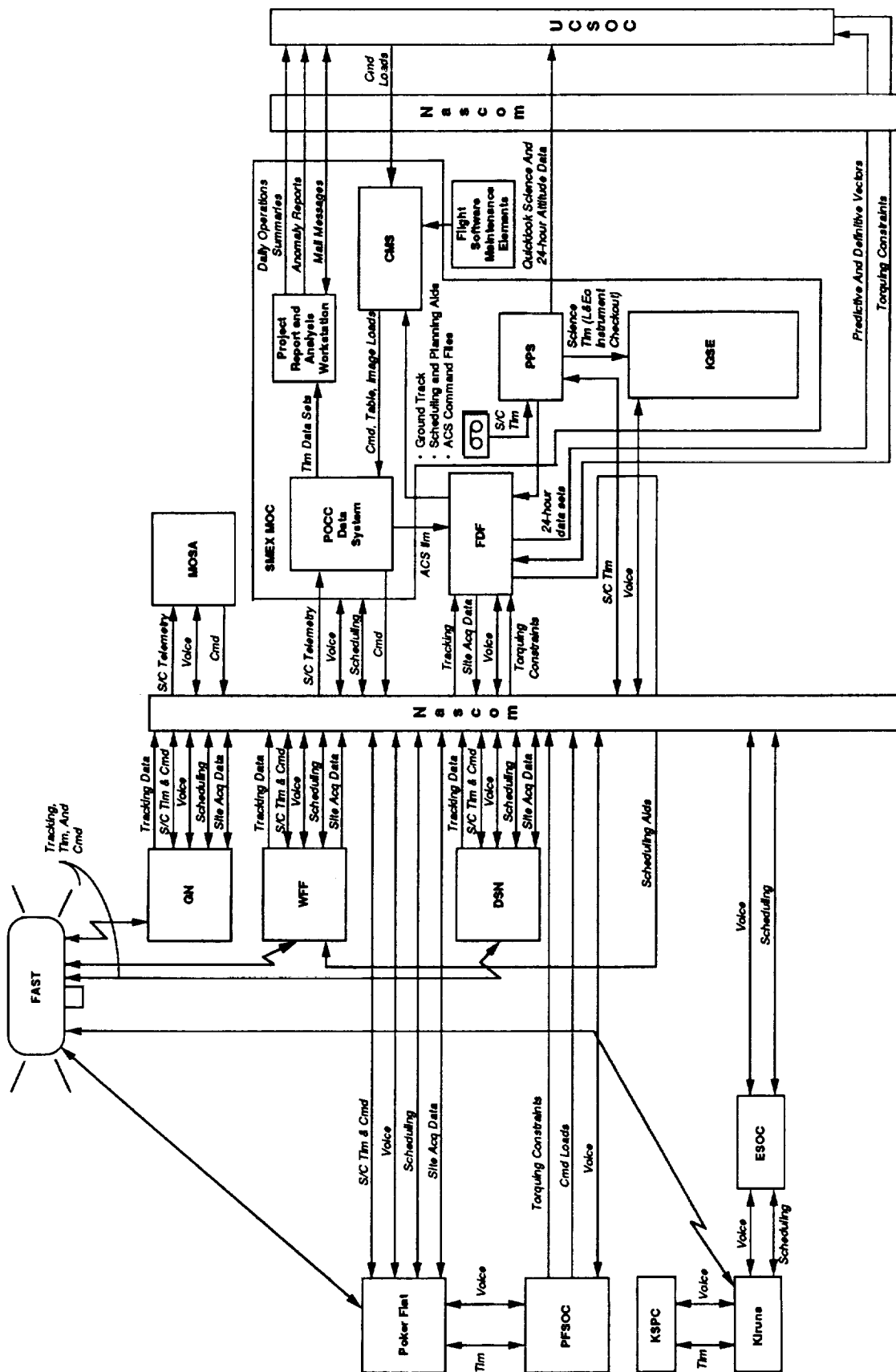
Figure 15-16. SAMPEX Ground System Data Flow Diagram

15.3.2.2 Fast Auroral Snapshot Explorer (FAST) Mission Description

FAST is the second explorer of the SMEX multimission program. The primary objective is to investigate the plasma physics of the low altitude auroral zone, that is auroral particle acceleration and wave production. The principal science measurements will be taken when the spacecraft passes through the earth's auroral zones, which is the circular region at magnetic latitudes between 65–75 degrees. FAST instruments include electric and magnetic field instruments and plasma particles instruments such as the Electrostatic Analyzers (ESA), Time-of-Flight Energy Analyzing Mass Spectrograph (TEAMS), and Wave/Particle Correlator (WPC). The University of California at Berkley provides the SOC function for the FAST mission. FAST will be launched from the Western Range on a Pegasus XL launch vehicle into a 350 x 4200 km elliptical polar orbit. Figure 15-17 illustrates the ground data flows for FAST.

15.3.2.3 Submillimeter Wave Astronomy Satellite (SWAS) Mission Description

SWAS is the third spacecraft of the SMEX program. The mission is an outgrowth of the scientific interest in the exploration of the submillimeter wavelength region of astronomy. SWAS is designed to study molecular clouds in the galactic plane, providing a mini and full survey of the clouds, leading towards the development of maps. SWAS has a single instrument for science data collection. The instrument consists of an off-axis Cassegrain telescope receiver, Acousto-Optical Spectrometer (AOS), instrument control electronics and a thermal control subsystem. The SWAS SOC function is provided by the Smithsonian Astrophysical Observatory (SAO) in Cambridge, Massachusetts. Launched from the Western Range on



LA9 540010-133m
March 1985

Figure 15-17. FAST Ground System Configuration

a Pegasus XL, SWAS will be placed into a 600 km circular orbit at 65 degrees inclination. Figure 15-18 shows the ground data flow for the SWAS mission.

15.3.2.4 Transition Region and Coronal Explorer (TRACE) Mission Description

Selected as the fourth spacecraft in the SMEX series, TRACE will study the magnetic structures which emerge through the solar surface and define both the geometry and the dynamics of the upper atmosphere. The spacecraft is planned for launch in 1997 from the Western Range on a Pegasus XL vehicle and will be placed into a 700 km circular orbit at 98 degrees inclination. This mission is in the early planning stage.

15.3.2.5 Wide-field Infrared Explorer (WIRE) Mission Description

The fifth SMEX mission will use a single cryogenically cooled infrared telescope to survey more than 100 square degrees of sky (selected target areas) in two infrared bands. Planned for launch in 1998 on a Pegasus XL vehicle from the Western Range, the spacecraft will be placed into a 400 km circular orbit at 97.2 degrees inclination. Planning for this mission is in the early planning stage.

15.3.2.6 Ground System Communications

Spacecraft-to-ground communications are via the Wallops Flight Facility and the Deep Space Network (DSN) ground stations at Goldstone, Canberra and Madrid. The MOC function is provided by the Goddard MOC using a Transportable POCC system. Real-time telemetry processing support is provided by the SDPF/PACOR. Commands are formatted into CCSDS telecommand packets; these telecommand packets are formatted into Nascom blocks for transmission at a 2 kb/s data rate to the appropriate ground station for uplink to the spacecraft. Telemetry is also CCSDS formatted and transported to the ground station as a 900 kb/s composite stream consisting of Virtual Channels 0 (real-time data), 1 (recorded spacecraft attitude and instrument data), 2 (recorded science data), and 7 (CCSDS fill packet data).

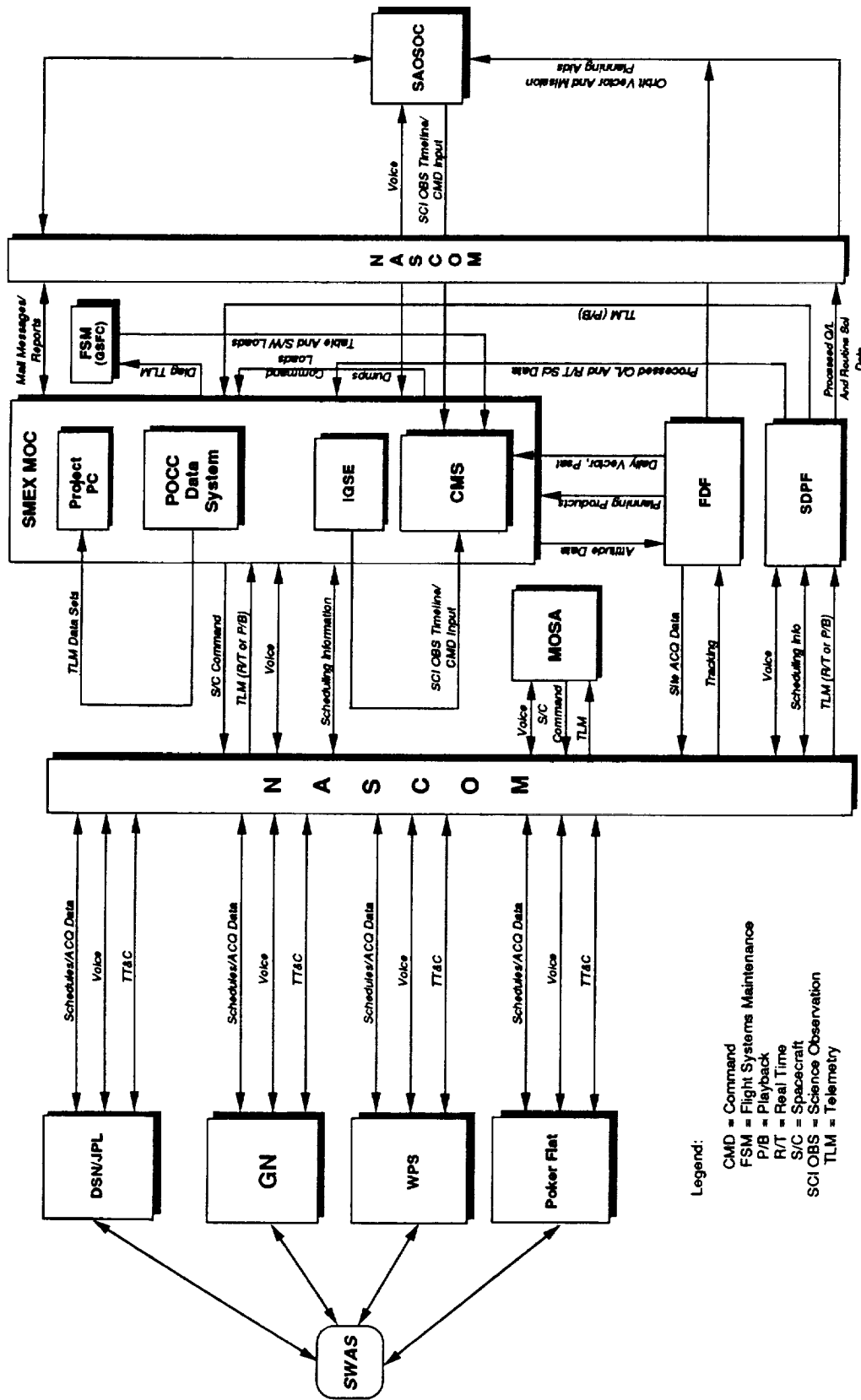
15.3.2.7 Nascom Support for SAMPEX

Nascom transports command and telemetry data between the ground stations and the MOC. Ground stations format the telemetry data from the virtual channels into 4800-bit blocks for transport by Nascom to the MOC and SDPF/PACOR. WFF transmits its data at a 900 kb/s data rate over the Nascom-2000 system. The DSN cannot support 900 kb/s data rates, even with the planned upgrades of its Nascom wideband circuitry, and therefore will provide VC 0 at a data rate of 16 kb/s while performing playback of the remainder of the data at 16 kb/s. Between PACOR and the SOC, Nascom transports processed data via an X.25 packet switched system at a line speed of 56 kb/s.

15.3.3 Total Ozone Mapping Spectrometer-Earth Probe (TOMS-EP)

15.3.3.1 TOMS-EP Mission Description

The TOMS-EP spacecraft bus integrates all of the required subsystems and TOMS instrument into a free-flying spacecraft. The instrument will accomplish a contiguous survey of the



LAS 540010-134m
March 1995

Figure 15-18. SWAS Ground System Configuration

Earth's global ozone layer each day. The TOMS-EP will be launched from the Western Range on a Pegasus XL vehicle into an intermediate orbit. The Orbit Adjust Subsystem will raise the spacecraft into the final operational circular orbit of 955 km, sun-synchronous.

15.3.3.2 Ground System Communications

Spacecraft-to-ground communications will be provided by the Wallops Flight Facility and the Deep Space Network ground stations. The TOMS Mission Operations Center (TMOC) at GSFC will generate all spacecraft commands and receive all telemetry data from supporting stations. Level zero processing will be performed by the TMOC who will transfer data sets to the Science Operations Center (SOC), also located at GSFC.

15.3.3.3 Nascom Support for TOMS-EP

Communications services between the the TMOC and supporting ground stations will use the existing capabilities provided by Nascom. Telemetry, tracking, and command data will be transported in 4800-bit blocks. Figure 15-19 shows the interfaces between elements supporting the TOMS-EP mission.

15.3.4 Advanced Composition Explorer (ACE)

15.3.4.1 ACE Mission Description

The primary objective of ACE is to determine and compare the elemental and isotopic composition of several distinct samples of matter, including the solar corona, interplanetary matter, local interstellar matter, and galactic matter. These observations will span five decades in energy, from solar wind energies to galactic cosmic ray energies, and will cover the element range from hydrogen to zirconium. A Delta II launch vehicle will be used to place the ACE spacecraft into a near earth parking orbit. The second stage will reignite to put the spacecraft into a L1 transfer trajectory. Approximately 100 days after launch, halo orbit insertion will occur where periodic station keeping maneuvers will be performed to maintain the orbit.

15.3.4.2 Ground Communications

Ace will be supported by the DSN 26 and 34 meter stations. The command rate is 1 kb/s while telemetry is 0.434 and 6.944 kb/s real-time, and 76.384 kb/s playback. Current planning is to introduce the Internet Protocol (IP) as the standard protocol for data transport replacing the 4800-bit block format. Figure 15-20 shows the elements supporting ACE and connectivity between the ground system elements.

15.3.5 Ground Network-supported Expendable Launch Vehicle Missions

15.3.5.1 ELV Mission Description

Preoperational SN missions launched on expendable launch vehicles generally require only launch and early orbit support on the GN. Some are provided with contingency orbit support. The majority of these missions are launched to geostationary orbits, which involves GN

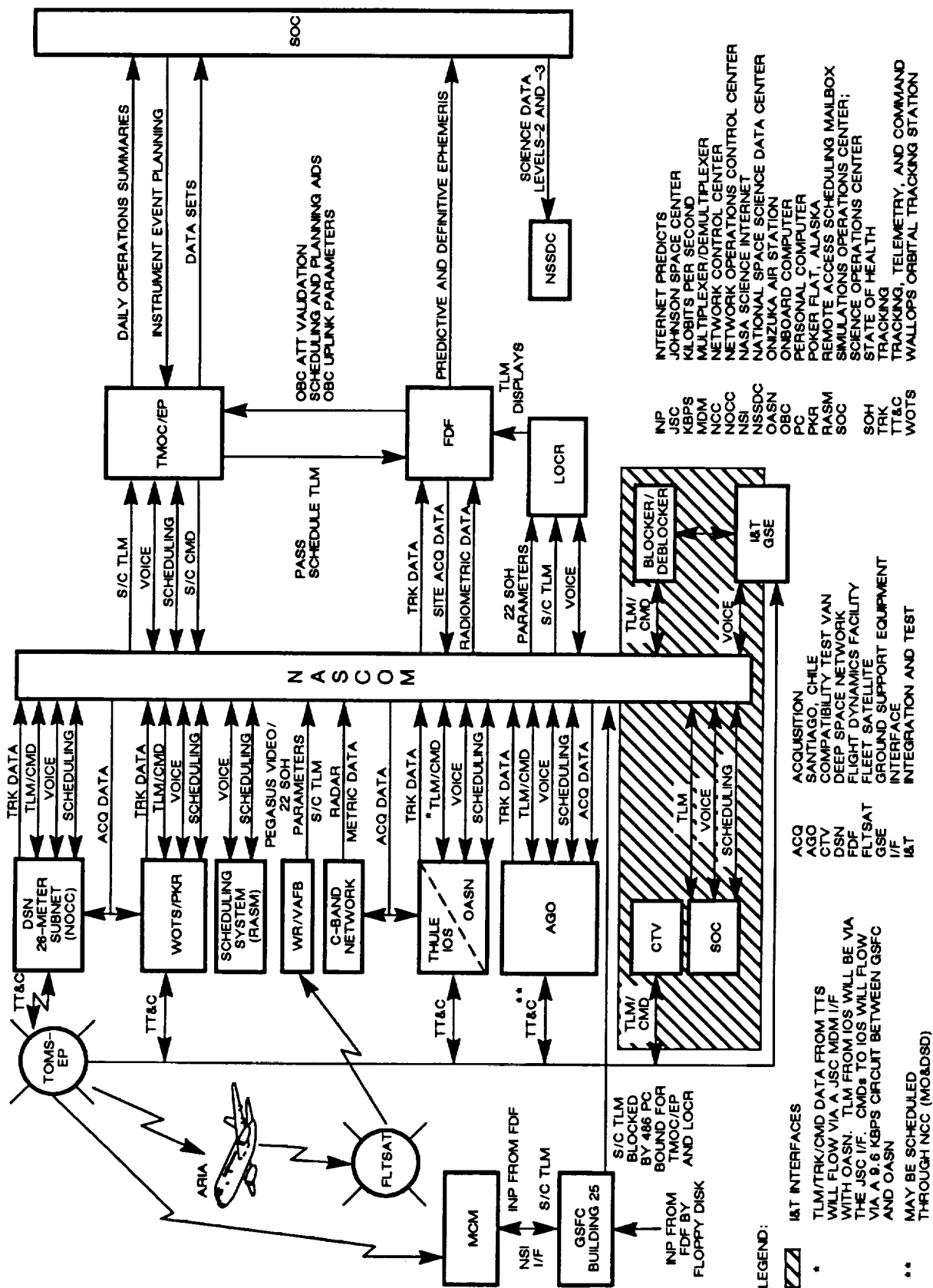
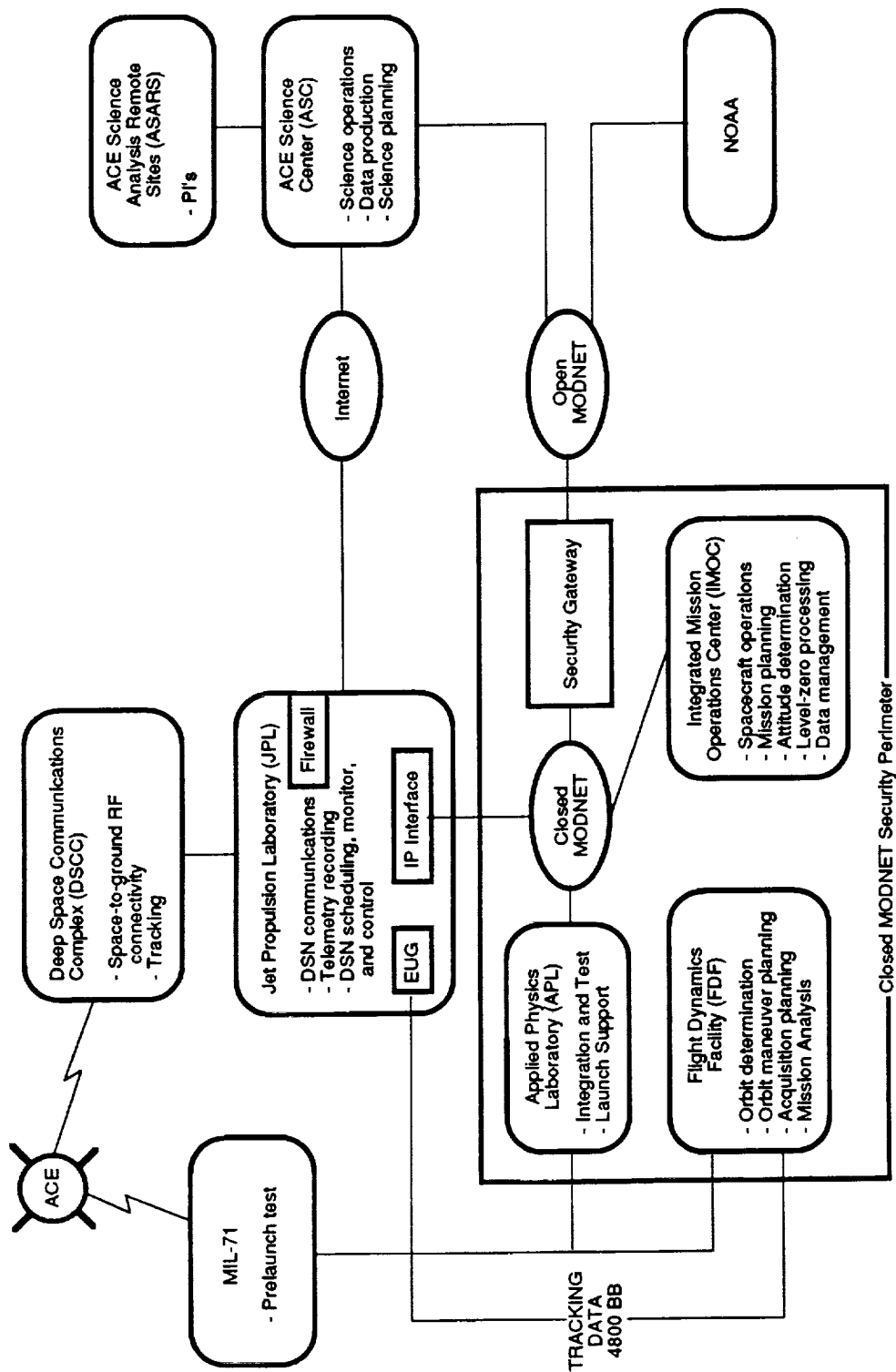


Figure 15-19. TOMS-EP Ground Data System



LORAL 540/010-120m
March 1995

Figure 15-20. Proposed ACE Data Flow

support of the spacecraft through transfer orbit, apogee firing, and drift orbit phases. Others involve GN coverage of near-Earth phases of deep space missions or limited special coverage of high-Earth orbiter missions combined with DSN support. Future missions include such launch vehicles as the U.S. Atlas-Centaur and Delta class vehicles, the Japanese Nippon Launch Vehicle (NLV), and the French Ariane. STDN No. 803 lists all future mission launches, identifies the launch vehicle, and those launches that will have GN support. It also identifies the GN stations and types of support given to the launch vehicles, in addition to the spacecraft payloads. The DSN 26-meter stations will support ELVs and contingency/emergency support of the spacecraft.

15.3.5.2 Nascom Support for ELV Missions

Nascom is providing traditional support services for the ELV missions that include system engineering support, logistics support, facility installation, technical control services, and administrative services. The provision for wideband circuits is the most common form of Nascom support service. This support is described in the following paragraphs:

- a. Existing Nascom circuits to GN sites will support spacecraft data flows from the stations for these missions. In addition to spacecraft telemetry, command, and ranging support, GN provides launch vehicle telemetry support. Delta vehicle high-rate format telemetry is transmitted via 56-kb/s circuits to GSFC Nascom MSS, which distributes it to Delta project, elements at FDF, MSOCC, and to the MIL station, where it is extended via circuits to Hangar AE and CCAFS. Additionally, low-rate Delta data format is transmitted by the GN sites via GSFC/Nascom to McDonnell-Douglas in Huntington Beach, CA, on two 9.6-kb/s circuits extended from GSFC via the West Coast Switching Center (WCSC).
- b. For the Ariane and NLV launches, data from GN support stations is routed via existing Nascom/GSFC and Madrid interfaces with launch facilities at Kourou, French Guiana; with CNES, France; and with the Japanese Tanegashima and Tsukuba Space Centers. The 9.6-kb/s and voice interfacing circuits from the Nascom interfacing points to these locations have been provided by those foreign space agencies. For NOAA missions, an interface exists between GSFC and the NOAA-NESS control center at Suitland, MD.
- c. Nascom/GN support for future missions in this category will be supported by MIL/BDA stations for pad and launch support. The Nascom network will continue involvement with ELV mission support via DSN's 26-meter stations.

15.3.6 STDN/Nascom Support of STS Payloads

15.3.6.1 Overview of Nascom Support

All real-time telemetry and command communications between remote payload POCCs and the payload – for both free-flier or sortie-type payloads supported by the STDN/Nascom during the attached phase (within the STS payload bay, or within the vicinity of the Orbiter), all real-time telemetry and command communications between remote payload POCCs, and the payload, – must be routed via the JSC/MCC, and via the Orbiter/STDN/Nascom opera-

tional links. The Nascom MDM system between GSFC and JSC may be used for data transported by remote POCCs.

15.3.6.2 Remote POCC's Payload Commands

Commands in payload format are generated by the POCC. Commands are encapsulated in Nascom 4800-bit blocks and transmitted to JSC via the MDM system. These POCC command transmissions must adhere to the POCC interface agreements with the JSC/MCC regarding protocol, metering, and format. The MCC converts these commands into Orbiter-compatible command format and transmits them via its Nascom/STDN uplink command interface to the Orbiter, where it is transferred to the payload.

15.3.6.3 Remote POCC's Payload Telemetry

Onboard the Orbiter, the attached payload telemetry is interleaved with Orbiter downlink data, which must be relayed via the STDN/Nascom interface to JSC/MCC for deinterleaving. The downlink data is processed at JSC by the Payload Data Interleaver Subsystem (PDIS). The PDIS transmits directly to remote POCCs or via the MDM interface to GSFC for relay to remote POCCs. The payload telemetry data is relayed in either serial or blocked form, along with Orbiter systems ancillary and status data, if required.

15.3.6.4 STS Services for Remote POCC

Other data services provided by JSC to remote POCCs via the Nascom MDM system include command acceptance, command histories, trajectory and related services, and tape-to-tape services. The remote POCC payload operations voice coordination may accommodate up to nine voice loops provided by Nascom for this function between GSFC and JSC. Data services between JSC and GSFC that can be accommodated on the current in-place MDM system are regarded as STS standard service. JSC/MCC Remote POCC Capabilities Document, latest revision, provides detailed information on its remote POCC payload services.

15.3.6.5 User-Nascom Interface

Remote POCC mission planners desiring access to JSC/MCC payload services must plan for and arrange interfaces with the Nascom Network at GSFC. Remote POCCs are encouraged to make this interface one that is standard and COTS supportable, e.g., IP or X.25. Refer to paragraph 8.1.4 or 9.1.4 for a statement of Nascom data transmission policy.

15.4 DSN-supported Missions

15.4.1 General Information

Missions currently supported by DSN are listed and summarized in the Deep Space Network Mission Support Requirements Document, JPL 870-14, a quarterly publication issued by JPL that is similar to GSFC's 501-803 document.

15.4.2 Current Ongoing DSN Mission Support

Section 14, Tables 14-2, 14-3, and 14-4 briefly describe each DSN current mission, including data rates.

15.4.3 Future DSN Mission Support

Table 15-8 contains a brief description and approximate launch date of each project included in the future DSN mission set for which Nascom support will be required.

Table 15-8. Future Deep Space Network Mission Support Requirements (1 of 3)

| Mission (Acronym) | Mission Title (Approval Status) Documentation | Launch Vehicle/ Site/Date | Supported Event/ Periods | Supporting Ground Stations | Data Rates |
|--------------------|--|---|--|-----------------------------------|---|
| ACE | Advanced Composition Explorer (Approved) DMR August 1993 | DELTA II/WR August 1997 | Prime Support 2 Years/5 Years Goal | CAN, GDS, RID 26 or 34-m subnets | Command: 1.0 kb/s Telemetry: 434, 6.944, 76.384 kb/s |
| ADEOS | Advanced Earth Orbiting Satellite (Approved) MRR August 1993 | H-II/Japan February 1996 | Prime support 3 years | CAN, GDS, RID 26-m subnet | Command: 500 b/s Telemetry: 1-60 Mb/s |
| CASSINI | CASSINI (Approved) MRR and DSN MSR July 1994 | Titan IV/ER October 6, 1997 | Prime support 10.7 years | CAN, GDS, RID 34 and 70-m subnets | Command: 7.8125 to 500 b/s Telemetry: 20 b/s to 249 kb/s |
| EOS AM-1, -2, -3 | Earth Observing System AM-1 (Approved) AM-1 MRR November 1992 | ELV/WR AM-1 June 1998 AM-2 June 2004 AM-3 June 2010 | TDRSS backup/5 years each spacecraft | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 16, 512 kb/s |
| EOS PM-1, -2, -3 | Earth Observing System PM-1 (Approved) PM-1 MRR April 1993 | ELV/WR PM-1 December 2000 PM-2 December 2006 PM-3 December 2012 | TDRSS backup/5 years each spacecraft | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 16, 512 kb/s |
| FAST | Fast Auroral Snapshot Explorer (Approved) DMR March 1993 | Pegasus/WR August 1, 1995 | Primary support/1 year | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 4, 900 kb/s, 1.5, 2.25 Mb/s |
| FUSE | Far Ultraviolet Spectroscopic Explorer (Unapproved) Draft MRR January 1994 | Delta 7925/ER October 2000 | Emergency support/ 3 years | CAN, GDS 26-m subnet | Command: 2.0 kb/s Telemetry: 8, 64, 128 kb/s |
| GMS-5 | Geostationary Meteorological Satellite-5 (Approved) DSN MSR July 1994 | H-II/Japan February 1, 1995 | Transfer and drift orbit phases/30 days | RID 26, 34-m antennas | Command: 128 b/s Telemetry: 250 b/s |
| GOES-J, -K, -L, -M | Geostationary Operational Environmental Satellite (Approved) GOES I-M SIRD December 15, 1996 | Atlas-I/ER J May 19, 1995 K April 1999 L March 2000 M April 2005 | Launch through S/C checkout (45 days), CDA backup thereafter/5 years | CAN, GDS, RID 26-m subnet | Command: 250 b/s Telemetry: 2.0 kb/s |
| GTC | Grand Tour Cluster (Unapproved) Pre-Phase A | Delta II/ER January 2000 | Prime support 3.5 years | CAN, GDS, RID 26-m subnet | Command: TBD Telemetry: 2 kb/s, 2.2 Mb/s |

Table 15-8. Future Deep Space Network Mission Support Requirements (2 of 3)

| Mission (Acronym) | Mission Title (Approval Status) Documentation | Launch Vehicle/ Site/Date | Supported Event/ Periods | Supporting Ground Stations | Data Rates |
|----------------------|---|---|---|--|---|
| ISO | Infrared Space Observatory (Approved) MRR and DSN MSR July 1984 | Ariane/Kourou September 1985 | Prime support 2 years | GDS 26, 34-m antennas | Command: 2.0 kb/s Telemetry: 4, 8, 16, 32 kb/s |
| ISTP/COSTR | International Solar Terrestrial Physics Program/Cooperative Solar-Terrestrial Research (Approved) SOHO DMR Issue 2 CLUSTER DMR Issue 1 | Atlas II AS/ER SOHO November 3, 1995 Ariane/Kourou CLUSTER December 1995 | Prime support 2 years | CAN, GDS, RID 26 and 34-m sub- nets | SOHO Command: 2.0 kb/s Telemetry: 245.7 kb/s CLUSTER Command: n/a Telemetry: 4, 240 kb/s |
| ISTP/GGS | International Solar Terrestrial Physics Program/Global Geospace Science (Approved) WIND/POLAR SIRD | Delta II/WR November 21, 1995 | Prime support 3 years | CAN, GDS, RID 34-m subnet prime, 26-m subnet back- up | Command: 2.0 kb/s Telemetry: 55.6, 256, 512 kb/s |
| Landsat-7 | Land Satellite-7 (Approved) DMR November 1993 | Delta II/WR January 1998 | Launch and SN backup support 5 years | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 11.5, 300 kb/s |
| Mars Pathfinder | Mars Pathfinder (Approved) MRR August 1994, DSN MSR July 1994 | Delta II/ER December 5, 1996 | Prime support 2 years | CAN, GDS, RID 34-m prime, 70-m for rover operations | Command: TBD Telemetry: TBD |
| MAUDEE | Mars Upper Atmosphere Dynamics, Energetics, and Evolution (Unapproved) Pre-Phase A | Delta II/ER January 2001 | Prime support 2 years | CAN, GDS, RID 34-m subnet | Command: 1.0 kb/s Telemetry: 1, 3.4 kb/s |
| NEAR | Near Earth Asteroid Rendezvous (Approved) DSN MSR May 1994 | Delta II/ER February 24, 1996 | Prime support 4 years | CAN, GDS, RID 34-m subnet | Command: 7.8, 100 b/s Telemetry: .01, .11, 1.1, 6.6, 13.2, 26.5, 87.8 b/s |
| NOAA-K, -L, -M | National Oceanic and Atmospheric Administration (Approved) DMR November 1993 | Titan II/WR K November 1995 L September 1997 M November 1998 | Launch/early orbit 21 days | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 8.32, 16.64 kb/s |
| RADARSAT | Radar Satellite (Approved) DSN MSR July 1994 | Delta II/WR August 16, 1995 | Launch/early orbit 90 days, emergency ther- after (5 years) | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: .5, 2, 4, 32, 128 kb/s |

Table 15-8. Future Deep Space Network Mission Support Requirements (3 of 3)

| Mission (Acronym) | Mission Title (Approval Status) Documentation | Launch Vehicle/ Site/Date | Supported Event/ Periods | Supporting Ground Stations | Data Rates |
|-------------------|--|---|---|------------------------------|--|
| SFU | Space Flyer Unit (Approved) SIRD Rev. C September 1991 DSN MSR July 1994 | H-II/Japan February 1, 1995 | Early orbit/observation/recovery phases 6 months | CAN, GDS, RID 26-m subnet | Command: 1.0 kb/s Telemetry: 1, 128 kb/s |
| SPOT-4 | Système Probatoire d'Observation de la Terre (Approved) MRR February 1994 | Ariane/Kourou December 1997 | Orbit 2/3 1 day | GDS 26-m | Command: 2.0 kb/s Telemetry: 2,048 kb/s |
| SWAS | Submillimeter Wave Astronomy Satellite (Approved) DMR December 1992 | Pegasus/WFF July 3, 1995 | Backup to Wallops and Poker Flats stations 2 years | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 18, 1.8, 900 kb/s |
| TDRS-G | Tracking and Data Relay Satellite (Approved) SIRD Rev. 4 January 1991 | STS-ILUS/KSC June 22, 1995 | Prime support launch, early orbit, drift phases; thereafter emergency support 10 years | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: .25, 1 kb/s |
| TIMED-H, -L | Thermosphere-Ionosphere-Meosphere-Energy and Dynamics (Unapproved) Phase A/B | Light-medium/WVR H November 1998 L January 1999 | Prime support | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: <3.0 Mb/s |
| TOMS-EP | Total Ozone Mapping Spectrometer-Earth Probe (Approved) DMR April 1994 | Pegasus/WVR May 10, 1995 | Prime support 2 years | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 1, 125, 20,625, 202.5 kb/s |
| TRACE | Transition Region and Coronal Explorer (Unapproved) SMEX Project Office | Pegasus/WVR October 1997 | Backup to Wallops and Poker Flats stations 1 year | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 2, 18.75, 900 kb/s, 1.8 Mb/s |
| TRIMM | Tropical Rainfall Measuring Mission (Approved) DMR July 1994 | H-II/Japan August 16, 1997 | Sn backup support 3 years | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 1, 1024 kb/s |
| WIRE | Wide-Field Infrared Explorer (Unapproved) SMEX Project Office | Pegasus/WVR October 1998 | Backup to Wallops and Poker Flats stations 4 months | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 2, 18.75, 900 kb/s, 1.8 Mb/s |
| XTE | X-ray Timing Explorer (Approved) DMR September 1993 | Delta 7920/ER August 31, 1995 | SN backup support 2 years | CAN, GDS, RID 26-m subnet | Command: 2.0 kb/s Telemetry: 32, 1024 kb/s |

Section 16. Network Upgrade and Advanced Systems Developments and Plans

16.1 Purpose

This section reports current activities of Nascom and its supporting contractors in the area of Network Upgrade (NU) and Network Advanced Systems development. More specifically, this section encompasses the Nascom upgrades and projects scheduled or being planned for implementation over the next five years in support of Nascom's strategic planning activity.

16.2 Long Range Planning

16.2.1 History

- a. **Nascom 1986 Long-term Plan.** Contained in a two-volume briefing book, the Nascom Long-term Plan (LTP) was developed in 1986 as an internal document. Development of the LTP did two vital things: (1) it made visible and thus provided recognition for some very significant change drivers to the Nascom System and (2) it demonstrated the need for a methodology for long-range planning, including establishing a system baseline, high-level goals and objectives, plan strategies, elements of the plan itself, and a mechanism for its update. See paragraph 17.2.3 for a discussion of the Nascom Long Range Plan (LRP).
- b. **Drivers for Change.** Drivers for change are both internal and external, and they include environmental factors. Examples of principal external drivers include future network user requirements and new interfaces associated therewith [EOS/EOS Data and Operations System (EDOS) program] and the requirement for data rates and volumes an order of magnitude higher than those supported during the 1980s decade; the fact that technology advancements drive paradigm shift changes in the telecommunications industry; the SN has planned significant changes resulting from the advent of the STGT, the WSC, a larger TDRS constellation and the follow-on TDRSS-II; planned changes in user operations (e.g., telescience); requirements for interoperability with the space networks of other countries' space agencies (ESA and NASDA); budgetary pressures; and resource limitations. Internal drivers characterized as being principally of a management nature, e.g. becoming more proactive in the planning and implementation of telecommunications services in the decade of the 90s and further, thereby asserting its leadership and fostering high-visibility participation in interagency planning and coordination activities. There are also the technology-based drivers that require internal Nascom R&D and study and analysis activities. In support of the foregoing, there are the planning and management actions necessary not only to maintain but also to expand the range and depth of skills available to Nascom both from its Civil Service staff and from its supporting contractor sources. Of particular impact are the Open Systems Interconnection (OSI) networking standards and protocols.

- c. Nascom Planning Council. The LTP also established a Nascom Planning Council chaired by the Division Chief and composed of Nascom Division management at the branch level and above, and including a research and planning manager. The primary focus is to provide coordinated planning direction to Division elements. The Planning Council conducts periodic planning activities and provides planning strategies, sets objectives, and allocates and assigns responsibilities and tasks.

16.2.2 LTP/LRP Goals and Objectives

At the highest level, Nascom goals and objectives may be summarized as follows:

- a. Provide efficient and effective institutional Nascom operational communications services that meet the requirements of the 1990s and beyond.
- b. Develop and maintain in-house management skills sufficient to meet these requirements for Nascom communications services.
- c. Develop the management, engineering, and operations plans necessary for effecting the necessary enhancements within the Nascom network and the development of "new" networks as required to meet the need of major flight programs, e.g., EOS.

16.2.3 LRP Scope and Content

A Nascom Long Range Plan (540-007, issued in January 1991) was developed in 1990 as a separate top-down mandated document prepared in accordance with guidelines and requirements promulgated by the GSFC Mission Operations and Data Systems Directorate (MO&DSD). The LRP was prepared in a form similar to that of the MO&DSD LRP; its content was coordinated with that of the MO&DSD LRP in a manner showing how Nascom plans and projects supported those of the Directorate.

The Nascom 1990 LRP, in effect, captured in high-level summary form the material contained in the NSDP of that year. One of the value added functions provided by the LRP was the establishment of a set of key service objectives and the description of how these objectives relate to the MO&DSD Directorate's service objectives as identified in the Directorate's LRP. The 1990 LRP further summarized near-term and long-term Nascom capabilities, and provided a look at Nascom's strategic plan for transition to the networks of the future.

16.2.4 New Directions

At its inception, Nascom quickly discovered that it was not only operating at the forefront of technology but was significantly instrumental in pushing forward the technological developments necessary to fulfill its commitments to the space program. As a result, Nascom fielded a significant percentage of its infrastructure in the form of development items: proprietary and/or built for Nascom. The 4800-bit block was developed before there were international standards for data transmission in packetized form. Today, there are mature (and maturing) international and government standards for data communication (ISO, CCITT, CCSDS, TCP/IP, etc.), and vendors are offering standards based equipment and software on a Commercial, Off-The-Shelf (COTS) basis. Space and earth science programs are now employing these standards based COTS offerings.

With the emphasis on doing NASA's business in ways which are "better, cheaper, faster," there is an opportunity now to develop a program for delivery of even more efficient and effective telecommunication network services with emphasis on customer satisfaction, quality, technical excellence, and cost effectiveness. There is now an opportunity to provide networking solutions adaptable to all projects rather than developing separate and distinct solutions for each project. Standards based COTS technologies, common to both the data user and data transport functions, allow this to happen. At the same time, there are opportunities to attain economies of scale and shared resources by carefully bringing the communication networks resources under single management.

With these strategic visions in mind, Nascom is an active participant in the MO&DSD's Reusable Network Architecture for Interoperable Space Science Analysis, Navigation, and Control Environment (RENAISSANCE) initiative. Nascom is also a leading player in the development of the NASA Office of Space Communications Strategic Plan. Internally, Nascom has developed an Evolution Action Plan (NEAP) with the following objectives in mind:

- a. Review development plans for current and future systems to discover opportunities for insertion of standards based COTS products which offer opportunities to simplify operations, maintenance, and sustaining engineering support and thus reduce life-cycle costs.
- b. Review the necessity for Nascom-specific protocols and identify (industry) standards based protocols that can be used to guide COTS insertion.
- c. Review the Nascom-wide system engineering practices to take advantage of the flexibility of COTS packages to reduce the number of systems and their operational complexity.
- d. Combine the results of these reviews into an Action Plan to chart the future of Nascom.

In May of 1994, Nascom presented a strategic review describing its vision for the future of Nascom. The approach to attaining it will be evolutionary and include the following:

- a. Full implementation of FTS2000 by Nascom. This has largely been done, and the resulting network is now called Nascom-2000.
- b. Maximum use of COTS products to meet communication requirements. This includes both equipment and the software necessary to make it work.
- c. Model, analyze, and testbed the technologies of the future that Nascom may intend to use. The laboratory that Nascom has built in support of the EOSDIS Backbone Network (EBnet) project is representative of how this step is executed. New products, protocols, and management systems will be evaluated rigorously and their capability to meet Nascom requirements will be documented.
- d. Develop an integrated network management structure that is largely automated, capable of providing an end-to-end picture of each Nascom system, and supplying detailed network status and accounting information, all of which may enable the reduction of operational manpower.

- e. Integrate Asynchronous Transfer Mode (ATM) switching technology into the Nascom backbone as the capabilities of ATM to support the multimedia transmission needs of Nascom are satisfactorily demonstrated. Ultimately, the Nascom backbone is envisioned to consist of ATM switching and Synchronous Optical Network (SONET) transmission paths, at least between the three major nodes: GSFC, JSC, and WSC.

It is a Nascom objective to eliminate the need to support the 4800-bit block in any and all of its varied forms by not later than Fiscal Year 1997. Accordingly, parties to these legacy 4800-bit block interfaces are encouraged to commence now coordinating the conversion of their interfaces to a COTS standard one that Nascom supports, e.g., CCITT X.25 or, preferably, TCP/IP. The Nascom Mission Planner (GSFC Code 542.1) assigned to the mission/project can provide detailed information to help with planning the conversion of each existing 4800-bit block interface as well as for new standards, COTS-based interfaces.

Figure 16-1 portrays, at a very high level of abstraction, one possible end position that might be attained as Nascom follows this evolutionary process.

16.3 Current LRP Strategic Plan

Present Nascom long-range planning strategy has separated advanced systems development activities, which include a major EOS Communications (Ecom) project from specific and current NU activities. Ecom draws upon work done for Nascom II before termination of NII procurement authority in FY92-1. These two activity areas are conducted concurrently. The following is a definition and expanded explanation of these terms and strategies.

16.3.1 Definition of Network Upgrading

16.3.1.1 High-level Definition

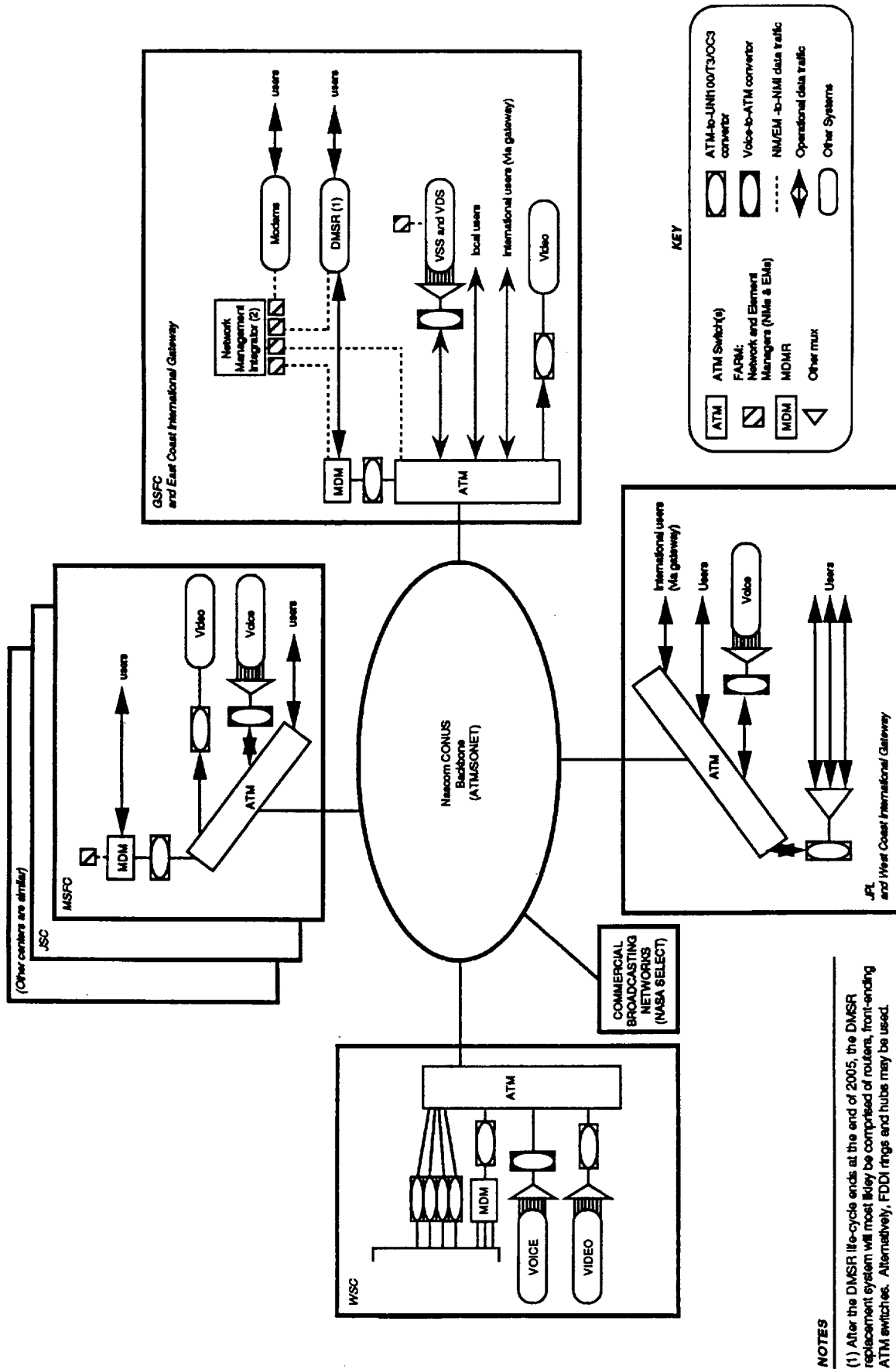
NU consists of any additions, modifications or enhancements, or replacements needed for existing Nascom systems, in order to continue to reliably support NASA missions using current aerospace data standards and practices.

16.3.1.2 Scope of NU Activities

NU activities sustain the major Nascom ground network systems currently supporting the STS/Orbiter/Spacelab/ Attached Payloads, Missions and Programs, and the life expectancy of the present on-orbit near-Earth and deep space missions that are supported by the GN, SN, and DSN networks. Additionally, NU upgrades these systems to provide support to the missions already planned for these existing ground network systems; e.g., HST, GRO, UARS (near-Earth missions), ISTP (high-Earth orbital missions), and Magellan, Galileo, Ulysses, and MARS Global Surveyor (MGS) (deep space missions).

16.3.1.3 NU Relationship to LRP

The Nascom LRP recognizes the continued need for planning modifications, upgrades, and subsystem replacements because of aging or obsolescence. Technology advancements and



LAS 540/010-298m

Figure 16-1. A Conceptual Architecture for Nascom, Circa 2005

the continued ability to provide near-term planning for, and relatively quick-response to, new or changing requirements for these missions are important elements of the Nascom LRP-NU commitment.

16.3.2 Definition of Advanced Network Systems Development Activities

16.3.2.1 High-level Definition

These activities encompass the entire spectrum required, directly or indirectly, to meet the requirements of flight projects employing advanced orbital systems communication methods. Entirely new Nascom systems are under consideration with the focus being on CCSDS packet data transmission. These new systems will be data driven rather than schedule driven. An example is EBnet which is now being designed by Nascom for the exclusive support of EOS. As other flight projects formally establish their requirements, it would not be unreasonable to assume that additional Nascom projects could be initiated to provide a similar type of system-service for them. In this respect, the EBnet project serves as both a benchmark and a point of departure for evolving to the Nascom of the first decade of the twenty-first century.

16.3.2.2 Scope of Activities

These activities include: Nascom Advanced System Program technology studies and assessments particularly in the area of OSI Networking; participation in the ESDIS project initiatives at GSFC including certain R&D prototype developments in cooperation with GSFC Code 520 and the EOS project; continuing investigation and information gathering of missions and users support requirements; inter-agency systems planning and integration/coordination; development of architectural concepts, operations concepts, trade/feasibility studies and documented system design requirements leading to and including the various phases of procurement and implementation of EBnet; the development of interface agreements, control documentation, element and user interface compatibility, acceptance testing and full system documentation.

16.4 Network Upgrading Activities and Projects

In the following paragraphs, NU activity/project descriptions are each identified as: recently completed, approved and/or undergoing implementation, or proposed and under evaluation. Projects or activities reported as completed will be removed from Section 16 in subsequent reissues. Results will be integrated into system descriptions in Sections 3 through 14, if system modifications have been completed; results may be reflected in follow-on projects or plans, if applicable.

16.4.1 Digital Matrix Switch Replacement (DMSR) Project (DMS II)

16.4.1.1 Project Objectives

A Digital Matrix Switch Replacement Project was established to meet the expanding needs of Nascom users for circuit switched services. The capacity of the current DMS, 192 input and 192 output channels, has been exceeded as more GSFC users have been added to the Nascom network. The existing matrix switch cannot be economically expanded.

The primary objective of the DMSR project was to develop a replacement system to meet the current and future circuit switching requirements of the GSFC user community. The chosen approach is a single switch with the capability to interconnect 512 input ports and 512 output ports. Each port is simplex and consists of two signals (data and clock) at any rate from 100 b/s to at least 2.048 Mb/s, which shall be switched simultaneously. The second objective is to provide for a diagnostics capability that will perform the fault isolation function down to the single board level.

16.4.1.2 Background and Schedule

To support the revised termination requirements for the MDM replacement system, and the growing pool of GSFC users, a replacement DMS is urgently required. The existing DMS, a one-of-a-kind product developed for Nascom by the Applied Physics Laboratory, implements Clos nonblocking switch theory and consists of input buffers, a matrix switch, output buffers, and a DMS Control System. Figure 5-1 in Section 5 presents a simplified block diagram of the current DMS, and paragraph 5.3 provides a description of the existing system. The DMSR was procured using a modular implementation approach and COTS hardware and software to the maximum extent possible.

The successful bidder for the DMS II (what the DMSR has come to be called) was Cornet, Inc. of Springfield, Virginia. Cornet is now delivering the DMS II on the following schedule (unless otherwise indicated, all events occur in 1995):

a. Development Switch

- | | |
|----------------------------------|------------------|
| 1. Factory Acceptance Test (FAT) | December 1994 |
| 2. Delivery to Nascom | January |
| 3. Acceptance Testing | January |
| 4. O&M Manuals | January |
| 5. Spares and Maintenance Kit | January |
| 6. Nascom Acceptance Testing | January-February |
| 7. Acceptance by Nascom | February |

b. First Operational Switch

- | | |
|-------------------------------|-------------|
| 1. Plans (Training, FAT, QA) | February |
| 2. FARM Simulator | March |
| 3. FAT | March-April |
| 4. Delivery to Nascom | April |
| 5. Spares and Maintenance Kit | April |
| 6. Documentation | April |
| 7. Installation and Checkout | April-May |

| | |
|--------------------------------------|----------------|
| 8. Connection of Nascom Patch Panels | April-June |
| 9. Nascom Acceptance Testing | May-July |
| 10. Nascom Acceptance | June-July |
| 11. Four M&O Training Classes | June-October |
| c. Second Operational Switch | |
| 1. FAT | June |
| 2. Delivery to Nascom | July-August |
| 3. Spares and Maintenance Kit | July-August |
| 4. Installation and Checkout | July-August |
| 5. Nascom Acceptance Testing | July-September |
| 6. Nascom Acceptance | August-October |

Within Nascom, the switch system delivered by the DMSR project has been named "DMS II."

16.4.1.3 Description

The replacement Nascom digital matrix switch, a Cornet MTX-48, is a nonblocking, high-speed digital matrix that enables the interconnection of up to 512 digital ports. Designed for operations up to 6.312 MHz on each channel, the DMS II interfaces with high-speed data and clock signals utilizing a pair of twinaxial connectors, two per port (one each for data and clock). Interfacing with user circuits is done by the Port Concentrator Unit (PCU). This device converts 32 user interface ports to RS-422 levels for transmission to the matrix chassis. At the matrix chassis, the signals are converted to TTL where all switching functions are done with Programmable Array Logic (PAL) circuits.

Nascom is receiving two matrix switch configurations. The development switch is a 64 by 64 port switch mounted in a single rack. The operational switch is a fully loaded 512 by 512 port switch that is delivered in six racks. Both switches use the same components and are controlled by the same control proprietary software, CorScan 100.

The DMS II, as delivered by Cornet, Inc., has the following features:

- a. Nonblocking Crosspoint Design.
- b. Dual Terminal Control.
- c. Dual Ethernet Interface.
- d. Transparent to all Protocols.
- e. Switches Data Rates up to 6.312 MHz.
- f. Redundant Control Cards.
- g. Battery-Backed Dual NV RAM.
- h. Dual Redundant Power Supplies.
- i. Built-In Background Circuit Assurance Checks.
- j. Highly Reliable Design.
- k. LEDs Indicate Control Card Status.

- l. LEDs Indicate Data and Clock Status of PCUs.
- m. Group Switch Mode.
- n. Broadcast Mode.
- o. Monitor Mode.

The basic design of the Nascom matrix consists of a matrix chassis, dual redundant power supplies, fan panels, interchassis cabling, and PCUs.

The system is designed to cross-connect up to 512 physical signal ports. A signal port connection is defined as a simplex connection from one input port to one output port, with both data and clock connected through the switch. The data signal is switched through one physical matrix and the associated clocking signal is switched through a second physical matrix switch.

The function of the PCU is threefold:

- a. Establish a connection point to the matrix.
- b. Convert the user data into a physical and electrical format that can be transmitted to the main matrix chassis.
- c. Establish a backup point in the event of a matrix switch I/O card failure.

The PCU takes the user input data, converts it to TTL for test purposes, then converts it back to RS-422 and places it on one pair of wires for transmission to the matrix. Each data port at the PCU is serviced by two wires to the matrix (input data) and two wires from the matrix (output data). Likewise, each clocking signal is serviced by two wires to the matrix (input clock) and two wires from the matrix (output clock). An extra PCU to matrix cable is configured on the PCU to accommodate the built-in backup function. This function allows the backing up of the PCU to matrix cable and the switch I/O card in the matrix.

When the RS-422 signal arrives at the matrix chassis, it is received by the matrix switch I/O card and converted to TTL levels. These TTL signals are then placed on the motherboard bus for the matrix switching cards. Each chassis can accommodate up to 16 matrix switch I/O cards and 16 matrix switch cards. Each switch and switch I/O combination will handle up to 16 individual data path inputs and 16 individual data path outputs. A fully loaded chassis can have up to 256 input and 256 output data paths on the motherboard at any one time. A data path is defined as being the route between one data port input and another data port output. A full 512 port matrix switch requires four matrix chassis for each data signal being switched.

Each matrix switch card is capable of accepting data from any one of the 256 data path inputs and connecting (switching) that path to one of 16 output paths available on that individual matrix switch card. Each matrix switching card can do this 16 times, allowing it to connect any 16 of the available 256 inputs to any 16 of the card outputs. Each matrix switch card is dedicated to the 16 output paths associated with the chassis slot in which it is installed. All cross point connections are made on the switching cards utilizing PAL chips.

When the data signal is switched to the appropriate output path, it is accepted by the switch I/O card where it is converted back to RS-422 signal levels and driven to the PCU as an

output signal. The PCU will receive the data signal, convert it to TTL, run a test on the data, then convert it back to the user interface levels and present it to the user equipment.

The matrix control processor card incorporates a Non-Volatile Random Access Memory (NV RAM) that holds the current system configuration. In the event of a power loss, the NV RAM will automatically configure the switch on power-up to the last known configuration. If one of the two control processor cards are changed, the data from the other NV RAM will automatically be loaded to the new card.

A spare switching card is configured in each matrix chassis to perform a backup function in the event of a path failure through that matrix. This backup switch card is located in chassis position 17 and will provide up to 16 backup paths, one for each matrix switch card output path configured in the switching system. This card can back up individual paths on a switch card or the entire switch card.

All matrix cards are "hot swappable". They are designed to be removed from the chassis without first removing the system power.

Control of the matrix is from a 486 Personal Computer (PC) running the CorScan 100 control software installed in the Local Control Computer (LCC).

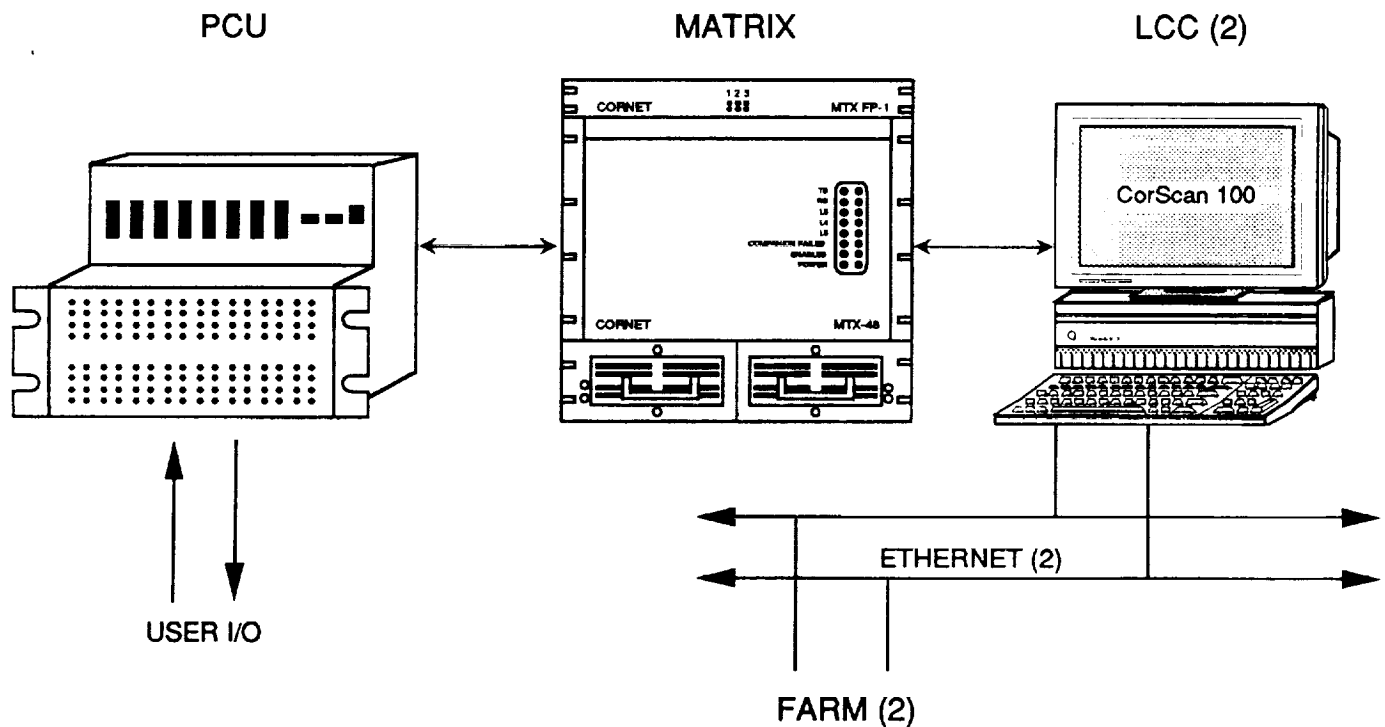
Two LCCs are used to perform single port switching, group switching, and broadcast switching on the Nascom digital matrix. In the event that both LCCs issue commands at the same time, the first LCC (or FARM, when it comes on-line) to gain access will control the matrix, while all commands from the second will be stored until the first LCC/FARM is finished. At that time, the commands from the second LCC/FARM will be acted upon. The basic configuration of the DMS II is illustrated in Figure 16-2.

Circuit Assurance Checks (CAC) are automatically run in the background on all ports in the Nascom matrix. Three of these tests run continuously, one on the main switching chassis, and two in the PCU, one for the input signals, and one for the output signals. The combination of CAC tests will allow the user to determine where a problem is located.

Physically, the matrix switch chassis is 12.25 inches high by 19 inches wide and 16 inches deep. The basic MTX switch consists of a single chassis and can accommodate up to 256 physical signal interface ports. Each matrix switch I/O card contains one physical I/O connector (78-pin) that accommodates the input and output paths for 16 data channels to half of one PCU. An additional pair of 44-pin connectors (one for input and one for output signals) permits system expansion to 512 channels. Each signal port of the PCU consists of an input and an output path that physically terminates on the 78-pin high density connector located on the rear of the matrix switch I/O card.

The matrix chassis holds up to 17 front-mounted switching cards, 17 rear-mounted I/O cards, two front-mounted control processor cards, and two rear-mounted control interface cards. The 17th switching card is used for switch path redundancy. This 17th card provides 16 extra paths through the switch that are used in the event of a prime path failure. The 17th switch I/O card is cabled to a chain of eight PCUs that are associated with that switch chassis.

The redundant power supply is mounted in a separate 5.25-inch high chassis and is cabled into the rear of the chassis. One dual redundant power supply will power two fully loaded



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Figure 16-2. DMS II Basic Configuration

matrix switch chassis. The interface PCU racks require one dual redundant power supply for each four I/O chassis.

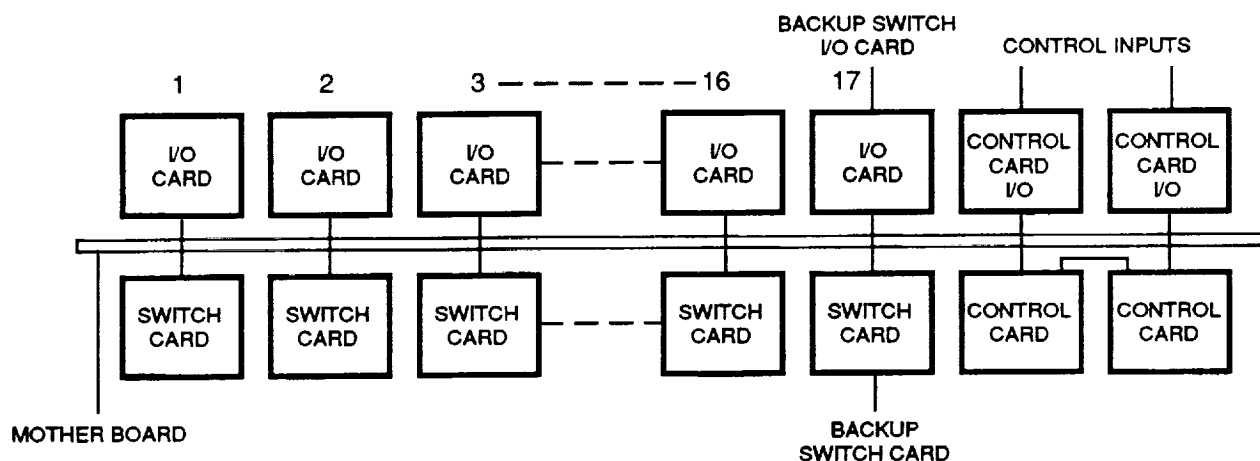
16.4.1.4 System Architecture

A high-level depiction of the matrix chassis architecture and system configuration is shown in Figure 16-3. The redundancy of critical components, such as the power supply and the control cards are illustrated in the figure; the backup switch card and backup switch I/O card is also shown. A midplane mother board runs down the entire length of the MTX chassis and is the mechanical interface for all control, switch, backup, and I/O cards.

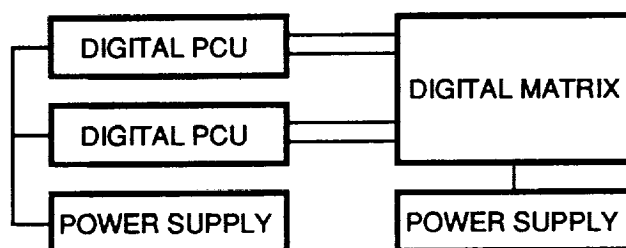
All active components of the MTX are mounted on easily removable Printed Circuit (PC) cards. These cards have been designed such that they can be removed from the chassis without first removing the main power. All PC cards include specially designed card edge ejectors to assist in their removal and installation.

16.4.1.5 System Components

A fully loaded MTX digital matrix chassis, capable of interconnecting 256 separate data ports, consists of one main chassis, 16 switching cards, one backup switching card, two control cards, and 16 interface I/O cards. The power supply module is a separate chassis mounted directly below the main matrix chassis. A separate PCU is required for the user interface



MATRIX CHASSIS ARCHITECTURE



MATRIX SYSTEM CONFIGURATION

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Figure 16-3. Chassis Architecture and System Configuration

connection. The Nascom PCU interfaces 32 user input and 32 user output data and clock connectors to the matrix chassis.

- Main Chassis.** The front of the main chassis consists of 19 slots that hold up to 16 matrix switching cards (slots 1-16, left to right from the front), one backup switch card in slot 17, and two control cards in slots 18 and 19. The rear of the main chassis consists of 16 slots for interface I/O cards, one slot for the switch I/O backup card, and two slots for the control I/O card.
- Control Processor Card.** Two control processor cards are located in positions 18 and 19 of the equipment chassis. Each control card is capable of controlling a fully loaded 512 port matrix with 512 inputs (data and clock) connected to 512 outputs (data and clock). A nonvolatile battery-backed memory is included on each control card to maintain the connection table in the event of a power failure. Should a loss of power be experienced, the switch will read this connection table on power up and

automatically return to the last configuration established prior to the power failure. Also, if a new control card is inserted, all of the necessary configuration information will be copied from the other installed control card.

The MTX is designed to be controlled from a 486 PC running the CorScan 100 control software. Each control card can be connected to a separate control PC, allowing dual control of the matrix. The interface between the control card and the control PC is the control I/O card, located directly behind the control processor card. Both control cards can be operated simultaneously. Any command issued to control card #1 will be stored in the NV RAM, acted upon, then loaded into the companion control card, #2.

With the matrix configured as a four chassis, 512 port switch (Nascom's DMS II configuration), the control processor cards are chained together through the control I/O card. A specific chaining DB-9 connector is on each control card for this purpose.

- c. **Control I/O Card.** The control I/O card interfaces between the control PC and the control processor card. Three DB-9 connectors are mounted on the rear of the card for interfacing with the control PC, chaining the control to a second matrix chassis, and interfacing with the PCU/Fan control bus. The function of this card is to convert the incoming signals to TTL for application to the control processor card. The chaining output port is used in the two, four, or eight chassis matrix configurations.
- d. **Matrix Switching Card.** The matrix switching card is responsible for establishing the connections requested by the user. These connections are established on PAL devices at the TTL level. Up to 17 matrix switch cards can be configured in each matrix chassis. Sixteen of these cards are used for the matrix crosspoint connections, and the 17th is used as a backup for the first 16. Each matrix switch card is capable of establishing crosspoint connections for 16 ports; therefore, each chassis is capable of establishing connections for a maximum of 256 ports. A crosspoint connection is defined as one input signal connected to one output signal.

The matrix switch card is a 16 x 272 crosspoint switch capable of taking any of the normal 256 inputs available on the motherboard and connecting 16 of them to the 16 available outputs on that particular matrix switch card. Those 16 specific outputs are hardwired to the switch I/O card which is hardwired to the output side of one PCU. The additional 16 ports on each switch card are used for the backup function. When a backup connection is made to bypass either a single path through the matrix switch card or an entire card, the extra 16 outputs are used on both the backup switch card and the switch card I/O.

Single point connections or multiple point connections (broadcast mode) are made on the matrix switch card. All inputs are available to all switch cards, therefore, broadcast mode connections can easily encompass multiple matrix switch cards, depending on which output ports are selected for inclusion in the broadcast connection.

Software control disallows connecting multiple inputs to the same output. However, a single input can be connected to any or all of the available outputs.

The configuration of each matrix switch card is stored on the NV RAM located in the matrix control processor card. If a switch card becomes defective and is replaced, the control processor card will automatically load the new switch card with all current connection information.

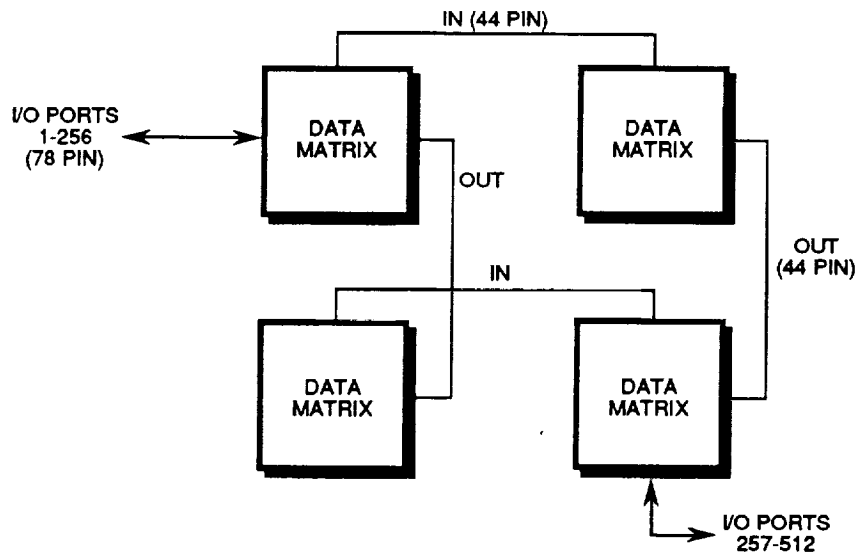
- e. **Backup Switch Card.** The function of the MTX backup switch card is to allow backup data paths in the event of a path failure. This card is positioned in chassis slot number 17 and is identical to all of the other matrix switch cards. Slot 17 is the 17th from the left as you view the chassis from the front. When the built-in CAC testing detects a faulty data path, the faulty path can be bypassed and user data placed on the position 17 backup card.

If a switch card should become totally defective, or when the switch card must be replaced, all circuits passing through it can be rerouted to the 17th position. Once this is accomplished, the defective card can be removed and replaced with a known good one. Removal and replacement of the matrix switch cards can be done without removing the system power.

When the new card is installed, it will automatically be configured from the NV RAM located on the control processor card. Now, the user can take all of the bypassed circuits and place them back on the newly replaced switch card.

The backup card contains a total of 16 backup paths. Each matrix switch card contains a total of 6 output paths. Each output path is tied to the 17th position where an additional tri-state driver can take over the output function. All inputs are available to the 17th card as well as all the other switch card positions; therefore, a simple user command will take the current defective path and switch it to the 17th card position path. All switch cards are identical, so a switch card that would normally be in position 1 can easily be placed in position 17 and take over the role of the backup card.

- f. **Switch I/O Card.** The function of the switch I/O card is to convert the RS-422 level signals from the PCU chassis to TTL level signals suitable for placement on the matrix motherboard for use by the matrix switch cards. This card also accepts TTL input from the matrix switch cards and converts them to RS-422 levels for transmission to the PCU chassis. The switch I/O card mounts in the MTX from the rear and plugs into the chassis midplane motherboard. The signals from the switch I/O card to the matrix switch card are placed on the motherboard where they can be accepted and used by any or all (broadcast mode) of the switching cards. The input signals from each switch I/O card are placed on the matrix motherboard where they can be connected to the output of any switch card in the system. The I/O card is designed to be removed from the MTX chassis without first removing the main power. Figure 16-4 depicts a 512 port configuration.
- g. **Power Supply.** A redundant power supply is used with the MTX design to assure reliability and uninterrupted operation in the event of a power supply failure. This



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Figure 16-4. 512 Port Configuration

power supply consists of a 5.25-inch chassis that contains two independent power supply modules. Each power supply module is capable of running two fully loaded MTX chassis or four PCU chassis. Individual power supplies operate on 115 volts ac delivered at 47-63 Hz. Power supplies can be replaced while the matrix is on line without affecting system operations.

16.4.1.6 System Configurations

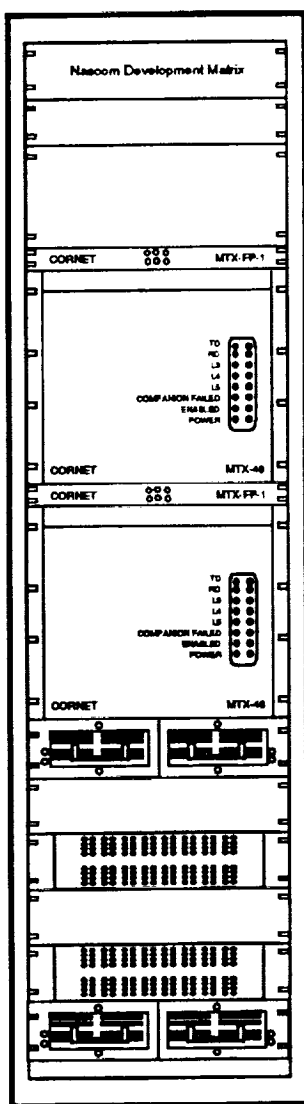
The Nascom matrix will be shipped in two basic configurations. The development switch will be configured as a 64 by 64 port switch and occupy one equipment cabinet. A total of two matrix chassis, two PCU chassis, a pair of fan panels, and two power supplies will constitute the entire matrix. Control will be through two LCCs. The LCCs will consist of two 486 PCs loaded with DOS 6.2, Windows 3.1, CorScan, and a pair of Ethernet Network Interface Cards (NIC). Figure 16-5 portrays the rack elevation of the development switch.

The operational switch will be configured as a 512 by 512 port switch requiring six equipment cabinets. A total of eight switch chassis, 16 PCUs, 16 fan panels, and eight power supplies constitute the entire matrix. The LCC control is identical to that supplied with the development switch. Figure 16-6 illustrates the operational matrix switch.

16.4.1.7 Nascom Local Control Center

The DMS II is delivered with two LCCs. Each LCC is capable of full control of the DMS II.

- a. Pre-FARM Control. An LCC consists of a 486 PC (33 MHz) loaded with DOS 6.2, Windows 3.1, and CorScan 100 Control Software; two Ethernet NICs are also installed. The computer also includes a 3.5-inch high density floppy disk drive, a 300



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Figure 16-5. Development Switch

Mbyte hard drive, a mouse-pointing device, a 101-key keyboard, and a 14-inch VGA CRT. The mouse can be used for all LCC functions (except data entry). The two Ethernet NICs are used to interface with the NASA FARM interface.

Each LCC is connected to its assigned control processor I/O cards (one of the two available). Both LCCs are connected to the same matrix chassis, with the remaining matrix chassis being "chained" together from the main chassis with a 9-pin control cable connected to the DB-9 located on the control processor I/O card. All alarming from the port concentrator units are connected to the master control processor I/O card, where the alarms are routed to the LCCs for user notification and alarm logging.

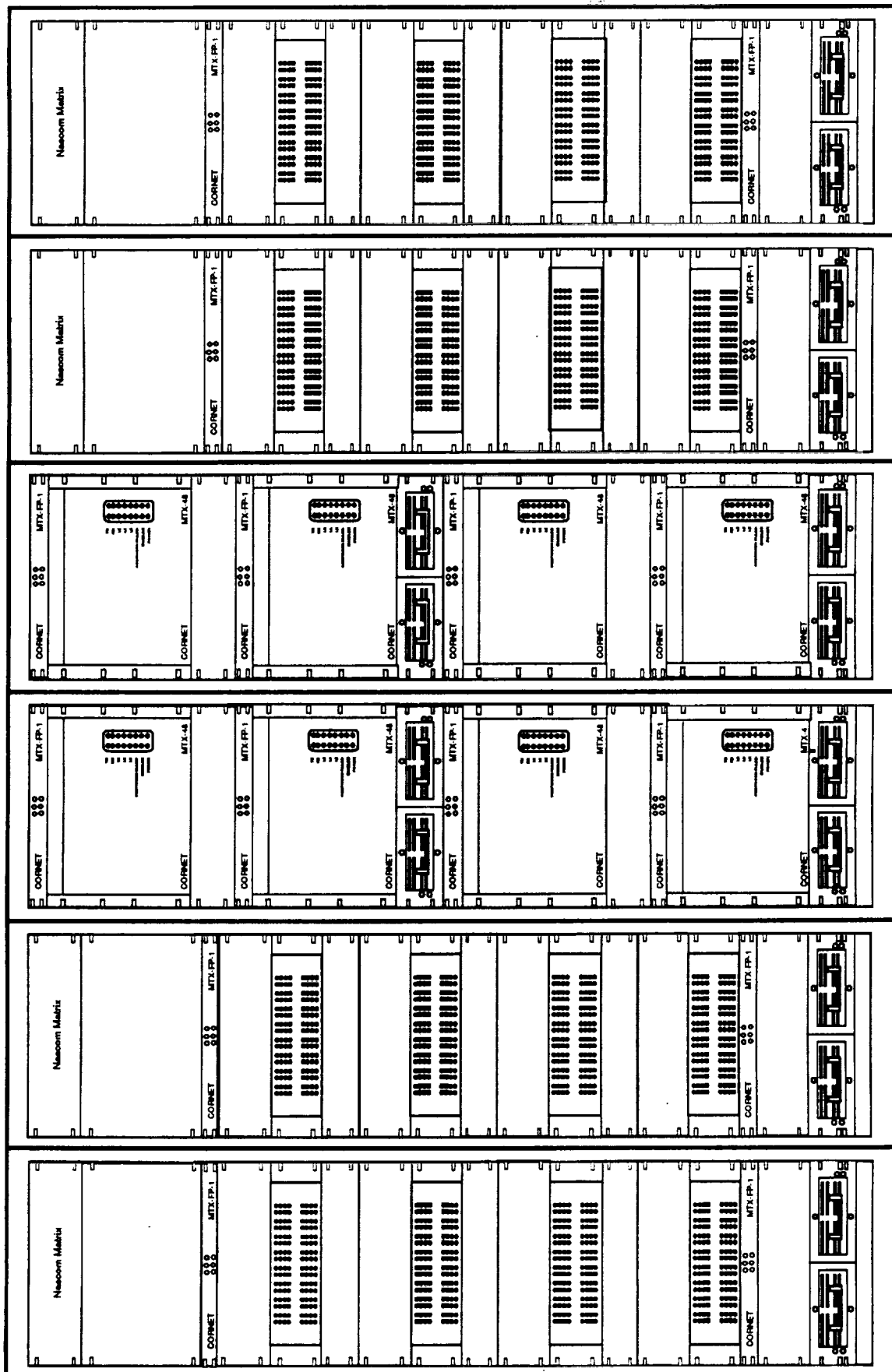


Figure 16-6. Operational DMS II

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- b. **FARM Control.** FARM input to the LCC is via TCP/IP on an Ethernet LAN. A Cornet-supplied Management Information Base (MIB) resides in both the FARM's Simple Network Management Protocol (SNMP) Manager and in the LCC. An SNMP proxy agent in the LCC interfaces with the MIB and the two Ethernet NICs to allow control of the matrix switch from the FARM. All functions that can be performed at the LCC can also be performed from the FARM. Figure 16-7 illustrates the FARM interface with the DMS II.

The heart of the matrix control system, whether its pre- or post-FARM implementation, is the WindowsTM-based CorScan 100 proprietary control software package developed by Cornet, Inc. for control of its Comet series of matrix switching equipment. Its design accomodates multilevel security for both the user and the lines interfacing the matrix.

CorScan controls all switching functions, such as single connections, group connections, and broadcast switching. It also allows the user to run specific diagnostics for determining system problems. The card "Sparing" function is accessed from a CorScan screen.

All alarms and all activity performed on CorScan are logged to the CorScan screen and the hard drive. All logged alarms and activities can be printed on the system printer at any time.

The main CorScan screen consists of the "drop down" windows and an alarm/activity log area. All CorScan functions are performed by selecting a "drop down" window and making selections within that window. All activities are logged in the alarm/ac-

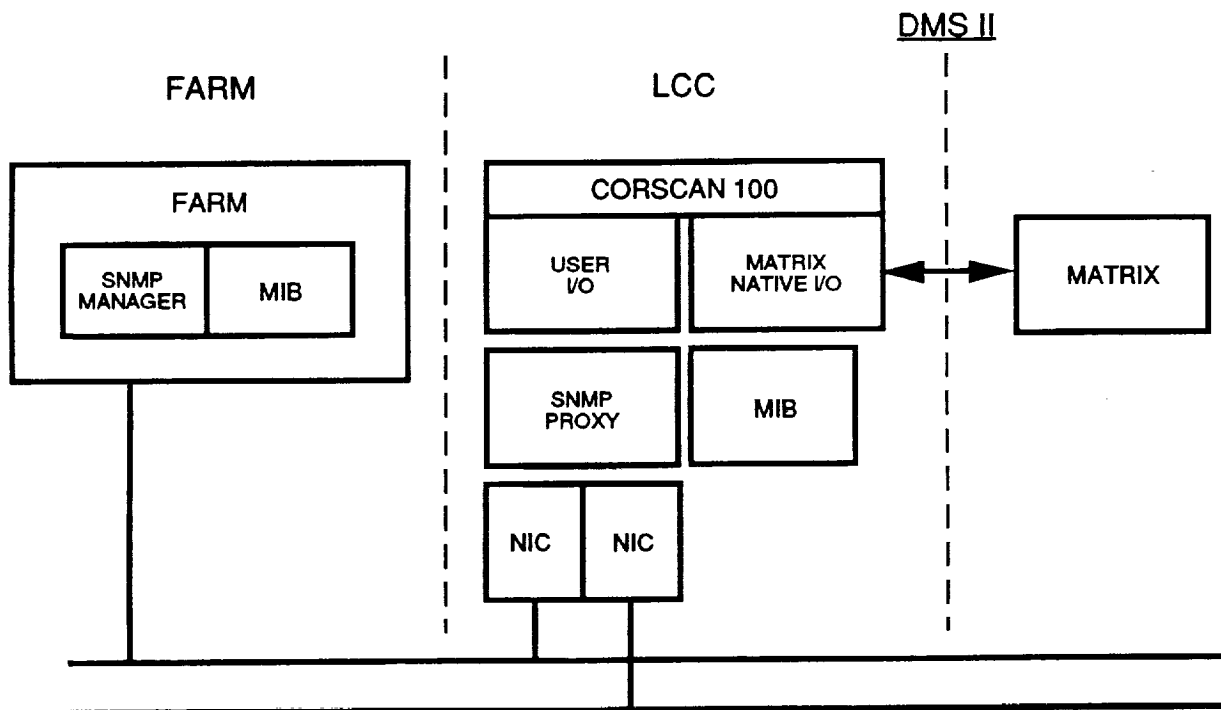


Figure 16-7. FARM/DMS II Interface

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tivity window with a Time/Date stamp and the name of the current user. If the activity requires a response from the matrix, the result of that action will be logged in the Results portion of the alarm/activity window. This information is also automatically logged on the hard drive. The main CorScan window functions are illustrated in Figure 16-8.

Acknowledgement: Technical descriptive material for the DMS II was excerpted from Nascom Digital Matrix Switch, a document prepared by Cornet, Inc. under contract number NAS5-32704, and presented during the design review of November 10, 1994.

16.4.2 STGT-DIS Related Activities

16.4.2.1 STGT-DIS Overview

The establishment of the Second TDRSS Ground Terminal (STGT) is a major goal of the planned augmentation of SN in accordance with the approved NASA 10-year plan for SN. It is a level 1 project of the MO&DSD. The STGT is an additional element of the SN. The STGT is established as an enhancement of the TDRSS ground segment. The functional features of STGT and its Data Interface System (DIS) are summarized in the following paragraphs:

- a. The STGT provides, in conjunction with the TDRSS, forward (ground-to-space) and return (space-to-ground) communication and tracking services for TDRSS user satellites, as well as to perform tracking, telemetry, and command functions for the TDRS.

CORSCAN 100

| | | | | | | | |
|----------------------------------|--------|-------|-----------|-------------|---------|--------|------|
| LOGON | LOGOFF | SETUP | OPERATION | DIAGNOSTICS | QUERIES | EXIT | HELP |
| <p>WINDOW SELECTION AREA</p> | | | | | | | |
| DATE | TIME | USER | EVENT | | | RESULT | |
| CURRENT ACTIVITY/ALARM REPORTING | | | | | | | |

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Figure 16-8. Main CorScan Window Functions

- b. The STGT now functions as the sole operational TDRS ground terminal located at WSC. This will remain the case while the former WSGT/NGT undergoes its upgrade.
- c. The STGT is established in a facility provided by the Government at the NASA White Sands Test Facility (WSTF), NM, approximately 3 miles north of WSGT/NGT.
- d. The STGT processes and provides the required levels of protection for national security classified information. In addition to its other functions, the DIS also provides support for classified information by receiving, processing, storing, transmitting and otherwise handling it in a secure manner.
- e. The DIS, as implemented, includes MDM and SM equivalent subsystems for interface with the Nascom-provided Common Carrier Interface (CCI), at WSGT, via the Interfacility Link (IFL). The DIS includes matrix switching for routing of user service interfaces and a defined set of interfaces allocated to both the local GTE CCI and the IFL. MDM channels have been reterminated and reassigned for these interfaces which are controlled through NCC, DIS, and ADPE software.
- f. The Interfacility Link (IFL) between WSGT/NGT and STGT provides for the exchange of user data between the NGT (WSGT/U) and the STGT-DIS. In addition it provides for the baseband data crossstrapping and interconnection for access to diversely routed Nascom common carrier data throughput systems and the single 50 Mb/s service at WSGT/U.
- g. STGT follow-on plans for refurbishment and replacement of the WSGT/NGT with a WSGT Upgrade (WSGT/U) now that the STGT is operational are being implemented. The WSGT/U will be functionally identical to the STGT. While the WSGT is down for refurbishment, the STGT will assume the primary TDRS support role. When the WSGT/U returns to service, both ground stations will transition to a joint support role for the expanded TDRS constellation planned for the Space Station era.
- h. STGT/WSGT/U Phasing Schedules. Standalone STGT service started in March 1995 when WSGT/WSC was taken down for its refurbishment. Final configuration will be achieved when WSGT/U returns to service.

16.4.2.2 Nascom Support

Nascom will provide the communications services between the WSGT/U and STGT/DIS ground system baseband interfaces and corresponding SN user elements. New configuration requirements are being identified and Nascom/SEAS support studies are in progress as a continuing effort for both near-term (pre-Space Station) and Space Station era planning. Establishment of the initial STGT-DIS facility along with the other new SN-related requirements has a significant impact on the existing Nascom System architecture (i.e., MDM, DMS, and MACS equipment, and CSS software). Nascom support for the STGT/WSGT/U consists of the following activities:

- a. Assume an active role in the development of the DIS.
- b. Design and construction/implementation of the IFL fiber-optic cables and transmission systems, including the cross-strapping designs for access to/from the CCIs.

Figures 16-9A, B, and C provide an IFL configuration overview for forward and return link baseband interface systems respectively. Note in Figure 16-9(A) that each site's return link includes a two-channel cross-strapping multiplexer which aggregates the MDM composite outputs of both sites. Thus, the return common carrier transport links become redundant, each carrying the same (both sites) data; one will be designated as prime link, the other will be an alternate (or backup) link as in the present BDS. Also note in Figure 16-9(B) that the forward link uses a similar prime and alternate arrangement; both links are bridged into WSC carrying the same forward data, but only one transport system is terminated at the destination at both sites through an A/B switch selection arrangement. Figure 16-9(C) shows that the 50 Mb/s service is available to only one return link at any given time. However, each site will have nonsimultaneous, schedulable access to the SM.

- c. Implementation of the new CCI for STGT/WSGT/U, and the attendant upgrade of the redundant long-haul transport system architecture; one of the two existing BDS Earth Stations has now been relocated to the STGT site.
- d. Attendant upgrades of CSS/DMS systems, and NCC interface as required.
- e. Implementation of the local administrative telephone service.

16.4.2.3 Status of Nascom Support

Items b and d of paragraph 16.4.3.2 are the major Nascom support efforts underway at this time:

- a. IFL Implementation. The IFL implementation is complete and fully operational.
- b. Nascom Interface Integration. Interface integration plans for the new DIS/Nascom MDM channel interface for NCC/CSS scheduling control, including port address assignments, has been the subject of close Code 530-540 coordination. Presently, Nascom MDM channels are hardwired to TDRSS interface channels. This will change: the new STGT/WSGT/U complex will provide baseband switching functions between TDRSS user services and the ground transport interface via the Low Rate Black Switch (LRBS). Nascom has negotiated a series of port addresses for the MDM system which reassigns and dedicates MDM channels to generic TDRSS user service types and to specific user data streams to and from control center (MOCC) interfaces. These assignments are documented in the Nascom Space Network Systems Upgrade (MDMR/MACSU) Operations Transition Plan, 542-045, dated September 1992. This document is configuration controlled by the Nascom Division CCB. These ITU/OTU assignments will also be incorporated in the Nascom SN Data Book, 542-016. Nascom-2000 (FTS2000) will also play a role in the interface integration plans by supporting a portion of the voice/data links into STGT.

16.5 Advanced Network Systems Development Activities

16.5.1 Activities Overview

As indicated in paragraph 16.3.2, these include activities directly or indirectly related to the development and implementation of new Nascom data transport system(s) for the late 1990's

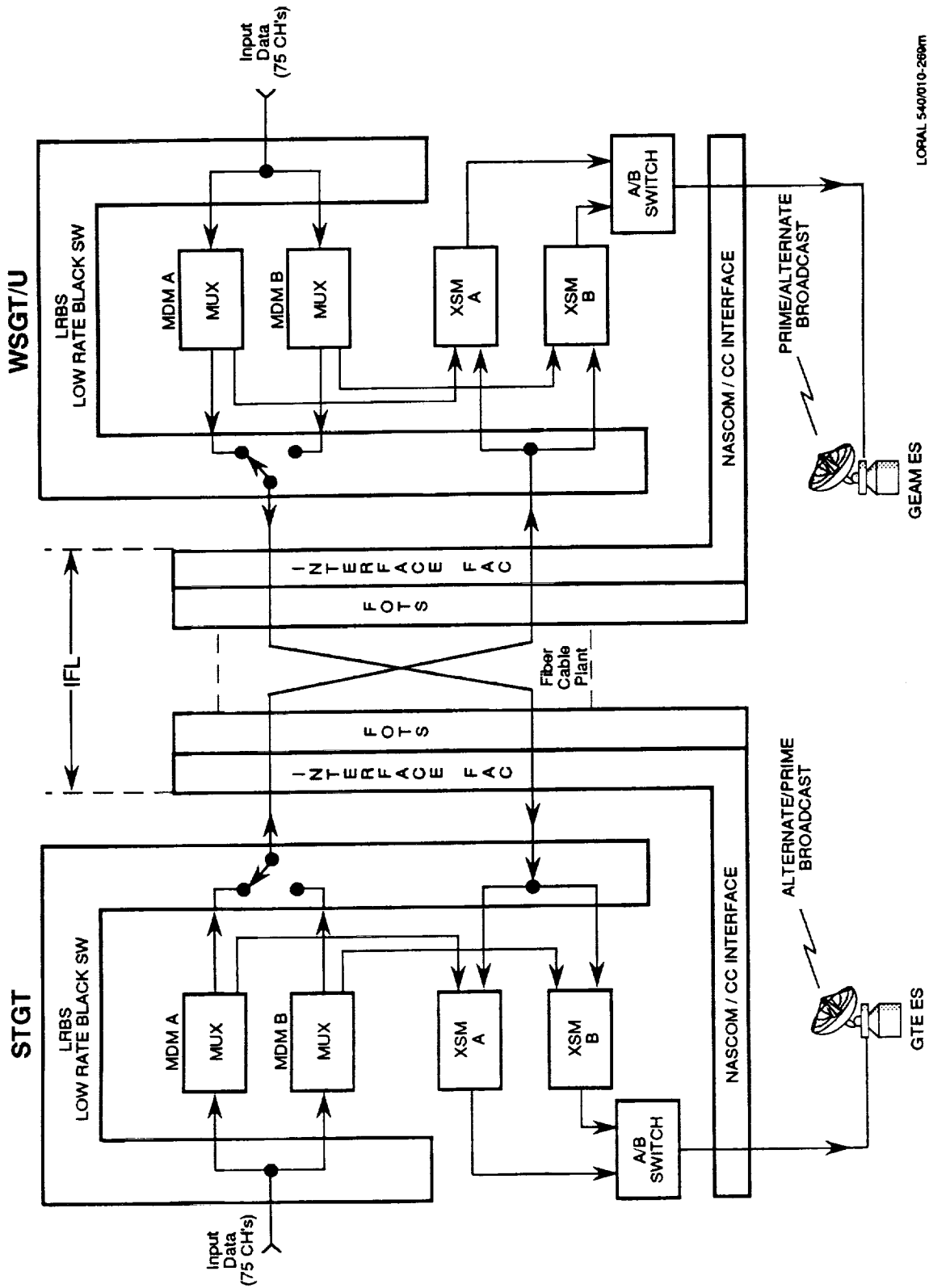


Figure 16-9A. IFL and Associated Systems Overview Showing MDM Forward Link Interface

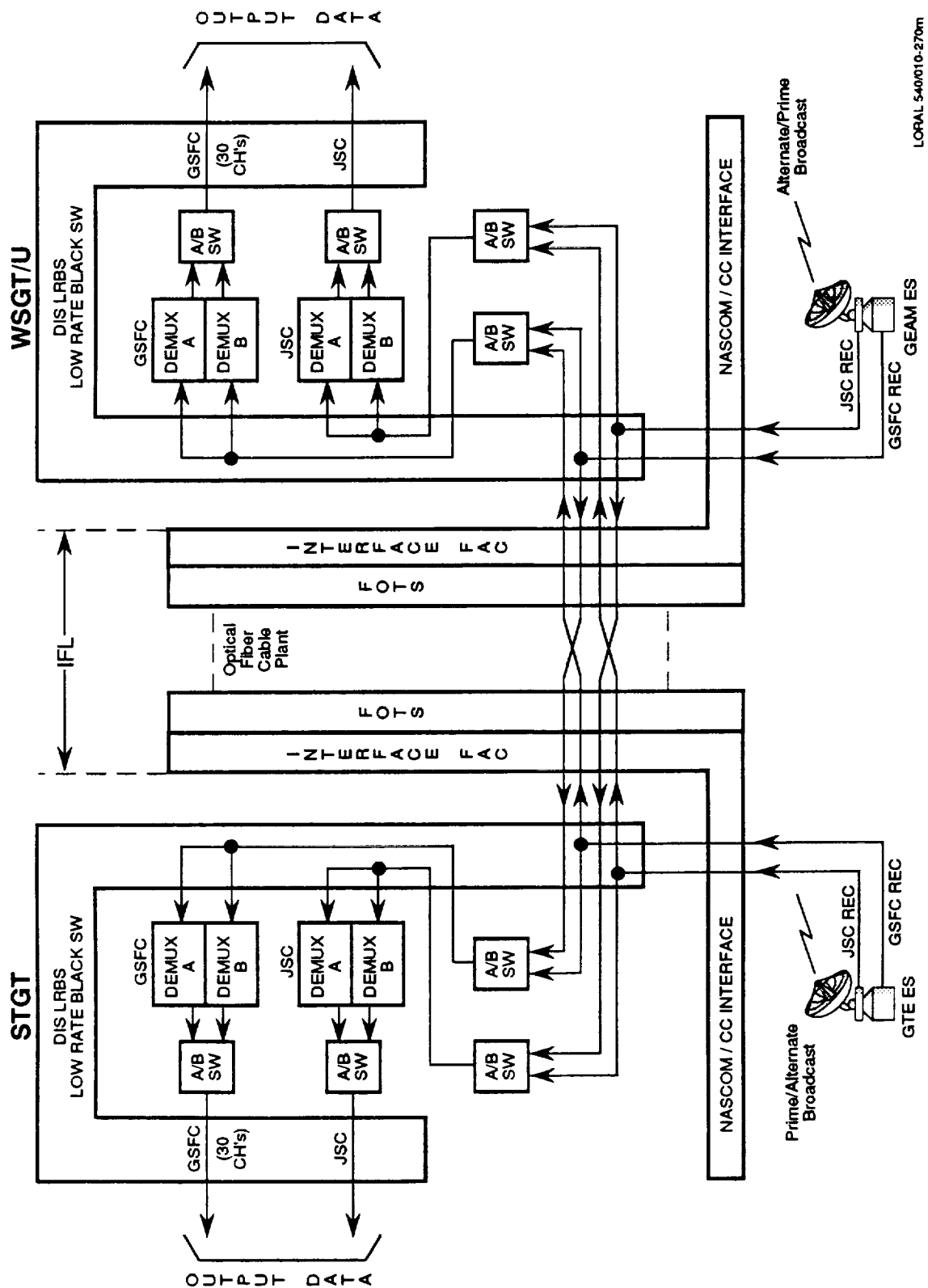


Figure 16-9B. IFL and Associated Systems Overview Showing MDM Return Link Interface



Figure 16-9C. IFL and Associated Systems Overview Showing High Rate Data/Video Return Link Interface

and early 2000's. These activities also include a variety of ongoing research and development projects, and SEAS contractor-tasks analysis studies. The following is a topical summary of advanced development-related activities that are addressed in paragraph 16.5:

- a. Facilities and Resources Management (FARM).
- b. Common Transmission Infrastructure (CTI).
- c. EOSDIS Backbone Network (EBnet).

16.5.2 Facility and Resource Manager (FARM)

Information for a description of the FARM project is drawn from two documents that are still being developed: *Nascom Facility and Resource Manager (FARM) Operations Concept Document*, 541-xxx, March 1995, and *Nascom Facility and Resource Manager (FARM) System Requirements Document (SRD)*, 541-208, Revision 1, February 1995.

16.5.2.1 Goals

The FARM system will provide for automated operation of Nascom communication resources supporting Space Network (SN) data flows and comprehensive, combined management of all Nascom systems. The major goal is to provide continuous data availability for SN data users and to do this by automating as many of the data flow resource configurations as technology will currently allow.

Secondary goals of the FARM system include maintaining compatibility with existing and future Nascom systems; minimizing life-cycle costs for implementation, operation, and maintenance of the network; and preventing unauthorized use of the FARM's resources.

16.5.2.2 Functional Processes

The FARM will provide automated command, monitor, and management interface capabilities for all Nascom equipment located at Nascom points of presence through the use of its SN element manager, enterprise manager, and support utilities. Eventually, this capability will be expanded to combine automated operation of Nascom resources supporting SN data flows with management of Nascom equipment. To do this, processes have been allocated to three different functions.

The Element Management (ELM) function provides for the automated configuration of Nascom resources that are schedule-driven. In all instances, source schedule information is provided to Nascom by the SN's Network Control Center (NCC). FARM's configuration manager decides the supportability of a scheduled event by determining if Nascom resources are available, and if there is sufficient bandwidth on the prescribed path at the time the data flow is scheduled. This functionality also detects fault conditions and corrects for the fault by commanding a failover to backup equipment or to a redundant module.

The Enterprise Management (ENT) function monitors Nascom resources (devices, ports, circuits), correlates alarms reported by each resource, and notifies the operator via visual and aural means. This functionality performs calculations and generates reports that can be displayed in real time as a snapshot of Network performance during a specified period of time.

The third function is called support utilities. This functionality includes a database for storage and retrieval of FARM information. The database will have backup and recovery features sufficient to prevent loss of network management information.

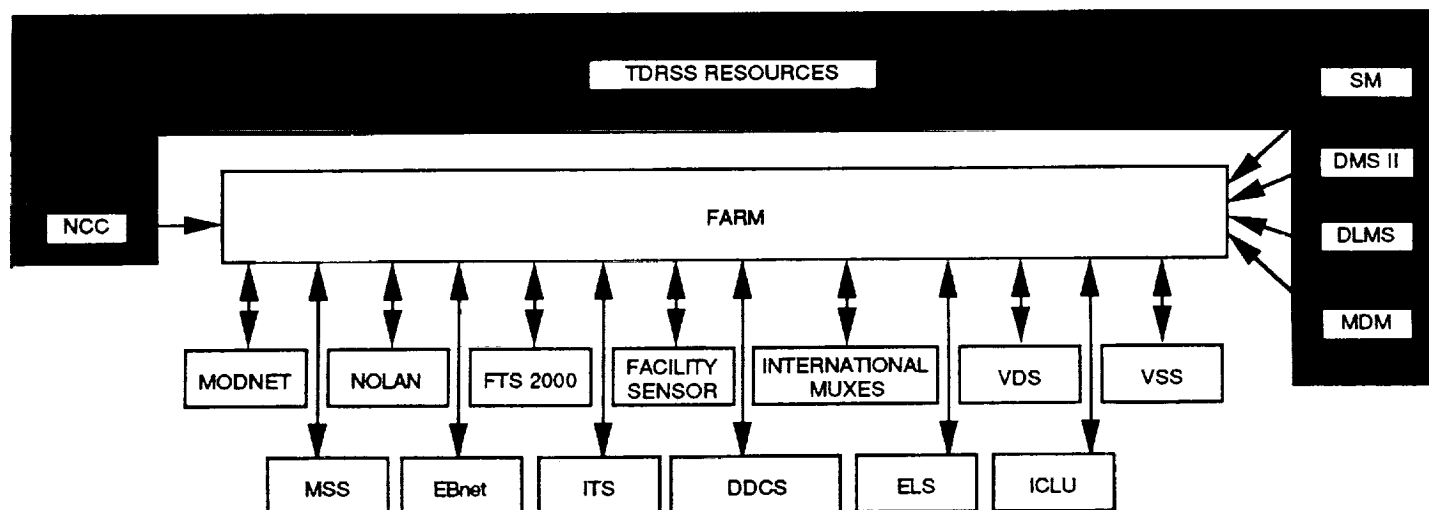
16.5.2.3 External Interfaces

FARM will support interfaces for the exchange of network management and operational information with Nascom systems located at GSFC, as well as with other organizational entities such as the NCC. These systems and their projected data flows are shown in Figure 16-10.

16.5.2.4 Operations Concept

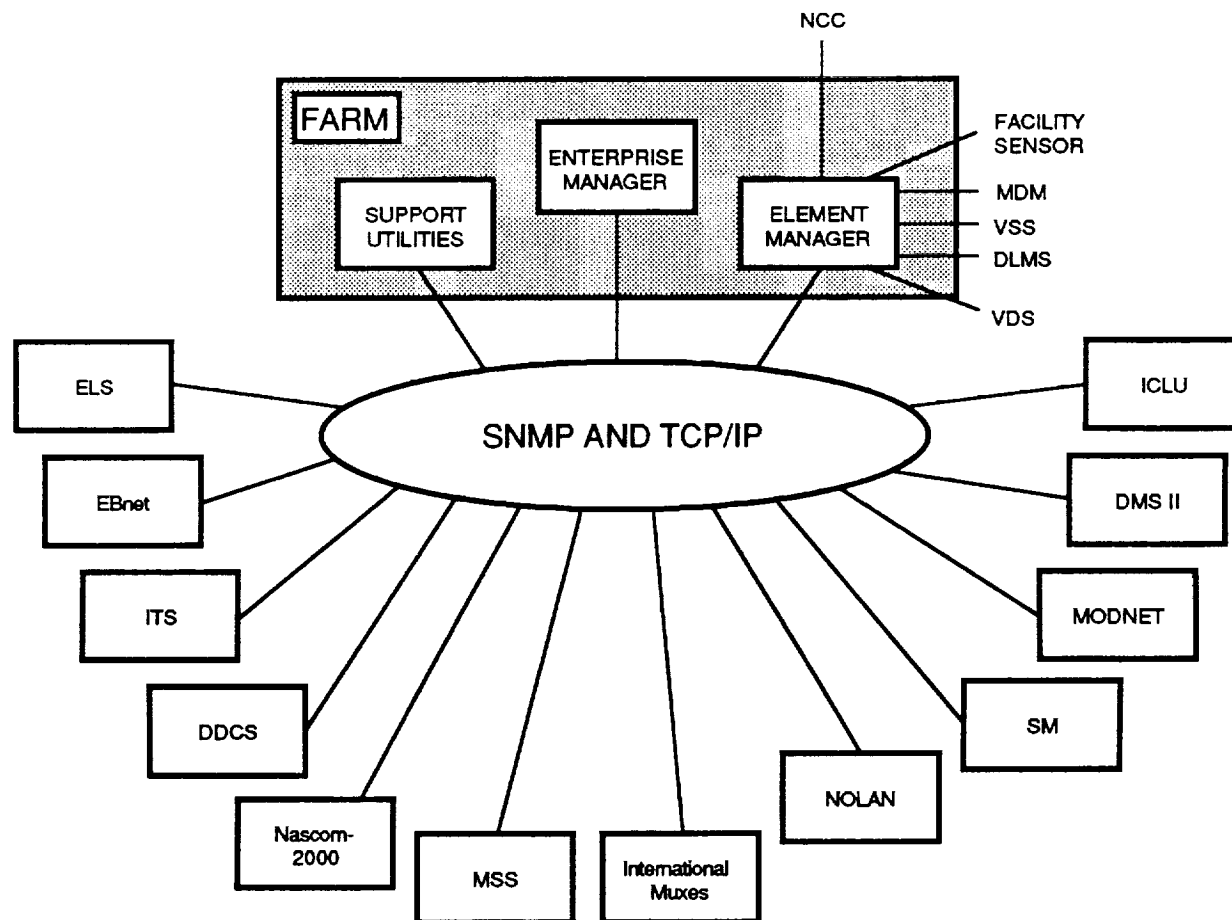
- a. **Enterprise Management.** As shown in Figure 16-10, Nascom comprises a number of subnetworks and systems. The ENT builds a top-level view of Nascom by integrating network management information sent to it by the various ELMs. The ENT automates the fault identification, isolation, and restoration process.

Physically, the ENT will be an integrated Network Management System (NMS) comprised of COTS equipment. At its core will be an SNMP-based NMS with add-on packages integrated for functional enhancements. Figure 16-11 depicts this relationship. ENT operations will be conducted from one centralized location; namely, Nascom's network management center. Using work stations and X-terminals, operators will oversee the network and perform their day-to-day operations. The operator interface with the NMS will be graphical; i.e., network maps and pull-down menus for point-and-click access.



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Figure 16-10. FARM Data flow



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Figure 16-11. The FARM

Operationally, the ENT supports the traditional NMS functions: configuration management, fault management, performance management, security management, and administrative management.

- b. **Element Management.** Space Network element management is associated with the following: the Baseline Data System elements at GSFC, JSC, MSFC, and WSC, and the HDRS statistical multiplexers at GSFC, MSFC, JSC, WSC, and ARC. FARM will manage the NCC interface to the FARM, the DMS II (also known as DMSR) at GSFC, and the MDMs located at GSFC, JSC, and MSFC. FARM will receive status information from the MDMs at WSC, and from the DLMSs at GSFC, JSC, MSFC, and WSC. FARM will have the capability to do one or the other of the following: (1) status and configure elements, or (2) status only designated elements.

16.5.2.5 Schedule

FARM will be implemented in phases, each of which is being designed to accomplish a specific subset of FARM's goals and objectives. However, FARM has not yet issued an implementation schedule because of still being in the very early stages of its system life cycle.

16.5.3 Common Transmission Infrastructure (CTI)

16.5.3.1 Objective

Information for the CTI was obtained from the *Code O Common Transmission Infrastructure (CTI) Pilot Plan*, dated January 27, 1995.

An objective of the NASA Headquarters Office of Space Communications (OSC) is the development of a common backbone system that will allow both Nascom and PSCN to share facilities, reduce future costs by increasing the utilization of circuits, share circuits more efficiently, and realize the economies of scale savings associated with such a common backbone structure. ATM technology has been selected for this backbone system.

In pursuit of this objective, OSC, Code OS, is first developing a CTI pilot project to resolve and test network infrastructure solutions. From the pilot project, OSC will be able to refine its requirements for switches, carrier circuits and services, adaptation devices, and network management systems prior to fielding the operational network. The CTI pilot will also enable NASA to view and study the behavior of customer traffic in an ATM environment.

16.5.3.2 CTI Concept and Management

The CTI is one physical infrastructure supporting two separate logical networks: Nascom and PSCN. Nascom and PSCN are users of the CTI and they are also peer network managers. CTI provides common nodes, circuits, a network management architecture, and service interfaces. OSC has one point-of-presence at each node site.

It is envisioned that the CTI will employ both dedicated circuits and ATM services, each provided by common carriers. Nascom (and PSCN) will continue to provide connections to their users, e.g., via routers, ATM switches, and more traditional devices. As such, the CTI will be transparent to end users, e.g., control centers, principle investigators, and managers. Figure 16-12 provides a representation of this concept.

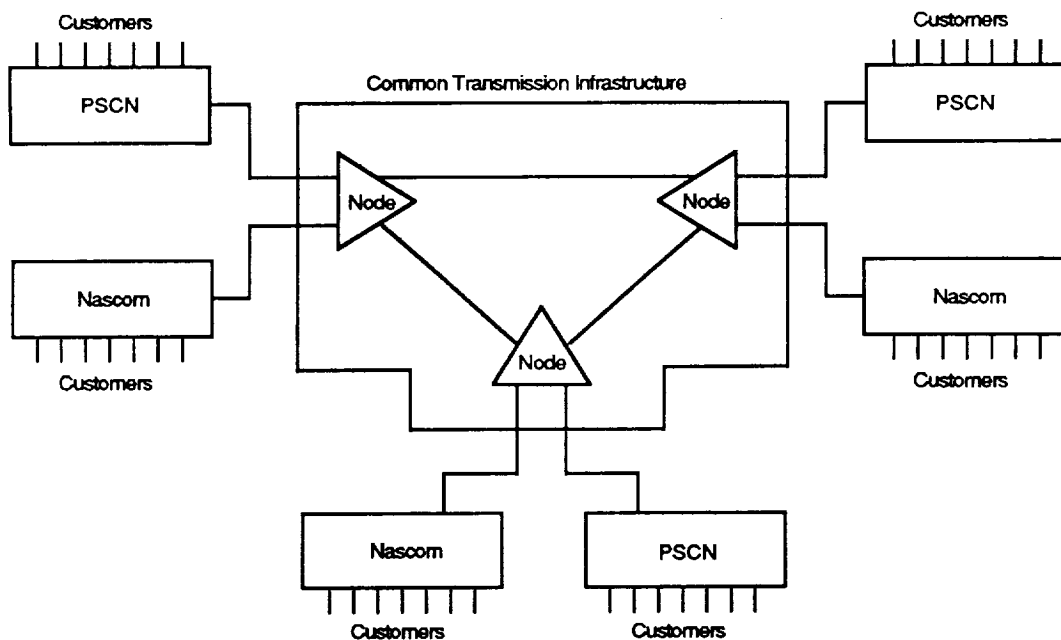
A management team concept is employed. The Strategic Planning Management Team (Code OS Director, Communications Systems Chief, Nascom Division Chief, and PSCN Division Chief) advises the CTI Program Manager. GSFC, MSFC, and JPL each have their own project managers responsible for assigned areas of the CTI program, including the CTI pilot. The management structure is represented in Figure 16-13.

16.5.3.3 Topology and Architecture

Pilot nodes are planned for implementation at ARC, GSFC, JPL, and MSFC starting in FY 95. In FY 96, a pilot node would be added at the WSC. Each node should have local connections to end-user devices that will be used to generate simulated and/or real traffic. Node topology to be implemented in FY95 is depicted in Figure 16-14. A representative nodal architecture is shown in Figure 16-15. Pilot node equipment identified for use at each of the three FY 95 nodes is listed in Table 16-1.

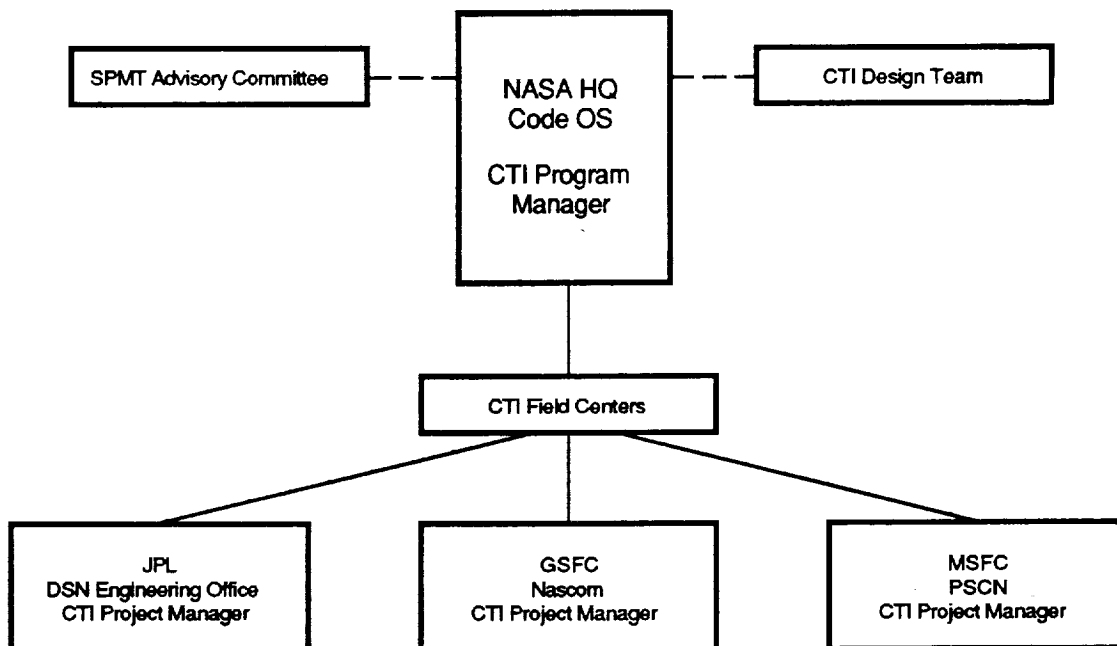
16.5.3.4 Pilot Traffic

The role of the pilot CTI network is to address and resolve technical issues associated with the transmission infrastructure, equipment, user interfaces, and operational issues. Issues not peculiar to the CTI will be resolved in each network's local test bedding environment.



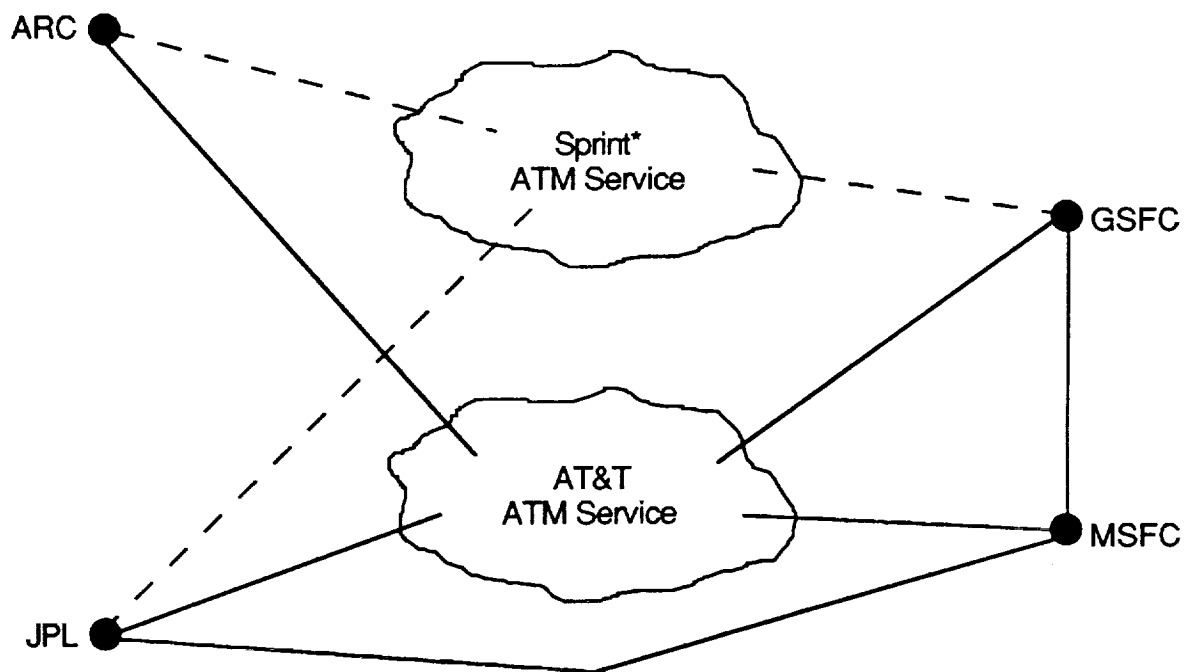
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Figure 16-12. CTI Concept



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Figure 16-13. CTI Organizational Relationships



* Interoperability tests over Sprint planned for FY 96

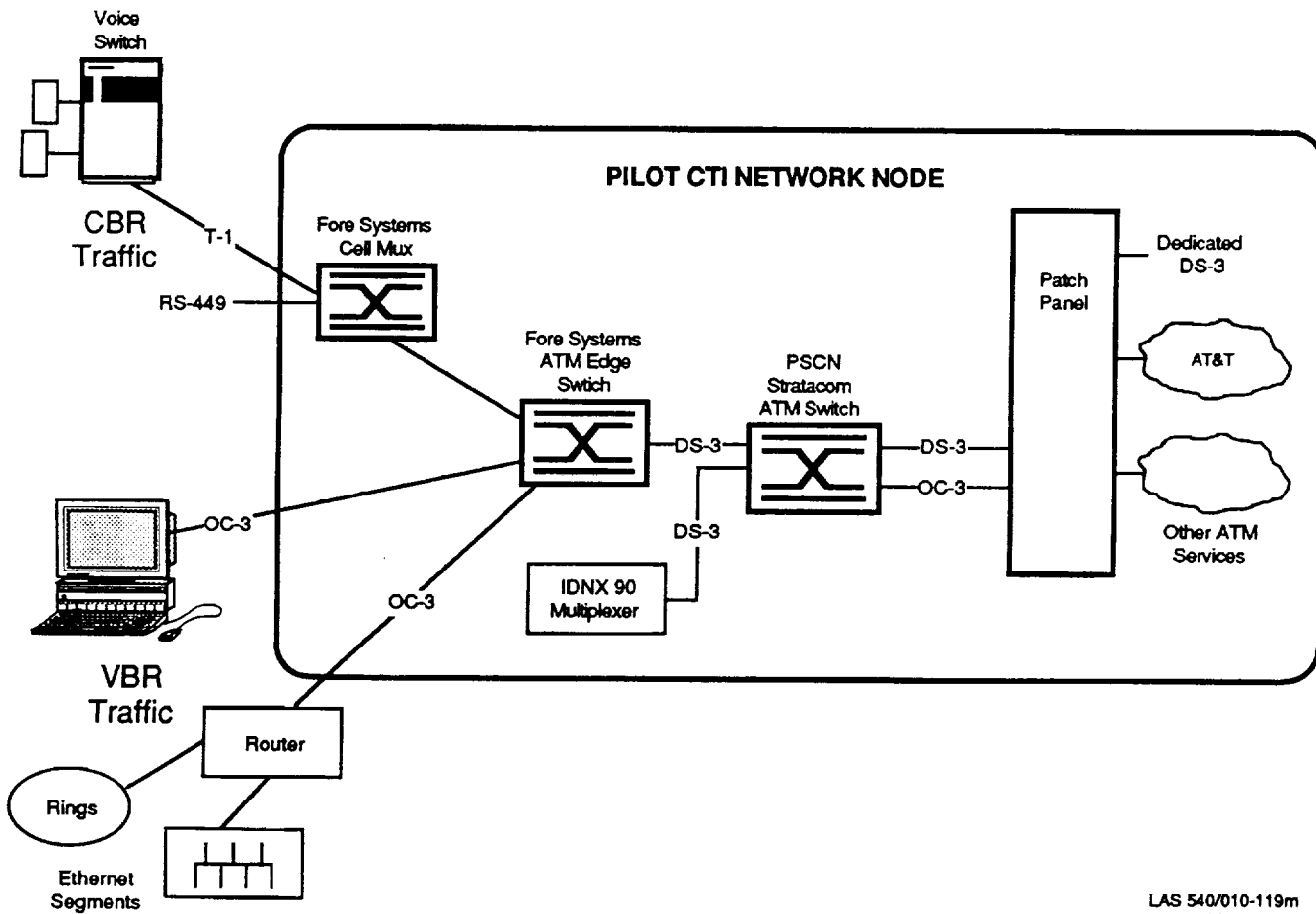
Legend:

DS-3 (45 Mb/s) ———
 DS-3, Upgrade to
 OC-3 (155 Mb/s) - - -

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Figure 16-14. CTI Pilot Nodes and Connectivity In FY95

Candidate Pilot
User/Customer Interfaces



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Figure 16-15. Typical Node Architecture

The CTI team is selecting representative traffic mixes from current and future Nascom and PSCN communications systems and customer applications. Table 16-2 characterizes the traffic and the source system. Of particular interest to Nascom are the traffic types identified in the top portion of the table (rows 1-6), especially determining performance vis-a-vis Constant Bit Rate (CBR) data.

Table 16-1. CTI Pilot Node Equipment

| Site | Items |
|------|--|
| ARC | Stratcom ATM switch Fore switch 2 Workstations with OC-3c NICs Cisco 7000 router w/ATM |
| GSFC | Stratcom ATM switch Fore switch Fore Cell multiplexer 2 Workstations with OC-3c NICs Cisco 7000 router w/ATM |
| JPL | Stratcom ATM switch Fore switch Fore Cell multiplexer 2 Workstations with OC-3c NICs Cisco 7000 router w/ATM |
| MSFC | Stratcom ATM switch Fore switch Fore Cell multiplexer 2 Workstations with OC-3c NICs Cisco 7000 router w/ATM |
| WSC | Configuration to be determined in FY 96 |

Table 16-2. Candidate Traffic for CTI Pilot

| Traffic Requirements | Primary Locations | Bandwidth | Type of Traffic |
|--|-------------------|----------------------|-----------------|
| VSS/VDS voice network | GSFC/JPL | Low | CBR |
| MDM (with OC-3 MM UNI adaptation) | GSFC/MSFC | Moderate (6 Mb/s) | CBR* |
| Simulated TDRSS SM user data (from GSFC) | GSFC/JPL/MSFC | High (~ 50 Mb/s) | CBR* |
| DSN GCF spacecraft data | GSFC/JPL | Moderate | CBR |
| Simulated Ecom to DAAC | GSFC/JPL/MSFC | High (18 to 70 Mb/s) | VBR |
| Simulated VITS conferencing system | MSFC/JPL | Low | CBR |
| AEROnet data | ARC/MSFC/JPL | High | VBR |
| PSCN Internet data | All | Moderate | VBR |
| PSCN IDNX-90 | All | High | CBR |
| Simulated EOSDIS inter-DAAC traffic | All | High | VBR |

Notes:

Bandwidth

Low < 1.5 Mb/s

Moderate < 10 Mb/s

High > 10 Mb/s

Type of Traffic

CBR Constant Bit Rate

VBR Variable Bit Rate

* Treated as CBR because of limited delay requirements of the conversion device.

** A selected subset of this traffic will be demonstrated in FY 95.

16.5.3.5 Nascom-specific Interest Areas

Nascom expects to use the facilities available in the EMAT facility to install Nascom equipment (such as the MDM), and interface it through an ACD to an ATM switch. If possible, Nascom prefers to demonstrate feasibility in a laboratory environment prior to actually connecting equipment to the CTI pilot network.

- a. Nascom's VSS provides worldwide services, both point-to-point and conferenced. To migrate the VSS onto an ATM-based network, the following technical issues will be addressed:
 1. CBR interfaces between VSS devices and the CTI pilot ATM switches.
 2. Efficient bandwidth utilization for CBR voice traffic.
 3. Dynamic setup and disconnection of circuits.
- b. Nascom's MDM data system presents aggregate signals with bandwidths ranging from 2.5 to 6.0 Mb/s. Currently, these signals are broadcast by satellite between GSFC, JSC, and WSC. MSFC is connected to GSFC by a single, point-to-point, full duplex, 4 Mb/s data circuit routed via satellite. To migrate the MDM system onto an ATM-based network, an ATM Conversion Device (ACD) must be developed. The following technical issues must then be resolved:
 1. Ability of the ACD to tolerate cell-delay jitter.
 2. Ability of ATM switches to provide Permanent Virtual Circuit (PVC) rerouting in the event of primary circuit failure.
 3. Ability of ATM switches to bump lower priority traffic in the event of primary circuit failure.
 4. Ability of ATM switches to prioritize multiple traffic types.
- c. Nascom's Statistical Multiplexer Data System (SMDS) provides a return path for up to four channels of statistically multiplexed data from WSC to GSFC, JSC, MSFC, and (currently) ARC. Data rates are between 124 kb/s and 48 Mb/s. To migrate the SMDS from the satellite broadcast system to a terrestrial ATM network, an ACD is under development to provide Emitter Coupled Logic (ECL) emulation over an ATM network. How well this device works will be tested over the CTI ATM pilot network. Technical issues to be resolved include the following:
 1. Ability of the ACD to tolerate cell delay jitter.
 2. Ability of ATM switches to provide PVC rerouting in the event of primary circuit failure.
 3. Ability of ATM switches to bump lower priority traffic in the event of primary circuit failure.
 4. Ability of ATM switches to prioritize multiple traffic types.

- d. The ability to migrate GSFC-JPL DSN GCF T-1 links to an ATM-based network will also be tested using the CTI ATM pilot network. Technical issues to be resolved by this testing include the following:
 - 1. How well CBR interfaces between DSN GCF devices and CTI pilot ATM switches function.
 - 2. How efficiently bandwidth is utilized by CBR traffic.
 - 3. The setup and disconnection of circuits based on mission schedules.
- e. Ecom-to-DAAC and DAAC-to-DAAC traffic will also be tested using simulation techniques (the network to support these traffic flows is not yet installed). The data flows are expected to be high-speed file transfers using the TCP protocol suite. Technical issues to be resolved include the following:
 - 1. Performance of TCP over a wide-area ATM network.
 - 2. Ability of ATM switches to provide PVC rerouting in the event of primary circuit failure.
 - 3. Ability of ATM switches to allow TCP file transfers to utilize all available bandwidth.

16.5.3.6 Network Management

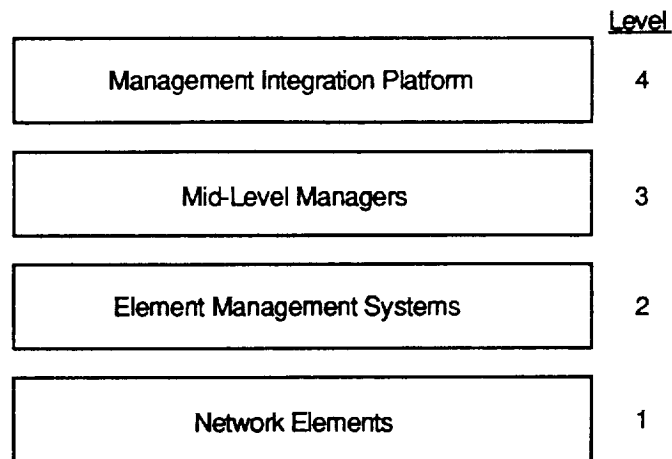
Network management within the CTI is envisioned to have one single logical point for monitoring and managing all network resources. As a starting point, a Unified Network Management Architecture is shown in Figure 16-16. Developed by AT&T in the 1980s, the architecture presents a four-level management hierarchy, each level of which is to be evaluated in the pilot network.

Network elements, e.g., ATM switches, multiplexers, and other resources of the CTI such as routers and ACDs (where used) are grouped at Level 1. Their evaluation is addressed in the previous paragraph.

Element Management Systems (EMS), grouped at Level 2, handle specific subsets of network elements and may be used for functions such as establishing PVCs between designated ATM switches.

Mid-Level Managers (MLM), grouped in Level 3, monitor alarms from the EMSs. Agents residing at the first two levels report management information to the MLM. MLMs may be further subgrouped by the protocol being supported; each integrating management information is received from agents belonging to the same protocol family.

The overall network Management Integration Platform collects management information from the MLMs and selected EMS to create a unified database for controlling and viewing the entire CTI. Ideally, such a system should be made available to both Nascom and PSCN, the principle users of the CTI. One factor that the CTI must keep in the forefront is that management of the CTI requires that both the equipment and the management systems provide a capability for two peer network managers to manage one physical network that is logically divided.



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Figure 16-16. Network Management Hierarchy

16.5.3.7 Security Management

The security management function of the CTI will limit/preclude unauthorized access to CTI operations and transmission services. The CTI is required to meet or exceed the requirements of the Nascom Access Protection Policy and Guidelines documents (541-107). Because the CTI pilot will not carry mission-critical traffic, it may be used to develop, test, and evaluate different security approaches.

16.5.4 Earth Observing System Backbone Network (EBnet) Project

16.5.4.1 General

The EBnet project provides a unique ground-to-ground data transport system for operational EOS communications; EBnet is being built to address EOS-specific requirements. (A high level summary of the EOS project is presented in Section 15.) The system provided by EBnet will transport forward link commands, return link telemetry and payload science data, and operational data flowing between EDOS elements and between EDOS and the Distributed Active Archive Centers (DAAC). Additionally, EBnet/Nascom will provide the communications between the EOS Operations Center (EOC) and the MO&DSD institutional systems (1) controlling and scheduling Space Network resources (the NCC), and (2) determining spacecraft orbit and attitude (the FDF) as well as the contingency support communications interfaces with the GN, Wallops Orbital Tracking Station (WOTS), and the DSN.

This year, the scope of the EBnet project has been potentially expanded to include the Wide Area Network (WAN) portion of the EOS Science Network (ESN), also referred to as DAAC-to-DAAC communications. ESDIS project management (Code 505) has undertaken to define the optimum network to meet EOS communication requirements. Once that determination is made, management will determine the implementation roles to be assigned

to the variously and currently involved organizational entities. Included in this redefinition activity are ESN, the Version Zero (V0) network, a prototype for the ESN WAN developed by Code 520 for inter-DAAC data transport, EBnet, and the Nascom Operational LAN (NO-LAN) build-out to satisfy some of the requirements associated with particular locations and facilities supporting EOS.

Also entailed in this potential modification to the scope of the EBnet project is a significant design change. EBnet's System Design Review (SDR) of February, 1994 presented an ATM-based network for delivery of real-time information, and the initial distribution of science data, i.e., from the DPF to the DAACs. Subsequent to that design review, management decisions were made within the ESDIS project stating that a router-based network offered the best assurance of satisfying requirements across the project, inclusive of EBnet. The EBnet project had been planning to conduct a delta SDR in late March or early April to present the design changes, including the WAN portion of the ESN. However, Code 505 project management has determined that more time is required to define the most suitable architecture for the network, and to (re)define the roles that each of the players will have. Only after these issues are resolved will appropriate program and design reviews be considered for scheduling by EBnet.

In view of the foregoing, some of EBnet's router-based network design information will be presented. However, the reader must be cautioned that this information is not "approved" by the ESDIS management and should be viewed as illustrative and strictly hypothetical at this time.

16.5.4.2 Goals and Requirements

The goals of EBnet are to:

- a. Implement an automated system maximizing use of Commercial-Off-The-Shelf (COTS) equipment.
- b. Maintain compatibility with existing and enhanced versions of NASA institutional systems as needed to meet EOS requirements.
- c. Minimize life-cycle costs for implementation, operation, and maintenance of the network.
- d. Allow for growth, adaptability to changing requirements, infusion of new technology, and upgrading interfaces throughout its life cycle.
- e. Prevent the unauthorized use of EBnet resources.
- f. Operate with a minimum of human intervention.

In embracing these goals, some of the requirements that EBnet will support are as follows:

- a. Transport traffic in a data driven mode between specified locations.
- b. Accommodate operations, simulations and testing on a concurrent basis.
- c. Comply with a standard addressing convention per Open Systems Interconnection (OSI) Network Service Access Point addressing and Internet Protocol (IP). Ecom will support the TCP/IP protocol suite.
- d. Route on IP.
- e. Perform protocol and address mapping.

- f. Expand to add new nodes.
- g. Expand modularly the number of physical interfaces and/or the aggregate throughput rate of any node.
- h. Provide network monitoring and control capabilities to manage network topology and resource allocation with display of same.
- i. Manage network operations, administration, planning and security functions.
- j. Perform fault management functions inclusive of fault detection, isolation and resolution.
- k. Collect and report accounting and network utilization information.
- l. Ensure users comply with NASA Communications Access Protection Policy and Guidelines and provide user authorization.

16.5.4.3 Topology and Architecture

Figure 16-17 depicts a hypothetical topology and high-level architectural view of a router-based logical network for the transport of EOS science data, inclusive of the inter-DAAC communication requirements. Table 16-3 lists the end-to-end science data rates that were

Table 16-3. N-Squared Representation of Projected Science Traffic (In Mb/s)

| To From | ASF | DPF | EDC | GSFC | JPL | LaRC | MSFC | NSIDC | NOAA | WFF | WSC |
|---------|-------|--------|--------|--------|-------|---------|-------|-------|-------|-------|-----|
| ASF | 0.213 | | | 0.021 | 0.031 | 0.019 | 0.025 | 0.037 | 7.5 | | |
| DPF | | | | 15.643 | | 6.970 | | | | | |
| EDC | 0.001 | | | | 0.036 | 0.053 | 0.123 | 0.005 | | | |
| GSFC | 0.003 | | | | 0.958 | 145.151 | 8.070 | 1.412 | | | |
| JPL | 0.001 | | | 0.291 | 0.175 | 0.096 | 0.020 | 0.009 | 0.125 | | |
| LaRC | 0.003 | | 13.315 | 0.624 | 0.154 | | 0.067 | 0.021 | | | |
| MSFC | 0.001 | | 1.059 | | 0.036 | 1.992 | 7.449 | 0.005 | | | |
| NSIDC | 0.006 | | | 0.413 | 0.031 | 0.019 | 0.025 | 0.590 | | | |
| NOAA | | | | | 0.125 | | | | | 0.141 | |
| WFF | | | | | | | | | | 0.125 | |
| WSC | | 47.941 | | 0.251 | 0.041 | | | | | | |

Legend:

| | | | |
|------|---------------------------------|-------|---|
| ASF | Alaska SAR Facility | LaRC | Langley Research Center |
| DPF | Data Processing Facility (EDOS) | MSFC | Marshall Space Flight Center |
| EDOS | EOS Data Operations System | NSIDC | National Snow and Ice Data Center |
| EDC | EOS Data Processing Center | NOAA | National Oceanic & Atmospheric Administration |
| GSFC | Goddard Space Flight Center | SAR | Synthetic Aperture Radar |
| JPL | Jet Propulsion Laboratory | WFF | Wallops Flight Facility |
| | | WSC | White Sands Complex |

used to develop the topology and architecture shown in Figure 16-17. Figure 16-18 depicts a similarly hypothetical topology and high-level architectural view of a router-based logical network for the transport of EOS real-time data. Some of the design rules permitted by a

substantial relaxation of Reliability, Maintainability, Availability (RMA) criteria previously imposed by ESDIS may now be stated as follows:

- a. For science data, the path between any two points may include as many as three hops. Secondary paths are not required. For real-time data, the primary path between any two points is still one hop; a secondary path may also be provided using one hop but employing a different circuit with its own routing.
- b. Design utilization of available bandwidth remains at less than 80 percent.
- c. Diverse path routing is required only for real-time data.

Figure 16-19 shows an EBnet concept that is essentially valid regardless of the actual architecture and topology finally implemented.

EBnet is divided into functional subsystems: transport, common carrier, network management, and engineering support. In the absence of decisions governing the scope of EBnet, it is premature to provide specific information regarding transport and common carrier subsystems. However, the following information can be provided concerning the network management and engineering support subsystems.

16.5.4.3.1 Network Management Subsystem

The network management subsystem (NMS) is comprised of central management equipment (CME), located at GSFC, and nodal network management equipment. The CME monitors, manages, and controls the TS. It also monitors the CCS via the TS using standard NM protocols and COTS software to the maximum extent possible. The CME performs these functions from the NMCC in Bldg 3-14. The CME was formerly intended to interface with the EDOS Operations Management Function through the TS, with the NMCC console operators through the OSs, and with the M&O technicians through a human-machine interface (HMI) at each node. It is now quite evident that the CME will also interface with the EOC's SMC for network management information. Communication between the CME and the TS uses the SNMP protocol to the maximum allowable extent. The CME will support Management Information Base (MIB) II as a minimum. The network management functions, listed in paragraph 16.5.4.2, are performed by the NMS. The CI architecture of the NM is depicted in Figure 16-20; the functions allocated to each OS are listed as part of the different CIs associated with each numbered OS.

16.5.4.3.2 Engineering Support Subsystem

The engineering support subsystem (ESS) is comprised mainly of CIs common to the TS and NMS. It is designated as a separate subsystem because it contains some additional CIs that are specific to engineering support. The ESS includes three test nodes (test nodes are nonoperational and do not interface the TS) which, taken together, contain at least one piece of every kind of equipment found in the TS. Sufficient equipment is provided to enable two of the test nodes to be configured to support the maximum single stream data rate supported by the network, and so that alternate routing, switchover (failover), and service restoral scenarios can be tested. The ESS may also support the NMS function. Preliminary indications are that the ESS is to be equipped with one OS-1 or OS-2, one OS-3 or OS-4, one each high-

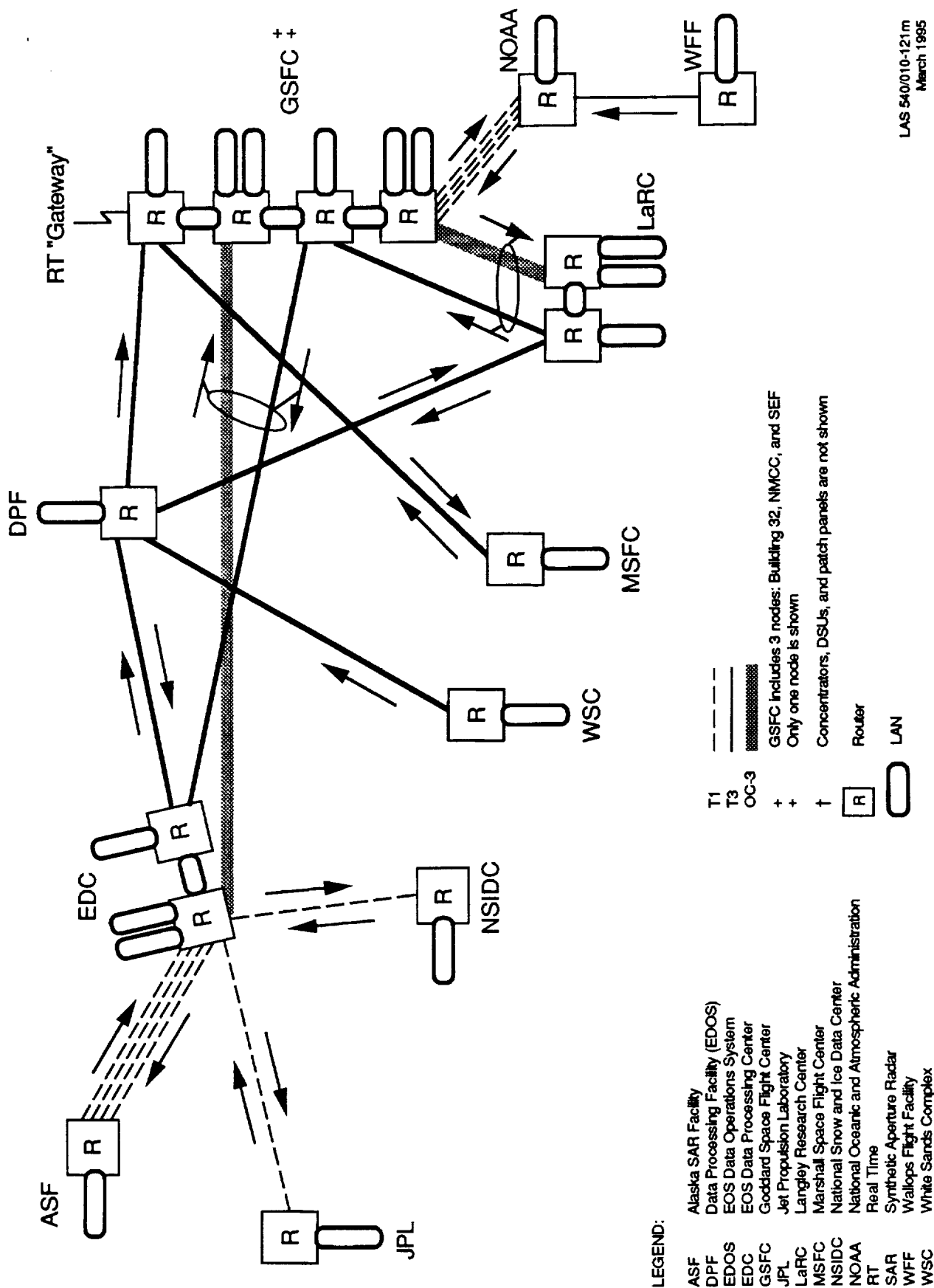
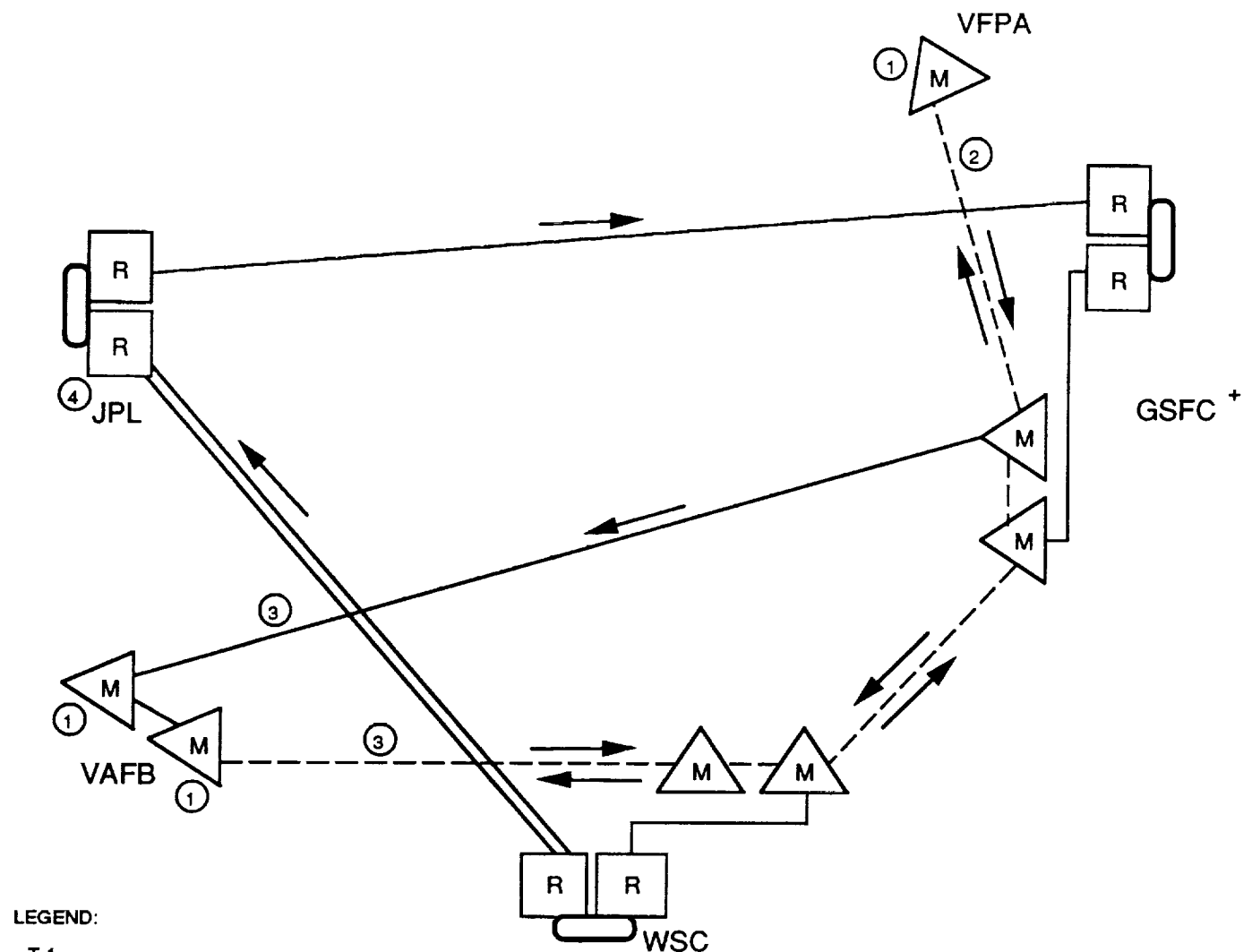


Figure 16-17. Hypothetical Topology and Simplified Architecture for Science Traffic

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LEGEND:

- T-1 ———
- 64k ———
- ↑ Concentrators, DSUs, and patch panels are not shown
- R Router
- LAN
- M T-1 Multiplexer

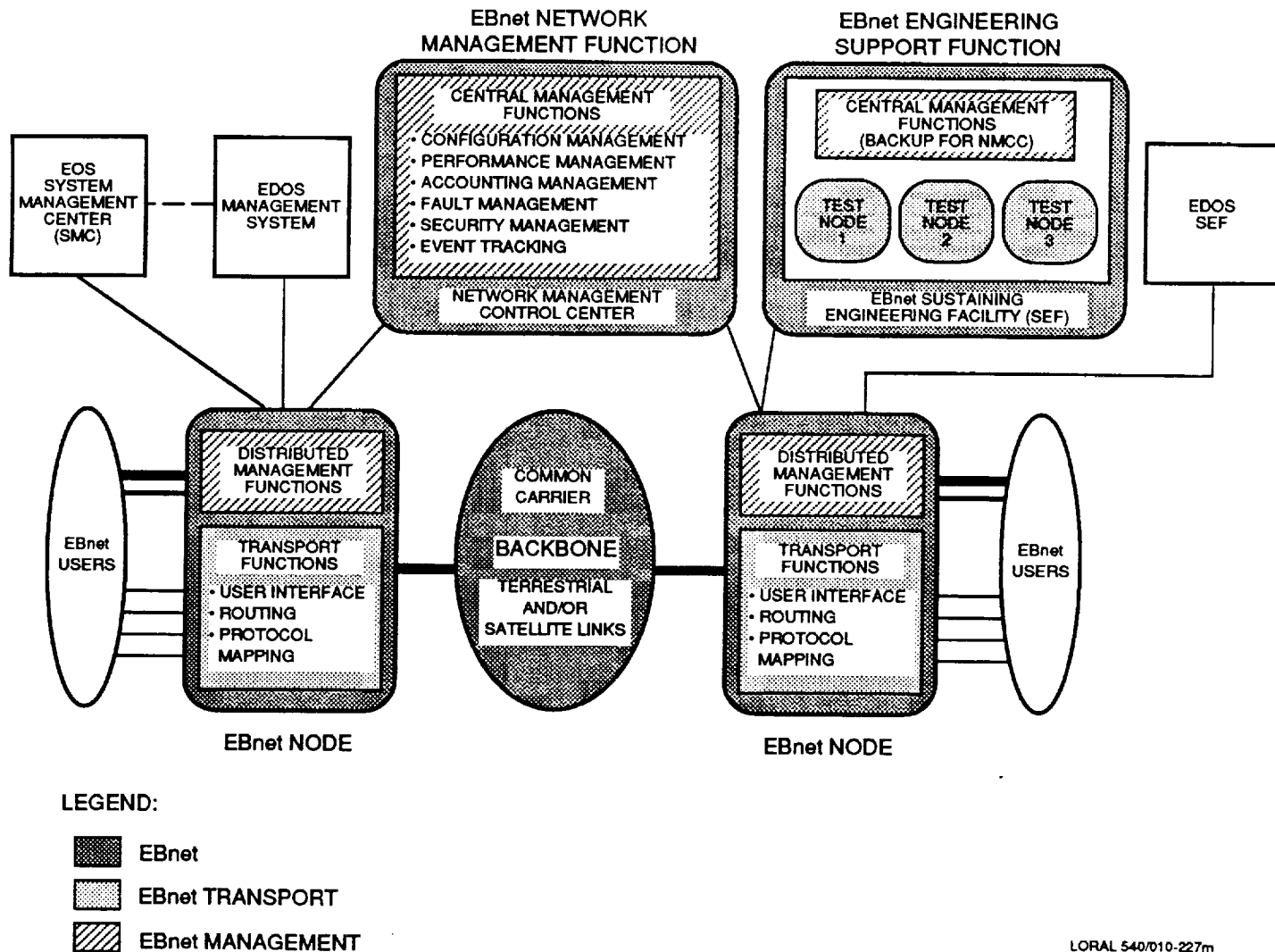
GSFC Goddard Space Flight Center
 JPL Jet Propulsion Laboratory
 VAFB Vandenberg Air Force Base
 VFPA Valley Forge, Pennsylvania
 WSC White Sands Complex

NOTES:

- ① Spacecraft requires serial data interface.
- ② No redundant circuit: test facility only.
- ③ Redundant circuits: test facility with launch schedule constraints.
- ④ JPL is gateway for Japanese Instrument RT data.

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Figure 16-18. Candidate Topology and Simplified Architecture for Real-time Traffic



LORAL 540/010-227m
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Figure 16-19. Conceptual Architecture

and low-speed laser printers, two nodal human-machine interfaces, a maintenance terminal, two dial modems, one asynchronous data switch, and two modeling and development workstations. So equipped, the ESS would be able to function as an emergency network control center in the event of a catastrophic failure of the NMCC. A functional depiction of the ESS equipment and its relationship to the TS is presented in Figure 16-21.

16.5.4.4 Implementation Approach

Implementation of the EBnet project is a responsibility of the NASA Communications Division, GSFC Code 540. To lead the project, Nascom has assigned a full time project manager at the "Assistant Chief for" level. The project is being implemented in-house and lead by civil servant employees, predominantly from the Advanced Development Section, Code 541.3, augmented by existing support contractor vehicles [Systems, Engineering, and Analysis Support (SEAS) and Network and Mission Operations Support (NMOS) contracts] for engineering, project management, and Independent Test and Verification/Acceptance

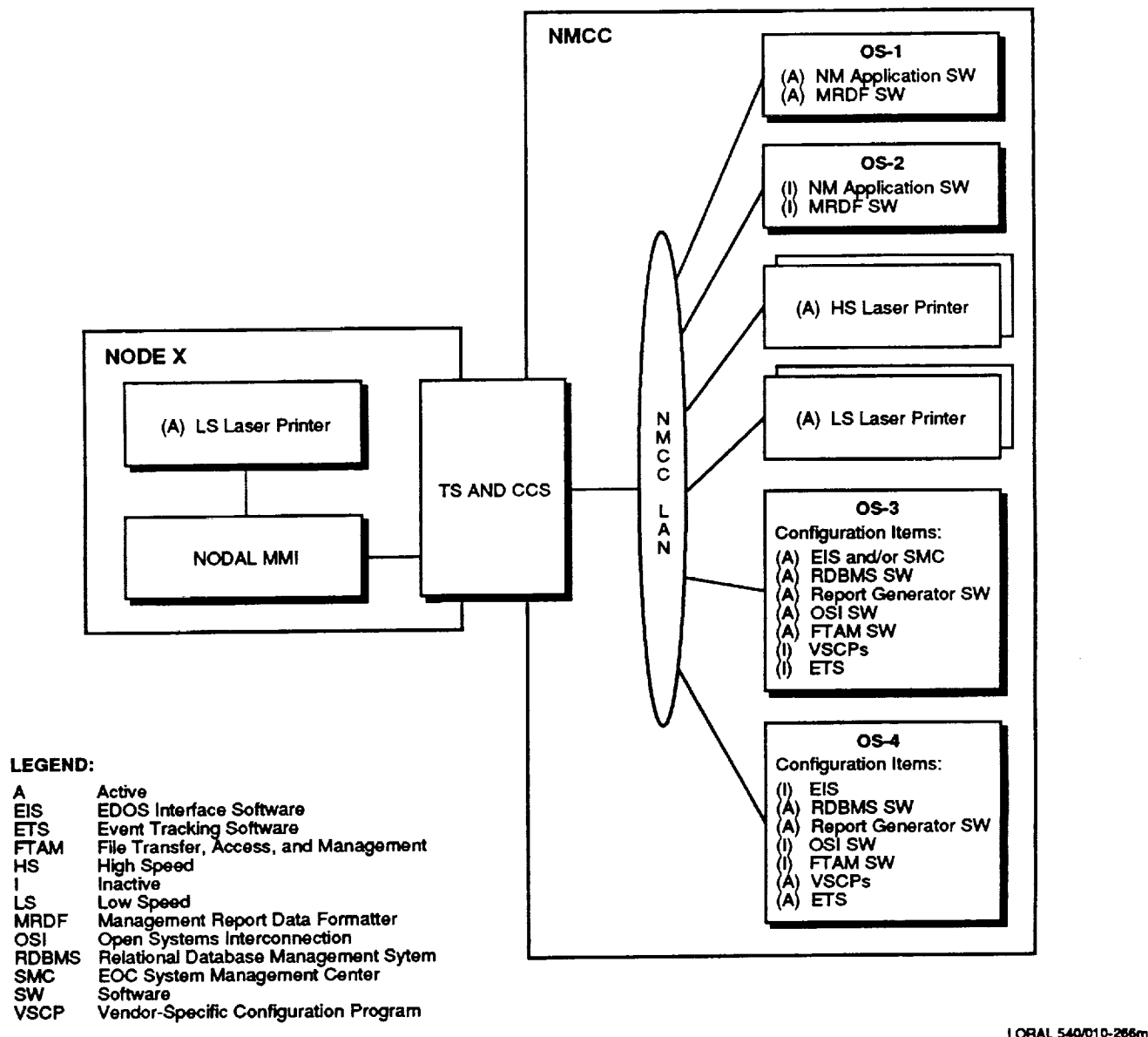
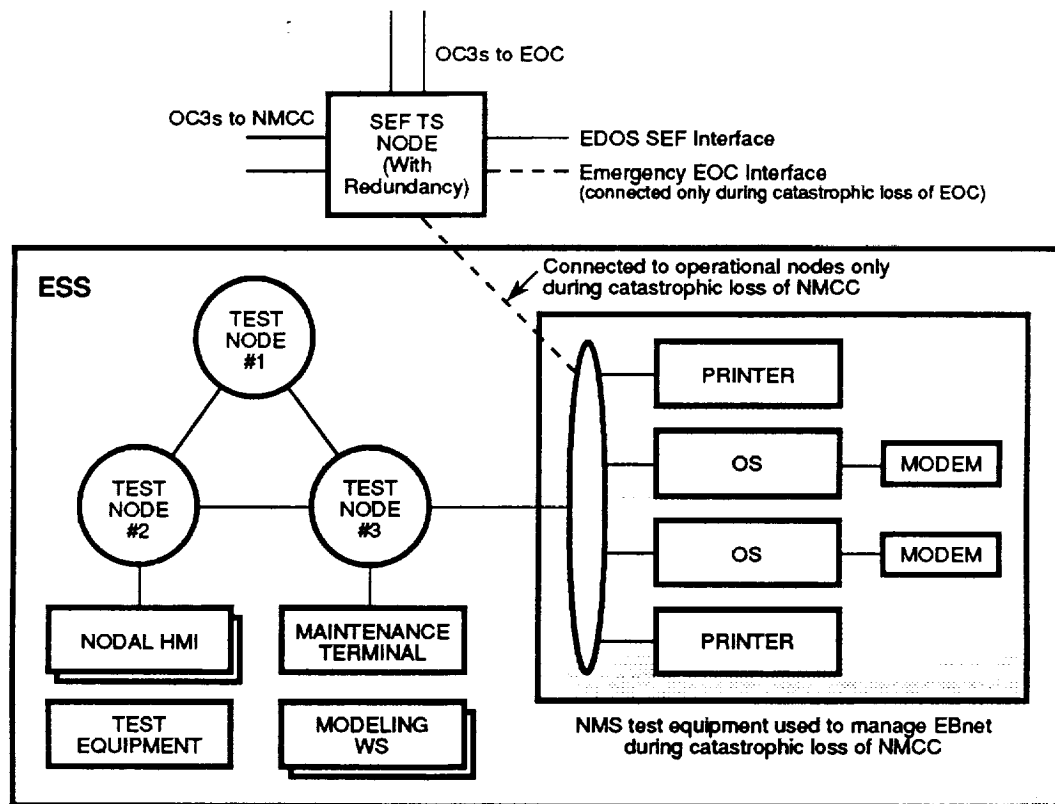


Figure 16-20. Conceptual Network Management System

Testing (IT&V/AT) support. Also assigned to the implementation management team are civil servant and contract personnel from Data Systems Assurance, Code 303, and the Logistics Management Section, Code 535.3.

EBnet Configuration Item (CI) equipment is virtually all COTS and therefore may be purchased directly from the vendor under the Science and Engineering Work Station (SEWP) contract. For those items that required development, based on the initial set of requirements that EBnet needed to satisfy, in-house development was undertaken through the SEAS contract. The Development Configuration Items (DCI) have largely completed their review cycles and are, or will be, ready for integration when the CIs are integrated into nodes and installed at their respective sites.

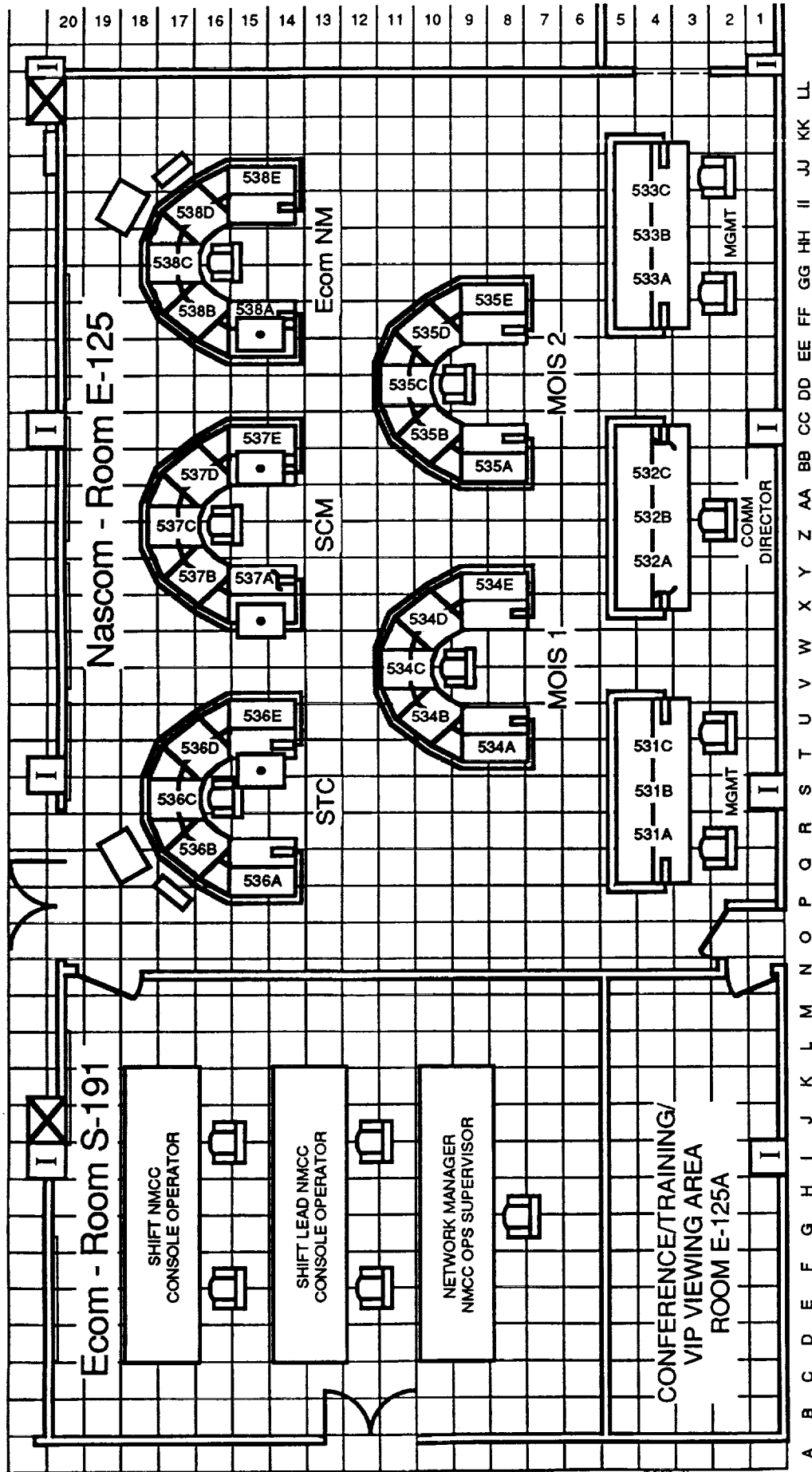


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Figure 16-21. Conceptual Engineering Support Subsystem

16.5.4.5 Facilities

Nascom Interface Facilities (NIF) (see Section 3) will be established at each location supporting an EBnet node. Remote nodes will be provided staffing by Nascom, except for the Martin Marietta, Inc., Spacecraft Integration and Test Facility (SCITF) node which will be operated and maintained by the spacecraft contractor, and the Launch Site location which will be attended by Air Force personnel. As Nascom attended facilities, they also meet the criteria of a Nascom Point of Presence facility (see Section 3). To house the NIFs, physical facilities are required at each location where an EBnet node will be activated. The EBnet Facility Plan and Utilization document, at this stage in the project, provides only "typical" requirements information for an EBnet facility: 1050 square feet for EBnet equipment, common carrier interface equipment, and a maintenance and operations work area. From what has been determined by the replan activity to date, facility space requirements may be expected to be reduced by a substantial amount. The EBnet presence at each facility should be no more than just a few equipment racks. The floor plan for the NMCC is shown in Figure 16-22. NIFs, the NMCC, and the SEF, prior to the "change in scope" activity described in paragraph 16.5.4.1, were to be established and tested for acceptance into the network. This is indicated in Table 16-4.



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Figure 16-22. NMCC Floor Plan

16.5.4.6 Staffing

The EBnet Maintenance and Operations Management Plan indicates that Nascom will utilize existing site facility maintenance and operations (M&O) technicians at each of the remote nodes. At GSFC, sufficient M&O technicians will be added to the NMOS contractor's authorized staffing level to provide NMCC console operations personnel on a full period basis and to provide M&O technicians to cover the EOC node, NMCC, and SEF on a dispatch basis. For the Install I and II facilities, staffing will be phased in over two cycles, i.e., about half of the Install I M&O staff will be hired, trained, and assigned to their respective duty locations during the Install I period; the remaining M&O technicians for Install I sites will be supplied during the Install II period. In a similar fashion, Install II site personnel will be phased in during the periods of Installs II and III. Install III M&O staff will be provided during the Install III period. Note: With the substantial reduction in strict RMA requirements originally imposed upon EBnet, initial staffing and even the maintenance concept for each node may substantially change.

16.5.4.7 Training

The EBnet Training Plan indicates that the initial formal training will be provided to the M&O staff, the installation contractor's installation team, the IT&V/AT team, and to persons from the Network Test and Training Facility (NTTF) who will be responsible for follow-on training. For the M&O staff, initial formal training is followed by a period of On-the-Job Training (OJT) conducted by members of the engineering/installation team.

Table 16-4. EBnet Nodes and Activation Schedule

| Node | System Test Schedule |
|--|--|
| Install I GSFC/NMCC GSFC/EOC WSC/EDOS DIF Fairmont, WV/EDOS DPF MMC/PA/SCITF VAFB, CA/LF | 3rd Quarter, FY96 3rd Quarter, FY96 3rd Quarter, FY96 3rd Quarter, FY96 3rd Quarter, FY96 3rd Quarter, FY96 |
| Install II GSFC/SEF Sioux Falls, SD/EDC JPL, DAAC & IP GW LaRC/DAAC | 1st Quarter, FY97 1st Quarter, FY97 1st Quarter, FY97 1st Quarter, FY97 |
| Install III MSFC/DAAC | 4th Quarter, FY97 |

16.5.4.8 Schedule

The EBnet project completed the System Requirements Review phase on February 26, 1993, when the Nascom Project Review Board Chairman issued a formal authorization to proceed with the design phase. The Project presented is System Design Review on February 7, 1994.

As indicated in paragraph 16.5.4.1, a substantial replan of EBnet has occurred. Until the replan activity is completed, EBnet is not expected to update its Project Master Schedule.

16.5.4.9 Observation

EBnet represents a paradigm shift in the way Nascom provides operational communication services to flight missions and other users. The network will be data driven, i.e., will transport data from (ground data system) source to (ground data system) sink, using information contained in the header of the data packet. There will be no need to externally schedule and configure the network resources required for support of each service. The network will be comprised of COTS equipment and software in so far as possible. Standard protocols will be employed. The network will be highly automated, performing routine network management functions without need of human intervention. Also of significance, EBnet is Nascom's first new network to be implemented under the guidelines established in NASA's Decision Memorandum No. 25: the network is funded by, designed to the requirements of, and dedicated in providing its communications services to the EOS program.

Appendix A. History and Justification

A.1 History

A.1.1 Origins of Nascom Network

The origins of the Nascom Network may be traced to Project Vanguard during the period of U.S. participation in the International Geophysical Year (IGY) 1957–1958. This project, under responsibility of the Naval Research Laboratory (NRL), placed into orbit and tracked the first U.S. artificial earth satellite, and acquired data related to experiments conducted onboard. The NRL established a network of Minitrack sites for acquisition and tracking the satellite, with the Vanguard Control Center located at the Naval Research Laboratory, Washington, D.C., and the Vanguard Computation Center in downtown Washington, for the purpose of determining and predicting LC satellite orbits. A teletype communications net was established linking the remote Minitrack stations with the Vanguard Control and Computation Centers. This Minitrack network was the predecessor of the Satellite Tracking and Data Acquisition Network (STADAN) system. The original Minitrack stations were established in a north–south chain and at other points in the following locations:

| | |
|--|----------------------------|
| Blossom Point, M | Antofagasta, Chile |
| Fort Stewart, GA | Santiago, Chile |
| Havana, Cuba | Antigua, British W. Indies |
| Quito, Ecuador | San Diego, California |
| Lima, Peru | Woomera, Australia |
| Olifantsfontein, Union of South Africa | |

Direct point-to-point teletypewriter circuits were originally set up by the Army Command and Administrative Network (ACAN) system to all sites except Australia, which was served by a military torn-tape system. Communication switching and technical control functions were identified at the Vanguard Control center and developed to a point where separation from project control and computation functions became necessary for efficient operations. These were designated first as “SPACON” and later “SPACECOMM.”

In 1959, the Vanguard Control and Computation Centers were transferred to the new NASA organization, and were relocated to the Goddard Space Flight Center (GSFC) in Greenbelt, Maryland. Also in 1959, the direct teletypewriter circuit to South Africa was converted into a commercial refile circuit for improvement of service. The communications network was expanded to tie in various agencies cooperating in the scientific exploration of space via leased commercial circuits. Gradually, the communications network evolved from military to commercial facilities, and a manual torn-tape switching system was established in the SPACE-COMM communication center at GSFC. Meanwhile, communications separately developed and used by the Deep Space Network (DSN) of the Jet Propulsion Laboratory

(JPL) was brought into the SPACECOMM system to time-share its circuits with DSN stations in Australia and South Africa, which were collocated with Minitrack stations in those areas.

In 1960, the Project Mercury network of radar tracking, telemetry, and command stations was established by the NASA organizations at Langley Research Center (LaRC).

Centralized communications control and computation for Project Mercury were established at GSFC. This network included full period, common carrier leased, point-to-point teletype-writer circuits linking GSFC with all domestic and overseas remote sites, and with Mercury Control Center at Cape Canaveral. These circuits were tied into automatic electromechanical torn-tape message switching systems at GSFC, and automatic switching points were provided at London and Honolulu. A remote switching center was later established at Adelaide, Australia. The system also provided full period, common carrier leased, voice circuits to Australia, Hawaii, various U.S. sites, Cape Canaveral and Bermuda, terminating on a special Switching, Conferencing, and Monitoring Arrangement (SCAMA). After implementation, the Project Mercury network was transferred to GSFC management for maintenance, operation, and further development. This network evolved to the Manned Space Flight Network (MSFN), with communications switching and technical control established at GSFC. The communications control facilities for Project Mercury and for SPACECOMM at GSFC were physically adjacent, and to a very limited extent, circuit facilities and traffic were interchangeable between the two networks.

A.1.2 Establishment of Nascom

Starting with the inception of NASA in 1958, three primary tracking and data acquisition networks developed as separate systems for earth orbiting science, planetary, and manned space missions, because of the unique requirements necessary to support the different types of missions. The operational ground communications requirements of the three networks, STADAN, DSN, and MSFN became more demanding because of the increasing number, variety, and complexity of spacecraft. There were also parallel developments for unique operational communications systems for other NASA development and control centers, and test and evaluation facilities. Recognizing the need for unified communications management control, in 1964 NASA Headquarters defined all NASA operational longline communications, which are operated by NASA, as "Nascom," and Nascom became a part of the National Communications System (NCS). The Office of Tracking and Data Acquisition (OTDA), was charged with Nascom management responsibility, which in turn delegated to GSFC for the current and long-range planning, budgeting, design, implementation and maintenance of Nascom to meet the operational communications requirements of all NASA programs and projects. Reference current NASA Management Instruction 2520.1D.

A.1.3 Evolution of the Integrated Nascom Network

For reasons of economy, workload, and responsiveness to project requirements, GSFC has delegated certain responsibilities for several existent unique operational communications systems to cognizant centers or field activities. However, to the extent possible, GSFC has brought into the Nascom Network, under its management, all operational communications facilities, to unify and improve communications reliability and efficiency.

The nature of existing and new programs and missions requires frequent additions and modifications, and generally, improvements to the Nascom Network on a continuing basis. Requirements for improvement of communications reliability in conjunction with economic considerations, created an increasing and compelling need to share existing circuits and facilities of the STADAN, DSN, and MSFN. This, in turn, led to the concept of a primary switching center where circuit-sharing and flexibility with centralized facilities control could be achieved. Through such consolidations, the total Nascom communications resources became available for use on any mission, and consequently, diversely routed Nascom communications channels became available as a first line restoration capability in the event of isolated circuit malfunctions or failures, in addition to the secondary restoration abilities available in the Common Carrier's system.

In 1971, with the approaching end of the Apollo Program, the STADAN and MSFN Networks were unified under a single management organization at GSFC. The planning and implementation of this unified network which is now referred to as the Spaceflight Tracking and Data Network (STDN) was initiated, with coordination planning for common user Nascom Network support. The DSN continued as a separately (JPL) managed network, but its long-haul communications were and are still obtained from the common user Nascom system. The NASA Communications Division, while organizationally under the Networks Directorate at GSFC, was chartered to provide operational ground communications support service to all NASA missions.

A.2 Justification

A.2.1 Integrated Network

Three main reasons for establishing an integrated communications network are reliability, economy, and performance efficiency. The dominant element in justification is network integrity. Performance efficiency is a result of the reliability factor, which provides network integrity, and although the economic factor will be reflected, economics will not prevail over network integrity considerations.

A.2.1.1 Reliability

As a result of circuit sharing, Nascom circuits are in use a greater part of the time. Continual use and exercise of circuits and equipment is the best method of ensuring a high degree of network reliability. Potential trouble spots are identified far enough in advance to permit remedial action before major trouble develops. Personnel training and efficiency are maintained at a high level. Because the Nascom Network combines requirements of various users and often provides these services on diverse routes, circuits may at times be made available for restoration purposes in the event of outages. Circuit scheduling priorities, at a given time, may also allow temporary restoration of the most critical service among users. Centralized facilities control provides more rapid service restoration than can be obtained when networks are separately controlled.

A.2.1.2 Economy

A single voice-data circuit from GSFC to Australia, with 9.6-kb/s capability, leases for about \$156K per year. An SCPC 56 kb/s circuit leases for about \$318K per year. Obviously,

establishing a number of these circuits is expensive. It is imperative that circuits such as these not remain idle for periods ranging from hours to months. An integrated network permits sharing of circuits to the maximum possible extent, thereby reducing the total number of circuits required, and permits economy of scale.

The cost of data communications (dollars-bit) continues to decrease, notwithstanding inflation. This reduction in cost can be attributed to a rapidly developing technology; i.e., communication satellites, the opening of the U.S. domestic communications market to competition by common and specialized communications carriers, etc. At the same time, operating costs for data handling (data stripping, taping, store-and-forward) at remote sites are increasing rapidly. A favorable tradeoff for more communications bandwidth for less remote site data handling in the network has become a paramount network economy driver.

A.2.1.3 Performance Efficiency

Nascom promotes more efficient use of engineering, operating, and support personnel through elimination of duplication of efforts by overlapping organizational responsibilities. Through an integrated network, it is possible to work toward standardized equipment and performance standards throughout the network, with the resultant advantages. Total resources of the Nascom Network can be brought to bear on individual projects or missions as required.

A.2.2 Primary Switching Center

All global circuits are presently routed through the GSFC Switching Center, which is the switching center for circuits used in support of earth satellites, manned space flight missions, and for deep space probes. The feasibility of a primary switching center has been suitably demonstrated and will be continued for the following major reasons:

A.2.2.1 Centralized Facilities Control

A single point of contact for trouble-clearing and reporting to domestic and overseas common carriers and remote switching centers greatly enhances the reliability of the Network. It reduces the number of "orderwires" or "service channels" required and speeds trouble reporting and circuit restoration.

A.2.2.2 Assignment of Operational Responsibility

A primary switching center facilitates assignment and identification of responsibilities for operation of the Nascom Network, without diffusing responsibility to various mission control centers for various time intervals for operation of overseas facilities. The risk of incorrect actions by operating personnel is greatly reduced if areas of responsibility are clearly defined and do not change on an hourly or daily basis.

A.2.2.3 National Communications System

The primary switching center at GSFC is the single point of exit and entry into the Nascom Network within the United States. This solves the problem of maintaining a communications

network capable of supporting NASA flight missions and simultaneously functioning as a portion of the National Communications System (NCS).

A.2.2.4 Status of Nascom Consolidations

The integration of the original three separate communications networks that served STADAN, DSN, and MSFN, into a single Network (Nascom) has been accomplished through consolidation and definition of management responsibility, establishment of primary and remote switching centers, and facilities that provide greater capabilities and flexibility for circuit manipulation, technical control, and circuit message sharing. Network integration is a continuing process of attempting to achieve a goal through improved coordination among the various programs and project planners, establishment of standards, further improvements of network facilities, and improved technical network management.

The unique real-time aspect of the Nascom Network does not make it feasible to integrate further than already established on a message-switched basis with communications networks of other government agencies (Defense Communications Agency [DCA], General Services Administration [GSA], Federal Aviation Administration [FAA] networks, etc.). Circuits that can be made available from other government agencies are used to the fullest extent possible; however, compatible interfacing between the Nascom Network and elements of the NCS is being developed to make available all communications resources during periods of national emergency.

A.2.2.5 Continued Nascom Development

The continuation and development of various national programs for the scientific exploration of space requires continued development of the Nascom Network as a part of an overall NASA Tracking and Data Acquisition system capability to meet the unique communications requirements of each program. Therefore, this NSDP (required by NMI 2520.1D) is sustained to describe the facilities being planned to serve the expressed communications requirements of all NASA programs.



Appendix B. Block Format Definitions

Nascom Interface Standard for Digital Data Transmission (542-003) contains the official description of the 4800-bit block used by Nascom. Section 3 of that document is reprinted for use here.

SECTION 3. INTERFACE SPECIFICATIONS

3.1 NETWORK CONTROL

3.1.1 GENERAL

The data source is responsible for generating the 4800-bit block format required by the network configuration and providing all of the required field entries.

3.1.2 BLOCK FORMATS

3.1.2.1 General. There are three block formats that may be used by spacecraft projects. These are the Ground Network (GN), the Space Network (SN), and the Deep Space Network (DSN) blocks. Each block consists of five major elements: a network header, a user header, a time field, a data field, and a block error control field. Nascom is responsible for configuration control of the network header and the block error control field. The user is responsible for configuration control of the remainder.

3.1.2.2 GN Block. The GN block, also known as the throughput block, is used to transport digital data on the GN for support of spacecraft projects that are compatible with the Tracking and Data Relay Satellite System (TDRSS) and for launch support. The block format is shown in Figure 3-1. The following paragraphs describe each field:

- a. Network Header (Bits 1-48). The first 48 bits contain routing and block accounting information required for Nascom switching and routing purposes.
 - (1) Nascom Sync (Bits 1-24): A fixed code (627627 hexadecimal) used to indicate the beginning of a 4800-bit block.
 - (2) Source Code (Bits 25-32): A Nascom-assigned code used to identify the geographic source (originator) of the data block.
 - (3) Destination Code (Bits 33-40): A Nascom-assigned code used to identify a single or multiple geographic destination of the data block. This field will be used by Nascom to route blocks to users.
 - (4) Block Sequence Number (Bits 41-43): A 3-bit counter used to identify the sequence in which each block of multiple-block messages were transmitted. This field may be used by Nascom to check the order in which blocks are received.
 - (5) Format Code (Bits 44-48): This 5-bit code identifies the general type of data contained within the block, i.e., telemetry, tracking, or command.
- b. User Header (Bits 49-96). This 48-bit field is reserved for information required by the user to route and process data contained in the block.
 - (1) Spacecraft Identification (ID) (Bits 49-56): This 8-bit field identifies the spacecraft being supported.

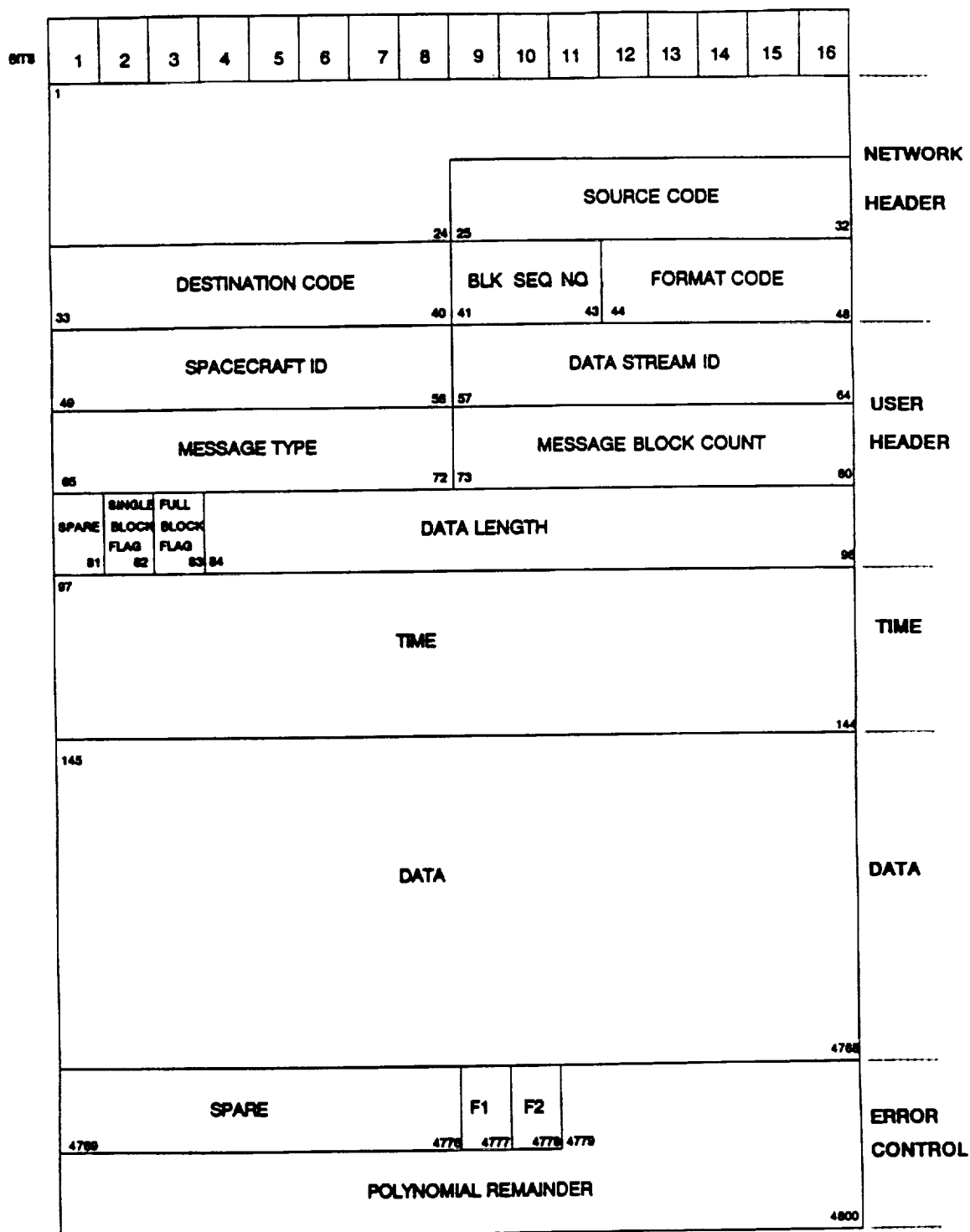


Figure 3-1. Ground Network Block

(2) Data Stream ID (Bits 57-64): This 8-bit field identifies the telemetry data format being transmitted.

(3) Message Type (Bits 65-72): This field contains a code that identifies the type of data contained in the block.

(4) Message Block Count (Bits 73-80): This 8-bit binary counter is normally used to count the blocks in a single transmission.

(5) Spare (Bit 81): This bit is not used and should be set to binary 0.

(6) Single Block Command Flag (Bit 82): For telemetry, this bit is set to a binary 0. For commands, this bit is set to a binary 0 when a command exceeds 4624 bits. This bit is set to a binary 1 when a command message is contained in a single block.

(7) Full Block Flag (Bit 83): A binary 1 indicates a full block. A binary 0 indicates fill bits are contained in the data field.

(8) Data Length Field (Bits 84-96): A 13-bit binary counter used to indicate the number of data bits, exclusive of fill bits, contained in the data field. This field is used to assist in the removal of fill data when processing the data field.

c. Time (Bits 97-144). This 48-bit field is reserved for a time code.

d. Data (Bits 145-4768). This 4624-bit field is used to transport data. When the data field contains fill bits, they will follow the real data bits in the field.

e. Block Error Control Field (Bits 4769-4800). This 32-bit trailer is used to determine if bit errors occurred during block transmission as follows:

(1) Spare (Bits 4769-4776): These 8 bits are not used and shall be set to all ones.

(2) Polynomial Status Flag F1 (Bit 4777): Source block error detection equipment will set this flag to a binary 1 following the block encoding process. Destination block error detection equipment will set this bit to a logic 0 following the block decoding process to indicate the block passed a polynomial check, or will be left as a binary 1 if an error is detected in the block. The destination user should inspect this field to determine the error control status of the block.

(3) Polynomial Status Flag F2 (Bit 4778): Source block error detection equipment will set this flag to a binary 1 following the block encoding process. The user may need this field for a second error check.

(4) Polynomial Remainder (Bits 4779-4800): A 22-bit field that contains the polynomial remainder which results from encoding the block at the source. An explanation of its use is provided in the Appendix.

3.1.2.3 SN Block. The SN block is used to route digital data via the Nascom Multiplexer/Demultiplexer (MDM) over the SN. The MDM will accept either blocked or unblocked data. If blocked data is provided at the interface, the user has two options. The data may be provided in the SN 4800-bit block format (see Figure 3-2) providing all the network header information, and the MDM will transport the block unchanged. This is the unmodified header option. For the modified header option, data will still be provided in the SN 4800-bit block format, but the MDM will modify the source header by inserting a fixed source code, a specifiable data stream ID, and a sequential port sequence number. The user may also elect to provide serial (unblocked) data at the interface. The MDM will block the data and insert all the required routing and block accounting information (see Figure 3-3). All telemetry data received from the NASA Ground Terminal (NGT) will be in the SN unmodified header block format, unless the unblocked (serial) option is selected.

3.1.2.4 SN Block Fields. The fields in the SN block with an unmodified header used for network control are described in the following paragraphs.

a. Unmodified Network Header (Bits 1-48). The first 48 bits contain routing and block accounting information required for Nascom switching and routing purposes. The bits are used as follows:

(1) Nascom Sync (Bits 1-24): A fixed code (627627 hexadecimal) used to indicate the beginning of a 4800-bit block.

(2) Spare (Bits 25-32): For telemetry data, the MDM sets this field to all ones. For command data, the MDM does not care what is in this field.

(3) Data Stream ID (Bits 33-40): For telemetry data, the user data ID's are assigned by the Network Control Center (NCC). They are inserted by the MDM as scheduled by the NCC and the user. For command data, the MDM does not care what is in this field.

(4) Port Sequence Number (Bits 41-48): For serial input data this is an 8-bit binary count generated by the MDM on a port basis by the first transmitting multiplexer. It is used for block accounting. For blocked input data, the MDM does not care what is in this field.

b. Modified Network Header (Bits 1-48). The first 48 bits contain routing and block accounting information required for Nascom switching, routing, and user message accounting purposes. The bits are used as follows:

(1) Nascom Sync (Bits 1-24): A fixed code (627627 hexadecimal) used to indicate the beginning of a 4800-bit block.

(2) Source Code (Bits 25-32): A Nascom-assigned code used to identify the geographic source (originator) of the data block.

(3) Data Stream ID (Bits 33-40): For telemetry data, the user data ID's are assigned by the NCC. They are inserted by the MDM as scheduled by the NCC and the user. For command data, the MDM does not care what is in this field.

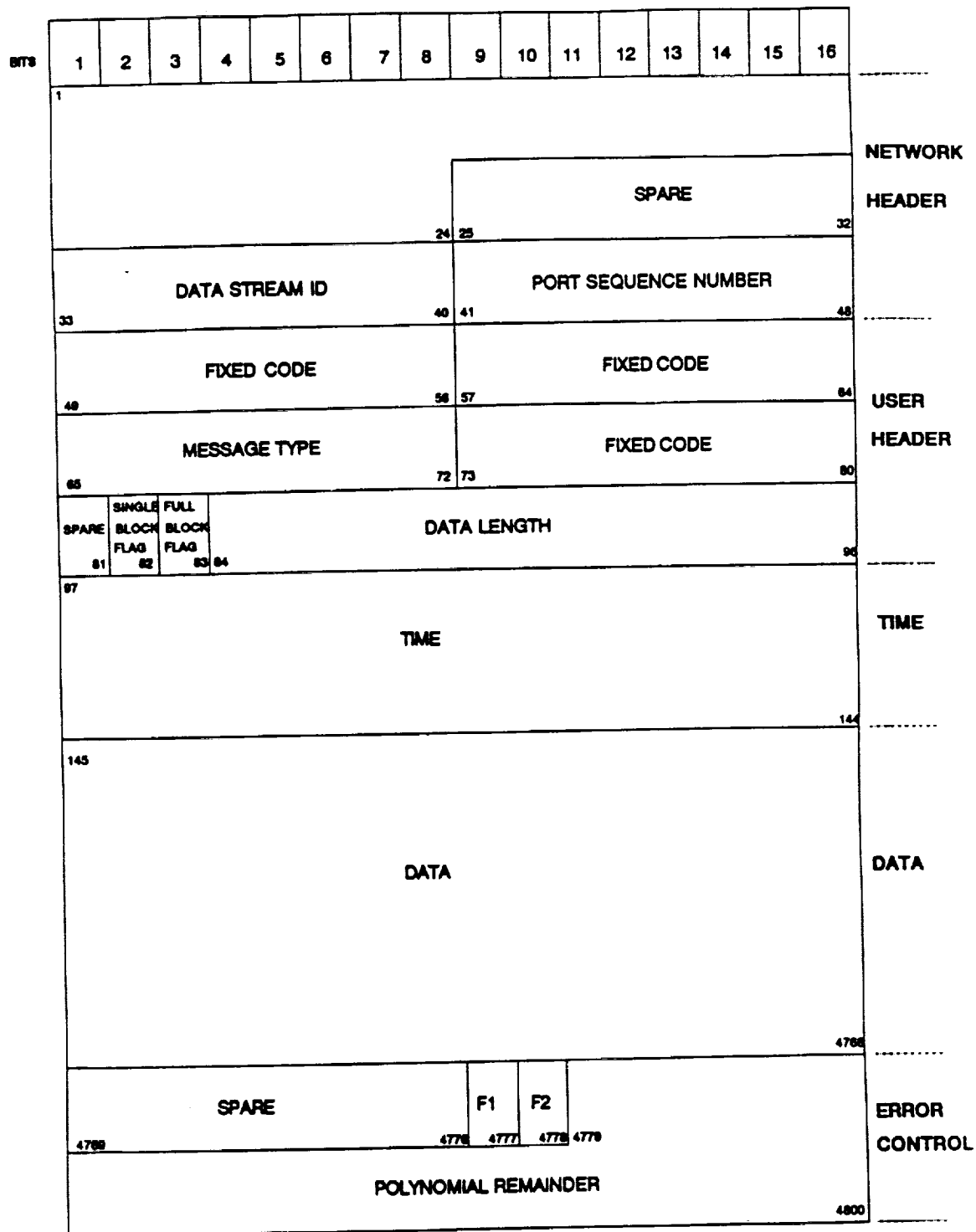


Figure 3-2. Space Network Block - Unmodified Header

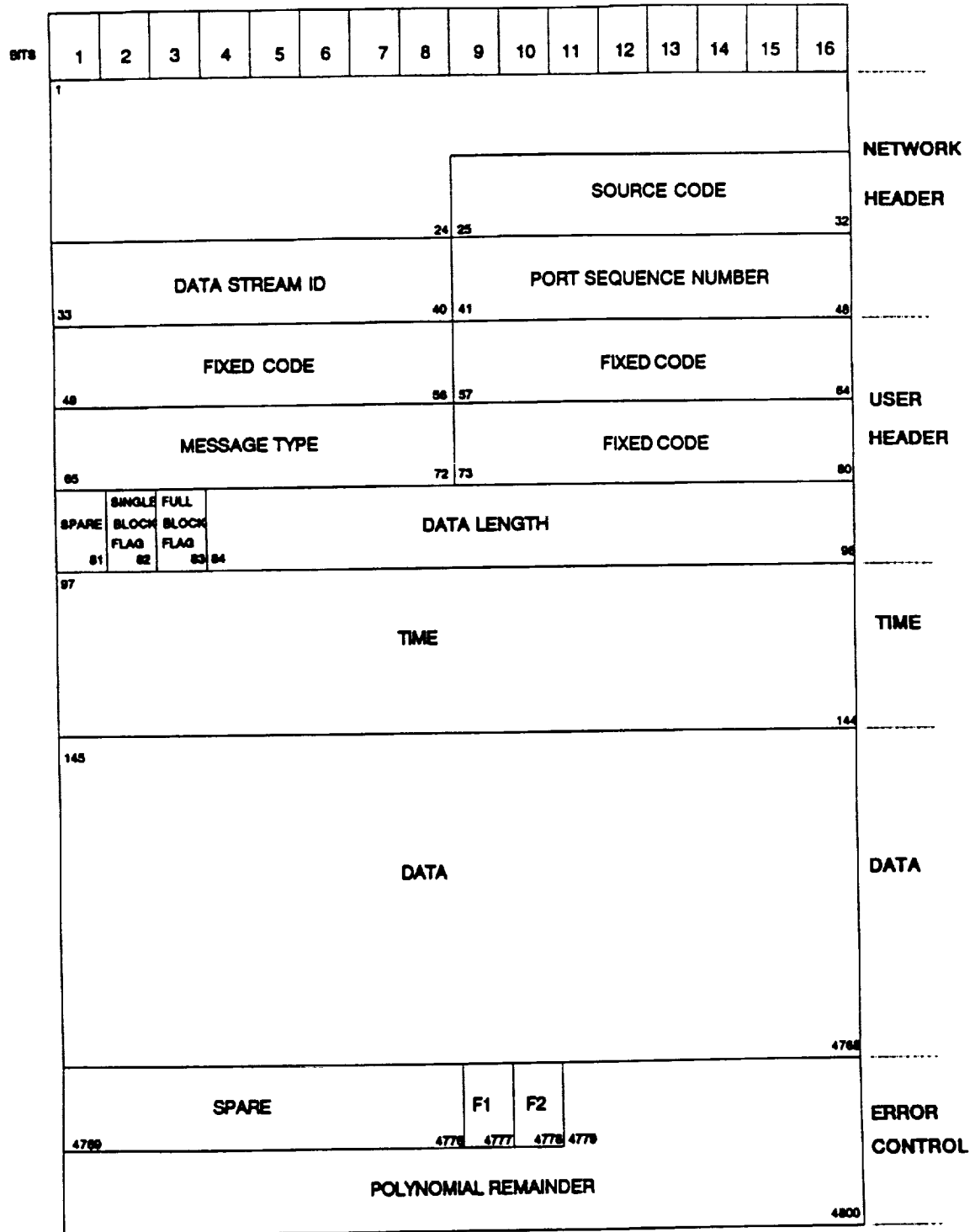


Figure 3-3. Space Network Block - Modified Header

(4) Port Sequence Number (Bits 41-48): For serial input data, this is an 8-bit binary count generated by the MDM on a port basis by the first transmitting multiplexer. It is used for block accounting.

c. User Header (Bits 49-96). This 48-bit user header is normally reserved for information required by users to route and process data contained within the block. Functionally, on the forward link, this field contains the information necessary for stripping command data out of a block and maintaining a bit-contiguous uplink for multiblock commands. On the return link, this field is used in a like manner, but the data stripping function may be performed either by the MDM or the user facility.

(1) Fixed Code (Bits 49-56): For telemetry data, this field contains a fixed code (00000001). For command data, the MDM does not care what is in this field.

(2) Fixed Code (Bits 57-64): For telemetry data, this field contains a fixed code (00000001). For command data, the MDM does not care what is in this field.

(3) Message Type (Bits 65-72): For serial input data, this field contains a fixed code that indicates whether the block originated at NGT, JSC, or GSFC. For blocked input data, the MDM does not care what is in this field.

(4) Fixed Code (Bits 73-80): For telemetry data, this field contains a fixed code (00000001). For command data, the MDM does not care what is in this field.

(5) Spare (Bit 81): Set to binary 0.

(6) Single Block Command Flag (Bit 82): For telemetry, this bit is set to a binary 0. For commands, this bit is set to binary 0 when a command exceeds 4624 bits. This bit is set to a binary 1 when a command message is contained in a single block.

(7) Full Block Flag (Bit 83): A binary 1 indicates a full block. A binary 0 indicates fill bits are contained in the data field.

(8) Data Length Field (Bits 84-96): A 13-bit binary counter used to indicate the number of data bits, exclusive of fill bits, contained in the data field. This field is used by NGT (commands) and the user (telemetry) to assist in the removal of fill data when processing the data field.

d. Time (Bits 97-144). For telemetry, the time code in the NASA PB-4 format is used to indicate the time in Greenwich Mean Time (GMT). This time, with a resolution of 12 microseconds indicates the time that the MDM received the first data bit in the data field. For commands, the MDM does not care what is in this field.

e. Data Field (Bits 145-4768). This 4624-bit field is used to transport user data. When the data field contains fill bits, they follow the user's data.

f. Block Error Control Field (Bits 4769-4800). The following 32-bit trailer is used to determine if bit errors occurred during block transmission:

(1) Spare (Bits 4769-4776): An 8-bit field not currently designated for use. The source user should fill this field with logic 1's.

(2) Polynomial Status Flag F1 (Bit 4777): A 1-bit field indicating a block either passed (logic 0) or failed (logic 1) a polynomial check prior to transmission to the source MDM data system. Always a logic 0 in MDM data system generated blocks. The user may use this field for a second error check.

(3) Polynomial Status Flag F2 (Bit 4778): The source MDM will set this flag to a binary 1 upon transmission. The destination MDM will set this bit to a logic 0 to indicate that the block passed the polynomial check, or leave it as a binary 1 if an error is detected in the block.

(4) Polynomial Remainder (Bits 4779-4800): A 22-bit poly code which results from the encoding process performed by the source MDM. The destination MDM does not remove or alter this field during the decoding process. It is passed to the user where a further check can be made. An explanation of its use is provided in the Appendix.

3.1.2.5 DSN Block. The DSN block, also known as the DGIB block, is used to transport telemetry and command digital data via the DSN for spacecraft projects that require contingency or emergency support should the TDRSS be inoperable for an extended period of time. The use of this block must be coordinated with the Jet Propulsion Laboratory (JPL). The block format is shown in Figure 3-4. The following paragraphs describe each field:

a. Network Header (Bits 1-48). The first 48 bits contain routing and block accounting information required for Nascom switching and routing purposes as follows:

(1) Nascom Sync (Bit 1-24): A 24-bit fixed code (627627 hexadecimal) used to determine the beginning of a 4800-bit block.

(2) Source Code (Bits 25-32): An 8-bit Nascom-assigned code used to identify the geographic source (originator) of the data block.

(3) Destination Code (Bits 33-40): An 8-bit Nascom-assigned code used to identify a single or multiple geographic destination of the data block. This field will be used by Nascom to route blocks to users.

(4) Block Sequence Number (Bits 41-43): A 3-bit number used to identify the sequence in which each block of multiple-block messages was transmitted. This field may be used to check the order in which blocks are received.

(5) Format Code (Bits 44-48): This 5-bit code identifies the general type of data contained within the block, i.e., telemetry, tracking, or command.

b. User Header (Bits 49-96). This 48-bit field is reserved for information required by the user to route and process data contained in the block as follows.

(1) Spacecraft ID (Bits 49-56): This 8-bit field identifies the spacecraft being supported.

(2) Data Stream ID (Bits 57-64): This 8-bit field contains a code that identifies the type of data contained in the block.

(3) Message Type (Bits 65-72): This field contains a code that identifies the type of data contained in the block.

(4) Message Block Count (Bits 73-80): For telemetry, this 8-bit counter provides a sequential count of multiple blocks belonging to the same message.

(5) Spare (Bit 81): This bit is not used and should be set to binary 0.

(6) Single Block Command Flag (Bit 82): For telemetry, this bit is set to a binary 0. For commands, this bit is set to binary 0 when a command exceeds 4624 bits. This bit is set to a binary 1 when a command message is contained in a single block.

(7) Full Block Flag (Bit 83): A binary 1 indicates a full block. A binary 0 indicates fill bits are contained in the data field.

(8) Data Length Field (Bits 84-96): A 13-bit binary counter used to indicate the number of data bits, exclusive of fill bits, contained in the data field. This field is used by NGT (commands) and the user (telemetry) to assist in the removal of fill data when processing the data field.

c. Time (Bits 97-144). This 48-bit field is reserved for a time code.

d. Data (Bits 145-4736). This 4592-bit field is used to transport data. When fill bits are used, they follow the data bits.

e. Block Serial Number (Bits 4737-4752). A 16-bit binary counter of blocks since the first for a data stream.

f. GCF Error Correction (Bits 4753-4776). This 24-bit field is reserved for error correction. This field is filled with binary 0's because GCF error correction is not currently used.

g. Block Error Control Field (Bits 4777-4800). This 24-bit trailer is used to determine if bit errors occurred during block transmission as follows:

- (1) Polynomial Status Flag F1 (Bit 4777): This bit is used to indicate that the block passed (logic 0) or failed (logic 1) a polynomial check prior to transmission over the network. The source user should set the flag to a logic 1 upon transmission. The destination user should inspect the field to determine the error control status of the block.
- (2) Polynomial Status Flag F2 (Bit 4778): This bit is used to indicate that the block passed (logic 0) or failed (logic 1) a polynomial check subsequent to transmission over the network.
- (3) Polynomial Remainder (Bits 4779-4800): A 22-bit field that contains the polynomial remainder which results from encoding the block at the source. An explanation of its use is provided in the Appendix.

3.1.3 CONTROL AND ASSIGNMENT OF SOURCE/DESTINATION AND FORMAT CODES

3.1.3.1 The source/destination and format codes are controlled and assigned to network users by Nascom for its switching, routing, legal, linkage, and priority functions. Any application of these codes to user processing functions must not be in conflict with these Nascom functions.

3.1.3.2 Users must ascertain that they are using valid codes in the network header field, coordinated with and assigned by Nascom, before implementing them in software. Internal user validation and routing functions may be based on information contained within the data field, or information included in the user header field.

3.1.4 NETWORK OPERATING PROCEDURES

The Nascom Division promulgates its operational management disciplines and responsibilities for the Nascom Network through the issuance of the Nascom Manual, Volumes I through III. It devises, implements, and updates the procedures for the most prompt and efficient network control of data communications.

3.2 PHYSICAL CONTROL

3.2.1 GENERAL

Physical control level activities are confined to specification of the data transfer rate and the identification of the electrical, mechanical, and functional characteristics of the media used to transfer data.

3.2.2 DATA TRANSFER RATE

The data transfer rate across the interface is normally derived from a Nascom-provided clock with an accuracy equal to or greater than ± 0.01 percent. With agreement from Nascom, the timing element may be derived from a user-provided clock, providing the clock is at least equally accurate and stable. The maximum data transfer rate is a controlled parameter governed by the signaling rate in use on the particular link.

3.2.3 ELECTRICAL/FUNCTIONAL/MECHANICAL CHARACTERISTICS

3.2.3.1 Data Service up to 20 kb/sec

a. Electrical. Circuits transporting data at rates within this range have unbalanced voltage electrical characteristics as specified in Federal Standard 1030A (EIA RS-423A). Distortion limits are per EIA standard RS-334A.

b. Functional/Mechanical. The functional and mechanical relationship for data circuits, control circuits, timing circuits, and ground or common return will be determined and specified on a case-by-case basis.

3.2.3.2 Data Service from 20 kb/sec to 10 Mb/sec

a. Electrical. Circuits transporting data at rates within this range have balanced voltage electrical characteristics as specified in Federal Standard 1020A (EIA RS-422A). Distortion limits are per EIA standard RS-334A.

b. Functional/Mechanical. The functional and mechanical relationship for data circuits, control circuits, timing circuits, and ground or common return will be determined and specified on a case-by-case basis.



Appendix C. Nascom Performance Objectives and Standards

C.1 Voice-grade Circuits

C.1.1 Standards

There are no specified tariff standards for voice-only circuits. The common carrier's responsibility is to provide a circuit that is free from distortion and noise, and is usable in the exchange of normal speech.

C.1.2 Performance Objectives

Optimum performance of the voice system demands that all users adhere to commonly accepted standard telephone operating procedures as established by international agreements and practices. These procedures are described in detail in the NASA Communications Operating Procedures (NASCOP).

C.1.3 Testing Objectives

Circuit continuity and quality are ascertained by periodic voice checks performed between the GSFC Voice Controllers and distant station personnel using the standard procedural "strength and readability" test. Circuits are evaluated on a scale of 1 to 5, with 1 the lowest and 5 the highest value. Nascom standards consider a voice-only circuit to be performing satisfactorily if it passes a "loud and clear" (5 by 5) voice transmission.

In addition, it is the responsibility of each Nascom station to ensure that the composite amplitude level, within the voice frequency spectrum, is nominally 12 dB below the station's assigned Transmission Level Point (TLP). The TLP is used as a reference for all other levels. Each station has been assigned a specific TLP commensurate with its end-to-end alignment. Within Nascom, this is normally "0 dB." To verify circuit amplitude levels "test tones" are exchanged. The standard test tone is a 1004 Hz signal through an impedance of 600 ohms at a level of 10 db below the sending station's TLP. At stations where the TLP is not "0 dB," the power of the test tone is adjusted relative to the assigned TLP.

As is the case with teletype circuits, long-term tests are not conducted on voice-only circuits; however, most are voice checked daily, and all mission support circuits are checked for quality and proper levels prior to actual mission configuration.

The operational aspects of the system are reliably sustained by the maintenance of continuous four-wire integrity, end-to-end, and restrictions from interconnecting any path-inhibiting or feedback-causing device to the network.

C.2 High-speed Data (HSD) Circuits

C.2.1 Standards for Narrowband Analog Channels

Generally, spacecraft data is received at the remote tracking site and packed into a standard 4800-bit block format for relay over Nascom's data transmission network to GSFC and

subsequently to the Project Operations Control Centers (POCC). Circuits used to transmit this data are operated at bit rates commensurate with the project requirements and type of data being transmitted. Data is transmitted at 2400, 7200, and 9600 bits per second on analog data or alternate voice-data circuits used for high-speed data transmission. These are commonly leased, four-wire, private line commercial circuits having controlled analog parameters that are specially designed for the transmission of digital data.

The four basic considerations for the proper transmission of high-speed data in the Nascom network are:

- a. Those industry standards that apply to the digital interface between the user equipment and the data communications equipment.
- b. Those operating practices required for the proper transmission power levels, impedance, and test tone frequency.
- c. Those requirements that apply to the common carrier domestic and international data communications channel parameters.
- d. Those bit and block error tolerances established as the Nascom performance objectives.

The Electronics Industries Association (EIA) standards and the International Telegraph and Telephone Consultative Committee (CCITT) standards have been used to form Nascom standards that apply to the interface of user equipment and data communications equipment and to the long-haul transmission system used to support Nascom. These standards and requirements apply equally to services provided over analog or digital carrier systems and are detailed in NASCOP.

For Nascom point-to-point high-speed data channels, the long-term bit error performance minimum standard is 1×10^{-5} . This is generally met on overseas channels and is often exceeded in U.S. point-to-point channels. Errors in point-to-point communications channels tend to be bursty (nonrandom distribution). For this reason channel error performance is more meaningful if measured in terms of block error performance.

The transmission power level, test tone frequency, and impedance specifications that apply to analog transmission systems were explained previously in the voice grade circuit performance section, and they are the same for narrowband high-speed data channels.

In addition, data transmission on analog systems require the strict control of certain other channel parameters in order to meet performance objectives. These parameter limits, taken primarily from the CCITT standards, recommendation M1020, and the Bell System Technical Specifications for C-conditioned circuits, are met by ordering special conditioning on selected circuits. Nascom data-conditioned circuits are nominally the C2 or D1 type on the domestic links and the "M1020" on the international segments.

Narrowband data and alternate voice-data circuits are typically designed for a 300 to 3000 Hz bandwidth, and FCC tariffs provide, as a minimum, circuit specifications that cover frequency response and envelope delay distortions within this range. They are used by Nascom in checking and accepting data channels. Also, Nascom data channels must conform to specifi-

cations common to C-conditioned designed circuits with respect to level variations, background and impulse noise, harmonic distortions, frequency interference, phase jitter, and frequency error. These additional specifications are not tariffed items; however, if their limits are not met and the data throughput is affected, the commercial carriers will take action to correct the problem or improve the circuit.

C.2.2 Standards for Attenuation and Envelope Delay Distortion for Operation on Analog Systems

The data circuit standards are:

- a. The following are the industry standards and Nascom specifications for attenuation distortion (Frequency Response):

Frequency Range Attenuation Distortion (not more than)

300 to 500 Hz plus 2 dB to minus 6 dB

500 to 2800 Hz plus 1 dB to minus 3 dB

2800 to 3000 Hz plus 2 dB to minus 6 dB

Measured end-to-end with reference to a 1004-Hz signal at the station's test tone level.

- b. The following are the standards for envelope delay distortion:

Frequency Range Delay Distortion (not more than)

500 to 600 Hz 3000 microseconds

600 to 1000 Hz 1500 microseconds

1000 to 2600 Hz 500 microseconds

2600 to 2800 Hz 3000 microseconds

Measured referenced to a frequency point between 500 and 2800 Hz at which the channel delay is at its minimum.

C.2.3 Additional Data Circuit Parameter Standards for Narrowband Analog Systems

Nascom standards are established for all parameters that have an effect on the data transmission performance of voice bandwidth data channels. They do not necessarily represent commercial carrier service obligations, but are used as operating criteria for determining whether data can be passed satisfactorily, and for releasing circuits for in-house or commercial carrier quality control actions. Those additional parameters are:

- a. Long- and short-term power level variations.
- b. Message circuit (background) noise.
- c. Harmonic distortion.

- d. Frequency shift (translation).
- e. Dropouts.
- f. Gain hits.
- g. Phase hits.
- h. Phase jitter.
- i. Single tone interference.
- j. Impulse jitter.

Parameter limits for these items were drawn from Bell System specifications, FCC tariffs, CCITT recommendations, and Nascom engineering documentation. Nascom standards were developed and established by operating and test experience with voice bandwidth data channels. Detailed information concerning these parameters is not covered here. However, they are published in the NASCOP, and are available upon request, from the NASA Communications Division at GSFC.

C.3 Wideband Circuits

C.3.1 Standards for Wideband Analog Channels

At present, all Nascom wideband circuits are digital transmission systems, except that certain international circuits have foreign terrestrial analog extensions. For these extensions the following specifications apply:

- a. Data shall be transmitted to the wideband modem at 0 dBm if the full group spectrum is used (nominally 56 kb/s).
- b. Test tones shall be transmitted at -5 dBm 0 at a frequency of 25 kHz.
- c. Nominal terminating impedance shall be 135 ohms, balanced.

Other parameter specifications for these wideband extensions are primarily the same type outlined for narrowband channels and both are detailed in NASCOP. These parameter limits pertain to the characteristics of the baseband spectrum (nominally 1 kHz to 37 kHz) as seen by a wideband data set and can be directly related to wideband data transmission performance. For that reason, they are observed as standard criteria when quality testing a wideband analog. However, the predominate method of testing Nascom wideband transmission systems for quality is by bit and block error tests using a pseudo-random test pattern generated by a Fredricks 600, Aydin 604 (or equivalent) data test set.

C.3.2 Standards for All-digital Service Channels

Presently in progress in the telecommunications industry is a transition from adapting analog channels to digital transmissions to an all-digital service. As a result, a new set of circuit standards and parameter criteria is in development. In the interim, Nascom standards and performance objectives have been applied to ensure the satisfactory passage of data.

The transition is continuing in the overseas segments. The performance criteria for a data channel comprised of a foreign analog extension and a combination of U.S. and international digital segments is 1×10^{-6} while maintaining 99.5 percent error-free seconds.

C.4 Data Circuit Performance Objectives

C.4.1 Data Throughput Performance Objectives for Services to Overseas Locations

The performance objectives for end-to-end data services between the overseas Ground Network (GN) and Deep Space Network (DSN) complexes and GSFC are as follows:

Bit error rate 1×10^{-6} (24-hour average)

Error-free seconds 99.5% (24-hour average)

The performance requirements for the individual domestic and international segments are:

Bit error rate 1×10^{-7} (24-hour average)

Error-free seconds 99.5% (24-hour average)

The performance objective for the foreign segments depends on the length of the segment and the facilities involved, but its contribution should not degrade the end-to-end performance below 1×10^{-5} .

C.4.2 Data Throughput Performance Objectives for Services to U.S. Locations

The performance objectives for end-to-end service between GSFC and U.S. locations such as JPL and domestic GN sites, including HAW, are as follows:

Bit error rate 1×10^{-7} (24-hour average)

Error-free seconds 99.5% (24-hour average)

C.4.2.1 Error-free Seconds

As used by Nascom and others, Error-free Seconds (EFS) is a measurement of the number of seconds during which no data errors were observed. It is expressed as a percentage and the value of 99.5 percent as previously mentioned indicates that, averaged over a 24-hour period, 995 out of 1000 seconds are expected to be error free.

To measure EFS, for quality control purposes, Nascom personnel use a block length equal to, or a multiple of, the data rate of the circuit concerned. For example, for a 56-kb/s circuit, the data transmission test set (DTTS) would be configured for a block size of 56,000 bits. Thus, the test is independent of the number and burst patterns of the bit errors occurring in a 1-second interval. Since the blocks are 1-second in duration, a block count by definition in this case, is also a second count. The throughput calculation thus yields the EFS calculation and vice versa.

EFS testing is a baseline test for verifying, both short and long term, that circuits meet the criteria specified in circuit orders and that these circuits can be expected to perform satisfac-

torily during mission support. Normally, Nascom digital wideband circuit testing is conducted first using the project block size (nominally 4800 bits) and then using the baseline EFS test. In either case, data quality and throughput, and therefore circuit quality, are determined by error rate tolerances established for the various speeds and transmission systems.

C.4.2.2 Bit and Block Error Rates

Bit error rate and block error rate are defined as the measure of bits, or blocks, received in error out of the total number received. It is obtained by simply dividing the number of bits, or blocks, received in error by the total number received.

Throughput is the percentage of good blocks received during a given period. It is derived as follows:

$$\text{Throughput (\%)} = \frac{\text{Blocks Received} - \text{Bad Blocks}}{\text{Blocks Received}} \times 100$$

Block error tests are the most meaningful type of test and they are the primary form of testing in the Nascom Network. The following are the established bit and block error rates and data throughput objectives for the Nascom Network:

a. Analog Transmission Systems

1. Bit Error Rate Tolerances

| <u>Data Rate</u> | <u>Data Set</u> | <u>Allowable Error Rate</u> | <u>Maximum Bit Errors</u> | |
|------------------|-----------------|---------------------------------|-------------------------------|---------------|
| | | | <u>15 Min</u> | <u>24 Hrs</u> |
| 2400 b/s | 201C/205 | 1×10^{-5} | 21 | 2,073 |
| 7200 b/s | 209 | 1×10^{-5} | 64 | 6,220 |
| 9600 b/s | 209/2096 | 1×10^{-5} | 86 | 8,294 |
| 56 kb/s | 303 | 1×10^{-5} | 504 | 48,384 |

2. Block Error Rate Tolerances (Block size = 4800 bits)

| <u>Data Rate</u> | <u>Data Set</u> | <u>Through- put (%)</u> | <u>Maximum Block Errors</u> | |
|------------------|-----------------|-----------------------------|---------------------------------|---------------|
| | | | <u>15 Min</u> | <u>24 Hrs</u> |
| 2400 b/s* | 201C | 99.0 | 9 | 864 |
| 7200 b/s | 203L6/209 | 99.0 | 14 | 1,296 |
| 9600 b/s | 209/2096 | 99.0 | 18 | 1,728 |
| 56 kb/s | 303 | 99.0 | 105 | 10,080 |

*2400-bit blocks

b. Digital Transmission Systems

Since digital transmission systems, even with analog extension, should out-perform fully analog carrier systems, Nascom standards and error rate tolerances for digital systems are more stringent than those for analog systems. Circuit orders for digital data service specify these performance limits with respect to allowable error rates.

1. Bit Error Rate Tolerances

| <u>Data Rate</u> | <u>Allowable Error Rate</u> | <u>Maximum Bit Errors</u> | |
|------------------|---------------------------------|-------------------------------|---------------|
| | | <u>15 Min</u> | <u>24 Hrs</u> |
| 9600 b/s | 1×10^{-7} | 1 | 82 |
| 56 kb/s | 1×10^{-7} | 5 | 483 |
| 168 kb/s | 1×10^{-7} | 15 | 1,451 |
| 224 kb/s | 1×10^{-7} | 20 | 1,935 |
| 1.544 Mb/s | 1×10^{-7} | 138 | 13,340 |
| 2.048 Mb/s | 1×10^{-7} | 180 | 17,690 |

2. Block Error Rate Tolerances (Block size stated)

| <u>Data Rate</u> | <u>Block Size</u> | <u>Through- put (%)</u> | <u>Maximum Block Errors</u> | |
|------------------|-------------------|-----------------------------|---------------------------------|---------------|
| | | | <u>15 Min</u> | <u>24 Hrs</u> |
| 9600 b/s | 4,800 bits | 99.5 | 9 | 864 |
| 56 kb/s | 4,800 bits | 99.5 | 52 | 5,040 |
| 56 kb/s | 56,000 bits | 99.5 | 5 | 432 |
| 224 kb/s | 4,800 bits | 99.5 | 210 | 20,160 |
| 224 kb/s | 56,000 bits | 99.5 | 8 | 1,728 |
| 1.544 Mb/s | 4,800 bits | 99.5 | 1,447 | 138,960 |
| 1.544 Mb/s | 77,200 bits | 99.5 | 90 | 8,640 |

On 15 minute calculations, the decimal portions are dropped. For 24-hour totals, the 15-minute decimals are included, but the final decimal portions are dropped. The tolerances listed are for single data links (circuits). Regenerated long-line connections are allowed a higher tolerance commensurate with the number of links in the connections. A loss of circuit continuity, or exceeding the 24-hour accumulative block allowance, constitutes an outage. The test is restarted when the service is restored.

Bit error tests and their associated tolerances are normally used only when special engineering or operational testing is deemed appropriate. This would be during implementation of special facilities or during troubleshooting of problem circuits or links with evidence of recurring instability.

C.4.3 Circuit/Channel Availability Objectives

In addition to the data transmission throughput criteria, circuit availability, trouble isolation and service restoral objectives have been established for these systems. These are:

C.4.3.1 Nascom End-to-End Availability

The end-to-end availability objective for all Nascom circuits has been established as at least 99.80 percent (long-term average) when considering all causes for lost time. A minimum acceptable availability level has been established at 99.5 percent (long-term average). Long term is considered to be at least three months. It should be noted that end-to-end Nascom circuits generally comprise several individual links, including one-to-several foreign, domestic, or U.S.-based international carrier's links, and, local user terminating facilities (end links). Nonavailability time will be counted from the start of a reported outage and will stop when either the failed circuit is returned to the user or an equal bandwidth circuit is offered as a replacement.

Availability percent is defined as:

- a. Scheduled operating hours minus lost time divided by scheduled operating hours times 100.
- b. Scheduled operating hours are calculated as 24 hours per day, 7 days a week (full-period service) less scheduled (approved) release time.
- c. Lost time events are all those conditions which render a circuit-channel unusable for its designated purposes. These may be either Government or commercial equipment-power or personnel faults, as well as failures caused by circumstances beyond the control of neither, i.e., fire, flood, acts of nature or man-made damage to facilities.
- d. Delays of maintenance that are granted, once a loss of service has been reported, are considered lost time for the purpose of this calculation.

C.4.3.2 Nascom Availability Requirements for Commercial Services

With respect to and when ordering individual links from a domestic or U. S.-based international carrier, an availability requirement of 99.95 percent is specified with Mean Time Between Failures (MTBF) and Mean Time To Restore (MTTR) adequate to achieve this figure. It is not anticipated that a single-thread circuit would meet this criteria, however, it is achievable through the use (by commercial carrier) of redundant equipment, remote sensing and switching, and "protected" systems.

In addition, the following criteria are established:

- a. No more than 20 minutes to isolate a source of trouble after a lost of service report, and
- b. Less than 2 hours maximum time to restore service.

C.5 Additional Information

Additional information on the above standards and objectives and the testing methodologies for Nascom circuitry can be found in the current edition of NASCOP.

Appendix D. Circuit Ordering Process

The following are acronyms used in this appendix.

| | |
|--------|---|
| CSAM | Communications Services Advisory Message |
| CSB | Carrier Selection Board |
| CSR | Communications Service Request |
| NASCOP | Nascom Operating Procedures |
| RFP | Request for Proposal |
| RGCS | Request for Ground Communications Service |

D.1 Process Overview

This appendix presents a concise description of the process used by Nascom to order a circuit that cannot be provided using Nascom-2000 (FTS2000) services. The process includes the following eight steps; each step is described in detail in the remaining paragraphs.

- Step 1 A project expresses a requirement for a communications service that cannot be met using existing capabilities.
- Step 2 The Mission Planner (Code 542.1) assigned to that project prepares a Communications Service Request (CSR).
- Step 3 Using the CSR, Engineering (Code 541) prepares a Request for Ground Communications Services (RGCS).
- Step 4 Using the RGCS, Communications Services (Code 542.3) prepares a Request for Proposal (RFP).
- Step 5 The RFP is issued by Code 542.3 to start the bid process, resulting in receipt and evaluation of carrier proposals.
- Step 6 Nascom management convenes a Carrier Selection Board (CSB) that selects the carrier to supply the service.
- Step 7 Communications Services Section prepares and issues a Communications Services Authorization to the winning carrier; this becomes the NASA/Carrier contract.
- Step 8 Nascom transmits a Communications Services Advisory Message (CSAM) which advises the users of the carrier selected to provide the service, the service activation date(s), and the location with technical control responsibility for the circuit.

D.2 The Requirement

Requirements may be originated externally, e.g., by a flight project or mission, or internally, e.g., by a Level II project managed by Code 540. Normally, requirements will contain at least the following information:

- a. Source – destination.

- b. Information transfer (user data) rate.
- c. Diversity requirements, if any.
- d. Need date(s) and end date(s).
- e. Latencies, if applicable.
- f. Point of contact.

D.3 The CSR

Within the Mission Planning Section, responsibility for specific missions, launch vehicles, and NASA centers are apportioned and assigned to specific mission planners. The Mission Planner, in coordination with the requester and the Flight Mission Support Office (Code 501) and/or Systems Management Office (Code 502), as appropriate, prepares the CSR. The CSR contains the information listed in paragraph D.2 to which the number of circuits has been added.

D.4 The RGCS

The RGCS is prepared by engineering, normally the Communications Engineering Section (Code 541.1). For internal projects managed by the Computer Systems Section (Code 541.2) or Advanced Development Section (Code 541.3), the RGCS would be written by that section. Typically, the RGCS contains the Statement of Work and Specifications for the carrier service. Typical of the types of information included in the RGCS are the following:

- a. An overview of the required service.
- b. A detailed description of the terminations including:
 - 1. What the carrier is to provide
 - 2. To what will the carrier be interfacing
 - 3. Electrical and physical interface descriptions
 - 4. Timing conventions to be used
 - 5. Special modem features

- c. **Service Performance Requirements**

Generally, the applicable standards contained in the NASCOP are incorporated. For services for which no NASCOP standard exists, best industry practice (or what Nascom determines to be essential to meet the user requirement) is generated and included. Also included are items such as bit (and/or block) error rate, errored seconds, the reliability/maintainability/availability numbers, and response times.

- d. **Service Operation Requirements**

- 1. Facility manning, e.g., response time during unattended periods, and identification of the periods during which the carrier is expected to have technicians onsite or in the carrier's facility.

2. Testing requirements, e.g., the minimum set of test capabilities that the carrier is expected to have available and ready for use to support fault isolation and service restoral activities.

e. **Cost and Schedule Information**

This information is contributed by the Communication Services Section.

D.5 Circuit/Service Provisioning Lead Times

D.5.1 The Nascom Circuit/Service Provisioning Lead Times

The Nascom circuit/service provisioning lead times listed in D.5.2 have been established to assist flight projects/missions in their planning for Nascom services. These lead times are intended for use as planning guidelines only; it is entirely possible that similar appearing requirements may have distinctive aspects that either increase or decrease the lead times from those shown.

Some of the items listed immediately below may be required by Code 540 in order to meet the project's requirements. If so, the lead time reflected for each applicable item must be added to the lead time shown for the appropriate category described in D.5.2.(1-4). The category described in D.5.2.5 reflects a project for which each of the additional items applies.

- a. Requirements definition and ICD development – 6 months.
- b. System design and RFP package(s)– 6 months.
- c. Procurement action and site preparation– 12 months.
- d. Installation of communication system– 6 months.
- e. Internal Nascom testing – 4 months.
- f. End-to-end testing – 6 months.

NOTE

Budget Lead Time: The GSFC Code 540 budgeting process is such that Nascom must budget for new or additional funds to support a requirement at least one full fiscal year prior to the year in which the service is to begin, or the project must provide funding.

D.5.2 Provisioning Lead Time Guidelines By Service Category

- a. Services via existing resources requiring coordination between other NASA Centers, facilities, and users.

Lead time = 4 months

- b. Services commonly provided by commercial carriers and which do not require special engineering. Examples include standard voice and data rates: 56 kb/s, 224 kb/s, and 1.544 Mb/s (T-1).

Lead time = 6 months

- c. Services provided by commercial carriers and which do require special engineering and/or carrier/Nascom special equipment, e.g., nonstandard modems, blocking/de-blocking equipment, or 4-wire terminal equipment.

Lead time = 12 months

- d. Services requiring special engineering and/or construction of new facilities, e.g., new earth stations or facilities into remote areas. This category also includes requirements for data rates in excess of 1.544 Mb/s (T-1).

Lead time = 18 to 24 months

- e. The design and implementation of a major new ground communication system to support new programs, e.g., EOS and SSFP.

Lead time = 40 months

Appendix E. X.25 and IP Protocols

E.1 General

As noted in multiple sections in the main body of the NSDP, Nascom intends to cease use of the 4800-bit block in FY97. In its place, Nascom will support use of standards-based protocols that are implemented in COTS products. Examples of supported protocols are CCITT Recommendation X.25, already in use on the Data Distribution and Command System, and the Internet Protocol (IP) of the Transmission Control Protocol/Internet Protocol (TCP/IP) suite. This appendix briefly describes these two protocols from a Nascom interface perspective.

E.2 CCITT Recommendation X.25

CCITT Recommendation X.25 defines the peer protocols for the lower three layers of the OSI reference model, i.e., the network, data link, and physical layers. A portrayal of the OSI reference model and the layers associated with X.25 packets and frames is shown in Figure E-1.

There are two choices of framing available to users desiring a CCITT X.25 interface with Nascom; namely, the basic mode (modulo 8), and the extended mode (modulo 128). Actual selection of the mode to be utilized is made when a user requests an X.25 interface with Nascom. Figure E-2 depicts the frame format for an X.25 extended frame.

Figure E-3 depicts X.25 packet types for both the DCE-to-DTE and DTE-to-DCE directions of flow.

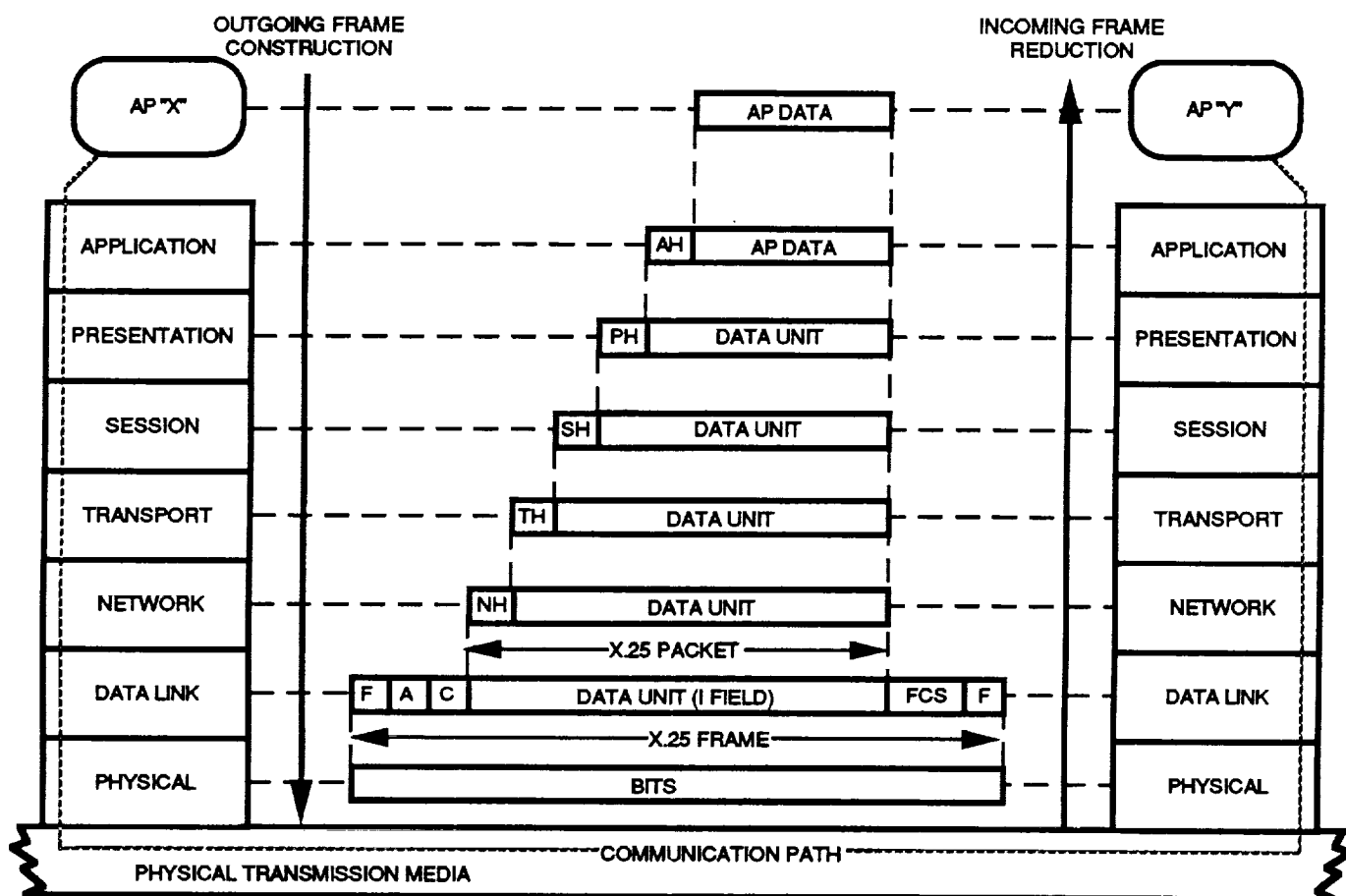
Both the call request and data packets contain key protocol information. Accordingly, the packet formats for call request/incoming call packets are depicted in Figure E-4. DTE/DCE data packets are depicted in Figures E-5 and E-6, respectively.

E.3 TCP/IP

Nascom believes that most of its customers will want to interface with the Nascom network using the TCP/IP protocol suite. The following paragraphs provide a brief summary of the TCP/IP protocol with particular emphasis upon the role of the IP protocol at the network (Nascom) interface.

E.3.1 TCP/IP Protocol Stack

The TCP/IP stack is depicted in Figure E-7. Shown along with the stack are the OSI model's corresponding layers. In this figure, the Host (Name) refers to the "from" and the "to" hosts' names, e.g., pop500.gsfc.nasa.gov. These names are assigned to ease human interaction. Host system domain name servers translate these human readable names into actual machine-readable IP addresses.



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Figure E-1. X.25's Position in the OSI Reference Model

| FLAG | ADDRESS | CONTROL | INFORMATION | FCS | FLAG |
|---------------|-------------|-------------------|----------------|----------------|---------------|
| F 01111110 | A 8-BITS | C 8 OR 16 BITS | INFO N-BITS | FCS 16-BITS | F 01111110 |

FCS: FRAME CHECK SEQUENCE

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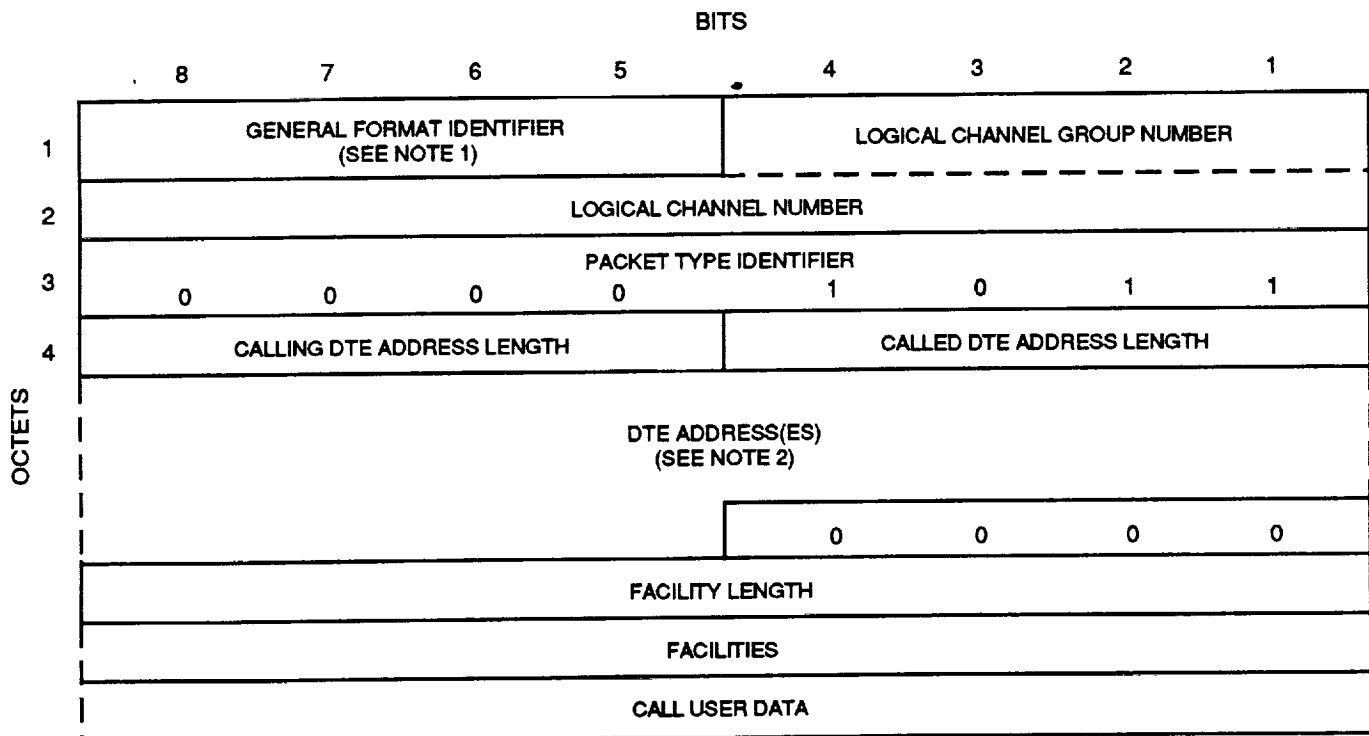
Figure E-2. X.25 Basic (Modulo 8) Frame Format

| PACKET TYPE | |
|---------------------------------|----------------------------|
| FROM DCE TO DTE | FROM DTE TO DCE |
| CALL SET-UP AND CLEARING | |
| INCOMING CALL | CALL REQUEST |
| CALL CONNECTED | CALL ACCEPTED |
| CLEAR INDICATION | CLEAR REQUEST |
| DCE CLEAR CONFIRMATION | DTE CLEAR CONFIRMATION |
| DATA AND INTERRUPT | |
| DCE DATA | DTE DATA |
| DCE INTERRUPT | DTE INTERRUPT |
| DCE INTERRUPT CONFIRMATION | DTE INTERRUPT CONFIRMATION |
| FLOW CONTROL AND RESET | |
| DCE RR (MODULO 8) | DTE RR (MODULO 8) |
| DCE RR (MODULO 128) * | DTE RR (MODULO 128) * |
| DCE RNR (MODULO 8) | DTE RNR (MODULO 8) |
| DCE RNR (MODULO 128) * | DTE RNR (MODULO 128) * |
| | DTE REJ (MODULO 8) * |
| | DTE REJ (MODULO 128) * |
| RESET INDICATION | RESET REQUEST |
| DCE RESET CONFIRMATION | DTE RESET CONFIRMATION |
| RESTART | |
| RESTART INDICATION | RESTART REQUEST |
| DCE RESTART CONFIRMATION | DTE RESTART CONFIRMATION |
| DIAGNOSTIC | |
| DIAGNOSTIC * | |
| REGISTRATION * | |
| | REGISTRATION REQUEST |
| REGISTRATION CONFIRMATION | |

* Not necessarily available on every network

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Figure E-3. X.25 Packet Types

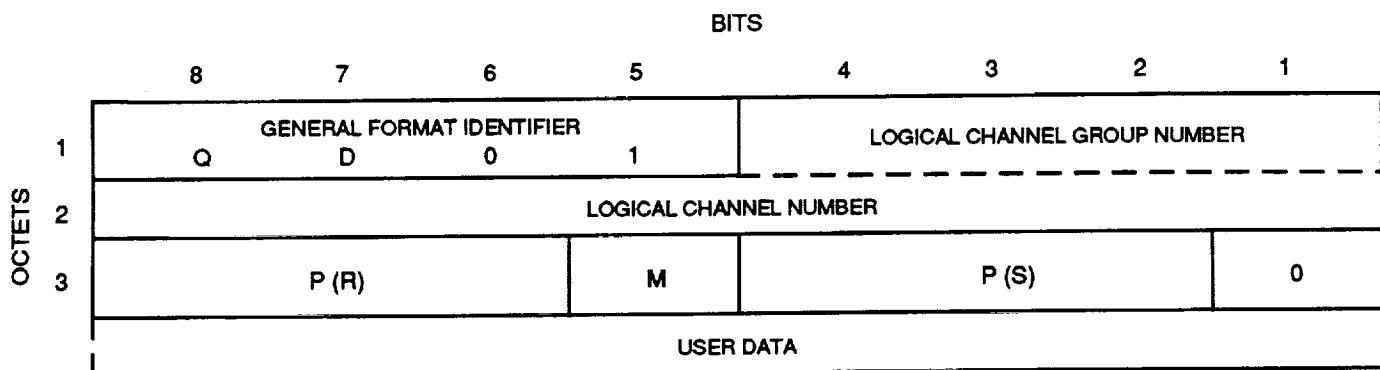


NOTES:

1. CODED 0X01 (MODULO 8) OR 0X10 (MODULO 128).
2. THE FIGURE IS DRAWN ASSUMING THE TOTAL NUMBER OF ADDRESS DIGITS PRESENT IS ODD.

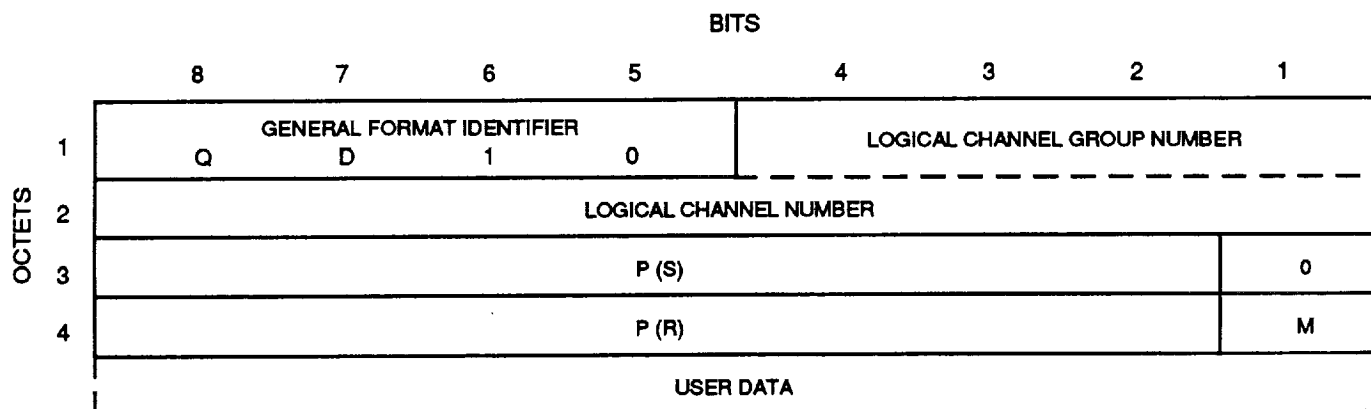
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Figure E-4. X.25 Call Request and Incoming Call Packet Formats



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Figure E-5. X.25 Basic DTE and DCE Modulo 8 Data Packet



(WHEN EXTENDED TO MODULO 128)

| | |
|---|---------------------------|
| D | DELIVERY CONFIRMATION BIT |
| M | MORE DATA BIT |
| Q | QUALIFIER BIT |

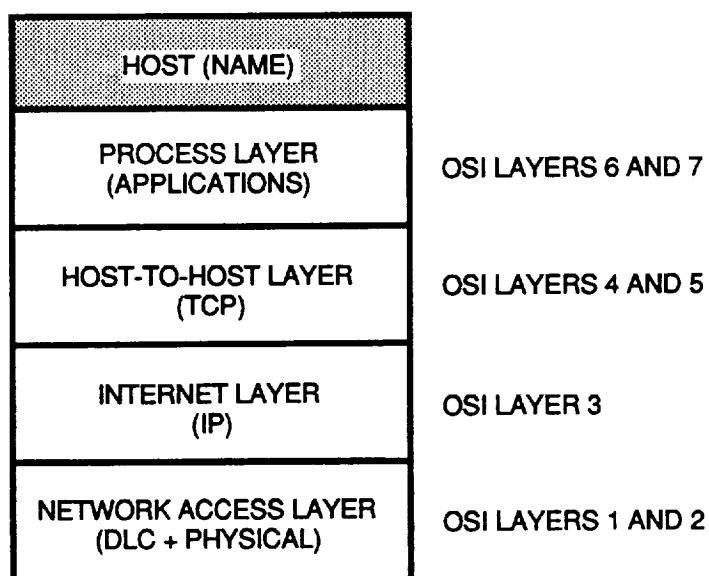
MORE DATA BIT

Q QUALIFIER BIT

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March 1995

Figure E-6. X.25 DTE and DCE Modulo 128 Data Packet



PROCESS LAYER (APPLICATIONS)

(APPLICATIONS)

OSI LAYERS 6 AND 7

**HOST-TO-HOST LAYER
(TCP)**

(TCP)

OSI LAYERS 4 AND 5

**INTERNET LAYER
(IP)**

(IP)

OSI LAYER 3

**NETWORK ACCESS LAYER
(DLC + PHYSICAL)**

(DLC + PHYSICAL)

OSI LAYERS 1 AND 2

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Figure E-7. TCP/IP Protocol Stack

The Process Layer (Applications) corresponds to OSI Layers 7 (Application) and 6 (Presentation). System services, e.g., File Transfer Protocol and TELNET, reside in this layer. These programs enable the transfer of information into and out of the network.

The Host-to-Host Layer/TCP corresponds to OSI Layers 5 (Session) and 4 (Transport). The TCP provides for the orderly transfer of sequenced data frames into and out of higher stack levels. TCP ensures that each message arrives at the end addressee or, if it has not arrived, delivers the reason for the failure. Examples of other protocols in the suite that may be used in this layer are the User Datagram Protocol (UDP), and the Internet Control Message Protocol (ICMP).

The Internet Layer (IP) corresponds to OSI Layer 3 (Network). This layer, using the Internet Protocol, provides "end-to-end" network addressing. The layer uses a 32-bit address field, allowing each station to have its own unique address. Mapping of system addresses to host names occurs here. Within IP are two address resolution protocols: the Address Resolution Protocol (ARP), and the Reverse Address Resolution Protocol (RARP).

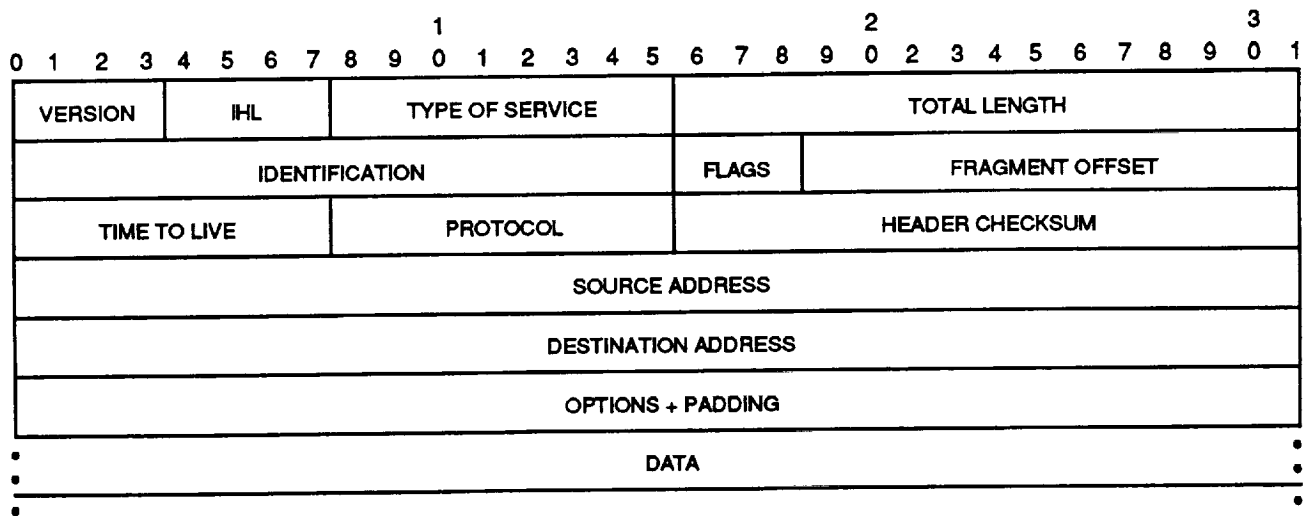
The Network Access Layer corresponds to OSI Layers 2 (Data Link) and 1 (Physical). At these levels, TCP/IP conforms to the media framing and timing standards (ethernet or FDDI).

E.3.2 Internet Protocol Format

The format of the IP frame is represented in Figure E-8.

Elements of the IP frame are briefly described as follows:

- a. Version: Which release is being used.
- b. IHL: IP header length.
- c. Type of Service: Precedence, reliability, delay, and throughput (as and when supported) may be entered here.
- d. Total Length: Number of bytes in the frame.
- e. Identifier: A unique tag for the particular frame.
- f. Flags: The fragmentation flag appears here.
- g. Time to Live: A value measured in network hops.
- h. Options: Values associated with security, loose or strict source routing, recordation of routing, and timestamp may be entered here.



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Figure E-8. Internet Protocol Frame Format



Abbreviations and Acronyms

| | |
|---------|---|
| 2w | Two-wire |
| 4w | Four-wire |
| ac | Alternating Current |
| ACAN | Army Command and Administrative Network |
| ACD | ATM Conversion Device |
| ACE | Advanced Composition Explorer |
| ACT | Australian Capital Territory |
| ADP | Automatic Data Processing |
| ADPCM | Adaptive Differential Pulse Code Modulation |
| ADPE | Automatic Data Processing Equipment |
| AED | Analog Event Distribution |
| AFB | Air Force Base |
| AFFTC | Air Force Flight Test Center |
| A-G | Air-to-Ground |
| AGO | Santiago |
| AGVS | Air-Ground Voice System |
| AIS | Automated Information Systems |
| AMS | Administrative Message System |
| ANC | Alternate Network Connectivity |
| ANT | Antigua |
| AOA | Abort-Once-Around |
| AOS | Acousto-Optical Spectrometer |
| AP | Application Processor |
| APL | Applied Physics Laboratory |
| ARA | Area Routing Assembly |
| ARPANET | Advanced Research Projects Agency Network |
| AS | Air Station |
| ASC | Ascension Island |

| | |
|-------|---|
| ASCA | Advanced Satellite for Cosmology and Astrophysics |
| ASCII | American Standard Communication Information Interchange |
| ASCR | Ames Strip Chart Recorder |
| ASF | Alaska SAR Facility |
| ASM | All Sky Monitor |
| ASRS | Automated Support Requirements System |
| AT | Acceptance Test |
| ATC | Australian Telecommunication Commission |
| ATM | Asynchronous Transfer Mode |
| AVD | Alternate Voice Data |
| BATSE | Burst and Transient Source Experiment |
| BDA | Bermuda |
| BDS | Baseline Data System |
| BED | Block Error Detector |
| BER | Bit Error Rate |
| BERK | Berkeley, California |
| BF | Block Formatter |
| BFX | Bulk File Exchange |
| Bldg | Building |
| BLT | Greenbelt Station |
| BOA | Basic Ordering Agreement |
| b/s | Bits Per Second |
| BRTS | Bilateration and Ranging Transponder System |
| BWG | Beam Wave Guide |
| C&T | Communications and Tracking |
| CAB | Circuit Assurance Block |
| CAC | Circuit Assurance Check |
| CAL | COW Alert Task |
| CAN | Canberra 26-Meter Station |
| CARAC | Caribbean-Atlantic Submarine Cable |

| | |
|------------------|---|
| CBD | Commerce Business Daily |
| CBR | Constant Bit Rate |
| CBX | Computer Branch Exchange |
| CCAS | Cape Canaveral Air Station |
| CCB | Configuration Control Board |
| CCBTS | Common Carrier Broadcast Transmission Service |
| CCC | Central Computer Complex |
| CCDTS | Common Carrier Domestic Satellite Transmission Service |
| CCI | Commercial Carrier Interface |
| CCIM | Command Computer Input Multiplexer |
| CCITT | International Telephone and Telegraph Consultative Committee |
| CCL | Closed Conference Loop |
| CCM | COW Baseline Configuration Change Task |
| CCP | Central Communication Processor |
| CCQ | COW Command and Query Task |
| CCRF | Consolidated Communications Recording Facility |
| CCS | Common Carrier Subsystem |
| CCSDS | Consultative Committee for Space Data Systems |
| CCT | Central Communications Terminal |
| CCTCF | Communications Circuit Technical Control Facility |
| CCTV | Closed Circuit Television |
| CD&SC | Communication Distribution & Switching Center |
| CDA | Command and Data Acquisition |
| CDB | COW Database Manager Task |
| CDF | Communication Data Formatter |
| CDHF | Central Data Handling Facility |
| CDL | COW Delogging Task |
| CDSCC | Canberra Deep Space Communications Complex |
| CELP | Codebook Excited Linear Predictive |
| CES | Control Electronics System |

| | |
|---------|---|
| CES | COW Expert System Task |
| CHC | COW Checkpoint Configuration Change Task |
| CHP | Command History Printer |
| CI | Configuration Item |
| CIF | COW/MSS Interface Task |
| CIN | COW Initialization and Recovery Task |
| CIS | Communications Interface System |
| CLD | COW Line Indicator Display Task |
| CLG | COW Logging Task |
| CMD | Command |
| CME | Central Management Equipment |
| CMF | Command Management Facility |
| CMG | COW Message Generator Debug Tool |
| CMS | Command Management System |
| CMS | Consolidated Management System |
| CNE | Centerwide Network Environment |
| CNES | Centre National D'Etudes Spatiales |
| CNIF | Canberra Nascom Interface Facility |
| CNV | Cape Canaveral |
| COA | COW Operator Assistance Task |
| CODEC | Coder/Decoder |
| COMMGR | Nascom Communications Manager |
| COMPTEL | Compton Telescope |
| COMSAT | Communications Satellite Corporation |
| COMSEC | Communications Security |
| CONS | Console Subsystem |
| CONUS | Continental United States |
| COR | Contracting Officer's Representative |
| COS | COW Operator Stations Task |
| COSTR | Collaborative Solar-Terrestrial Research Initiative |

| | |
|------|--|
| COTS | Commercial-off-the-Shelf |
| COW | Combined Operator Workstation |
| CPP | Capacity Projection Plan |
| CPU | Central Processing Unit |
| CRT | Cathode Ray Tube |
| CSA | Commercial Service Authorization |
| CSAM | Carrier Services Advisory Message |
| CSB | Circuit Selection Board |
| CSC | Computer Sciences Corporation |
| CSE | Configuration and Switching Equipment |
| CSF | Control and Simulation Facility |
| CSO | Computer Security Official |
| CSR | Communications Service Request |
| CSS | Control and Status System |
| CSS | Communications Services Section |
| CSTC | Consolidated Space Test Center |
| CSTS | Control Subsystem Transfer Switch |
| CSU | Customer Service Unit |
| CTA | Compatibility Test Area |
| CTC | Continental Telephone Company |
| CTCC | Continental Telephone of California |
| CTI | Common Transmission Infrastructure |
| CTMC | Communications Terminal Modular Controller |
| CTNE | Compania Telefonica de Espana |
| CTP | Circuit Terminating Package |
| CTS | COW Troubleshooting Task |
| CTV | Compatibility Test Van |
| CTV | Crew Transfer Vehicle |
| CU | COW Common Unit |
| CWL | Cable and Wireless Limited |

| | |
|-------|--|
| DAAC | Distributed Active Archive Center |
| DAF | Data Acquisition Facility |
| DAVID | Digital Above Video |
| DBCI | Data Base Change Instruction |
| dc | Direct Current |
| DCA | Defense Communications Agency (now Defense Information Systems Agency) |
| DCC | Data Computation Complex |
| DCCD | Digital Cross Connect Device |
| DCE | Data Circuit Terminating Equipment |
| DCF | Data Capture Facility |
| DCI | Developed Configuration Item |
| DCP | Data Communications Processor |
| DCR | Daily Communications Reports |
| DCS | DMS Control System |
| DDCS | Data Distribution and Command System |
| DDD | Digital Display Driver |
| DDF | Data Distribution Facility |
| DDHS | Dump Data Handling System |
| DDPS | Digital Data Processing System |
| DDS | Dataphone Digital Service |
| Demux | Demultiplexer |
| DFRF | Dryden Flight Research Facility |
| DGIB | DSN/GSFC Interface Block |
| DHE | Data Handling Equipment |
| DI | Dial Intercom |
| DIF | Data Interface Facility |
| DIS | Data Interface System (STGT) |
| DITAC | Department of Industry, Technology, and Commerce (Australia) |
| DKR | Dakar (Senegal) |
| DKS | Digital Key Set |

| | |
|---------------|--|
| DLMS | Data Link Monitoring System |
| DLR | Deutsche Forschungsanstalt fuer Luft-und Raumfahrt e.V. |
| DMA | Direct Memory Access |
| DMR | Detailed Mission Requirements |
| DMS | Digital Matrix Switch |
| DMSR | Digital Matrix Switch Replacement |
| DNS | Domain Name Service |
| DoD | Department of Defense |
| DOIS | Digital Operations Intercom System |
| DOMSAT | Domestic Satellite |
| DOS | Disk Operating System |
| DPF | Data Production Facility |
| DRF | Dryden Flight Research Facility |
| DSC | Data Switching Center |
| DSCC | Deep Space Communications Complex |
| DSCIM | Display Select Computer Input Multiplexer |
| DSM | Data Support Manager |
| DSN | Deep Space Network |
| DSS | Distribution Switching System |
| DSS | Deep Space Station |
| DSS | Digital Switching System |
| DSU | Data Service Unit |
| DTE | Data Terminal Equipment |
| DTS | Digital Television System |
| DTTS | Data Transmission Test Set |
| DVIS | Digital Voice Intercom System |
| EAFB | Edwards AFB |
| EBnet | EOSDIS Backbone Network |
| ECC | Emergency Control Center |
| ECIO | Experiment Computer Input/Output |

| | |
|--------|--|
| ECL | Emitter Coupled Logic |
| Ecom | EOS Communications |
| ECS | Error Correction and Switching |
| EDC | EROS Data Center |
| EDOS | EOS Data and Operations System |
| EFS | Error Free Seconds |
| EGRET | Energetic Gamma Ray Experiment Telescope |
| EI | Equipment Interface |
| EIA | Electronic Industries Association |
| ELM | Element Management |
| ELV | Expendable Launch Vehicle |
| EMAT | Engineering, Modeling, and Testing |
| EMS | Element Management System |
| ENT | Enterprise Management |
| EOC | EOS Operations Center |
| EOM | End of Message |
| EOR | Expedited Operations Requirement |
| EOS | Earth Observing System |
| EOSDIS | EOS Data Information System |
| EP | Explorer |
| ER | Eastern Range |
| ERBS | Earth Radiation Budget Experiment |
| EROS | Earth Resources Observation System |
| ES | Earth Station |
| ESA | European Space Agency |
| ESA | Electrostatic Analyzers |
| ESDIS | Earth Sciences Data Information System |
| ESN | EOS Science Network |
| ESOC | European Space Operations Center |
| ESS | Engineering Support Subsystem |

| | |
|-------|--|
| ETGT | Extended TDRS Ground Terminal |
| ETS | Event Tracking Software |
| EUVE | Extreme Ultra Violet Explorer |
| EVM | Enhanced Voice Module |
| EXP | Explorer |
| FAA | Federal Aviation Administration |
| FAR | Federal Acquisition Regulations |
| FARM | Facility and Resource Manager |
| FAST | Fast Auroral Snapshot Explorer |
| FAT | Factory Acceptance Test |
| FAX | Facsimile |
| FCC | Federal Communications Commission |
| FDDI | Fiber Distributed Data Interface |
| FDF | Flight Dynamics Facility |
| FDM | Frequency Division Multiplex |
| FDX | Full Duplex |
| FEP | Front End Processor |
| FIMS | Fault Isolation and Measuring System |
| FIPS | Federal Information Processing Standard |
| FIRMR | Federal Information Resources Management Regulations |
| FM | Frequency Modulation |
| FO | Fiber Optic |
| FOT | Fiber Optic Transceiver |
| FOT | Flight Operations Team |
| FPSO | Flight Project Support Office |
| FSR | Flight Support Requirement |
| FTH | Fort Huachuca, Arizona |
| FTS | Federal Telecommunications System |
| FY | Fiscal Year |
| GCF | Ground Communications Facility |

| | |
|----------------|--|
| GDC | General DataComm |
| GDC | GCF Digital Communication |
| GDS | Goldstone, California |
| GDSCC | Goldstone Deep Space Communications Complex |
| GE | General Electric |
| GEAM | GE Americom |
| GEOTAIL | Geomagnetic Tail Laboratory |
| GFE | Government Furnished Equipment |
| GMI | Goddard Management Instruction |
| GN | Ground Network |
| GPIB | General Purpose Interface Board |
| GPOC | German Payload Operations Center |
| GRO | Gamma Ray Observatory |
| GRTS | GRO Remote Terminal System |
| GSA | General Services Administration |
| GSE | Ground Support Equipment |
| GSFC | Goddard Space Flight Center |
| GSOC | German Space Operations Center |
| GTE | General Telephone and Electronics |
| GW | Gateway |
| HDDR | High Density Data Recorder |
| HDR | High Data Rate |
| HDRR | High Data Rate Recorder |
| HDRS | High Data Rate System |
| HDX | Half Duplex |
| HEXTE | High Energy X-ray Timing Experiment |
| HMI | Human/Machine Interface |
| HOSC | Huntsville Operations Support Center |
| HP | Hewlett Packard |
| HRBS | High-Rate Black Switch (STGT) |

| | |
|-----------------|---|
| HRDLM | High-Rate Data Link Manager |
| HRDM | High-Rate Demultiplexer |
| HRM | High-Rate Multiplexer |
| HSD | High-Speed Data |
| HSDS | High-Speed Data System |
| Hskg | House Keeping |
| HST | Hubble Space Telescope |
| HVAC | Heating, Ventilation, and Air Conditioning |
| Hz | Hertz |
| IBDDR | Interbuilding Data Dissemination Resource |
| IBDTS | Interbuilding Data Transmission System |
| IC | Input Controller |
| ICC | Inter-Center Communications, Inc. |
| ICCWG | Intercenter Communications Working Group |
| ICD | Interface Control Document |
| ICE | International Cometary Explorer |
| ICLU | Interbuilding Communication Link Upgrade |
| ICM | Isochronous Communications Module |
| ICV | Intercenter Vector |
| ID | Identification |
| IEEE | Institute of Electrical and Electronic Engineers |
| IF | Intermediate Frequency |
| IFL | Interfacility Link |
| IGSE | Instrument Ground Support Equipment |
| IGY | International Geophysical Year |
| IIRV | Improved Interrange Vector |
| ILC | Interlink Module |
| IMP | International Monitor Platform |
| InGaAs | Indium Gallium Arsenide |
| INMARSAT | International Marine Satellite |

| | |
|--------------------|--|
| INPS | Internet Predicts |
| INTA | Instituto Nacional de Technica Aeroespacial |
| Intelsat | International Telecommunications Satellite |
| IO | Input/Output |
| IP | International Partner |
| IP | Internet Protocol |
| IPA | International Partner Agency |
| IPD | Information Processing Division |
| IRC | International Record Carrier |
| IRU | Integrated Recovery Utility |
| IRV | Interrange Vector |
| ISAS | Institute of Space and Aeronautical Science |
| ISC | Integrated Secure Communications |
| ISDN | Integrated Systems Digital Network |
| ISO | International Organization for Standardization |
| ISS | International Space Station |
| IST | Instrument Support Terminal |
| ISTP | International Solar Terrestrial Physics |
| IT&V/AT | Independant Test and Verification/Acceptance Test |
| ITS | Interconnect Telecommunications System |
| ITU | Input Terminal Unit |
| IUE | International Ultraviolet Explorer |
| JDI | Jonathan Dickenson Island, Florida |
| JMRTS | Johnson-Marshall Redundant Transmission System |
| JPL | Jet Propulsion Laboratory |
| JSC | Johnson Space Center |
| kb | Kilobits |
| kb/s | kilobits per second |
| KEV | Thousand Electron Volts |
| kg | Kilogram |
| KG | Key Generator |

| | |
|--------------|---|
| kHz | Kilohertz |
| km | Kilometer |
| KMRTS | Kennedy-Marshall Redundant Transmission System |
| KPT | Kaena Point, Hawaii |
| KS | Key Set |
| KSA | Ku-band Single Access |
| KSC | Kennedy Space Center |
| KuSP | Ku-band Signal Processor |
| kva | Kilovolt amperes |
| KWJ | Kwajalein Atoll |
| LACN | Local Area Communications Network |
| LAN | Local Area Network |
| LAPB | Link Access Protocol B |
| LaRC | Langley Research Center |
| LCC | Launch Control Center |
| LCC | Local Control Computer |
| LDR | Low Data Rate |
| LED | Light Emitting Diode |
| LeRC | Lewis Research Center |
| LF | Launch Facility |
| LITT | Littleton, Colorado |
| LLTDS | Launch and Landing Trajectory Data System |
| LOR | Line Outage Recorder |
| LP | Line Processor |
| LPS | Launch Processing System |
| LRBS | Low-rate Black Switch |
| LRP | Long-range Plan |
| LSN | Low-speed Network |
| LSR | Launch Support Requirement |
| LSS | Low-speed System |

| | |
|-------|--|
| LTAS | Launch Trajectory Acquisition System |
| LTP | Long Term Plan |
| LZP | Level Zero Processing |
| M&O | Maintenance and Operations |
| MA | Multiple Access |
| MACS | MDM Automated Control System |
| MACSU | MACS Upgrade |
| MAD | Madrid |
| MAP | Maintenance Administration Position |
| MB | Megabits |
| MBI | MSS Backup Operator Interface Task |
| MBI | Multibus Interface |
| Mb/s | Megabits per second |
| MCC | Mission Control Center |
| MCC | Master Control Console |
| MCC | Mission Control Console |
| MCCC | Mission Control and Computing Center |
| MCMD | MSS Console Command Task |
| MCU | MSS/COW Common Utility Modules |
| MDD | MSS Database Distribution Task |
| MDI | Michaelson Doppler Imager |
| MDM | Multiplexer/Demultiplexer |
| MDMR | MDM Replacement |
| MDS | MSS Data Simulator Task |
| MDSCC | Madrid Deep Space Communications Complex |
| MER | Mission Evaluation Room |
| MEV | Million Electron Volts |
| MGS | MARS Global Surveyor |
| MHL | MSS High-speed Logging Task |
| MHS | MSS High-speed Switching Task |

| | |
|-------------------|--|
| MHU | MSS High-speed Utility Task |
| MHY | MSS Hybrid Data Task |
| MHz | Megahertz |
| MIA | Merritt Island Station |
| MIB | Management Information Base |
| MIDDS | Meteorological Interactive Data Display System |
| MIF | MSS/COW Interface Task |
| MIL-71 | DSN Test Facility at KSC |
| MILA | Merritt Island Launch Area |
| MILNET | Military Network |
| MIN | MSS Initialization and Recovery Task |
| MKI | Mechanical Key Set |
| MLA | Merritt Island Station |
| MLM | Mid-level Manager |
| MMC | Martin Marietta Corporation (now Lockheed Martin) |
| MMG | MSS Message Generator Debug Tool |
| MNIF | Madrid Nascom Interface Facility |
| MO&DSD | Mission Operations and Data Systems Directorate |
| MOC | Mission Operations Center |
| MODEM | Modulator/Demodulator |
| MODGW | MO&DSD Gateway |
| MODLAN | MO&DSD LAN |
| MODNET | MO&DSD Network |
| MOM | Mission Operations Manager |
| MOU | Memorandum of Understanding |
| MOW | Mission Operations Wing |
| MPC | Mission Planning Center |
| MRR | Mission Requirements Request |
| MSCN | Manned Space Communications Network |
| MSFC | Marshall Space Flight Center |

| | |
|--------|---|
| MSFN | Manned Space Flight Network |
| MSM | Mission Support Manager |
| MSOCC | Multi-Satellite Operations Control Center |
| MSS | Message Switching System |
| MSU | Message Switching System Upgrade |
| MTBF | Mean-Time-Between-Failure |
| MTL | Mount Lemon, Arizona |
| MTTR | Mean-Time-To-Restore |
| MU | MSS Common Units |
| MUDUMP | MSS Task Dump Utility |
| MUX | Multiplexer |
| MVL | Majority Voting Logic |
| NALF | Naval Auxiliary Landing Field |
| NASA | National Aeronautics and Space Administration |
| Nascom | NASA Communications |
| NASCOP | Nascom Communications Operations Procedures |
| NASDA | National Space Development Agency of Japan |
| NCAR | National Center for Atmospheric Research |
| NCC | Network Control Center |
| NCCDS | NCC Data System |
| NCIC | Network Communications Interface Common |
| NCL | Network Module |
| NCPS | Network Command Processing System |
| NCS | National Communications System |
| NCSS | NGT Control and Status System |
| NDPA | Network Data Processing Area |
| NEAP | Nascom Evolution Action Plan |
| NED | Network Encoder/Decoder |
| NES | Nascom Event Schedule |
| NESS | National Environmental Satellite Service |

| | |
|---------------|--|
| NEST | Network Engineering Support Team |
| NETEX | Network Executive |
| NEXRAD | Next Generation Radar |
| NGT | NASA Ground Terminal |
| NHB | NASA Handbook |
| NIC | Network Interface Card |
| NIF | Nascom Interface Facility |
| NII | Nascom II (two) |
| NIP | Network Interface Processor |
| NIS | Nascom Interface System |
| NIST | National Institute for Standards and Technology |
| NLV | Nippon Launch Vehicle |
| NM | Network Manager |
| NMCC | Network Management Control Center |
| NMI | NASA Management Instruction |
| NMOS | Network Maintenance and Operations Support |
| NMP | Network Management Processor |
| NMS | Network Management System |
| NNSG | Nascom Network Scheduling Group |
| NOAA | National Oceanic and Atmospheric Administration |
| NOC | Network Operations Center |
| NOCA | Network Operations Control Area |
| NOCC | Network Operations Control Center |
| NOCS | Nascom Overseas Communication System |
| NOLAN | Nascom Operational LAN |
| NOM | Network Operations Manager |
| NPSS | NASA Packet Switching System |
| NRL | Naval Research Laboratory |
| NRZ-L | Nonreturn-to-Zero Level |
| NS | Northrop Strip |

| | |
|-------|--|
| NS | Nanosecond |
| NSAP | Network Service Assurance Plan |
| NSDP | Nascom System Development Plan |
| NSIDC | National Snow and Ice Data Center |
| NSS | NGT Scheduling System |
| NTSC | National Television Standards Committee |
| NTTF | Network Technical Training Facility |
| NU | Network Upgrade |
| NV | Non-Volatile |
| NVTS | Nascom Video Transponder Service |
| OAS | Onizuka Air Station |
| OBC | Onboard Computer |
| OC | Output Controller |
| OCC | Operations Control Center |
| OD | Operations Director |
| OFTDS | Orbital Flight Test Data System |
| OI | Operator Interface |
| OI | Operational Instrumentation |
| OJT | On-the-Job Training |
| OMB | Office of Management and Budget |
| OR | Operations Requirement |
| ORR | Operations Readiness Review |
| OS | Operator Station |
| OSC | Office of Space Communications |
| OSI | Open System Interconnection |
| OSSE | Oriented Scintillation Spectrometer Experiment |
| OSTC | Observatory Test System Complex |
| OTDA | Office of Tracking and Data Acquisition |
| OTU | Output Terminal Unit |
| PABX | Private Automatic Branch Exchange |

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|--------------|---|
| PACOR | Packet Data Processor |
| PAD | Packet Assembly Disassembler |
| PAL | Programmable Array Logic |
| PAO | Public Affairs Office |
| PASS | POCC Applications Software Support |
| PAT | Patrick AFB |
| PB | Parallel Binary |
| PB | Play Back |
| PC | Personal Computer |
| PCA | Proportional Counter Array |
| PCM | Pulse Code Modulation |
| PCU | Port Concentrator Unit |
| PDF | Payload Data Formatter |
| PDI | Payload Data Interleaver |
| PDIS | PDI Subsystem |
| PDL | Ponce De Leon |
| PDPF | Packet Data Processing Facility |
| PDS | Protected Distribution System |
| PFOR | Passive Fiber Optic Racks |
| PIA | Primary Interface Adaptor |
| PID | Program Introduction Document |
| PIP | Payload Integration Plan |
| PM | Phase Modulated |
| PMI | Programmable Modem Interface |
| PMS | Performance Monitoring System |
| PMT | Point Magu, California |
| PMTC | Pacific Missile Test Center |
| PN | Pseudo Noise |
| PO | Purchase Order |
| POCC | Payload Operation Control Center |

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|-----------------|--|
| POLAR | Polar Plasma Laboratory |
| POP | Project Operations Plan |
| POP | Point-of-Presence |
| PORTS | POCC Operations Real-Time Support |
| PPM | Packet Processor Module |
| PR | Procurement Request |
| PRD | Program Requirements Document |
| PSCN | Program Support Communications Network |
| PSN | Packet Switch Node |
| PSN | Public Switched Network |
| PSN | Packet Switch Network |
| PSP | Program Support Plan |
| PT&T | Pacific Telephone and Telegraph Company |
| PTAT | Private Trans Atlantic Cable |
| PTP | Point Pillar, California |
| PTS | Pneumatic Tube Subsystem |
| PUMP | POCC Utilization Management Positions |
| PVC | Permanent Virtual Circuit |
| PWI | Plasma Wave Instrumentation |
| QA | Quality Assurance |
| QAM | Quad Asynchronous Module |
| QSC | Quad Synchronous Module |
| QSP | Quad Synchronous Processor |
| QVM | Quad Voice Module |
| R/L | Return Link |
| R&D | Research and Development |
| RAC | Remote Analysis Computer |
| RAM | Random Access Memory |
| RAP | Restricted Access Processor |
| RCC | Range Control Center |

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|--------------------|--|
| Renaissance | Reuseable Network Architecture for Interoperable Space Science, Analysis, Navigation, and Control Environment |
| RF | Radio Frequency |
| RFP | Request for Proposal |
| RGCS | Request for Ground Communications Services |
| RGRT | Remote Ground Relay Terminal |
| RIC | Remote Information Center |
| RISC | Reduced Instruction Set Computing |
| RMA | Reliability, Maintainability, and Availability |
| RMOC | Remote Mission Operations Center |
| RO | Receive Only |
| ROP | Receive Only Printer |
| RS | Reed Solomon |
| RS | Recommended Standard |
| RSA | Russian Space Agency |
| RSO | Range Safety Officer |
| RT | Real Time |
| RTC | Real Time Console |
| RTOP | Research Technology Objectives and Plans |
| S/N | Signal-to-Noise (ratio) |
| SAMPEX | Solar Anomalous and Magnetospheric Particle Explorer |
| SAMS | Support and Maintenance System |
| SAO | Smithsonian Astrophysical Observatory |
| SAR | Synthetic Aperture Radar |
| SATCOM | Satellite Communications |
| SCAMA | Switching, Conferencing, and Monitoring Arrangement |
| SCD | System Capability Document |
| Sci | Science Institute |
| SCITF | Spacecraft Integration and Test Facility |
| SCM | Shift COMMGR |
| SCP | Stored Command Processor |

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|-------|--|
| SCPC | Single Channel Per Carrier |
| SCR | Strip Chart Recorder |
| SCSI | Small Computer Systems Interface |
| SDD | Subchannel Data Distributer |
| SDPC | Shuttle Data Processing Complex |
| SDPF | Shuttle Data Processing Facility |
| SDR | System Design Review |
| SDSS | Shuttle Data Select Switch |
| SEAS | Systems, Engineering, and Analysis Support |
| SEF | Sustaining Engineering Facility |
| SEMIS | System Engineering Management Information System |
| SEWP | Scientific Engineering Workstation Procurement |
| SEWS | Science and Engineering Workstation |
| SF | Single Frequency |
| SFOF | Space Flight Operations Facility |
| SGL | Space Ground Link |
| SGLT | Space Ground Link Terminal |
| SHO | Scheduling Order (s) |
| SIPS | Signals Input Processor System |
| SKR | Serial KG Recombiner |
| SL | Spacelab |
| SLDPF | Spacelab Data Processing Facility |
| SLI | Single Line Instrument |
| SLPO | Spacelab Program Office |
| SM | Statistical Multiplexer |
| SMA | S-band Multiple Access |
| SMC | Systems Management Center |
| SMCC | Shuttle Mission Control Center |
| SMDS | Statistical Multiplexer Data System |
| SMEX | Small Explorer |

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|---------------|---|
| SMR | Statistical Multiplexer Replacement |
| SMTP | Simple Mail Transmission Protocol |
| SN | Space Network |
| SN | Space Net (a family of commercial satellites) |
| SNi | San Nicholas Island, California |
| SNMP | Simple Network Management Protocol |
| SOC | Simulation Operations Center |
| SOC | Science Operations Center |
| SOCC | Satellite Operations Control Center |
| SOGS | Science Operations Ground System |
| SOHO | Solar Heliospheric Observatory |
| SONET | Synchronous Optical Network |
| SPADE | Single Channel Per Carrier Pulse Code Modulation Multiple Access |
| SPC | Signal Processing Center |
| SPiF | Shuttle/POCC Interface Facility |
| SPK | Scott Peak, Arizona |
| SPPO | Spacelab Payload Project Office |
| SPX | Simplex |
| SR | Special Routing |
| SRD | System Requirements Document |
| SRR | System Requirements Review |
| SSA | S-band Single Access |
| SSAI | Science Systems and Applications, Inc. |
| SSC | Science Support Center |
| SSCN | Scientific Satellite Communications Network |
| SSFP | Space Station Freedom Program |
| SSIO | Spacelab Engineering Data Input/Output |
| SSP | Space Shuttle Program |
| STADAN | Space Track and Data Acquisition Network |
| STC | System Test Complex |

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|---------|---|
| STD | Standard |
| STDN | Spaceflight Tracking and Data Network |
| STGT | Second TDRSS Ground Terminal |
| STOCC | Space Telescope Operations Control Center |
| STOMS | (H) ST Observatory Management System |
| STS | Space Transportation System |
| STTCS | S-band Tracking, Telemetry, and Command System |
| STU | Secure Telephone Unit |
| SUPIDEN | Support Identifier |
| SVN | Shuttle Video Network |
| SW | Software |
| SWAS | Submillimeter Wave Astronomy Satellite |
| T&DA | Tracking and Data Acquisition |
| TAC | Telemetry and Command Processor |
| TAE | Transportable Application Environment |
| TAL | Transatlantic Abort Landing |
| TAT | Transatlantic Cable |
| TBD | To Be Determined |
| TCP | Transmission Control Protocol |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TCS | Technical Control System |
| TCTS | Traffic and Configuration Time Schedule |
| TDE | TDRS East |
| TDM | Time Division Multiplex |
| TDM | Tracking Data Message |
| TDMLZP | Tracking Data Messages Level Zero Processor |
| TDPS | Tracking Data Processing System |
| TDRS | Tracking and Data Relay Satellite |
| TDRSS | Tracking and Data Relay Satellite System |
| TDS | Tracking Data System |

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|-----------------|--|
| TDW | TDRS West |
| TEAMS | Time-of-Flight Energy Analyzing Mass Spectrograph |
| TELOPS | Telemetry On-Line Processing System |
| TIP | Transaction Interface Processor |
| TIPIT | Telemetry Input Processor for TELOPS |
| TKSC | Tsukuba Space Center |
| TLP | Test Level Point |
| TM | Trade Mark |
| TMOC | TOMS Mission Operations Center |
| TOMS-EP | Total Ozone Mapping Spectrometer-Earth Probe |
| TOPEX | Ocean Topography Experiment |
| TPC | Telemetry Preprocessing Computer |
| TPOCC | Transportable POCC |
| TRACE | Transistion Region and Coronal Explorer |
| TS | Transport Subsystem |
| TS | Timing Subsystem |
| TT | Terminal Timing |
| TT&C | Tracking, Telemetry, and Command |
| TTL | Transistor-Transistor Logic |
| TTY | Teletype |
| TV | Television |
| TVOC | TV Operations Center |
| TVSS | Television and Video Switching System |
| UARS | Upper Atmosphere Research Satellite |
| UDS | Universal Documentation System |
| UHF | Ultra High Frequency |
| UMSOC | University of Maryland Space Operations Center |
| UNH | University of New Hampshire |
| UNI | User Network Interface |
| UPS | Uninterruptable Power Source |

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|--------|--|
| USAEPG | United States Army Electronic Proving Ground |
| V0 | Version Zero |
| VAC | Volts Alternating Current |
| VAFB | Vandenberg AFB |
| VBR | Variable Bit Rate |
| VC | Video Conferencing |
| VC | Virtual Channel |
| VDC | Volts Direct Current |
| VDL | Voice Direct Line |
| VDMS | Voice Distribution Management System |
| VDS | Voice Distribution System |
| VGA | Video Graphics Array |
| VILSPA | Villafranca, Spain |
| VITS | Voice Intercom and Teleconferencing System |
| VLBI | Very Long Baseline Interferometry |
| VNB | Vandenberg AFB, California |
| VS. | as compared to |
| VSCP | Vendor-Specific Configuration Program |
| VSS | Voice Switching System |
| WAD | Work Authorization Document |
| WAN | Wide Area Network |
| WBDS | Wideband Data System |
| WCSC | West Coast Switching Center |
| WECO | Western Electric Company |
| WFF | Wallops Flight Facility |
| WHS | White Sands Missile Range, New Mexico |
| WIRE | Wide-Field Infrared Explorer |
| WLR | Wideband Loop Repeater |
| WOTS | Wallops Orbital Tracking Station |
| WPC | Wave/Particle Correlator |

| | |
|---------------|------------------------------------|
| WPS | Wallops S-band Station |
| WR | Western Range |
| WSC | White Sands Complex |
| WSGT | White Sands Ground Terminal |
| WSGT/U | WSGT Upgrade |
| WSMR | White Sands Missile Range |
| WSSH | White Sands Space Harbor |
| WSTF | White Sands Test Facility |
| WU | Western Union |
| XSM | Cross Strapped Multiplexer |
| XTE | X-ray Timing Experiment |
| ZOE | Zone of Exclusion |



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