N84-19382

# Spacelab Data Processing Facility

NASA

***Thundering roars from a spacecraft being propelled from its launch pad . . . cheering onlookers nudging into the scene of yet another bit of history . . . dramatic voice transmissions between earth and "beyond the horizon."***

## Foreword

All of these events still occur, but the emphasis at NASA today is more and more toward the efficient and "reusable" application of limited experimentation time in space after the delivery system has done its job.

One exciting project is Spacelab, a series of exacting missions designed to provide extensive knowledge of near and deep space.

Housed onboard the Space Shuttle Orbiter, a single Spacelab mission may feature many varied scientific experiments. Voluminous data streams result, requiring an adaptable, reliable facility to accept and process them. The Spacelab Data Processing Facility (SLDPF), at the Goddard Space Flight Center (GSFC), has been developed to handle the payload data from Spacelab missions. Furthermore, the SLDPF capabilities are not limited to Spacelab; the SLDPF can also support attached Shuttle payloads utilizing the Spacelab onboard data system.

NASA prepared this publication to highlight the capabilities of the SLDPF — the capturing, quality monitoring, processing, accounting, and forwarding of vital Spacelab data to various user facilities around the world.

# Concept

Flexibility, reliability, reusability . . . these are the advantages the Spacelab Data Processing Facility (SLDPF) offers to a user seeking to process space data.

Whether an onboard Spacelab experiment belongs to a space particles investigator in Japan or to a microwave remote-sensing experimenter in Germany, the SLDPF flexibility is shown by its ability to capture and record a wide variety of data types (digital, audio, and analog) as required to support an experiment.

The flexibility of the SLDPF is further demonstrated by the wide range of data rates that can be handled. K-band channels 2 and 3 digital data are captured by the SLDPF at a rate of up to 2 megabits per second (Mbps) for channel 2 and at a rate of 2 to 50 Mbps for channel 3. Analog data are also captured by the SLDPF, at a rate of 4.2 Megahertz (MHz), for an early Spacelab mission.

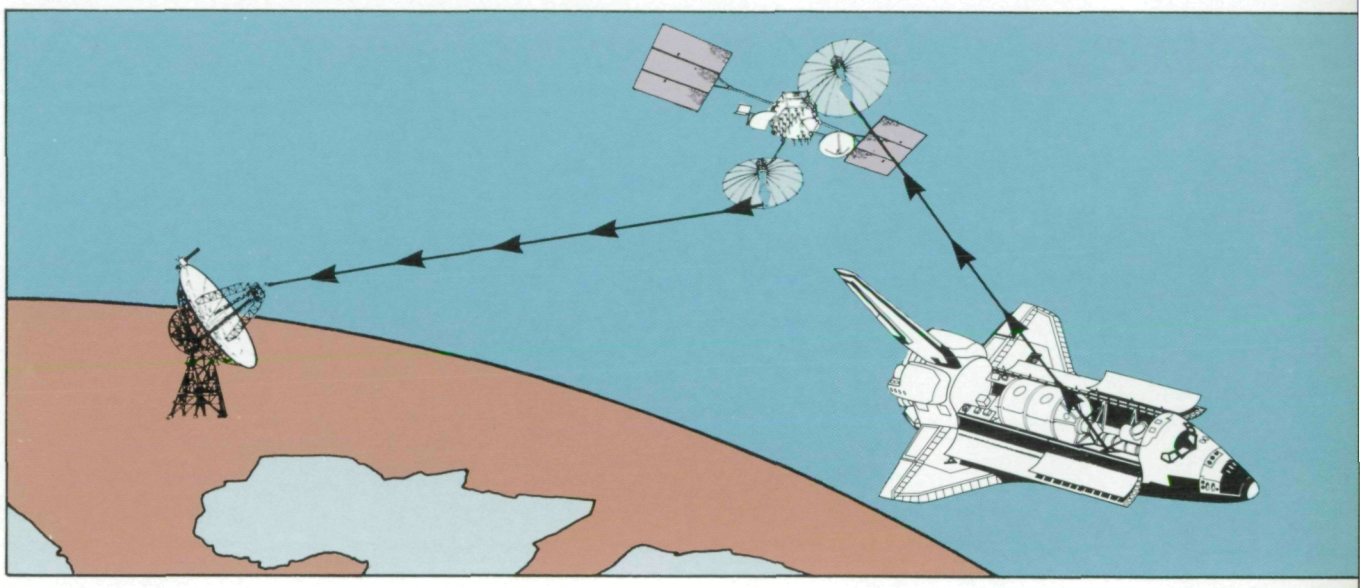
To implement this flexibility, the SLDPF is divided into two major functional elements — the Spacelab Input Processing System (SIPS) and the Spacelab Output Processing System (SOPS). After capturing the digital telemetry data stream, the SIPS demultiplexes, synchronizes, time tags, quality checks, accounts for the data, and formats the data onto computer-compatible tapes (CCTs). For further processing, the digital data are then transferred to the SOPS where they are edited, time ordered, quality checked, blocked, formatted for distribution, and recorded onto tapes for shipment to the user. Throughout this processing, data accountability is maintained by the SOPS. Audio and analog data products, which are generated in the SIPS, are output directly to the users. When specifically requested by the user, selected digital tape products may also be obtained from the SIPS.

Reliability has been incorporated into the SLDPF design. If any part of the SIPS online components becomes inoperable, a second system provides redundancy.

The Shuttle reusable concept is also reflected in the SLDPF. To ensure reusability of the SLDPF, input data stream characteristics and output data format requirements are not "hard coded" within the system. For example, the SIPS hardware is programmable during the mission for varying predefined input data stream characteristics. The SLDPF configuration utilizes parameter files that adapt the SIPS and SOPS software and hardware to the specific data processing requirements of each mission. Thus, the SLDPF is reusable from Spacelab mission to mission, as well as for other projects in the space program utilizing the Spacelab onboard data system.

## The Spacelab Data Network

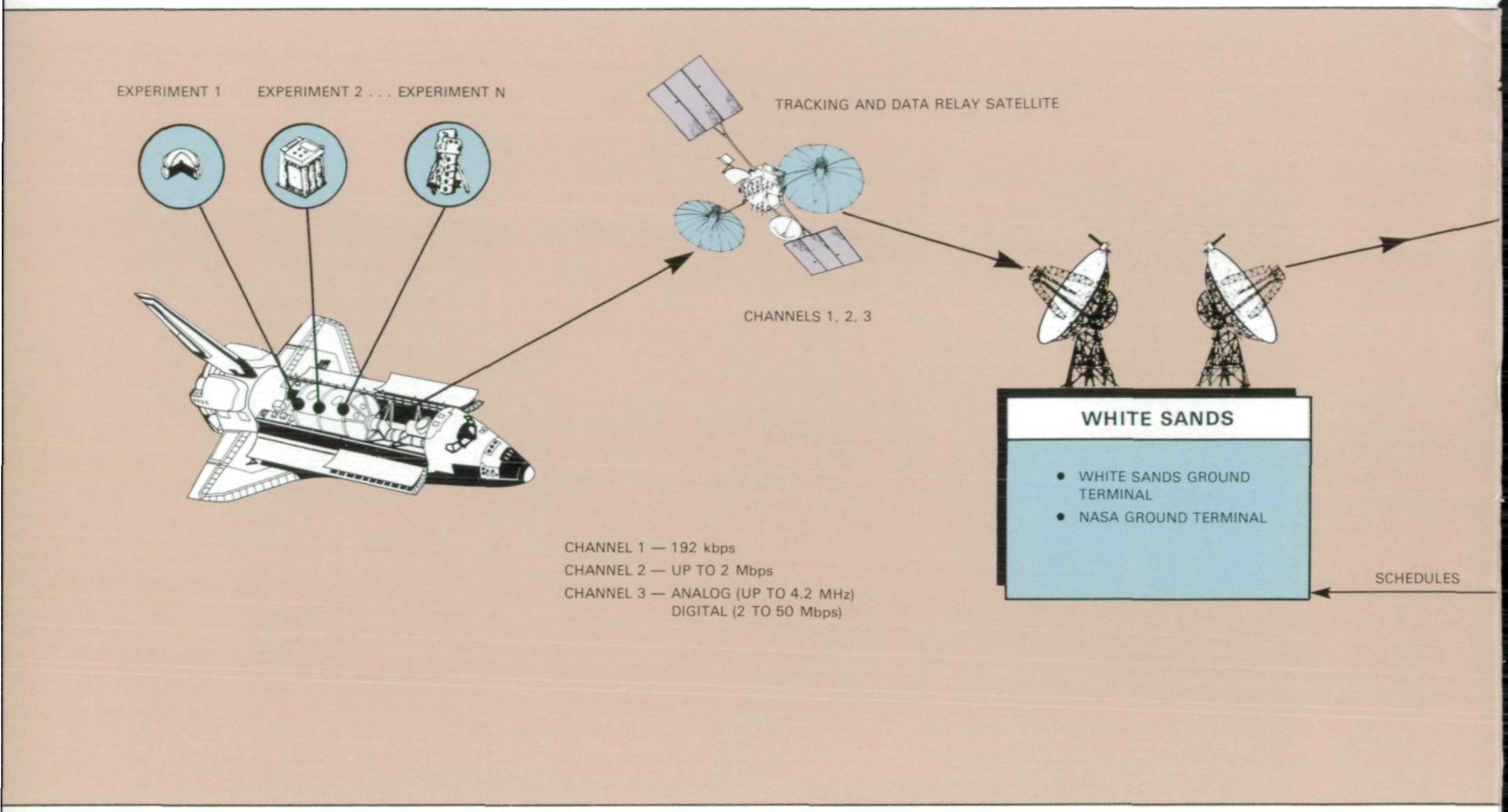
The Spacelab data network begins with the onboard Spacelab High-Rate Multiplexer (HRM), which gathers data for transmission to the Tracking and Data Relay Satellite System (TDRSS) through the Shuttle Orbiter K-band signal processor. The TDRSS/Domsat link then relays the data to GSFC. Here the data are captured and processed within the SLDPF before distribution to the users.



## The SLDPF Interfaces

In fulfilling overall system requirements, the SLDPF interfaces with other NASA centers — the Marshall Space Flight Center (MSFC), the Johnson Space Center (JSC), and the Kennedy Space Center (KSC). For prelaunch verification, the KSC provides test data for SLDPF premission processing and shipment to the users. The MSFC, which has mission management responsibilities for the early Spacelab missions, levies project requirements upon the SLDPF and supplies premission products essential to mission specific support. The JSC and the MSFC coordinate real time mission support that includes data quality monitoring and updating of the nominal timeline. After the mission is completed, the JSC also supplies Spacelab and Orbiter ancillary data to the SLDPF.

# The Spacelab Data Network




## Spacelab High-Rate Multiplexer

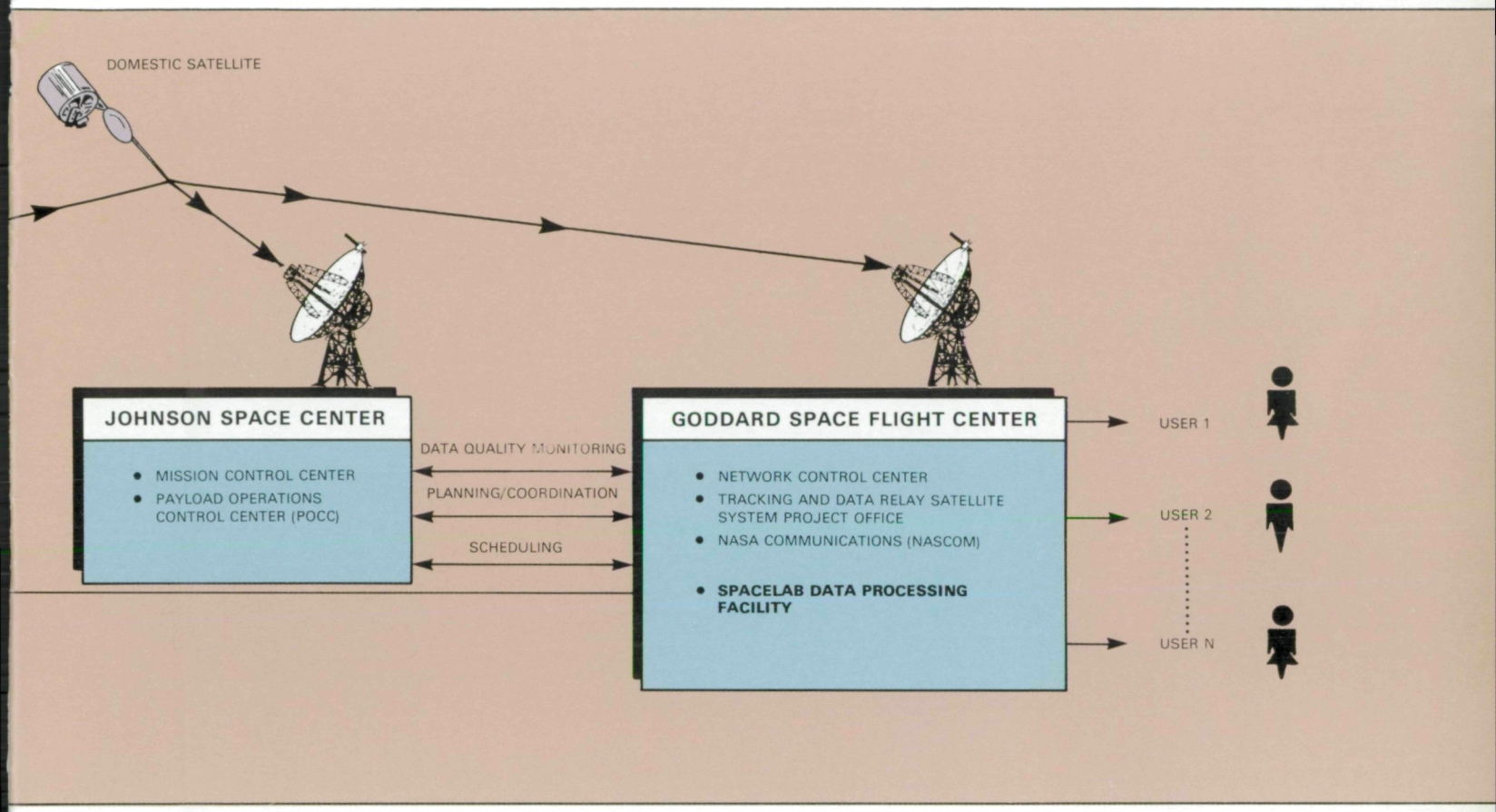
- Multiplexes experiment data
- Links with Orbiter K-band signal processor for transmission from Spacelab
- Records on high data rate and analog recorders if link is not available

## TDRS

- Receives signals from Shuttle/Spacelab
- Transmits signals to TDRSS receiver at White Sands

## White Sands

- Receives signals from TDRSs
- Operates and controls TDRSS
- Provides short-term recording of Spacelab data




## DOMSAT

- Receives signals from White Sands
- Transmits signals to Goddard Space Flight Center and Johnson Space Center

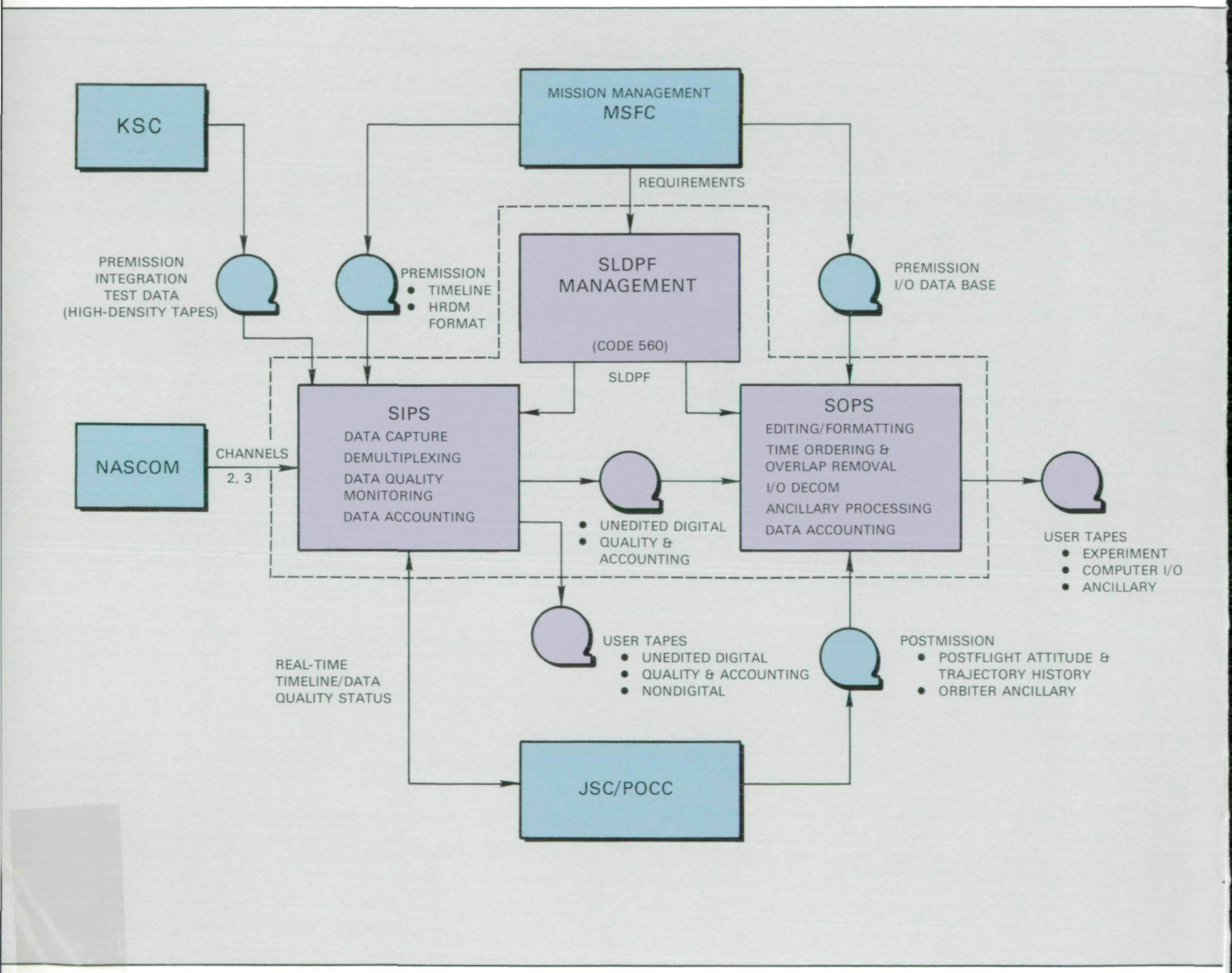
## JSC

- Operates and controls the mission
- Schedules data transmissions in conjunction with Network Control Center and TDRSS/ NASCOM management

## GSFC

- Receives signals from TDRSS and Domsat through NASCOM
- Coordinates network activities
- Captures, quality monitors, accounts for, and processes data for shipment to users
- Ships data tapes to user community

## SLDPF Interfaces



The SLDPF consists of two primary computing facilities, the SIPS and the SOPS. The SLDPF Management within GSFC (Code 560) coordinates all external interfaces and mission data processing requirements. To perform its functions, the SLDPF has the following interfaces:

## Marshall Space Flight Center/Mission Management

— Provides the mission requirements for the SLDPF
— Provides premission timeline and High-Rate Demultiplexer (HRDM) format tapes
— Provides premission I/O data base tape

## Johnson Space Center/ Payload Operations Control Center

— Provides timeline updates during the mission
— Coordinates real-time data quality status monitoring with the SIPS
— Provides postmission Spacelab Postflight Attitude and Trajectory History (PATH) and Orbiter Ancillary (OANC) data

## Kennedy Space Center

— Provides experiment integration Level IV test data (high-density tapes) for premission testing and user product verification
— Provides integration Level III, II, and I test data for prelaunch verification

## Goddard Space Flight Center/ Communications and Control Management

— Provides data link for K-band channels 2 and 3 data through NASA Communications (NASCOM)
— Provides supporting communication links through NASCOM
— Coordinates network activities through the Network Control Center (NCC)

# Utilizing the SLDPF

## What Are the User Requirements?

For full processing, the experiment data format must be compatible with the High-Rate Multiplexer (HRM). The HRM standards are contained in the Spacelab HRM Format Standards document (see Additional Reading list). If the experiment data format does not completely adhere to the HRM standards, limited processing of the data may still be available within the SLDPF.

Data rates must fall within a threshold acceptable to the HRM; data rates must be within 16 Mbps for dedicated channels and within 50 Mbps for a direct access channel.

## What Are the Project Requirements?

The mission manager must provide the following to the SLDPF:

— Mission specific parameters
— HRDM format tape
— Premission timeline tapes
— I/O data base tape
— Premission test tapes
— System mission unique requirements (if any).

## What Will the SLDPF Provide?

AUDIO Audio Tape — Contains selected voice data from the three voice channels for periods requested by the users.

ANALOG Analog Tape — Contains Verification Flight Instrumentation or filtered analog data for Spacelab-1.

IDT Instrumentation Data Tape — Contains selected HRDM output channels along with Spacelab Coordinated Universal Time.

HDT High-Density Tape — Contains the raw-captured K-band channels 2 and/or 3 data.

SEDT Spacelab Experiment Data Tape — Contains blocked and unedited, demultiplexed channel data from one or more dedicated experiment channels.

SIDT Spacelab I/O Data Tape — Contains blocked and unedited, demultiplexed Experiment Computer (EC) I/O and Subsystem Computer (SC) I/O channel data.

SQAT Spacelab Quality Control and Accounting Tape — Contains quality and accounting information for specified SEDT and/or SIDT files.

SECT Spacelab Experiment Channel Tape — Contains edited and formatted data from one dedicated experiment channel.

SICT Spacelab I/O Channel Tape — Contains selected decommutated words from the EC I/O and SC I/O channels edited and formatted for individual experimenters.

SANC Spacelab Ancillary Data Tape — Contains decommutated guidance, navigation, and control (GN&C) words from EC I/O channel with related ancillary parameters. Also contains decommutated and converted housekeeping parameters from the EC I/O and the SC I/O channels.

SPMA Spacelab Postmission Ancillary Tape — Contains SANC data that have been merged with PATH data received from the JSC.

OANC Orbiter Ancillary Tape — Contains K-band channel 1 ancillary data from the JSC. OANC tapes are copied and distributed to the users.

# Product Summary and Delivery Schedule

| | TAPE CHARACTERISTICS | | DELIVERY SCHEDULE[1] |
|---|---|---|---|
| | STANDARD | OPTIONS | |
| **SIPS PRODUCTS** | | | |
| SEDT/SIDT[2] | 6250-BPI, 9-TRACK | 1600-BPI, 9-TRACK | SLDPF DATA RECEIPT + 1 MONTH |
| SQAT[2] | 6250-BPI, 9-TRACK | 1600-BPI, 9-TRACK | |
| IDT[2] | ½", 7-TRACK | NONE | |
| CAPTURED HDTs[2] | 1", 28-TRACK | NONE | |
| AUDIO | AUDIO CASSETTES | EDITED COPIES OF AUDIO MASTERS | SLDPF DATA RECEIPT + 1 MONTH |
| ANALOG | ½", 7-TRACK | NONE | |
| **SOPS PRODUCTS** | | | |
| SECT | 1600-BPI, 9-TRACK | 800-BPI, 6250 BPI, 9-TRACK | SLDPF DATA RECEIPT + 2 MONTHS |
| SICT | 1600-BPI, 9-TRACK | 800-BPI, 6250 BPI, 9-TRACK | |
| SANC | 1600-BPI, 9-TRACK | 800-BPI, 6250 BPI, 9-TRACK | |
| SPMA | 1600-BPI, 9-TRACK | 800-BPI, 6250 BPI, 9-TRACK | PATH RECEIPT + 1 MONTH BUT NO EARLIER THAN 1 MONTH AFTER SANC PROCESSING |
| OANC COPIES | 1600-BPI, 9-TRACK | 800-BPI, 6250 BPI, 9-TRACK | RECEIPT OF OANC DATA + 1 MONTH |

## Notes:

[1] Delivery schedules are based on a 7-day mission average data rate of 1 Mbps for the SIPS and 500 Kbps for the SOPS. Delivery schedules for missions with higher rates must be negotiated.

[2] Tapes generated by the SOPS are the standard SLDPF digital products. Experimenters not conforming to standard HRM data formats or desiring earlier receipt of data may negotiate with the SLDPF for shipment of SEDTs, SIDTs, SQATs, IDTs, and/or captured HDTs.

# SLDPF Overall Processing Flow

## SIPS Phase 1

During the SIPS Phase 1 processing, K-band channel 2 and/or channel 3 data are captured onto high-density tapes. During the mission, the primary SIPS functions are the real time capture and quality monitoring of the data. The SIPS System Engineering Laboratories (SEL) 32/77 computers may perform digital processing in real time for those HRDM output channels whose aggregate data rate does not exceed the SIPS capability. Analog data from K-band channel 3 are also captured in real-time. After real-time data capture, the HDTs, including playback and direct access channel data, are postprocessed to produce SEDTs and/or SIDTs. During this phase, audio data are captured, and later edited and copied onto audio cassette tapes.

## SIPS Phase 2

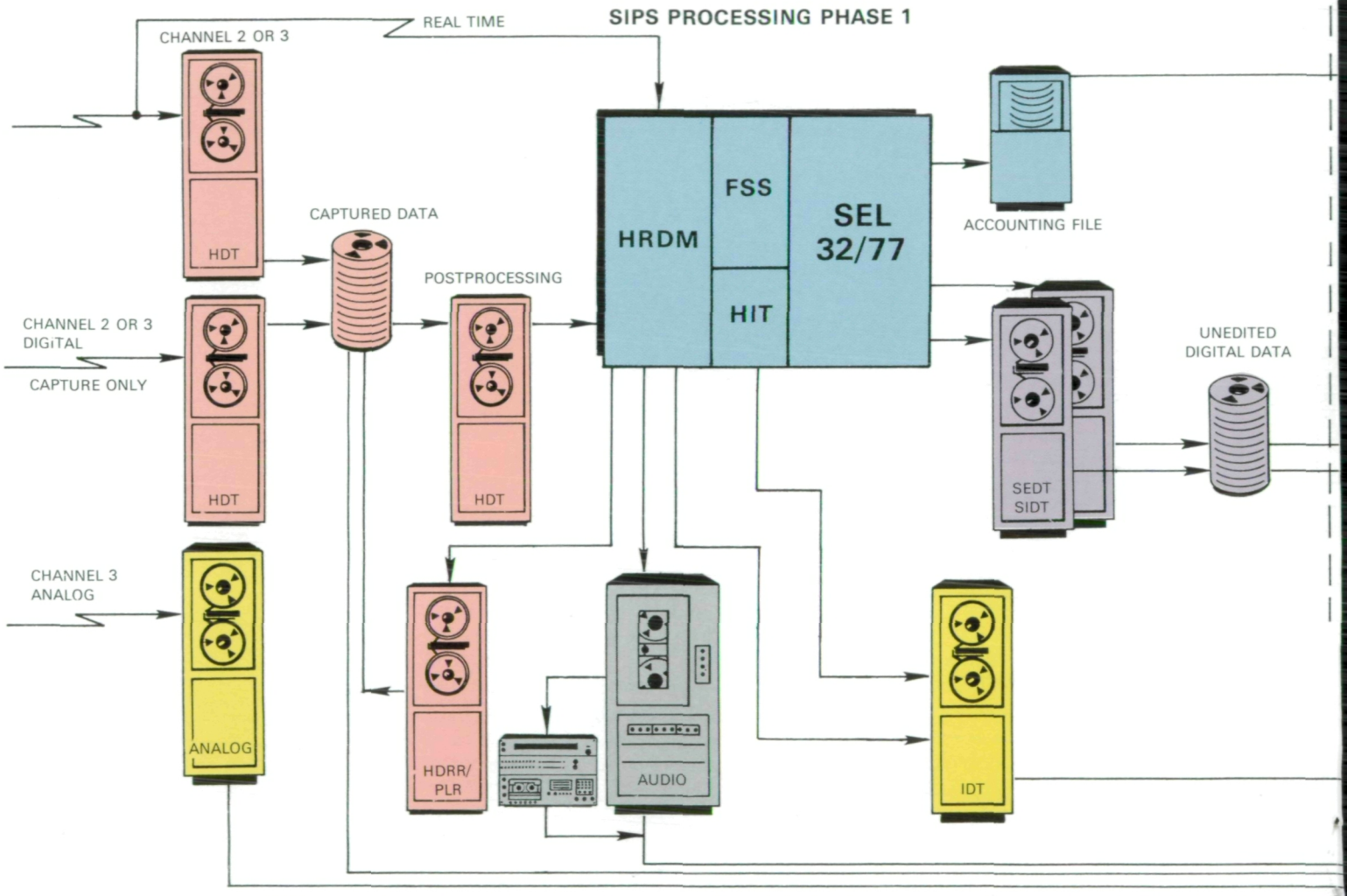
During the SIPS Phase 2 processing, the completed SEDTs and/or SIDTs are grouped, quality analyzed, and accounted for prior to release to the SOPS. The SQATs are generated at this time containing quality and accounting information corresponding to the SEDT and/or SIDT files to be released.

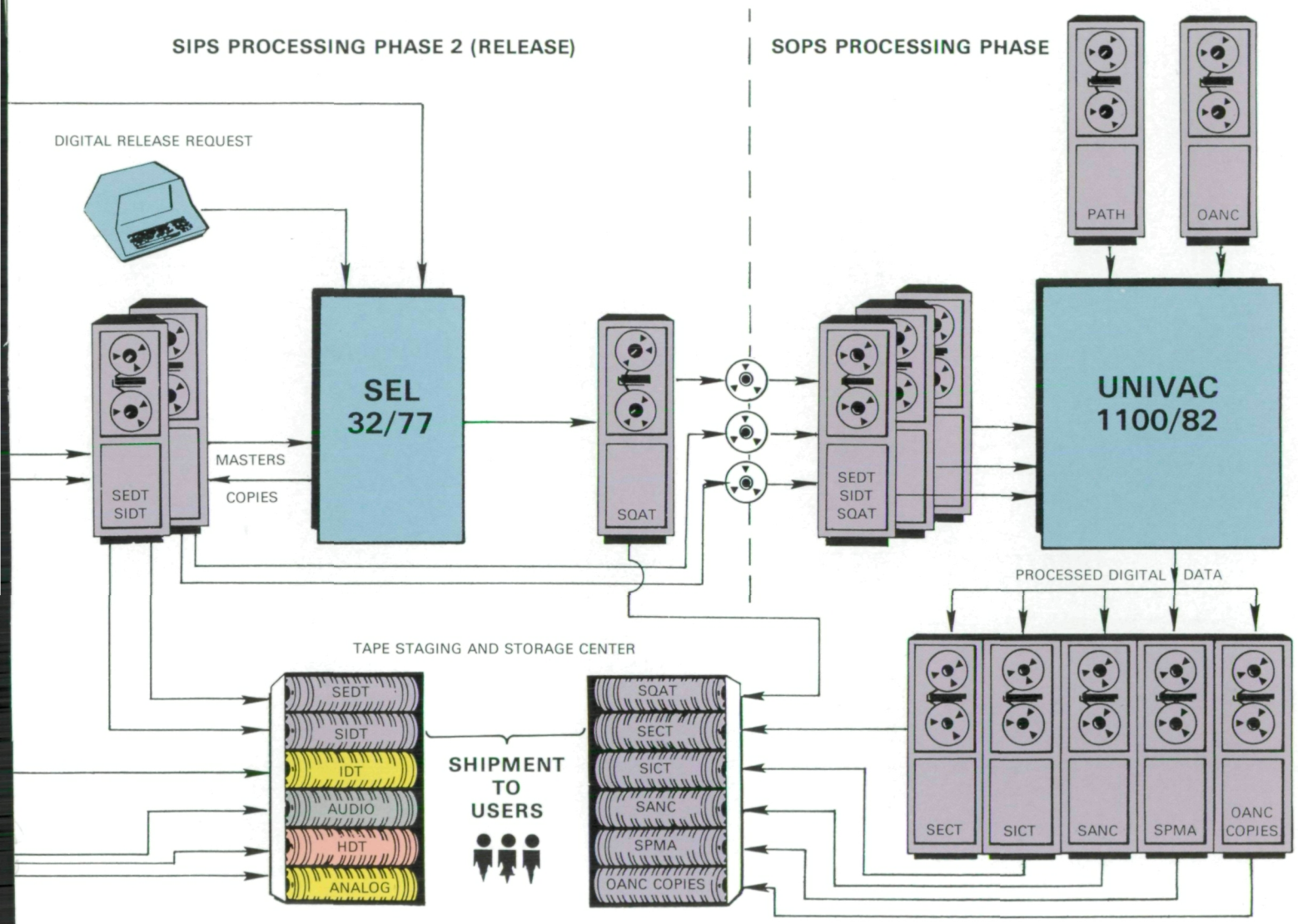
Copies of the SEDTs, SIDTs, and SQATs for users other than the SOPS are also generated during this phase. In addition, shipping letters for all SIPS products are generated.

## SOPS Phase

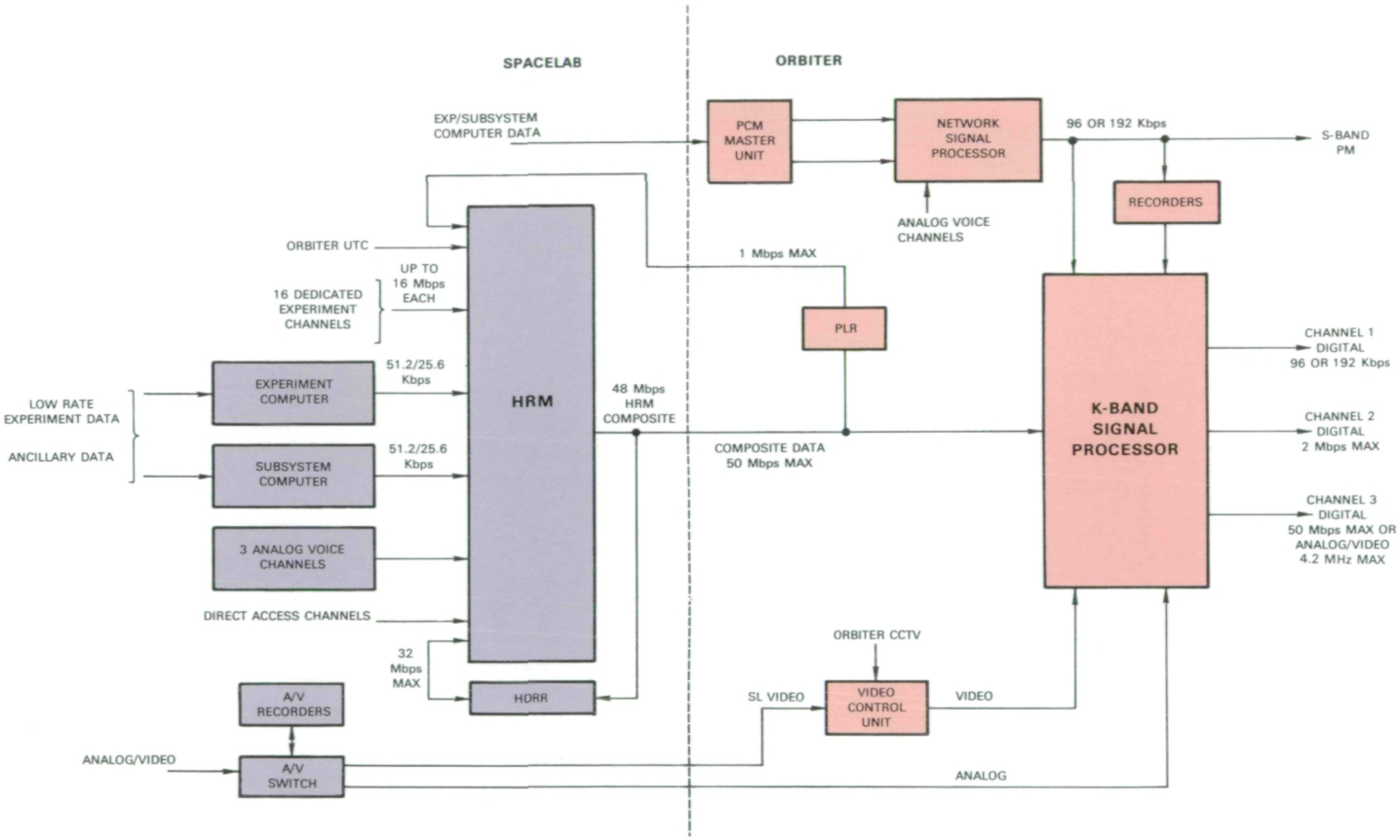
During the SOPS phase, the digital data contained on the SEDTs and SIDTs are further processed to produce experiment channel tapes, I/O channel tapes, and Spacelab ancillary tapes. The OANC copies are provided for shipment to the users. The major processing functions within the SOPS include time ordering, overlap removal, major frame editing, decommutating from the I/O channels, ancillary processing, and formatting and generating output products. All products distributed by the SOPS are accounted for and are accompanied by shipping information.

# SLDPF Overall Processing Flow




SIPS PROCESSING PHASE 2 (RELEASE)
SOPS PROCESSING PHASE
DIGITAL RELEASE REQUEST
SEL 32/77
SEDT
SIDT
MASTERS
COPIES
SQAT
SEDT
SIDT
SQAT
PATH
OANC
UNIVAC 1100/82
PROCESSED DIGITAL DATA
TAPE STAGING AND STORAGE CENTER
SEDT
SIDT
IDT
AUDIO
HDT
ANALOG
SHIPMENT TO USERS
SQAT
SECT
SICT
SANC
SPMA
OANC COPIES
SECT
SICT
SANC
SPMA
OANC COPIES

# Spacelab/Orbiter Data Flow



## High-Rate Multiplexer (HRM)

The asynchronous multiplexer collects various input data streams and multiplexes the data into a composite signal of up to 48 Mbps. Data can be formatted into any of 64 predefined formats.

A direct access channel bypasses the HRM functions internally and provides a 50-Mbps downlink capability for a given experiment.

## High Data Rate Recorder (HDRR)

Composite data are recorded on the HDRR onboard the Spacelab at rates of up to 32 Mbps during time intervals without TDRSS coverage. The HDRR is played back in reverse and can be multiplexed with real-time data in the composite data stream — this results in a second level of multiplexing.

## Payload Recorder (PLR)

The Orbiter PLR serves primarily as a backup to the Spacelab HDRR. Data can be recorded at a rate of up to 1 Mbps.

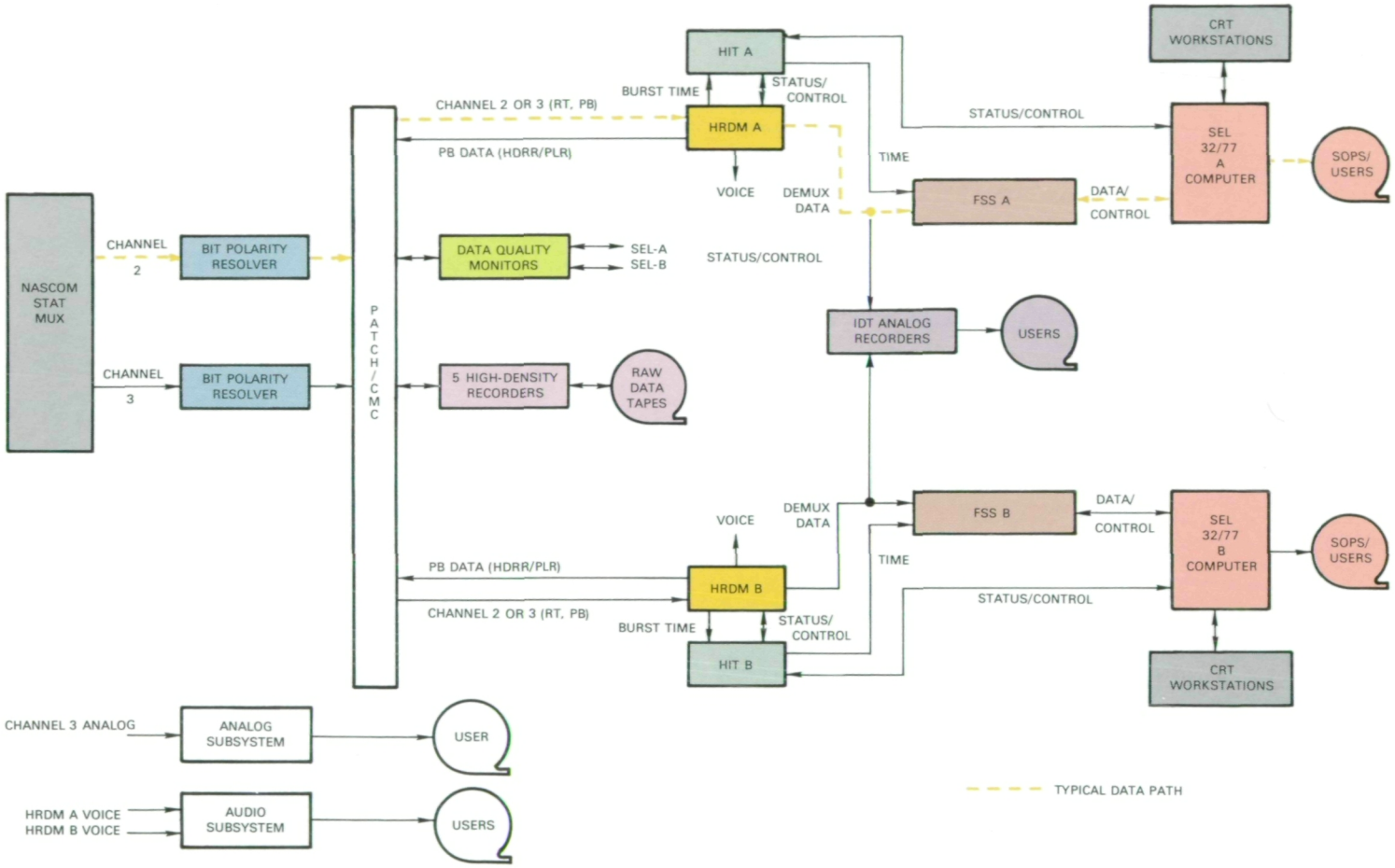
## K-Band Signal Processor

The K-band signal processor collects the composite data stream, the analog or video data stream, and the network signal processor output. These various data streams are selected for downlinking over channels 1, 2, or 3.

## Analog/Video (A/V) Recorders

There are two onboard A/V recorders onto which data are captured during time intervals without TDRSS coverage.

# SIPS Hardware Configuration



The SIPS consists of redundant special-purpose hardware and SEL 32/77 computers which share five high-density recorders. This redundancy ensures real-time processing capabilities. Audio and analog recording subsystems are also included.

## High-Rate Demultiplexer (HRDM) – Two Units

Each unit can receive a composite data stream from the NASCOM network or from an HDT. The HRDM performs the inverse function of the HRM and separates the composite stream into the original data signals that were multiplexed onboard the Spacelab. The HRDM is programmable and is indirectly controlled by the SEL.

## HRDM Interface Controller and Time Code Converter (HIT) – Two Units

Each unit interfaces the HRDM and the SEL to load the HRDM formats and to monitor the HRDM status. The HIT also converts the HRDM time codes for time tagging the digital data.

## Frame Synchronizer Subsystem (FSS) – Two Subsystems

Each FSS consists of 23 Frame Synchronizer Units (FSUs) that accept and synchronize serial data from the HRDM, from the composite stream, or from the HDT read after write. Each FSS passes time tagged data and/or status to the SEL.

## Audio Recording and Monitoring Subsystem (ARMS)

This specially designed system accepts the three incoming analog voice channels output from the HRDM. The ARMS will time edit the audio and make user cassette recordings upon request.

## Patch/Configuration Manager's Console (CMC)

This console, which interfaces with the SEL, monitors the setup and status of the SIPS hardware and provides signal-patching capabilities.

## SEL 32/77 Computers – Two Systems

The salient functions performed by each SEL are configuration and timeline control, HRDM format loading, data input, quality assessment, accounting, formatting, and tape generation.

# SIPS Functions

— Capture all digital data in real time on HDTs.

— Record the analog data stream in real time.

— Perform data quality monitoring in real time on the composite and demultiplexed data streams.

— Coordinate with the POCC in real time during the mission for data quality monitoring and timeline updates.

— Coordinate with NASCOM.

— Demultiplex the output of the HRM
  — Transfer demultiplexed experiment and I/O channels to the SEL 32/77
  — Record the audio data from the HRDM
  — Record data from selected HRDM channels on IDTs.

— Format and output the demultiplexed dedicated experiment channel data to SEDTs.

— Format and output the demultiplexed experiment computer I/O channel and the subsystem computer I/O channel data to SIDTs.

— Postprocess playback data (HDRR/PLR)
  — Reverse the HDT
  — Demultiplex the playback stream and generate output products.

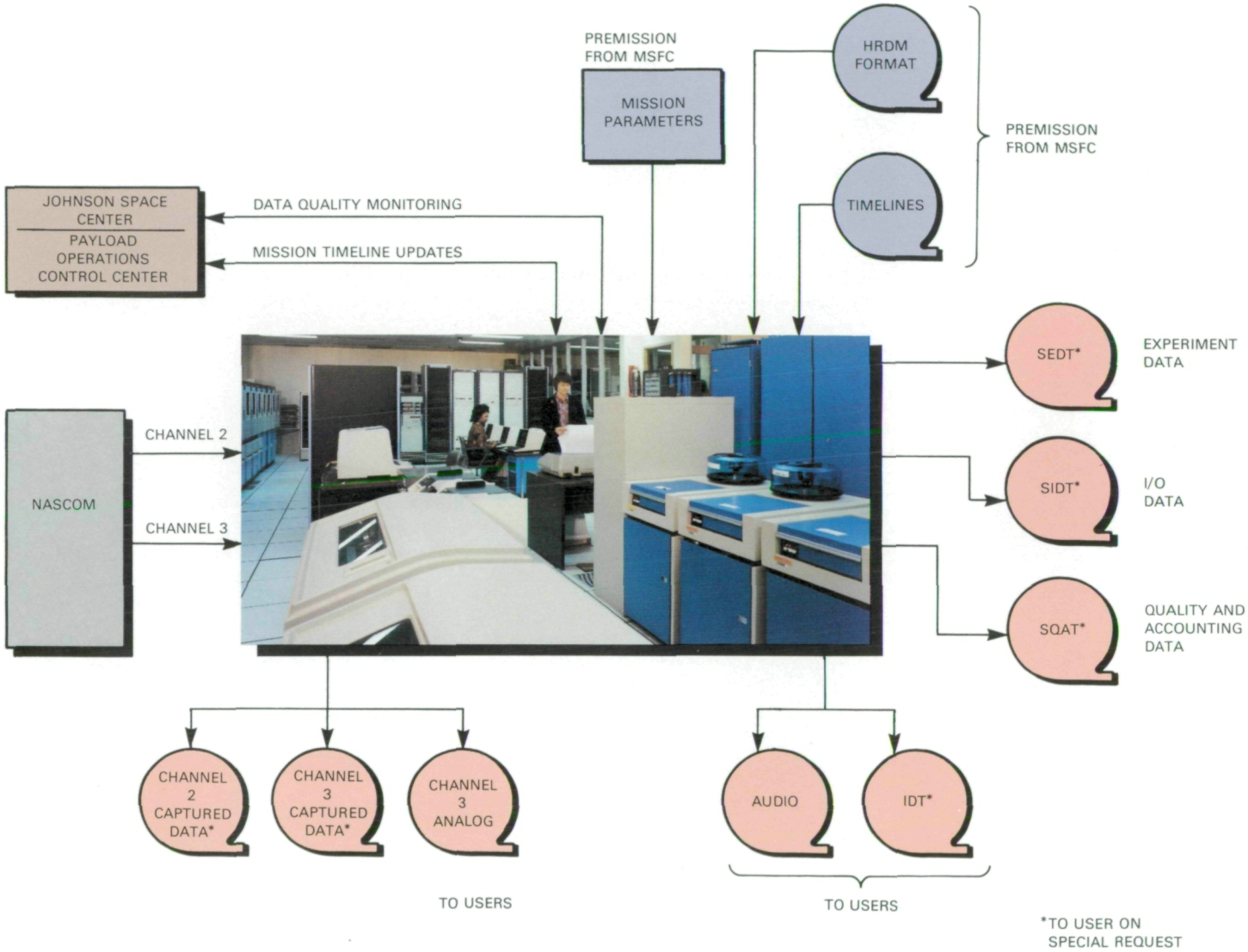
— Postprocess any channel 2 and/or channel 3 captured data not processed in real time.

— Postprocess direct access channel (DAC) data.

— Perform quality assurance (QA) and accounting procedures prior to shipping.

— Generate shipping letters for all user tapes.

# Spacelab Input Processing System



## SOPS Functions

— Edit the data.

— Time order the data.

— Remove data overlap.

— Format the experiment data onto individual experiment channel tapes (SECTs).

— Decommutate the I/O data.

— Format the decommutated I/O data onto individual I/O channel tapes (SICTs).

— Produce attitude and ephemeris translations from raw GN&C parameters contained in the EC I/O data.

— Convert selected payload ancillary data downlinked on channel 2 and channel 3 to engineering units.

— Generate ancillary tapes in standard format containing both converted GN&C and other ancillary data (SANCs).

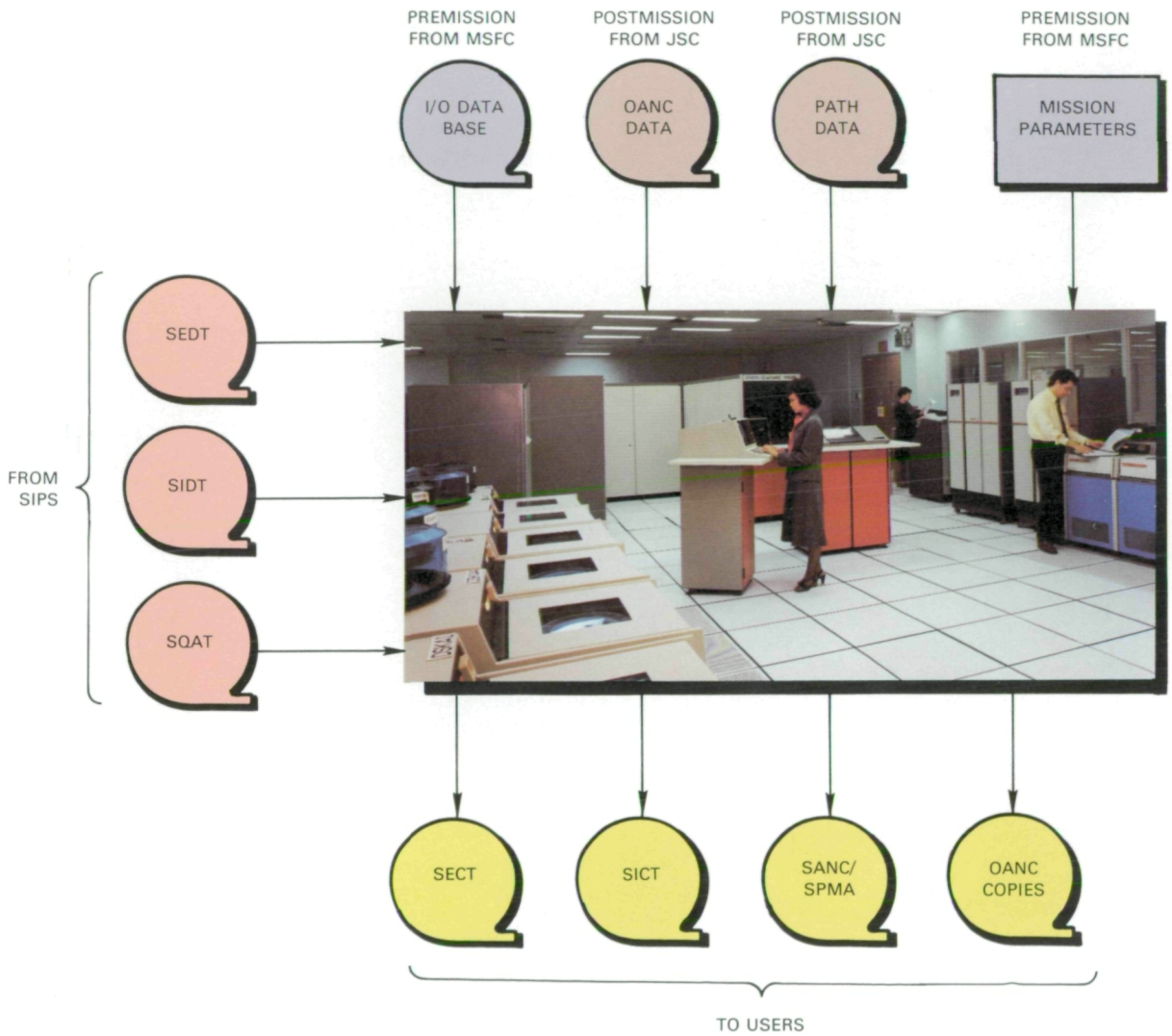
— Perform quality assurance (QA) and accounting procedures before shipping.

— Merge PATH and previously generated SANC data to generate postmission ancillary data (SPMAs).

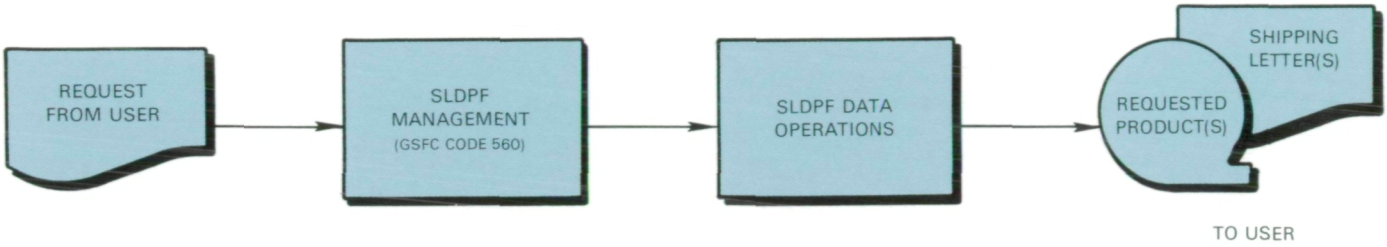
— Process (copy) OANC data.

— Generate shipping letters for all user tapes.

# Spacelab Output Processing System



# Postmission Reprocessing Requests




User requests for reprocessing are submitted to the GSFC Information Processing Division (Code 560). Copies of the requests are also submitted to the Mission Manager (at the MSFC for early Spacelab missions).

User Recopy Requests . . .

The entire tape is recopied if physical tape problems occur after release from GSFC. Tapes lost in shipment would also fall into this category of reprocessing requests.

User Redo Requests . . .

The original source tapes are used to regenerate data when the user expects the data quality to improve by reprocessing the suspect data.

Spacelab master tapes are archived for 12 months after a mission to ensure that all recopy and redo requests can be fulfilled.

# Summary

The SLDPF mirrors the "reusable concept" of the Space Shuttle — input data stream characteristics and output data formats can be varied within the system from mission to mission to ensure a reusable support facility. Parameter files are utilized to adapt the SIPS and SOPS software and hardware to the specific data processing requirements of each user being supported during a given mission.

The SIPS and SOPS are the two major components of the SLDPF. The SIPS captures digital, audio, and analog data. After capturing the digital data, the SIPS demultiplexes, synchronizes, time tags, quality checks, accounts for, and formats the data onto computer-compatible tapes. For further processing the digital data are then transferred to the SOPS where the SLDPF digital processing is completed. The SOPS edits, time orders, blocks, quality checks, formats for distribution, and records the data on tape for shipment to the users. In addition, the SOPS provides the SLDPF ancillary processing and accounts for the SOPS generated data products.

To take advantage of the SLDPF capabilities, the user's experiment must be compatible with the HRM onboard the Spacelab. Data rates must be within 16 Mbps for a dedicated channel and within 50 Mbps for a direct access channel to be acceptable for processing within the SLDPF. For each experiment proposed for a Spacelab mission, the user must provide the SLDPF with certain specific information through the mission manager. The mission manager provides this information to the SLDPF via the data processing requirements document, the HRDM format tape, the premission timeline tapes, and the I/O data base tape.

The SLDPF will provide to the user, as applicable, the following: computer-compatible tapes, audio tapes, analog tapes, high-density tapes, instrumentation data tapes, and related reports/shipping letters.

# Additional Reading


1. George C. Marshall Space Flight Center, *Spacelab High Rate Multiplexer Format Standards for Missions 1, 2, and 3.* MSFC-STD-630, Marshall Space Flight Center, Alabama 35812, April 1978.

2. --, *Spacelab Payload Mission 1 Spacelab Data Processing Facility Requirements Document.* JA-015 Revision A, Marshall Space Flight Center, Alabama 35812, October 1982.

3. Computer Sciences Corporation (CSC), *SLDPF Baseline Requirements Document.* CSC/SD-80/6027 UD3, GSFC, Greenbelt, Maryland 20771, October 1982.

4. --, *Interface Control Document for Spacelab Instrumentation Data Tapes (IDTs).* CSC/SD-80/6119 UD1, GSFC, Greenbelt, Maryland 20771, October 1981.

5. --, *Interface Control Document for Spacelab Input/Output Data Computer Compatible Tapes (SIDTs).* CSC/SD-79/6122 UD6, GSFC, Greenbelt, Maryland 20771, January 1983.

6. --, *Interface Control Document for Spacelab Experiment Data Computer-Compatible Tapes (SEDTs).* CSC/SD-79/6121 UD6, GSFC, Greenbelt, Maryland 20771, January 1983.

7. --, *Interface Control Document for Spacelab Mission-1 Analog Data Tapes (ANDTs).* CSC/SD-82/6027, GSFC, Greenbelt, Maryland 20771, March 1982.

8. --, *Interface Control Document for Spacelab Master Audio Tapes (MATs) and Audio Cassette Tapes (ACTs).* CSC/SD-81/6006 UD2, GSFC, Greenbelt, Maryland 20771, April 1982.

9. --, *Interface Control Document for Spacelab Input/Output Channel Tapes (SICTs).* CSC/SD-80/622 UD3, GSFC, Greenbelt, Maryland 20771, August 1983.

10. --, *Interface Control Document for Spacelab Experiment Channel Tapes (SECTs).* CSC/SD-80/6222 UD3, GSFC, Greenbelt, Maryland 20771, August 1983.

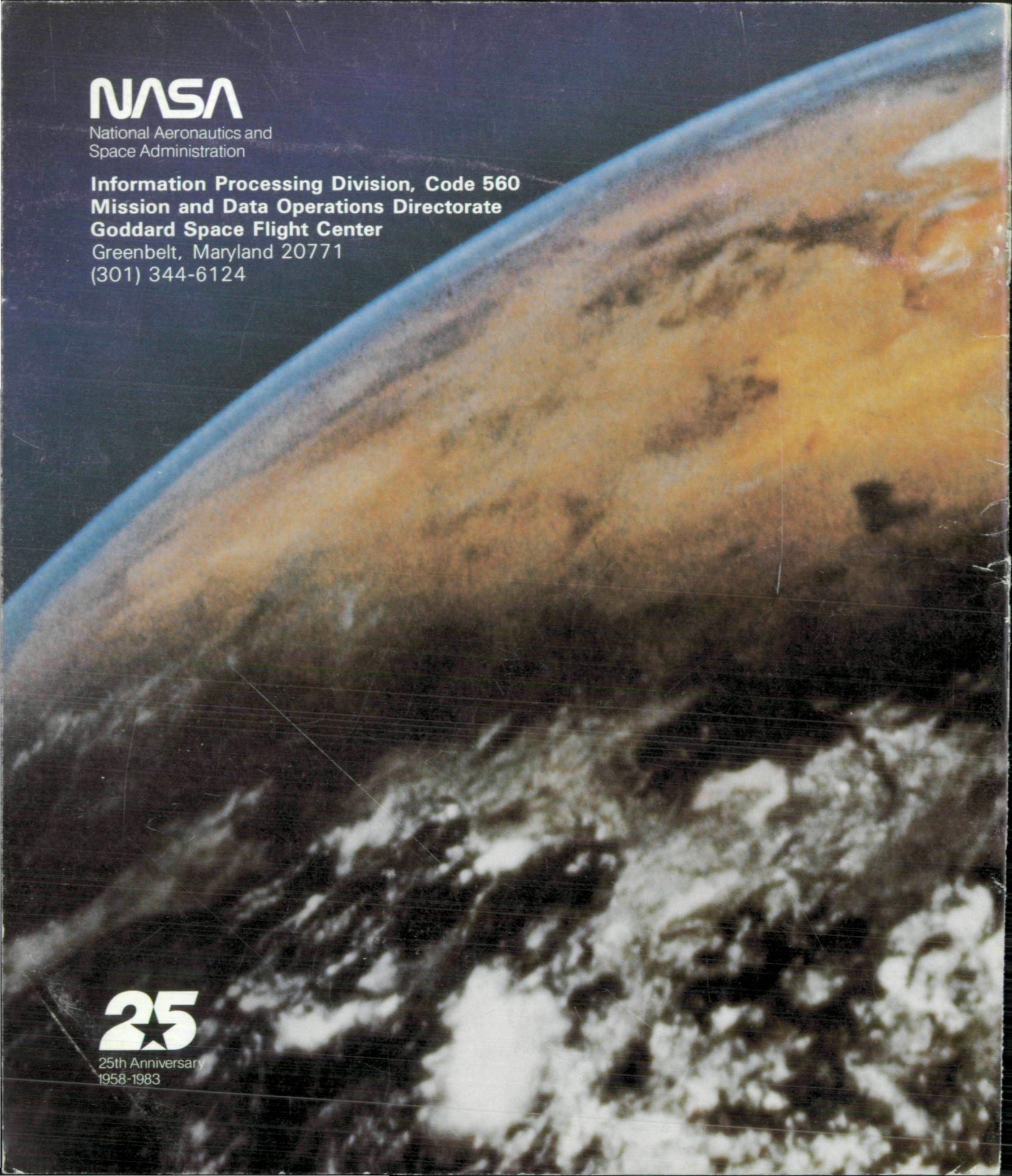
11. --, *Interface Control Document for Spacelab Ancillary Data Tapes (SANCs),* CSC/SD-80/6216 Revision 1 UD1, GSFC, Greenbelt, Maryland 20771, August 1983.

12. --, *Interface Control Document for Spacelab Quality Control and Accounting Data Computer-Compatible Tapes (SQATs).* CSC/SD-79/6123 UD6, GSFC Greenbelt, Maryland 20771, January 1983.

13. --, *Interface Control Document for Spacelab Post Mission Ancillary Data Tapes (SPMAs).* GSFC, Greenbelt, Maryland 20771, to be issued summer of 1983.

# Glossary

| | |
|---|---|
| ARMS | Audio Recording and Monitoring Subsystem |
| A/V | Analog/Video |
| BPI | Bits Per Inch |
| CCT | Computer-Compatible Tape |
| CCTV | Closed-Circuit Television |
| CMC | Configuration Manager's Console |
| DAC | Direct Access Channel |
| DEMUX | Demultiplexed |
| Domsat | Domestic Satellite |
| EC | Experiment Computer |
| FSS | Frame Synchronizer Subsystem |
| FSU | Frame Synchronizer Unit |
| GN&C | Guidance, Navigation, and Control |
| GSFC | Goddard Space Flight Center |
| HDRR | High Data Rate Recorder |
| HDT | High-Density Tape |
| HIT | HRDM Interface Controller and Time Code Converter |
| HRDM | High-Rate Demultiplexer |
| HRM | High-Rate Multiplexer |
| IDT | Instrumentation Data Tape |
| I/O | Input/Output |
| JSC | Johnson Space Center |
| Kbps | Kilobits per second |
| KSC | Kennedy Space Center |
| Mbps | Megabits per second |
| MHz | Megahertz |
| MSFC | Marshall Space Flight Center |
| NASA | National Aeronautics and Space Administration |
| NASCOM | NASA Communications |
| NCC | Network Control Center |
| OANC | Orbiter Ancillary |
| PATH | Postflight Attitude and Trajectory History |
| PCM | Pulse-Code Modulation |
| PLR | Payload Recorder |
| POCC | Payload Operations Control Center |
| PB | Playback |
| QA | Quality Assurance |
| RT | Real Time |
| SANC | Spacelab Ancillary Data Tape |
| SC | Subsystem Computer |
| SECT | Spacelab Experiment Channel Tape |
| SEDT | Spacelab Experiment Data Tape |
| SICT | Spacelab I/O Channel Tape |
| SIDT | Spacelab I/O Data Tape |
| SIPS | Spacelab Input Processing System |
| SEL | Systems Engineering Laboratories |
| SL | Spacelab |
| SLDPF | Spacelab Data Processing Facility |
| SOPS | Spacelab Output Processing System |
| SPMA | Spacelab Postmission Ancillary Tape |
| SQAT | Spacelab Quality Control and Accounting Tape |
| TDRS | Tracking and Data Relay Satellite |
| TDRSS | Tracking and Data Relay Satellite System |
| VFI | Verification Flight Instrumentation |



NASA

National Aeronautics and
Space Administration

**Information Processing Division, Code 560**
**Mission and Data Operations Directorate**
**Goddard Space Flight Center**
Greenbelt, Maryland 20771
(301) 344-6124

25th Anniversary
1958-1983