X-604-76-82

PREPRINT

REQUIREMENTS AND SPECIFICATIONS OF THE SPACE TELESCOPE FOR SCIENTIFIC OPERATIONS

NASA-TM-X-71160

D. K. WEST

MARCH 1976

GSFC
GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

(NASA-TM-X-71160) REQUIREMENTS AND SPECIFICATIONS OF THE SPACE TELESCOPE FOR SCIENTIFIC OPERATIONS (NASA) 36 p HC $4.00 CSCL 03A
N76-29100
Unclas
G3/89 48571

REQUIREMENTS AND SPECIFICATIONS OF THE SPACE TELESCOPE FOR SCIENTIFIC OPERATIONS

D. K. West

March 1976

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

REQUIREMENTS AND SPECIFICATIONS OF THE SPACE TELESCOPE FOR SCIENTIFIC OPERATIONS*

ABSTRACT

Requirements for the scientific operations of the Space Telescope and the Science Institute are used to develop operational interfaces between user scientists and the NASA ground system. General data systems are defined for observatory scheduling, daily science planning, and science data management. Hardware, software, manpower, and space are specified for several Science Institute locations and support options.

*Part II of the Space Telescope Science Institute Study.

GLOSSARY

BPI	Bits Per Inch
CPU	Central Processing Unit
FFT	Fast Fourier Transform
H/W	Hardware
I/O	Input/Output
IPF	Image Processing Facility
IUE	International Ultraviolet Explorer
JPL	Jet Propulsion Laboratory
MOC	Mission Operations Center
MY	Man-Years
OAO	Orbiting Astronomical Observatory
OTA	Optical Telescope Assembly
RFI	Radio Frequency Interference
SCPS	Support Computer Processing System
SECO	Secondary Electron Conduction Orthicon
SI	Scientific Instrument(s)
SOC	Scientific Operations Center
SSM	Support Systems Module
ST	Space Telescope
STDN	Spacecraft Tracking and Data Network
S/W	Software
TA	Target Acquisition
TELOPS	Telemetry Operations Processing System
TM	Telemetry
VICAR	Video Image Communication and Retrieval

REQUIREMENTS AND SPECIFICATIONS OF THE SPACE

TELESCOPE FOR SCIENTIFIC OPERATIONS

SPACE TELESCOPE
SCIENCE INSTITUTE STUDY
PART II

CONTENTS

ILLUSTRATIONS

TABLES

REQUIREMENTS AND SPECIFICATIONS OF THE SPACE

TELESCOPE FOR SCIENTIFIC OPERATIONS

I. ST OPERATIONAL REQUIREMENTS

The operational requirements for the Space Telescope (ST) presented here are those which are relevant to the relationship between the ST Science Institute and the NASA ground system. The requirements given in this section address the technical interfaces between mission operations, scientific operations and the NASA support facilities serving both these functions.

The requirements are presented in four areas: Spacecraft Operations, Spacecraft Data Management, Science Operations, and Science Data Management. In addition to the basic conceptual requirements which should not change significantly over the ST development period, there are quantitative requirements and specifications which are design and operational dependent. Current baseline values for this latter type are listed separately as System Parametric Data.

A. Spacecraft Operations

The primary function of Spacecraft Operations is to control the orbital operation of the spacecraft to insure the health and welfare of the ST for the life of its mission. Other important functions are: mission planning and scheduling of the Support Systems Module (SSM) and the Optical Telescope Assembly (OTA) subsystem tests; monitoring status and engineering data; spacecraft command control; routine and emergency analysis of ST performance; specification and update of all spacecraft operational constraints; and initiation of spacecraft emergency procedures.

The requirements for Spacecraft Operations are separated into three areas: mission planning, command message generation, and spacecraft security.

1. Mission Planning

The operation of the spacecraft requires long-range and daily planning in support of: the technical feasibility evaluation of guest observer's proposals, ST on-orbit updates and earth returns, routine SSM and OTA subsystem tests, special calibrations and other checkout procedures, and special maneuvers for constrained SI observations.

2. Command and Message Generation

The implementation of the mission plan requires: specification and updates to all spacecraft operational constraints and procedures, daily preparation and input of subsystem command procedures; and command message review, evaluation, and final approval.

3. Spacecraft Security

The health and safety of the ST requires: monitoring spacecraft engineering data in real-time and post pass, indepth analysis of spacecraft performance in both routine and emergency situations, controlling and transmitting all real-time commands as well as advanced planned stored commands, and the initiation of spacecraft emergency procedures.

B. Spacecraft Data Management

Spacecraft data management includes telemetry (TM) processing and engineering data display.

1. Telemetry Processing

The processing of spacecraft requires: TM staging, storage, and error checking; TM data processing and conversation to engineering units; limit checking and out of limit flagging; and data storage for on-demand call up.

2. Data Display

Engineering data display requirements are: display to subsystem controllers of all relevant subsystem data pages, instant alarm displays, strip chart recordings of time dependent data, printouts and history tapes of spacecraft performance data.

C. Scientific Operations

Scientific operations is mainly concerned with the planning and implementation of scientific programs on the ST. The requirements for SI operations fall into the logical categories of long-range observatory planning and scheduling, guest investigator support, daily planning, real-time operations, and quick-look data processing and display.

1. Long-Range Observatory Planning and Scheduling

The requirements in this area are: proposal evaluation for operational feasibility and total telescope time requirements; target availability as function of time of year, target list screening for operational constraints and guide star availability, specific time observations timeline generation, long term Observatory scheduling, preparation of computer input planning data, and the preparation of target acquisition aids (finder fields, etc.).

2. Guest Investigator Support

Guest Investigator support includes: the maintenance of user manuals for program planning including sample programs and data; user orientation training and familiarization with operational and data processing interfaces; staff astronomer assistance to the user for long-range planning prior to his observing run on the ST; staff astronomer and operator assistance to the user in the daily implementation of observations, target acquisition and the specification of data processing tasks; the collation and evaluation of quick-look and final processed data for the user's output data package; and staff astronomer response to questions arising during the user's scientific analysis and publication period.

3. Daily Planning

The daily planning of observations requires: target sequencing, background constraint timelining, SI operation sequencing, SI mode specification, observational and operational constraint checks, specific time and specific slew generation, preparation of real-time target acquisition and SI operational procedures, preparation of moving target (solar system) ephemeri, and the specification of offset guide stars.

The daily preparation of delayed mode observing plans requires: SI observation profile input tape generation, operational constraint checks, SI command load generation, and command message validation and approval.

The daily preparation for real-time operation requires: generation of real-time command procedures, preparation of target acquisition data and identification aids, generation of the real-time pass computer input file, and the validation and approval of real-time pass-profiles.

4. Real-Time Operations

Real-time operations requires: the real-time commanding of SI's, the execution of small adjustments to spacecraft pointing to accomplish closed-loop-to-ground target identification and target positioning in SI apertures, the commanding of ST data readout and TM transmission, and the processing and display of engineering and science data.

5. Quick-Look Data Display

SI and spacecraft operational verification using quick-look data displays requires: real-time and near-real-time display of selected engineering and science data, image condensation and zooming for real-time or near-real-time TV display and evaluation. The primary data display hardware is a computer interactive TV screen with pseudo color. Permanent hard copy, and supporting hard copy is in the form of strip chart recordings, photographic copy, and computer output tapes and printouts.

6. Quick-Look Data Processing

The evaluation of ST performance and science data quality requires: minimal geometric and radiometric corrections, pixel averaging and smoothing; annotation and guiding such as counts vs. wavelength, subframe selection, zooming and condensing for visual TV display, spatial and intensity enhancements, and color scale and gray scale assignment.

D. Science Data Management

Science data management presents very demanding requirements on ST ground data handling systems in terms of processing complexity and large data volumes.

The requirements for this task can be separated into the subtasks of: data preprocessing, data processing (including image processing), data enhancement, data calibrations, interactive processing, data products, support data, and final data archival and retrieval.

1. Data Preprocessing

Preprocessing of ST data requires: short term storage of all engineering and science TM; selection and conversion; quick-look processing; decomutation of science data; and output data formatting for high density tape, remote displays, and data storage and content documentation.

2. Data Processing

Science data processing is defined to be the application of standardized corrections and calibrations to the preprocessed data prior to its delivery to the user for scientific analysis.

Background corrections are required for the removal of backgrounds due to: particle radiation (such as in the South Atlantic Anomaly), scattered light from internal and/or external sources, and sky background (such as zodical light).

Noise correction techniques are required to remove noise due to: random noise sources present in sensor and camera electronics, and periodic noise induced by spacecraft radio frequency interference (FRI) and/or transmission links.

Geometric corrections to image data are required to correct pixels for: telescope optical image distortion, SI optical distortions, and electronic image distortions in sensor/camera systems.

Radiometric corrections are required to take care of: non-uniform response characteristics of optical photosensitive components, intensity transfer characteristics of sensors and camera systems.

3. Data Enhancement

Data enhancement techniques are useful tools for certain special applications of data and image processing and analysis.

Image enhancement techniques include: spatial frequency manipulations, contrast enhancement and intensity thresholding.

Deconvolution of spectral features which are emperical slit profiles and other instrumental functions to enhance spectral resolution will be a useful tool for several special analysis applications.

4. Data Calibrations

Wavelength calibration is required for spectral data. Calibration data is obtained from: analytical functions, and spectral line reference points in comparison spectra.

Flux calibration, both relative and absolute, is required. Flux will be calculated as a function of wavelength or filter bandpass. Calibration data will be obtained from standard star observations and SI sensitivity functions and internal sources.

Other calibrations required to be applied to the science data are: time correlation of spacecraft and/or SI engineering data with the science data, application of pre-determined calibration tables and functions, and conversion to user oriented measurement units.

5. Interactive Processing and Display

Manual intervention to on-line data processing through the use of computer interactive terminals will be applicable in cases where: interaction is necessary for non-standard data processing tasks, and when it is used as a software development tool. Black and white and color TV display of SI engineering and science data is required for real-time operations and for off-line retrieval and review of final data products.

6. Data Output Hard Copy Products

Final data output products requirements call for: high density tapes for long term storage; computer compatible tapes in several standard formats for user analysis; high resolution photographic output in standard sized prints, transparency and microfilm; plots, strip charts, and computer printouts.

7. Support Data

In addition to the calibration data requirements mentioned above, there is a requirement for observation related orbital, SI, and spacecraft information which includes: GMT correlations; SI status data; relevant temperature and voltage histories; spacecraft pointing, guidance errors and offsets; off-axis location of bright sources; background monitor data; orbital velocities relative to line of sight and orbit and attitude data.

8. Final Data Archival and Retrieval

Final processed data will be temporarily archived in the Science Institute for immediate, short term use and permanently archived in the National Space Science Data Center (NSSDC) where it will be made available to the public through an efficient and convenient retrieval system. The ST archival and retrieval system requirements include: long term storage of all final processed science data on tape and photographic media, maintenance and timely publication of ST "plate files" and observation lists, observation index, SI performance histories, computer interactive data displays for user preview of data, and rapid data retrieval and distribution.

E. GROUND SYSTEM PARAMETRIC DATA

1. Long Range Planning

Observing Proposal Cycle	1 yr
Astronomical Programs	25/yr
Principal Investigators	4/yr
Guest Investigators	50/yr
Spacecraft Pointings (including TA)	4000/yr
Guest Investigators Present	6/day
Plan Lead Time	3 mo

2. Daily Planning

Observations	50/day
Stored Commands (average)	10K/day
Spacecraft Slews (maximum)	10/day
Minimum Lead Time	12 hrs
Command Message Time Span	24 hrs
Maximum Lead Time	72 hrs

3. Real-Time and Quick-Look

Real-time Contacts (average)	2/orbit
Maximum Length	30 min
Minimum Length	5 min
Command Load Uplink (maximum)	1K/orbit
Display Data Points	500 × 500
Image Data Base Size	2000 × 2000
Image Update Delay Time	1 min

4. Data Preprocessing

Maximum Data Frames	50/day
Maximum Bit Rate	3×10^9 bits/day
Input Transmission Rate	1 MBS
Batch Output Delivery Time	24 hrs
Quick-Look Delivery Time	1 min
Temporary Storage of Raw Telemetry	1 week

5. Image Processing

Data Frames (average)	15 (2000 × 2000)/day 21 (512 × 512)/day
Bit Rate (average)	6×10^8/day
Output Delivery Time	1 week
Applications Software Update Time	1 day
Display size	500 × 500 elements

6. Data Archival and Retrieval

Data Frames (average)	5.5K (2000 × 2000)/yr 7.5K (500 × 500)/yr
Bit Volume (average)	2×10^{14}/yr
Storage Time	50 yrs
Retrieval Time	1 week
Bit Error Rate	10^{-6}/yr

II. DATA SYSTEMS DEFINITION

In this section, the operational requirements presented in Section I are followed in the development of the ground system design and the interfaces between the Mission Operations Center (MOC) and the Science Institute. Specifications for hardware, software, manpower, and space are derived for the Science Institute functions and responsibilities defined in the "Space Telescope (ST) Science Institute Study".

In order to better understand the total scope of the ST data systems, we will first develop the specifications for a completely independent dedicated capability for science planning and data management.

A. Observatory Scheduling and Daily Observation Planning

Hardware and software are required to support long-range observatory scheduling and daily observation planning. Computational tasks include: exposure time estimation, constraint violation checks, determination of accurate coordinates, guidestar selection, and target availability.

1. Software

GSFC has been working a low cost approach to generalize space astronomy science planning through the use of existing Orbiting Astronomical Observatory (OAO) and the International Ultraviolet Explorer (IUE) software. Existing software can be modified to meet ST requirements and incorporated into a long-range observatory scheduling software system for the ST. The general system is at present about 60% complete. The daily observational planning and scheduling system required for the ST can also be derived from existing IUE and OAO software.

Tables II-1 and II-2 show the program sizes for the long-range and daily science planning software systems. The total requirement is for 108K machine instructions and for about two hours of 360/75 equivalent computer time per day. These estimates are based on the sizes of identical and/or equivalent programs developed for OAO and IUE, as well as on the current work being done at GSFC to build the science planning systems through the use of existing software. The programs listed are written in Fortran and run on the IBM 360/75 and 360/91 computers.

2. Hardware

Hardware specifications are obtained from the requirements for program run time, core size, disk space, tape drivers, and interactive terminals.

As seen in Table II-3 and II-4, existing programs will fit in 100K words on a 360/75 computer or an equivalent of 3.2 million bits of core storage. Science long-range planning can be accomplished at any time and does not require a dedicated computer. Daily planning, however, must be done on an on-demand around-the-clock basis which does require a dedicated computer. Daily planning will take 108 minutes of 360/75 time per day. Long-range planning will run an average of 10 minutes per day.

Computers smaller than the 360/75 would be adequate for daily planning provided they can dedicate the required core and are not slower than 1/5 the speed of a 360/75. A medium sized computer like a Sigma 9 which is about 1/3 to 1/5 the speed of a 360/75 can be configured with 128K of core, at least four tape drives, interactive terminals, and large disk space. Detailed specification of this hardware is given in Table II-5.

3. Staff

The Science Institute will support mission operations by providing an operational crew co-located with the Mission Operations Center. The function of this staff will be to conduct all phases of on-line scientific operations required to effectively conduct mission operations. These functions include: daily planning, observation implementation, real-time operation, quick-look data verification, and the coordination of mission and science planning.

Table II-1
Observatory Planning and Scheduling Software Sizing

Program	Instructions (K)	Runs/Mo.	Mins	Mins/Mo.
Target Availability and Telescope Time Req.	15.5	4	20	80
Sky Contraints	8.3	4	10	40
Guide Stars, Finder Fields and Accurate Coords.	11.2	4	18	72
Scheduler	12.4	4	19	76
Output Compilations	8.0	2	5	10
Target File Maint.	2.6	2	2	4
User Planning Aids	2.0	2	3	6
Totals	60K			288 Mins/ Month

Table II-2
Daily Planning and Scheduling Software Sizing

Program	Instructions (K)	Runs/Day	Mins	Mins/Day
Input	1.6K	2	1.0 M	2
Subcycle Initialize	4.0	2	1.0	2
Segment Schedule	16.0	2	2.0	4
Command Generator	12.0	2	2.0	4
Output	4.0	3	2.0	6
Display Graphics	10.4	3	30.0	90
Totals	48K			108 Mins/ Day

Table II-3
Observatory Planning and Scheduling Hardware Sizing

Core Size	400K Bytes	3200K Bits
Disk Space	350K Bytes	2800K Bits
Tape Drives	3	
Terminals	1	

Table II-4
Daily Planning and Scheduling Hardware Sizing

Core Size	400K Bytes	3200K Bits
Disk Space	300K Bytes	2400K Bits
Tape Drives	3	
Terminals	2	

Table II-5
Daily Science Planning Computer Hardware

A typical medium sized computer system (Σ 9) which could be used for science planning would consist of:

Central Processing Unit	Σ 9
Core	128K Words
Disk	98M Bytes
Card Reader	1
Tape Drives	4
Printer	1
Display	1

B. Data Management

The most demanding of all ST operational requirements are those of science data management. The ST will transmit several image frames per orbit. Each frame requires preprocessing of raw telemetry data to strip out science data and output it in a format suitable for further data reduction tasks. Image processing of 20 to 50 frames per day requires fast computer hardware and highly sophisticated software systems. These requirements identify the need for significant resources.

In order to underline the scope of the ST data management and processing problem, we will now develop the specification of the hardware and software required for a complete SI dedicated data processing capability in the areas of data preprocessing, image processing, general data reduction and data output products.

1. Data Preprocessing

Data preprocessing consists of routine stripping, error checking, decoding, data conversion, and output formatting. A system which would meet the ST preprocessing requirements is specified in Table II-6.

2. Image Processing

The software requirements for a completely dedicated image processing system are shown in Tables II-7 and II-8. The tabulated program sizes are derived from existing image processing software developed for the IUE. The IUE image processing system will accomplish all the types of image processing required

Table II-6
ST Data Preprocessing
Hardware and Software Specification

Hardware	IPF
Software	5K Instructions
Space	1000 sq. ft.

Table II-7
Image Processing System Software Sizing

Program	Instructions
Control Executive	9 K
Communications Control	7 K
Diaglogue Handler	7 K
File Management	8 K
Accounting	2 K
Output	1 K
Utilities	7 K
Total	41 K

Table II-8
Image Processing Science Applications Software

Programs	Old Inst.	New Inst.	Total Inst.
1) Random Noise and Background Removal	4K	–	4K
2) Periodic Noise Removal	70K*	2	12
3) Geometric Correction	25	2	27
4) Enhancement and Deconvolution	8	1	9
5) Wavelength Calibration	20	2	22
6) Photometric Calibration	17	17	34
7) Output P. ducts Preparation	2K	–	2
8) Display	5K	–	5
Total			115K

*Includes 60K of IPF facility software.

by the ST. The IUE will produce about 20 SEC camera images (up to 1000 × 1000 data points, 8 bits deep) per day. The system is designed to provide 24 hour processed data delivery and will be operated 8 hours per day.

The ST will produce about 15 SEC camera images (2000 × 2000 data points, 10 bits deep) per day and about 21 other images (500 × 500) per day. Since the type of processing for ST is the same as IUE, the size of IUE systems programs (shown in Table II-7) can be used directly. Table II-8 gives the sizes for the image processing science applications programs required for the ST including new ST software additions.

The Central Processing Unit (CPU) and Input/Output (I/O) times shown in Table II-9 are in minutes of IBM 360/75 computer derived from test runs at GSFC. A standard computer like the IBM 360/91 comes close to meeting the ST requirements for speed and size.

Other solutions can be found in the form of specialized computer hardware systems. Parallel processors using several mini-computers with high speed I/O feeds similar to the Image Processing Facility (IPF) master data processor at GSFC is one example. Also, special purpose hardware (such as hardwired processors for fast Fourier transformation tasks) to accomplish high speed computations can be added to slower computers like IBM 300/75 or a CDC 6400.

A system similar to IPF, which would accomplish the ST image processing task, is shown in Table II-10.

3. General Data Reduction and Hard Copy Facility

Final data reduction and output products generation at the Institute requires a mini-computer and hard copy equipment.

A typical mini-computer system and hard copy facility are specified in Table II-11.

The software required to accomplish general data reduction (non-image processing) is estimated to be about 50K machine instructions.

The space required for these facilities will be about 500 square feet.

Table II-9
Image Processing Science Applications Software Timing

Program	Frame Size	Frames Per Day	Mins/Frame CPU	Mins/Frame I/O	Mins/Day CPU	Mins/Day I/O
1. Random Noise	2000 × 2000	16	1.9	1.6	30	26
and Background	500 × 500	21	0.1	0.1	2	2
2. Periodic Noise		16	60	1.6	960	26
Removal		21	3	0.1	63	2
3. Geometric		16	27	1.6	432	26
Correction		21	1.7	0.1	36	2
4. Enhancement		16	7.7	1.6	123	26
		21	0.03	0.1	1	2
5. Wavelength		0	6.7	3.2	0	0
Calibration		7	0.42	0.2	3	1
6. Flux (Photometric)		21	8	3.2	168	67
Calibration		16	0.5	0.2	8	3
7. Output Products		21	0.2	1.6	4	34
Preparation		16	0.13	0.1	2	2
8. Display		16	1	3.2	16	51
		21	1.1	0.2	23	4
Totals					1871	274

Table II-10
Image Processing Hardware Specifications

The hardware specification for a special purpose computer system similar to IPF is:

Central Computer	Σ 5 type
	ASP
Terminals	1
High Density Tape Recorders and Controllers	3-HDT
Computer Compatible Tape Drives	4-6250 BPI

Table II-11
General Data Reduction Facility Hardware Specification

The hardware for a typical mini-computer system and hard copy facility are specified as:

Mini-Computer System

CPU	PDP 11/70
Core	100K Words
Disk	32M Bytes
Tape Drives	4
Card Reader	1
Printer	1
Display	1

Hard Copy Facility

Dark Room	1
Film Processors	2
Photowrite	2
Plotter	2

III. SYSTEM CONFIGURATION FOR SCIENCE INSTITUTE LOCATION OPTIONS

Plans for the management of science data are highly dependent on the location of the ST Science Institute. Several configurations are considered: Institute at or near GSFC, Institute Remote-Independent, Institute Remote-Modified, and Institute Remote-Dependent.

A. Institute Located at or Near GSFC

Data management plans for this case assume the use of institutional facilities at GSFC.

Studies have identified several major resources at GSFC which are ideally matched to the ST hardware and software requirements in the areas of science planning and scheduling, data preprocessing, and image processing.

The International Ultraviolet Explorer (IUE) is an international observatory which will host at least 50 guest observers per year. Astronomers will come to Goddard to carry out their observations in a real-time operating environment similar to ground based observatories. Software and hardware for long-range guest observer scheduling and real-time target acquisition systems are currently being developed for a 1977 launch. These IUE scientific operations systems are ideally matched with the ST requirements for Observatory schedu-long, daily science planning, and real-time closed-loop-to-ground target acquisition.

The ST requirements for the temporary storage and preprocessing of spacecraft data and 1×10^9 bits per day of science data for merging, stripping, processing, formatting, and quick-look output can be completely satisfied by using the preprocessor in the Image Processing Facility (IPF).

The Image Processing Facility (IPF) under development at Goddard is a large scale fast computer system which will process up to 1×10^{11} bits per day. In addition, IPF is able to accommodate the scientists' need for direct control of calibration data sets, scientific algorithms and applications programs which can be developed and maintained by the user.

The IUE Image Processing System which is under development at GSFC is designed to perform geometric and radiometric corrections; flux and wavelength calibrations; and periodic and random noise removal. This system, which was derived from the JPL (VICAR) image processing system, can be modified and expanded to handle 2000 × 2000 Secondary Electron Conductio· ·con (SECO) Camera images produced by the ST. The IUE image proc· ·em will be operational early in 1977.

Figure III-1 shows the major elements of the ground system for the case of the Institute located at or nearby GSFC. Those elements which will provide institutional support services to ST are shaded. Unshaded blocks contain ST dedicated facilities. The mission planning computer (Support Computer Processing System (SCPS)), and Spacecraft Tracking and Data Network (STDN) presently provide institutional support services to OAO. These facilities are well demonstrated and need not be discussed here.

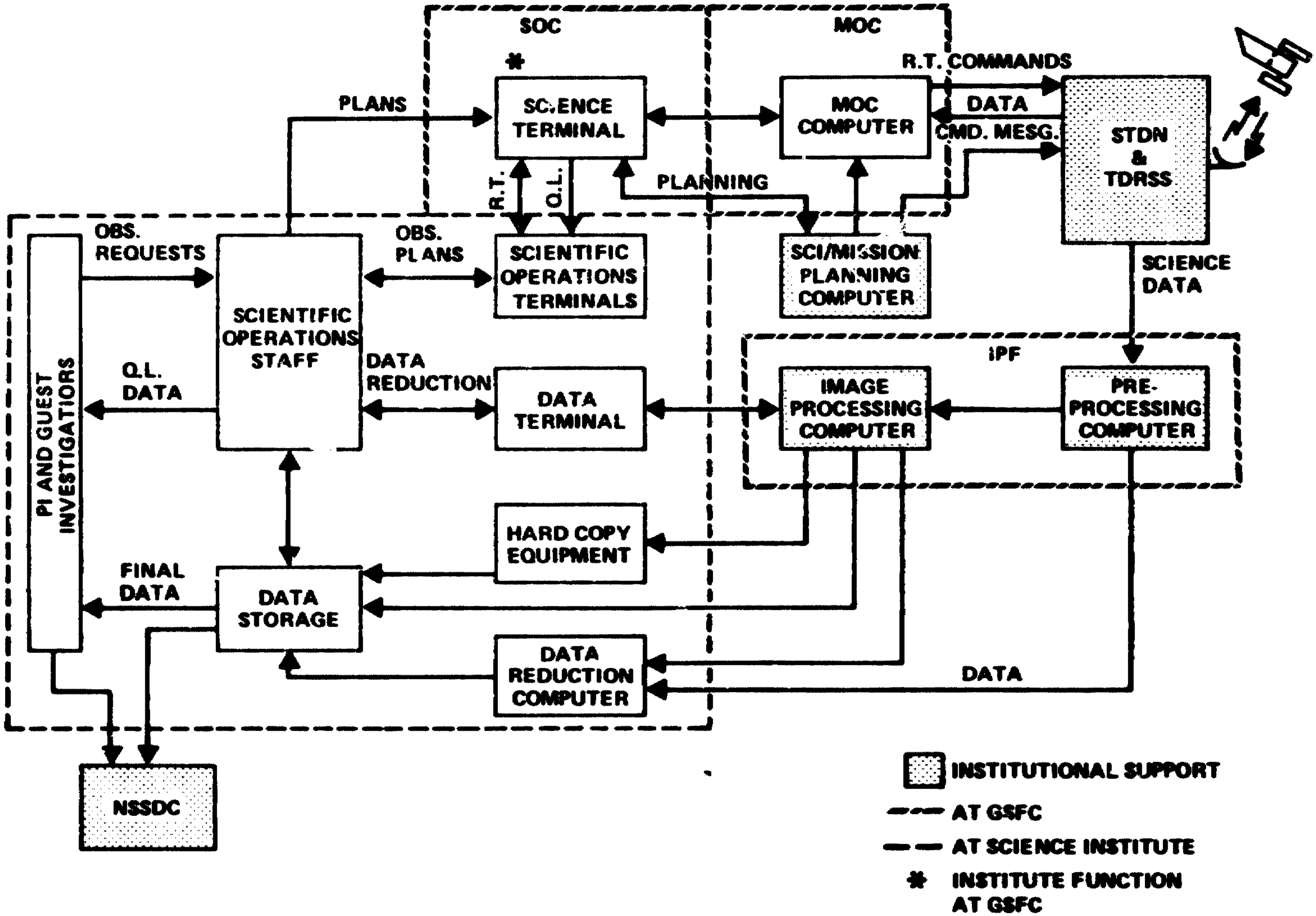

Figure III-1. Science Institute At or Near GSFC

On the following pages, we will list the hardware, software, manpower, and space required to develop and operate the scientific facilities as configured for the At or Near GSFC Option.

1. Preprocessing

Preprocessing of ST data at GSFC would be done in the IPF. The only additional hardware and software which the ST might require would be a display terminal and small amounts of software which might be considered project unique.

2. Image Processing

Most of the SI image processing software will be provided by modifying existing IUE programs. IPF will provide all the systems software required plus some standard correction programs. Special applications programs would be ST unique software.

IPF will provide the major hardware components for image processing. Unique ST hardware will be interactive terminals.

Hardware:

Computer System	IPF
Terminals	1
Integration	IPF

Software Development:

Program Analysis	3 MY
Old Instructions	50K
New Instructions	20K

Operations (16 hrs per day):

S/W Maintenance	8 MY
Technicians	4 MY

Space: 500 sq ft

3. Observatory Scheduling and Daily Planning

This function will be done on the GSFC Mission Planning Computer (SCPS) which will provide all system software and facility operations.

Hardware:

Computer System	SCPS
Terminals	1

Software Development:

Program Analysis	2 MY
Old Instructions	10K
New Instructions	10K

Operations (24 hrs per day):

Operators	4 MY
S/W Maintenance	2 MY
Technicians	2 MY
H/W Maintenance	2 MY

Space: 1500 sq ft

4. General Data Reduction and Hard Copy Lab

The Institute will, in all cases, have a dedicated facility for final data reduction and hard copy output products. The specifications for a typical mini-computer and photo lab are:

Hardware:	
Computer System	PDP 11/70
Hard Copy Lab	1
Software Development:	
Program Analysis	2M
New Instructions	50K
Operations (16 hrs per day):	
Operators	4 MY
H/W Maintenance	3 MY
S/W Maintenance	2 MY
Technicians	4 MY
Space:	800 sq ft

B. Science Institute Remote-Independent

Figure III-2 shows the major elements of the ST ground system for the case of a remotely located independent Institute. NASA support services provided by STDN and the MOC are unchanged. Also, the NASA requirements for an on-site Institute crew co-located with the MOC remains the same. The interface between the Science Institute and GSFC will be standard voice and land data lines. Institute staff will have voice and display terminal communication with the co-located Institute staff at GSFC. The Institute will transmit long-range science plans to GSFC for implementation and will receive SI engineering and science data for processing.

Data management in the case where the Institute is remotely located from GSFC is accomplished with ST dedicated hardware and software at the Institute.

Raw science data and engineering data will be recorded on tape at GSFC. This tape will be transmitted over standard data links or will be mailed to the Institute.

The Institute will be responsible for all science data preprocessing. Preprocessed data will be staged for subsequent processing on an image processing computer and final data reduction on the Institute's general data reduction computer.

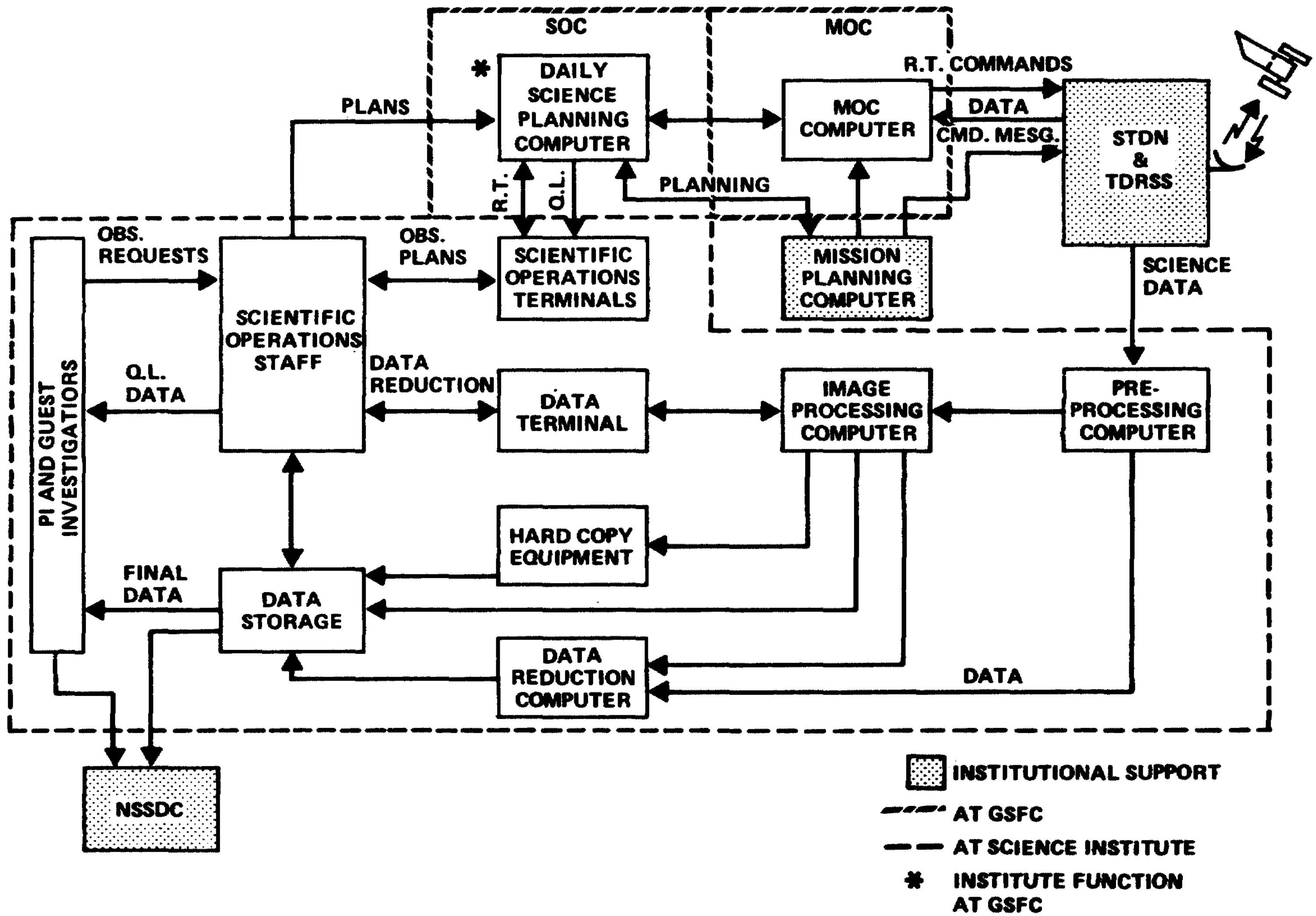

Figure III-2. Science Institute Remote from GSFC

It is assumed that these computers will be software compatible with existing GSFC software which would be given to the Institute for their conversion and modification tasks.

The following pages list the hardware, software, manpower, and space required to develop and operate the scientific facilities as configured for the Remote-Independent Option.

1. Preprocessing

Preprocessing of ST data can be accomplished at the Institute with a facility similar to IPF.

2. Image Processing

Image processing can be accomplished at the Institute through the use of conventional computers such as an IBM 360/91 or a 370/168 or with special purpose mini-computer systems such as GSFC's IPF. The latter system is recommended as the less expensive of the two and is specified here.

Hardware:

Central Computer	Σ 5 type ASP
Terminals	1
High Density Tape Recorders and Controllers	3-HDT
Computer Compatible Tape Drives	4-6250 BPI
Integration	5 MY

Software Development:

Program Analysis	10 MY
Old Instructions	120K
New Instructions	22K

Operations (16 hrs per day):

Operators	15 MY
S/W Maintenance	10 MY
Technicians	6 MY

Space: 2000 sq ft

3. Daily Science Planning

This function will be carried out on the Science Planning Computer which will be the responsibility of the Institute. A typical facility is specified as follows:

Hardware:

CPU	Σ9
Storage	100M Bytes
Tape Drives	4
Displays	1
Integration	2 MY

Software Development:

Program Analysis	3 MY
Old Instructions	50K
New Instructions	10K

Operations (24 hrs per day):

Operators	4 MY
H/W Maintenance	3 MY
S/W Maintenance	4 MY
Technicians	3 MY

Space: 1500 sq ft

4. Observatory Scheduling

This function can be performed on a dedicated Science Planning Computer or on the image processing system in an off-line mode. A dedicated facility is specified below:

Hardware:

Computer System	Σ 9
Terminals	1

Software Development:

Program Analysis	3 MY
Old Instructions	60K
New Instructions	10K

Operations (1 hr per day):

Operators	1 MY
S/W Maintenance	3 MY
Technicians	2 MY

Space: 500 sq ft

5. General Data Reduction and Hard Copy Lab

This facility is the same for all location options as specified in Section III-A4.

C. Science Institute Remote-Modified

This option considers the case where the Institute is remote and rents computer time on computers which are not compatible with existing software.

1. Preprocessing is done on the image processing computer.

2. Image Processing

Hardware:

Terminal	1

Software Development:

Program Analysis	10 MY
Convert Old Instructions	120K
New Instructions	22K
Computer Hours	5K

Operations (3 hrs per day):

Computer Time	1K hrs/yr
S/W Maintenance	8 MY
Technicians	4 MY

Space:	800 sq ft

3. Observatory Scheduling

Observatory scheduling would be accomplished by renting computer time at the existing facility.

Hardware:

Terminals	1

Software Development:

Program Analysis	4 MY
Old Instructions	60K
New Instructions	10K
Computer Time	3K hrs

Operations (1 hr per day):

S/W Maintenance	2 MY
Technicians	2 MY
Computer Time	300 hrs/yr

Space: 500 sq ft

4. Daily Science Planning

This function would be carried out on the Science Planning Computer at GSFC. The specification is the same as described in the Remote-Indpendent Option.

5. General Data Reduction and Hard Copy Products

This specification is the same for all options.

D. Science Institute Remote-Dependent

In this case the Institute is remote but depends on GSFC to provide preprocessing and image processing support.

1. Preprocessing

This function is accomplished on IPF as specified in the At or Near GSFC configuration.

2. Image Processing

This function is accomplished on IPF as specified in the At or Near GSFC configuration.

3. Observatory Scheduling and Daily Planning

These functions are accomplished as described in the Remote-Independent configuration.

4. General Data Reduction and Hard Copy Products

This specification is the same for all options.