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Radio Science Handbook

Mars Observer/Galileo/Ulysses Joint Gravitational Wave Experiment
Galileo Redshift Observations/USO Tests
Mars Observer Cruise Tests

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Galileo Science Team Chiefs please circulate your copy to team members.

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SECTION 1

INTRODUCTION

1.0 The Radio Science Handbook

The Radio Science Handbook is an internal reference document prepared and used by the Radio Science Support Team for planning, preparation, real-time operations, post-activity operations, and analysis of the activities listed on the cover page. It contains information, plans, strategies, and procedures to guide and assist the team members to achieve the goals identified for the activities being supported. It also contains descriptions of the various functions and roles, capabilities and facilities of the Radio Science Support Team.

This Handbook **does not** replace Flight Project or DSN documents and procedures. The Project Sequence Of Events (and associated redlines) and the DSN's Network Operations Plan and Keyword File are intended to be the controlling documents for Radio Science activities.

Since the Voyager Neptune encounter operations plan, the following volumes have been published by the RSST:

625-460 on February 1, 1990:
Radio Science Operations Plan for the Ultrastable Oscillator/Redshift Observations and Venus Range Fix Experiment

Volume 1 on 15 November 1990:
Galileo Earth 1 Flyby/Mass Determination
Ulysses First Opposition Test
Galileo Redshift Observations/USO Tests

Volume 2 on June 14, 1991:
Ulysses Solar Corona Experiment
Galileo Redshift Observations/USO Tests

Volume 3 on January 10, 1992:
Galileo Radio Scintillation Experiment
Galileo Redshift Observations/USO Tests
Ulysses Jupiter Encounter/IPTO Experiment
Ulysses Gravitational Wave Experiment

Volume 4 on January 22, 1993:
GLL/ULS/MO Joint Gravitational Wave Experiment
Galileo Redshift Observations/USO Tests
Mars Observer Cruise Tests

Experiments not addressed above will be included in future volumes of the Handbook.

1.1 The Radio Science Almanac

The Radio Science Almanac, shown in Figure 1-1, is a gross schedule of the major Radio Science observation opportunities spanning the period from the Voyager Neptune Encounter through 1993, including the Galileo, Ulysses, and Mars Observer opportunities. The Almanac is used for reference during planning of future Radio Science activities and resource allocation within the support team.

1.2 The Radio Science Library

The following documents contain information relevant to the Radio Science activities of interest. These documents may be found in the Radio Science Library (230-103A).

1.2.1 PROJECT AND DSN INTERFACE DOCUMENTS

1. Deep Space Network Operations Plan, Project Galileo, Document 870-7, Rev. B, Change 2, Sept. 15 1989.

2. Deep Space Network/Flight Project Interface Design Handbook, Document 810-5, Rev. D, July 15 1988.

3. Deep Space Network Systems Requirements Detailed Interface Design, Document 820-13, Rev. A.

4. Galileo Science Requirements Document, PD 625-50, Rev D, Jan. 18, 1989.

5. Galileo SIRD, PD 625-501, Rev. A, May 1988.

6. Galileo Mission Operations System Functional Requirements, Radio Science System, No MOS-GLL-4-233A, 27 August 1984. (A 1990 update is in preparation).

7. Galileo Orbiter Functional Requirements Document, GLL 3-300B May 9, 1989.

8. Ulysses Radio Science Requirements document, ISPM-PI-2138, Issue 4, Updated for 1990 launch.

9. Ulysses SIRD, document 628-6 Rev A April 29, 1989

10. Deep Space Network Operations Plan Mars Observer Project, Document 870-68, April 3, 1992.

11. Mars Observer Investigation Description and Science Requirements Document, Document 642-48, March 1989.

12. Mars Observer SIRD, Document 642-12, February 19, 1992.

13. Mars Observer MOS Specifications Volumes 1-8, Document 642-315.

1.2.2 ARTICLES RELEVANT TO THE SCIENCE EXPERIMENTS

1. B. Bertotti, R. Ambrosini, S. W. Asmar, J. P. Brenkle, G. Comoretto, G. Giampieri, L. Iess, A. Messeri, H. D. Wahlquist, "The Gravitational Wave Experiment," Astronomy and Astrophysics, Suppl. Ser. 1, January 1992.

2. Berotti, B., "The Search for Gravitational Waves with ISPM," in *The International Solar Polar Mission - Its Scientific Investigation*, K. P. Wenzel, R. G. Mardsen and B. Battrick, eds., ESA SP-1050, 1983.

3. Thorne, K. S., "Gravitational Radiation," in Three Hundred Years of Gravitation, S. W. Hawking and W. Israel, eds., Cambridge University Press, 1987.

4. T. P. Krisher, J. D. Anderson, J. K. Campbell, "Test of the Gravitational Redshift Effects at Saturn", Physical Review Letters, Vol. 64 No. 12, March 19, 1990.

5. S. W. Asmar, P. Eshe, D. Morabito, "Evaluation of Radio Science Instrument: A Preliminary Report on the USO Performance, JPL IOM 3394-90-061, August 10, 1990.

6. M. K. Bird, S. W. Asmar, J. P. Brenkle, P. Edenhofer, M. Patzold, and H. Volland, "The Coronal-Sounding Experiment," Astronomy and Astrophyiscs, Suppl. Ser. 1, January 1992.

7. R. Woo, "A Synoptic Study of Doppler Scintillation Transients in the Solar Wind," Journal of Geophysical Research, Vol. 93, No. A5, pp. 3919-3926, May 1, 1988.

8. J. W. Armstrong, "Spacecraft Gravitational Wave Experiments," Gravitational Wave Data Analysis, B. F. Schutz, ed., pp. 153-172, 1989.

9. G. Leonard Tyler, Georges Balmino, David P. Hinson, William L. Sjogren, David E. Smith, Richard Woo, Sami W. Asmar, Michael J. Connally, Carole L. Hamilton, and Richard A. Simpson, "Radio Science Investigations with Mars Observer", Journal of Geophysical Research, Vol. 97, No. E5, pp. 7759-7779, May 25, 1992.

10. H.T. Howard, V.R. Eshleman, D.P. Hinson, A.J. Kliore, G.F. Lindal, R. Woo, M.K. Bird, H. Volland, P. Edenhofer, M. Patzold, and H. Porsche, "Galileo Radio Science

Investigations", Vol. 60, pp. 565-590, May 1992.

11. J.D. Anderson, J.W. Armstrong, J.K. Campbell, F.B. Estabrook, T.P. Krisher, and E.L. Lau, "Gravitation and Celestial Mechanics Investigations with Galileo", Space Science Reviews, Vol. 60, pp. 591-610, May 1992.

12. M.K. Bird, S. W. Asmar, J.P. Brenkle, P. Edenhofer, O. Funke, M. Patzold, and H. Volland, "Ulysses Radio Occultation Observations of the Io Plasma Torus During the Jupiter Encounter", Science, Vol. 257, pp. 1531-1535, September 11, 1992.

13. Timothy P. Krisher, David D. Morabito, John D. Anderson, "The Galileo Solar Redshift Experiment", Physical Review Letters (to be published), 1993.

JET PROPULSION LABORATORY

JPL

RADIO SCIENCE 5 YEAR ALMANAC

11/7/90

	MILESTONES	1989	1990	1991	1992	1993
1	VOYAGER NEPTUNE ENCOUNTER	25				
2	GALILEO LAUNCH	12 21				
3	VENUS ENCOUNTER		10			
4	FIRST EARTH ENCOUNTER		8			
5	HGA DEPLOY			15		
6	FIRST OPPOSITION			10		
7	GASPRA ENCOUNTER			29		
8	FIRST CONJUNCTION			21		
9	SECOND OPPOSITION				8	
10	SECOND EARTH ENCOUNTER				8	
11	THIRD OPPOSITION					1
12	IDA ENCOUNTER					28
13	SECOND CONJUNCTION					2
14	ULYSSES LAUNCH		6			
15	FIRST OPPOSITION		30			
16	FIRST CONJUNCTION			21		
17	JUPITER ENCOUNTER				15	
18	SECOND OPPOSITION				27	
19	SECOND CONJUNCTION				2	
20	THIRD OPPOSITION					29
21	MARS OBSERVER LAUNCH				14	
22	GWE COVERAGE				22	11
23	MO INSERTION/ORBIT					6

SECTION 2

OBSERVATION DESCRIPTION

2.0 Introduction

Radio Science investigators examine the small changes in the phase and/or amplitude of the radio signal propagating from a spacecraft to an Earth receiving station in order to study the atmospheric and ionospheric structure of planets and satellites, planetary gravitational fields, shapes, and masses, planetary rings, ephemerides of planets, solar plasma and magnetic fields, and aspects of the theory of general relativity like gravitational waves, gravitational redshift, etc.

The Radio Science experiments described below have been implemented, are in progress, or are planned for the near future for the Galileo, Ulysses, and Mars Observer projects. Cassini Radio Science experiments will be described in future volumes of this document. Section 4 list investigators involved in these experiments. This section was prepared with assistance from Drs. J. Armstrong, T. Krisher.

For quick reference, Appendix F shows the exact schedule of tracking times for the experiments list on the cover.

2.1 GLL/ULS/MO Joint Gravitational Wave Experiment

The Joint Galileo/Mars Observer/Ulysses Gravitational Wave Experiment is a collaborative effort to search for low-frequency gravitational waves generated by massive astrophysical systems. Gravitational waves--waves of space-time curvature--are transverse, carry energy and momentum, and propagate from their sources at the speed of light. The strength of the waves is characterized by the strain amplitude, h, which measures the fractional change in the separation of test masses and the fractional change at which separated clocks keep time. In a spacecraft gravitational wave experiment, the earth and a distant spacecraft act as separated test masses, with the transponded 2- or 3-way Doppler signal continuously measuring the relative dimensionless velocity $\Delta v/c$ between the Earth and the spacecraft. The metric perturbation due to the gravity wave, h, produces a signature in the Doppler time series that is of order h in $\Delta f/f_0$ and is replicated three times in the Doppler time series: once when the wave "shakes" the Earth, once when the wave shakes the spacecraft (suitably delayed by a one-way light time) and once when the initial shaking of the earth is transponded back to the earth a two-way light time later. This three pulse response is crucial in discrimination of gravitational waves from a noise background.

The Joint Experiment will be most sensitive to waves having periods ~100-1000 seconds. Waves with these periods are generated by supermassive astrophysical systems undergoing violent dynamics.

As with the individual GLL/MO/ULS gravity wave experiments, searches will be made for gravitational waves of differing temporal character: bursts (e.g., produced during formation, collision, and coalescence of supermassive black holes), periodic waves (e.g., produced by black holes orbiting each other) and stochastic waves (e.g., produced at the Big Bang). Hybrids in this classification scheme (e.g. chirp waves from coalescing binaries) are also possible signals and the experiment will include processing for these signals.

The Joint Experiment represents an unprecedented opportunity for a simultaneous Doppler tracking experiment using three independent deep space transponders, and will have two important scientific advantages over a single-spacecraft gravitational wave search:

(1) the prospect for independent confirmation of any observed events, and

(2) the possibility of source-direction and polarization-state determination for any event observed jointly by the spacecraft.

As with a single-spacecraft gravitational wave experiment, care must be taken to maximize sensitivity. This leads to the following general requirements:

(1) To the extent practical, observations should be done in the antisolar direction in order to minimize solar wind phase scintillation noise. In the case of the Joint Experiment, this requirement has been traded off against the desire for long two-way light times (i.e., wide bandwidth to which the individual spacecraft experiments are sensitive).

(2) Tracking should be done with the highest radio frequencies possible, again to minimize solar wind scintillation noise. For the Joint Experiment, this means using X-uplink/X-downlink on MO, X-uplink/X-downlink on GLL (if available), and the X-downlink on ULS.

(3) Tracking should be done in the two- and three-way coherent modes.

(4) Stations should be configured for maximum Doppler stability.

(5) Data should be taken using both the closed and open loop receivers. Equipment availability dictates that MO should used the DSP and that GLL and ULS should use the closed loop receivers with the Doppler sample rate set to be as large as is practical to minimize aliasing of thermal noise into the digital

band.

(6) Where practical, an independent assessment of station stability as well as the tropospheric and ionospheric noise should be done.

(7) The spacecraft should be in quiet, minimum-dynamics modes.

(8) Engineering telemetry from the spacecraft, logs of station and spacecraft events, etc. should be gathered to create a master file of "veto signals".

(9) "Calibration signals" (electronically or mechanically introduced) should be injected to verify end-to-end sensitivity of the experiment.

2.2 Galileo Redshift Observations & USO Tests

The Redshift Observations are performed to measure the frequency shift caused by the motion of the spacecraft as it moves in and out of the solar (or planetary) gravitational field. One of the four predicted effects of Einstein's theory of General Relativity is the change of a clock rate (an oscillator frequency) in a varying gravitational potential. The Galileo Ultra Stable Oscillator (USO) is the signal source for these observations and has sufficient inherent stability to allow detection of this phenomenon. The Galileo VEEGA trajectory provides a unique opportunity to detect the USO frequency shift as it flies through the changing solar and planetary gravitational fields.

The objectives of the Redshift Observations and USO tests are:

1. Make a direct scientific measurement of the redshift phenomenon described above.

2. Make engineering measurements of the USO frequency and frequency stability for calibration of the Radio Science instrument.

3. Exercise the operational aspects of the Radio Science system in the Project and at the Deep Space Network.

4. Train the Project (including the Radio Science Support Team) and the DSN in the operations required in preparation for the Jupiter Encounter.

5. Exercise the Radio Science software and analysis tools.

Prior to the observations, the orbiter will be commanded to use the USO as the frequency reference for the downlink radio signal for a period of about two hours. The frequency and frequency stability of the carrier will be estimated. When the data are received by the RSST, either in the form of tracking ATDFs and, for some passes, open-loop ODRs, they will then be processed to produce frequency residuals. From these, phase noise and frequency stability (Allan variance) can be determined.

2.3 Mars Observer Cruise Tests

Radio Science experiments are unique in that the scientific measurements are made at DSN tracking stations and not on the spacecraft itself. The quality of these measurements depends directly on the performance of the spacecraft telecommunications subsystem (including the Ultra-Stable Oscillator) and the DSN Tracking and Radio Science Systems. The Radio Science "instrument" is easily the most complex science instrument on the Mars Observer Mission. The situation is made even more difficult by the fact that operating the instrument requires the efforts of personnel in a number of different organizations. For these reasons an extensive series of tests and calibrations are required before science data is taken during the Mapping Phase.

Three different tests are required in Cruise. These are:

(1) USO Tests. These tests are required to characterize the frequency output of the on-board ultra-stable oscillator (USO). Oscillators of this type are known to have a long term linear drift, which can be measured by conducting such tests. Compensation of USO drift will be applied to radio occultation data, obtained during mapping when the USO is the downlink frequency reference. Frequency stability (deviations not included in the linear drift model) of the received downlink will also be computed from data collected during the USO Tests. The USO Tests also provide opportunities to monitor the performance of the spacecraft telecommunications subsystem and the DSN Tracking System. Four USO tests will be performed in the occultation configuration (telemetry off) to maximize the carrier signal power.

(2) Tracking System Calibration Tests are needed to characterize the performance of the two-way coherent radio link, in much the same way as USO Tests characterize the performance of the one-way USO-referenced radio link. Range data will also be taken during these tests to determine the performance of the spacecraft/DSN ranging system.

(3) Radio Science Operations Readiness Tests will, as the names implies, test the readiness of equipment and personnel to support radio science mapping operations. Other elements of the Mars Observer Project are invited to use these tests as

operational readiness tests or training exercises as they see fit.

Tests of this nature are required in the Mars Observer Investigation Desciption and Science Requirements Document and all the test described are scheduled. The preliminary scheduling of these tests is in the Mars Observer Mission Sequence Plan. For the exact times these tests will occur, refer to the Mars Observer SOE.

SECTION 3

INSTRUMENT DESCRIPTION AND CONFIGURATION

3.0 Introduction

This section describes the instrumentation used in support of the Radio Science activities. The Radio Science instrument is distributed between the spacecraft and the Ground Data System (GDS). The latter includes several subsystems at the Deep Space Communication Complexes (DSCCs) as well as several facilities at JPL used for Radio Science communications and data monitoring.

3.1 The Spacecraft

3.1.1 THE GALILEO SPACECRAFT

The Galileo spacecraft is shown in Figure 3-1. The Galileo telecommunications subsystem is shown in Figure 3-2. It handles three types of data: command, telemetry, and radiometric. The latter provides the capability to navigate the orbiter as well as to perform Radio Science observations. The subsystem is equipped with two redundant transponders with dual frequency (S- and X-bands) uplink and downlink capabilities. This means that the spacecraft can have the following combinations of uplink/downlink: S/S, X/X, S/X&S.

The subsystem may be operated in the coherent mode (i.e., the downlink signal is referenced to the uplink signal) or the non-coherent mode (i.e., an ultrastable oscillator (USO) onboard the spacecraft provides the downlink signal reference). In the absence of an uplink signal, the subsystem will switch to the one-way mode automatically. The spacecraft can also be commanded to a specific mode (TWNC ON or OFF) and/or to one of the following states: spacecraft modulated telemetry alone, ranging alone, spacecraft telemetry and ranging, or carrier alone. A tape recorder onboard the spacecraft will store data for playback at a later time during periods when no ground station coverage is available.

The HGA is aligned with the spin axis of the spacecraft and is pointed at the Earth by the attitude control system. Low Gain Antenna 1 (LGA-1) is located at the end of the HGA feed and is thus aligned with the spin axis. Low Gain antenna 2 (LGA-2) is located at the end of a boom as shown in Figure 3-1. When the signal is transmitted through LGA-2, a sinusoidal signature in the received Doppler is induced since the spacecraft is spinning with the antenna being located 3.58 meters off the spin axis. S-band on the HGA is linearly polarized whereas X-band is RCP; both LGA's transmit RCP.

The spacecraft was launched (10/89) with the HGA in the stowed position. The planned deployment date was April 1991; it was unsuccessful at that time and the Project has been attempting various manuevers to open the antenna. On March 1, 1993, the Project will announce its plans for the planning of the remainder of the cruise and the orbital phases of the mission.

3.1.2 THE ULYSSES SPACECRAFT

The Ulysses spacecraft is shown in Figure 3-3. Figure 3-4 shows the radio frequency system of the Ulysses spacecraft. The system includes two S-band low gain antennas (LGA) for near-Earth communications and an S- and X-band high gain parabolic antenna (HGA) for deep space communications. The antennas are coupled to two redundant transponders, each housing a 5 W S-band power amplifier and an X-band exciter. The 20 W X-band output is produced by one of the two redundant TWTAs. The system has a considerable amount of cross-coupling. Each receiver may drive either, or both, modulators. Each X-band exciter may drive either of the two TWTAs. The output of the modulator is switched to drive either the S-band power amplifier or the X-band exciter, but not both. For modes where simultaneous S- and X-band downlinks are required, a chosen receiver drives the modulators of both transponders. One transponder then drives the S-band power amplifier and the other transponder drives the X-band exciter and a TWTA.

The transponders function in one of two modes: the coherent mode, in which the downlink signal is referenced to the uplink signal, and the non-coherent mode, where a free-running oscillator onboard the spacecraft provides the downlink signal reference. Commands to the spacecraft determine the selection of one of the following: spacecraft modulated telemetry alone, ranging alone, spacecraft telemetry and ranging, or carrier alone. Simultaneous ranging and commanding is not an operational mode of the Ulysses spacecraft. A tape recorder onboard the spacecraft will store telemetry data during periods when no ground station coverage is available for playback at a later time.

The HGA is aligned with the spin axis of the spacecraft and is pointed to Earth by control of the spin axis in inertial space. Typically, a daily attitude maneuver is performed. To perform this control, one reference is given by a sun-sensor while the other is given from CONSCAN processing of the uplink radio signal from Earth. For this reason, the S-band feed of the antenna is slightly offset from the spin axis. There is a minimum limit on the sun-probe-earth angle that can be tolerated thus forcing operational strategies for attitude control during conjunctions and oppositions.

For the Radio Science experiments, the radio system will be configured in the two-way coherent mode and both the S-band and

X-band links will be activated simultaneously (thermal limitations on-board the spacecraft may operationally prevent activating dual links at certain times). In this configuration, both transponders receive the same S-band uplink signal which is referenced to a highly stable Hydrogen maser frequency standard at the DSS, and transmit coherent S-band and X-band downlink signals.

The dual frequency coherent link is used by the experimenters to measure the differential range and Doppler to determine the total electron content along the spacecraft to Earth line of sight. The data are also used to measure the rate of change of the total electron content in the interplanetary and ionospheric plasma to correct the Doppler for these effects.

3.1.3 THE MARS OBSERVER SPACECRAFT

The Mars Observer spacecraft is shown in Figure 3-5 in the cruise configuration and in Figure 3-6 in the mapping configuration. A detailed diagram of the telecommunications subsystem is shown as Figure 3-7.

As shown in the spacecraft diagrams, the MO HGA, a 1.5 m steerable antenna, is located at the end of a deployable boom. This boom allows the HGA to reach over the solar panels and maintain constant Earth point. In the cruise configuration, which will exist until MOI (late August, 1993), the HGA boom is at its full length of 5.6 m, but oriented 180 degrees from its eventual position in mapping configuration. The antenna's relation to the spacecraft center of mass will therefore be different in the two positions. In the Cruise configuration, the antenna will be pointed along the +Y axis, in line to Earth. The 1992 Gravity Wave Experiment will take place in cruise configuration, while the orbital occultation experiments will occur in mapping configuration. In addition to the HGA, there are three LGAs, one transmit and two receive. The LGAs will be used in early in Cruise and, later, in emergencies. All antennas, the HGA and LGAs, are right-circularly polarized (RCP). After January 4, 1993, the primary link will be through the HGA for the rest of the mission.

Mars Observer will be the first mission to use solely X-band for uplink and downlink, and does not have any S-band equipment on board. There is also a Ka-band downlink; this will be used in conjunction with experimental DSN Ka-band receivers for the Ka-Band Link Experiment (KABLE). This equipment will not be used for spacecraft link operations and the low Ka band downlink signal strength makes this radio link of little or no use to Radio Science investigators. MO may be commanded (or have 2-way coherent tracking) only through the 34 HEF subnet, since only the HEF antennas have X-band uplink capability. The X-band telecommunications subsystem on board has almost total redundancy of components, with two MO Transponders (MOTs), two TWT power amplifiers, and two command detector units. The MOTs can transmit in two modes, by coherently transponding the uplink carrier to produce a downlink carrier or by independently generating the downlink carrier with either of two on-board sources. One of these is an ultrastable oscillator (USO), a very precise frequency source added to the spacecraft specifically for use during radio occultation measurements of the Martian atmosphere during Mapping. In addition, each MOT has its own oscillator, the performance of which is only suitable for a spacecraft telemetry downlink. For the Gravity Wave experiment, coherent tracking will be used, and for occultations, non-coherent (one-way, USO mode) tracking will be used.

Spacecraft attitude is controlled in three axes by three orthogonally mounted reaction wheels, with thrusters for maneuvers and reaction wheel unloading. During cruise, spacecraft attitude will be determined through celestial sensors, which detect star transits over the 0.01 rpm rotation ("array normal spin") about the Y axis. In the mapping phase, Mars horizon sensors will determine spacecraft attitude. In this phase, the spacecraft will be spinning at 0.0085 rpm about its Y axis in order to maintain pointing toward Mars of the onboard instrument located on the +Z panel during the (nominally) 117.65 minute orbit.

3.2 The Ground Data System

3.2.1 THE DEEP SPACE NETWORK

The Deep Space Communication Complexes (DSCCs) are an integral part of the Radio Science instrument, along with the other receiving stations and the spacecraft's Radio Frequency Subsystem. Their system performance directly determines the degree of success of the Radio Science investigations and their system calibration determines the degree of accuracy in the results of the experiments. The following paragraphs describe those functions performed by the individual subsystems of a DSCC. Figures 3-8 through 3-13 show the various systems relevant to the Radio Science activities.

3.2.1.1 DSCC Monitor and Control Subsystem

The DSCC Monitor and Control Subsystem (DMC) is part of the Monitor and Control System (MON) which also includes the ground communications Central Communications Terminal and the Network Operations Control Center (NOCC) Monitor and Control

Subsystem. The DMC is the center of activity at a DSCC. The DMC receives and archives most of the information from the NOCC needed by the various DSCC subsystems during their operation. Control of most of the DSCC subsystems as well as the handling and displaying of any responses to control directives and configuration and status information received from each of the subsystems is done through the DMC. The effect of this is to centralize the control, display and archiving functions necessary to operate a DSCC. Communication between the various subsystems is done using a Local Area Network (LAN) hooked up to each subsystem via a Network Interface Unit (NIU).

The DMC operations are divided into two separate areas: the Complex Monitor and Control (CMC) and the Link Monitor and Control (LMC). The primary purpose of the CMC processor for Radio Science support is to receive and store all predict sets transmitted from NOCC such as Radio Science, antenna pointing, tracking, receiver, and uplink predict sets and then, at a later time, distribute them to the appropriate subsystems via the LAN. Those predict sets can be stored in the CMC for a maximum period of three days under normal conditions. The CMC also receives, processes and displays event/alarm messages and maintains an operator log and produces tape labels for the DSP. Assignment and configuration of the LMCs is done through the CMC and to a limited degree the CMC can perform some of the functions performed by a LMC. There is one on-line CMC, one backup CMC, and three LMCs at each DSCC. The backup CMC can function as an additional LMC if necessary.

The LMC processor provides the operator interface for monitor and control of a link which is a group of equipment required to support a spacecraft pass. For Radio Science, a link might include the DSCC Spectrum Processing Subsystem (DSP) (which, in turn, can control the SSI), or the Tracking Subsystem. The LMC also maintains an operator log which includes the operator directives and subsystem responses. One important Radio Science specific function which the LMC performs is receipt and transmission of the system temperature and signal level data from the PPM for display at the LMC console as well as placing this information in the Monitor 5-9 blocks. These blocks are recorded on magnetic tape as well as displayed in the MCCC displays. The LMC is required to operate without interruption for the duration of the Radio Science data acquistion period.

The Area Routing Assembly (ARA), which is part of the Digital Communications Subsystem, controls all data communication between the stations and JPL. The ARA receives all required data and status messages from the LMC/CMC and can record them to tape as well as transmit them to JPL via the data lines. The ARA also receives predicts and other data from JPL and passes them on to the CMC.

3.2.1.2 DSCC Antenna Mechanical Subsystem

The multi-mission Radio Science activities require support from the 70-m, the 34-m HEF, and the 34-m STD antenna subnets. The antenna at each DSCC will function as a large aperture collector which, by double reflection, causes the incoming RF energy to enter the feed horns. The large collecting surface of the antenna focuses the incoming energy onto a subreflector, which is adjustable in the axial and angular positions. These adjustments are made to optimize the channeling of energy from the primary reflector to the subreflector and then to the feedhorns. The 70-m and 34-m HEF antennas have "shaped" primary and secondary reflectors, whose forms are that of a modified paraboloid. This customization allows more uniform illumination of one reflector by the other. Conversely, the 34-m STD primary reflectors are classical paraboloids, while the subreflectors are similarly standard hyperboloids.

On the 70-m and 34-m STD antennas, the subreflector reflects the received energy from the antenna onto the dichroic plate, a device which reflects S-band energy to the S-band feedhorn and passes X-band energy through to the X-band feedhorn. In the 34-m HEF, there is one "common aperture feed", which accepts both frequencies, and therefore no plate. RF energy to be transmitted into space by the horns is focused by reflectors into narrow cylindrical beams, pointed with high precision (either to the dichroic plate or directly to the subreflector) by a series of drive motors and gear trains that can rotate the movable components and their support structures.

The different antennas can be pointed by several common means. Two pointing modes commonly used during a tracking pass are 1) CONSCAN on, or 2) CONSCAN off (blind pointing). With CONSCAN on, once the closed-loop receiver has acquired a signal from the spacecraft to provide feedback, the radio source is tracked by conically scanning around it. Pointing angle adjustments are computed from signal strength information supplied by the receiver. In this mode, the Antenna Pointing Assembly (APA) generates a circular scan pattern which is sent to the Antenna Control Subsystem (ACS). The ACS adds the scan pattern to the corrected pointing angle predicts. Software in the receiver-exciter controller computes the received signal level and sends it to the APA.

The correlation of the scan position of the antenna with the received signal level variations allows the APA to compute offset changes which are sent to the ACS. Thus, within the capability of the closed-loop control system, the scan center is pointed precisely at the apparent direction of the spacecraft signal. An additional function of the APA is to provide antenna position angles and residuals, antenna control mode/status information and predict-correction parameters to the Area Routing Assembly (ARA) via the LAN, which then sends this information to JPL via the GCF for antenna status monitoring.

However, during periods when excessive signal level dynamics or low received signal levels are expected (e.g., in an occultation experiment), CONSCAN cannot be used. Under these conditions, blind pointing (CONSCAN off) is used, and pointing angle adjustments rely on a predetermined Systematic Error Correction (SEC) model.

Independent of the CONSCAN state, subreflector motion in at least the z-axis may introduce phase variations in the received Radio Science data. For that reason, during certain experiments, the subreflector in the 70-m and 34-m HEFs may be frozen in the z-axis at an elevation angle selected to minimize the phase change and signal degradation. This can be done via operator OCIs from the LMC to the Subreflector Controller (SRC) which resides in the alidade room of the antennas. The SRC passes the commands to motors that drive the subreflector to the desired position. Unlike the two antennas mentioned above, the 34-m STD is not an Az-El pointed antenna, but a HA-DEC antenna. The same positioning of the subreflector of the 34-m STD does not create the same effect as for the 70-m and 34-m HEF.

Pointing angles for all three antenna types are computed by the NSS from an ephemeris provided by the Project and converted into antenna pointing predicts for each station. These predicts are received and archived by the CMC. Before each track, they are transferred to the APA, which transforms the direction cosines of the predicts into Az-El coordinates for the 70-m and 34-m HEF, and into HA-DEC coordinates for the 34-m STD. The LMC operator then downloads the antenna Az-El or HA-DEC (respectively) predict points to the antenna-mounted ACS computer along with a selected pointing SEC model. The pointing predicts consist of time-tagged Az-El or HA-DEC points at selected time intervals, and also include polynomial coefficients for interpolation between the points.

The ACS automatically interpolates the predict points, corrects the pointing predicts for refraction and subreflector position, and adds the proper systematic error correction and any manually entered antenna offsets. The ACS then sends angular position commands for each axis at the rate of once per second. In the 70-m and 34-m HEF, rate commands are generated from the position commands at the servo controller and are subsequently used to steer the antenna. In the 34-m STD, motors, not servos, are used to steer the antenna, so there is no feedback once the antenna has been told where to point.

When not using binary predicts (the routine mode for spacecraft tracking), the antennas can be pointed using planetary mode, a simpler mode which uses right ascension (RA) and declination (DEC) values. These change very slowly with respect to the celestial frame. Values are provided to the station in text form for manual entry. The ACS quadratically interpolates between three RA and DEC points which are on one-day centers. Other than predict and planetary, a third mode, sidereal, is available and is usually used to track radio sources fixed with respect to the celestial frame as in radio astronomy applications.

Regardless of the mode being used to track a spacecraft, a 70-m antenna has a special, high-accuracy pointing capability called Precision mode. A pointing control loop derives the main Az-El pointing servo drive error signals from a two-axis autocollimator mounted on the Intermediate Reference Structure. The autocollimator projects a light beam to a precision mirror mounted on the Master Equatorial drive system, a much smaller structure, independent of the main antenna, which is exactly positioned in HA and DEC with shaft encoders. The autocollimator detects elevation/cross-elevation errors between the two reference surfaces by measuring the angular displacement of the reflected light beam. This error is compensated for in the antenna servo by moving the antenna in the appropriate (Az-El) direction.

If not using the optical link Precision mode, a less accurate computer mode can be used where the servo utilizes the Az-El axis encoder readout for positioning, as done in the 34-m HEF.

3.2.1.3 DSCC Antenna Microwave Subsystem

3.2.1.3.1 70-m Antennas

Each 70-m station has three feed cones installed on a structure at the center of the main reflector. The feeds are positioned 120 degrees apart on a circle. Selection of the feed is made by rotation of the subreflector. A dichroic mirror assembly, half on the S-band cone and half on the X-band cone, permit simultaneous use of the S- and X-band frequencies. The third cone is devoted to R&D and more specialized work.

The Antenna Microwave Subsystem (AMS) accepts the received S- and X- band signals at the feedhorn and transmits them through the polarizer plates to the orthomode transducer. The polarizer plates are adjusted so that the signals are directed to either of a set of redundant amplifiers for each frequency. For X-band, these amplifiers are Block IIA X-band Travelling Wave Masers (TWMs), and for S-band there are two Block IVA S-band TWMs.

3.2.1.3.2 34-m STD Antennas

These antennas have two feed horns, for S- and X-band energy, respectively. These horns are mounted on a cone which is fixed in relation to the subreflector. A dichroic plate mounted above the horns directs energy from the subreflector into the proper horn.

The AMS directs the received S- and X-band signals through the polarizer plates and on to amplification. There are two Block III S-band TWMs and two Block I X-band TWMs.

3.2.1.3.3 34-m HEF Antennas

Unlike the other antennas, the 34-m HEF uses a single feed horn for both X- and S-band. Simultaneous S- and X-band receive, as well as X-band transmit, is possible however, due to the presence of an S/X "combiner", which acts as a diplexer. As in the general case, the next component in the AMS on the X-band path is a polarizer, and then the orthomode transducer; for S-band, RCP or LCP is user selected through a switch, and not simultaneous, so neither device is present. X-band amplification can be selected from one of two Block II X-band TWMs or from a single X-band HEMT Low Noise Amplifier (LNA). S-band amplification is provided by one FET LNA.

3.2.1.4 <u>DSCC Receiver-Exciter Subsystem</u>

The Receiver-Exciter Subsystem is composed of three groups of equipment: the closed-loop receiver group, the open-loop receiver group, and the RF monitor group. This subsystem is controlled by the Receiver-Exciter Controller (REC) which communicates directly with the DMC for predicts and OCI reception and status reporting.

The exciter generates the S-band signal, (or X-band signal for 34-m HEF only), which is provided to the Transmitter Subsystem for the spacecraft uplink signal. It is tunable under the command of the Digitally Controlled Oscillator (DCO) which receives predicts from the Metric Data Assembly (MDA).

The diplexer in the signal paths between the transmitters and the feed horns for all three antennas (used for simultaneous transmission and reception) may be configured such that it is out of the received signal path (in listen-only or bypass mode) in order to improve the signal-to-noise ratio in the receiver system.

3.2.1.4.1 Closed-Loop Receivers

The Block IV receiver-exciter at the 70-m stations allows for two receiver channels, each capable of L-band, S-band or X-band reception, and an S-band exciter for generation of uplink signals through the low-power or high-power transmitter. The Block III receiver-exciter at the 34-m STD stations allows for two receiver channels, each capable of S-band or X-band reception and an exciter used to generate an uplink signal through the low-power transmitter. The receiver-exciter at the 34-m HEF stations allows for one channel only.

The closed-loop receivers provide the capability for rapid acquisition of a spacecraft signal and telemetry lockup. In order to accomplish acquisition within a short time, the receivers are predict driven to automatically search for, acquire, and track the downlink. Rapid acquisition precludes manual tuning even though the latter remains as a backup capability. The subsystem utilizes FFT analyzers for rapid acquisition. The predicts are NSS generated, transmitted to the CMC which sends them to the Receiver-Exciter Subsystem where two sets can be stored. The receiver starts acquisition at uplink time plus one round-trip-light-time or at operator specified times. In addition, the receivers can be operated from the LMC without a local operator attending them. The receivers send performance and status data, displays, and event messages to the LMC.

Either the exciter synthesizer signal or the SIM synthesizer signal is used as the reference for the Doppler extractor, depending on the spacecraft being tracked (and Project guidelines). The SIM synthesizer is not ramped; instead, it uses one constant frequency, the Track Synthesizer Frequency (TSF), which is an average frequency for the entire pass.

The closed-loop receiver AGC loop can be configured to one of three settings; narrow, medium or wide. It will be configured such that the expected amplitude changes are accommodated with minimum distortion. The loop bandwidth (2BLo) will be configured such that the expected phase changes can be accommodated while maintaining the best possible loop SNR.

3.2.1.4.2 Radio Science Open-Loop Receiver

The Radio Science Open-Loop Receiver (OLR) is a dedicated four channel, narrow-band receiver which provides amplified and downconverted video band signals to the DSCC Spectrum Processing Subsystem (DSP).

The OLR utilizes a fixed first Local Oscillator (LO) frequency and a tunable second LO frequency to minimize phase noise and improve frequency stability. The OLR consists of an RF-to-IF downconverter located in the antenna, an IF selection switch (IVC), and a Radio Science IF-VF downconverter (RIV) located in the SPC. The RF-IF in the 70-m antenna are equipped for four IF channels: XRCP, SRCP, XLCP, and SLCP. The 34-m HEF stations are equipped with a two-channel RF-IF: S-band and X-band. The IVC switches between IF sources, that is, from the 70-m or 34-m HEF stations.

The RIV contains the tunable second LO, a set of video bandpass filters, IF attenuators, and a controller (RIC). The LO tuning is done via DSP control of the POCA/PLO combination based on a predict set. The POCA is a Programmable Oscillator Control Assembly and the PLO is a Programmable Local Oscillator (commonly called the DANA synthesizer). The bandpass filters are selectable via the DSP. The RIC provides an interface between the DSP and the RIV. It is controlled from the LMC via the DSP. The RIC selects the filter and attenuator settings and provides monitor data to the DSP. The RIC could also be manually controlled from the front panel in case the electronic interface to the DSP is lost. Figures 3-7 and 3-8 (A,B,C) show block diagrams of the open-loop receiver. Calibrations will be performed on the OLR and the DSP NBOC using estimates of the peak signal levels expected during the experiments as described in section 3.2.2.

3.2.1.4.3 RF Monitor: SSI and PPM

The RF monitor group of the Receiver-Exciter Subsystem provides spectral measurements using the Spectral Signal Indicator (SSI), and measurements of the received channel system temperature and spacecraft signal level using the Precision Power Monitor (PPM).

The SSI provides a local display of the received signal spectrum at a dedicated terminal at the DSCC and routes these same data to the DSP which routes them to NOCC for remote display at JPL for real-time monitoring and RIV/DSP configuration verification. These displays are used to validate Radio Science System data at the DSS, NOCC, and Mission Support Areas. The SSI configuration is controlled by the DSP and a duplicate of the SSI spectrum appears on the LMC via the DSP. During real-time operations, the SSI data also serve as a quick look science data type for the Radio Science experiments.

The PPM measures system noise temperatures (SNT) using a Noise Adding Radiometer (NAR) and downlink signal levels using the Signal Level Estimator (SLE). The PPM accepts its input from the closed-loop receiver. SNT is measured by injecting known amounts of noise power into the signal path and comparing the total power with the noise injection "on" against the total power with the noise injection "off". That operation is based on the fact that receiver noise power is directly proportional to temperature, and thus measuring the relative increase in noise power due to the presence of a calibrated thermal noise source allows direct calculation of SNT. Signal level is measured by calculating an FFT to estimate the SNR between the signal level and the receiver noise floor whose power is known from the SNT measurements.

There is one PPM controller at the SPC which is used to control all SNT measurements. The SNT integration time can be selected to represent the time required for a measurement of 30 K to have a 1-sigma uncertainty of 0.3 K or 1%.

3.2.1.5 DSCC Transmitter Subsystem

The Transmitter Subsystem accepts the S-band frequency exciter signal from the Block III or Block IV Receiver-Exciter Subsystem exciter and amplifies it to the required transmitted output level. The amplified signal is routed via the diplexer through the feedhorn to the antenna and then focused and beamed to the spacecraft.

The Transmitter Subsystem power capabilities range from 18 kW to 400 kW. Power levels above 18 kW are available only at 70-m stations.

3.2.1.6 DSCC Tracking Subsystem

The Tracking Subsystem's primary functions are to acquire and maintain the communications link with the spacecraft and to generate and format radiometric data containing Doppler and range. A block diagram of the DSN tracking system appears in Figures 3-12 and 3-13.

The DSCC Tracking Subsystem (DTK) receives the carrier signals and ranging spectra from the Receiver-Exciter Subsystem. The Doppler cycle counts are counted, formatted, and transmitted to JPL in real-time. Ranging data are also transmitted to JPL in real-time. Also contained in these blocks is the AGC information from the Receiver-Exciter Subsystem. The Radio Metric Data Conditioning Team (RMDCT) at JPL produces an ATDF tape which contains Doppler and ranging data.

In addition, the Tracking Subsystem receives from the CMC frequency predicts (used to compute frequency residuals and noise estimates), receiver tuning predicts (used to tune the closed-loop receivers), and uplink tuning predicts (used to tune the exciter). From the LMC, it receives configuration and control directives as well as configuration and status information on the transmitter, microwave and frequency and timing subsystems.

The Metric Data Assembly (MDA) controls all of the DTK functions supporting the uplink and downlink activities. The MDA receives uplink predicts and controls the uplink tuning by commanding the DCO. The MDA also controls the SRA. It formats the Doppler and range measurements and provides them to the GCF for transmission to NOCC.

The Sequential Ranging Assembly (SRA) measures the round trip light time (RTLT) of a radio signal traveling from a ground tracking station to a spacecraft and back. From the RTLT, phase, and Doppler data, the spacecraft range is measured. A coded signal is modulated on an S-band carrier and transmitted to the spacecraft where it is detected and transponded back to the station. As a result, the signal received at the tracking station is delayed by its round trip through space and shifted in frequency by the Doppler effect due to the relative motion between the spacecraft and the tracking station on Earth.

3.2.1.7 DSCC Spectrum Processing Subsystem (DSP)

The DSCC Spectrum Processing Subsystem (DSP) located at the SPC digitizes and records on magnetic tapes the narrowband output data from the RIV. It consists of a Narrow Band Occultation Converter (NBOC) containing four Analog-to-Digital Converters (ADCs), a ModComp CLASSIC computer processor called the Spectrum Processing Assembly (SPA) and two to six magnetic tape drives.

The DSP is operated through the LMC. Using the SPA-R software, the DSP allows for real-time frequency and time offsets (while in RUN mode) and, if necessary, snap tuning between the two frequency ranges transmitted by the spacecraft: coherent and noncoherent. The DSP receives Radio Science frequency predicts from the CMC, allows for multiple predict set archival (up to 60 sets) at the SPA and allows for manual predict generation and editing. It accepts configuration and control data from the LMC, provides display data to the LMC and transmits the signal spectra from the SSI as well as status information to NOCC and the Project Mission Support Area (MSA) via the GCF data lines. The DSP records the digitized narrowband samples and the supporting header information (i.e., time tags, POCA frequencies, etc.) on 9-track magnetic tapes in 6250 or 1600 bpi GCR format. The data format on the tape (called Original Data Record, ODR) is defined in document 820-13 module RSC-11-10A.

Through the DSP-RIC interface, the DSP controls the RIV's filter selection and attenuation levels. It also receives RIV performance monitoring via the RIC. In case of failure of the DSP-RIC interface, the RIV can be controlled manually from the front panel.

All the RIV and DSP control parameters and configuration directives are stored in the SPA in a macro-like file called an "experiment directive" table. A number of default directives exist in the DSP for the major Radio Science experiments. Operators can create their own table entries. The items controlled by the directive are shown in Section 3.2.2.

Items such as verification of the configuration of the prime open-loop recording subsystem, the selection of the required predict sets, and proper system performance prior to the recording periods will be checked in real-time at JPL via the NOCC displays using primarily the remote SSI display at NOCC and the NRV displays. Because of this, transmission of the DSP/SSI monitor information is enabled prior to the start of recording. The specific run time and tape recording times will be identified in the SOE.

The DSP can be used to duplicate ODRs. It also has the capability to play back a certain section of the recorded data after the conclusion of the recording periods.

3.2.1.8 DSCC Frequency and Timing Subsystem

The Frequency and Timing Subsystem (FTS) provides all frequency and timing references required by the other DSCC subsystems. It contain four frequency standards of which one is prime and the other three are backups. Selection of the prime standard is done via the CMC. Of these four standards, there are two Hydrogen masers followed by clean-up loops (CUL) and two Cesium standards. These four standards all feed the Coherent Reference Generator (CRG) which provides the frequency references used by the rest of the complex. It also provides the frequency reference to the Master Clock Assembly (MCA) which in turn provides time to the Time Insertion and Distribution assembly (TID). which provides UTC and SIM-time to the complex.

The monitoring capabilities of the DSCC FTS at JPL are limited to the MDA calculated Doppler pseudo-residuals, the Doppler noise, the SSI, and via the GPS. The GPS receivers receive a one-pulse-per-second pulse from the station's (Hydrogen maser referenced) FTS and a pulse from a GPS satellite at scheduled times. After compensating for the satellite signal delay, the timing offset is reported to JPL where a database is kept. The clock offsets reported in the JPL database between the clocks at the three DSN sites are given in microseconds, where each reading is a mean reading of measurements from several GPS satellites and the time tag associated with it is a mean time of the measurements. The clock offsets provided include those of SPC 10 relative to UTC(NIST), SPC 40 relative to SPC 10,...,etc.

3.2.2 DSS CALIBRATION AND CONFIGURATION

3.2.2.1 Open-Loop Receiver Attenuation Calibration

The open-loop receiver attenuator calibrations are performed to establish the output of the open-loop receivers at a level that will not saturate the input signal to the analog-to-digital converters. To achieve this goal, the calibration is done using a test signal generated by the exciter/translator that is set to the peak predicted signal level for the upcoming pass. Then the output level of the receiver's video band spectrum envelope is adjusted to the level determined by the third equation below (to 5 sigma). Note that the SNR in the second equation is in dB, and the SNR in the third equation is not. Use the fourth equation to compute changes in RMS voltage levels.

$$P_N = -198.6 + 10\log(SNT) + 10\log(Filter\ BW \times 1.2)$$

$$SNR = P_S - P_N$$

$$Output\ Voltage\ (V_{rms}) = \frac{\sqrt{SNR+1}}{1+0.283\sqrt{SNR}}$$

$$V_2 = V_1\sqrt{\frac{1+SNR_2}{1+SNR_1}}$$

3.2.2.2 <u>Station Configuration</u>

The station configuration during the Radio Science activities is governed by Volume 2 of the Deep Space Network Operations Plan (NOP). This table, however, shows the recommended configuration of the DSCC Spectrum Processing Assembly (DSP) and open-loop system for the purpose of internal documentation by the Radio Science Support Team.

3.2.2.2.1 Joint Gravitational Wave Experiment Configuration:

The anticipated Doppler sample rate for the three spacecraft is as follows: Galileo = one per second; Ulysses = one per second; and Mars Observer = one per five seconds. The required frequency and timing reference is the Hydrogen maser for all three spacecraft. During the experiment, Galileo will use the 70-m subnet (except for DSS-43 which will be off-line for maintenance) (S-band); Ulysses will use the 34-m STD subnet (X-band); and, Mars Observer will use the 34-m HEF subnet (X-band). The DSP should be configured for Mars Observer as shown in Table 3-1.

3.2.2.2.2 Galileo Redshift Observation/USO Test Configuration:

The Doppler sample rate is one per second. The required frequency and timing reference is the Hydrogen maser. The DSP should be configured as shown in Table 3-2.

3.2.2.2.2 Mars Observer Cruise Tests

The Doppler sample rate for the USO and tracking system calibration tests is one per second and for the operations readiness test is one per ten seconds. The required frequency and timing reference is the Hydrogen maser. The DSP should be configured as shown in Table 3-3. (Note: Only in an unusual circumstance would MO use either the 70-m or 34-m STD subnets since neither of these subnets is capable of an X-band uplink.)

Table 3-1: Radio Science DSP Configuration - Joint Grav Wave Exp.

Parameter	DIRECTIVE	Setting	Notes
34-m HEF (DSS: 15, 45, or 65) (Mars Observer Only)			
Filter number	DEFFL	1 1 1 1	82/100 Hz BW
Filter offset	RIVOF	-150	in Hz
NBOC mode	MODE	1	
Sample rate	NBRAT	200	samp/sec
IVC switch	CFG	CROSS	
Chan. assignment	NBCHN		NBOC ch=RIV ch
		A = 1	XRCP
		B = 1	XRCP
		C = 1	XRCP
		D = 1	XRCP
Output to SSI	SSS	A	
Bit resolution	NBRES	8	
Tape density, bpi	DENS	6250	458.3 min/tape

Table 3-2: Radio Science DSP Configuration - GLL USO Tests

Parameter	DIRECTIVE	Setting	Notes
70-m (DSS: 14, 43, or 63)			
Filter number	DEFFL	1 1 1 1	82/100 Hz BW
Filter offset	RIVOF	-150	in Hz
NBOC mode	MODE	1	
Sample rate	NBRAT	200	samp/sec
IVC switch	CFG	PRIME	
Chan. assignment	NBCHN		NBOC ch=RIV ch
		A = 2	SRCP
		B = 2	SRCP
		C = 4	SLCP
		D = 4	SLCP
Output to SSI	SSS	B	
Bit resolution	NBRES	8	
Tape density, bpi	DENS	6250	458.3 min/tape
34-m STD (DSS: 42, or 61)			
Filter number	DEFFL	1 1 1 1	82/100 Hz BW
Filter offset	RIVOF	-150	in Hz
NBOC mode	MODE	1	
Sample rate	NBRAT	200	samp/sec
IVC switch	CFG	Not applicable	
Chan. assignment	NBCHN		NBOC ch=MMR ch
		A = 4	SRCP
		B = 4	SRCP
		C = 4	SRCP
		D = 4	SRCP
Output to SSI	SSS	B	
Bit resolution	NBRES	8	
Tape density, bpi	DENS	6250	458.3 min/tape

Table 3-3: Radio Science DSP Configuration - MO Cruise Tests

Parameter	DIRECTIVE	Setting	Notes
70-m (DSS: 14, 43, or 63)			
Filter number	DEFFL	3 3 3 3	2 kHz BW
Filter offset	RIVOF	2750	in Hz
NBOC mode	MODE	2	
Sample rate	NBRAT	2000	samp/sec
IVC switch	CFG	PRIME	
Chan. assignment	NBCHN		NBOC ch=RIV ch
		A = 1	XRCP
		B = 1	XRCP
		C = 1	XRCP
		D = 1	XRCP
Output to SSI	SSS	A	
Bit resolution	NBRES	12	
Tape density, bpi	DENS	6250	125 min/tape
34-m HEF (DSS: 15, 45, or 65)			
Filter number	DEFFL	3 3 3 3	2 kHz BW
Filter offset	RIVOF	2750	in Hz
NBOC mode	MODE	2	
Sample rate	NBRAT	2000	samp/sec
IVC switch	CFG	CROSS	
Chan. assignment	NBCHN		NBOC ch=RIV ch
		A = 1	XRCP
		B = 1	XRCP
		C = 1	XRCP
		D = 1	XRCP
Output to SSI	SSS	A	
Bit resolution	NBRES	12	
Tape density, bpi	DENS	6250	125 min/tape
34-m STD (DSS: 42, or 61)			
Filter number	DEFFL	3 3 3 3	2 kHz BW
Filter offset	RIVOF	2750	in Hz
NBOC mode	MODE	2	
Sample rate	NBRAT	2000	samp/sec
IVC switch	CFG	Not applicable	
Chan. assignment	NBCHN		NBOC ch=MMR ch
		A = 3	XRCP
		B = 3	XRCP
		C = 3	XRCP
		D = 3	XRCP
Output to SSI	SSS	B	
Bit resolution	NBRES	12	
Tape density, bpi	DENS	6250	125 min/tape

3.3 AMMOS and Other Facilities

3.3.1 AMMOS

AMMOS, the Advanced Multi-Mission Operations System, refers to the equipment, software and personnel that handle operations and data flow for flight projects. The AMMOS hardware and software used to support flight operations is called the Multi-mission Ground Data System (MGDS). Mars Observer, unlike Ulysses and Galileo, will use AMMOS exclusively for all telemetry, DSN monitor, radiometric, and, after May 1, 1993, radio science data delivery from the DSN. In addition, the Mars Observer Project delivers spacecraft commands to the DSN for transmission via AMMOS facilities. A block diagram of DSN->AMMOS data flow is shown as Figure 3-14.

Radio science data coming from the remote stations, including the new interface blocks RSC-11-11 (open loop samples) and RSC-11-12 (SSI and radio science monitor), is packaged with a DSN Standard Format Data Unit (SFDU) header (SFDUs are a type of standardized data identifier). It is then passed through the station gateway, the SCP (Station Comm Processor), over electronic links to the MGDS gateway, the CCP (Central Comm Processor), at JPL. The CCP routes data to the NOCC Gateway (NG) which supplies data to the NOCC and its monitor displays as well as to RODAN. The CCP also routes data to the SFOC Gateway (SG) which moves data onto AMMOS. Data passed to the SG is handed to the GIF which supplies an AMMOS SFDU header and routes it to the TIS which does some processing of the data. Examples of TIS processing are decommutation, where individual data types are extracted from data blocks, and channelization, where individual data types are identified and sorted by predetermined "channel" assignments (for example, USO Temperature is channel I-922). This data is then placed in the database for retrieval.

The blocks from the system just described are examined in some detail below. Explanations of acronyms are given in the block diagram, Figure 3-15.

3.3.1.1 Roles of the AMMOS Subsystems

GIF: The interface between the DSN and AMMOS (i.e., the "front-end" gateway for data coming into AMMOS from each DSCC). GIF captures the telemetry and ground station monitor data, packages it in a standard format ("wrapping" it in an SFDU), and routes it to the TIS. It also routes command files back to the DSCCs.

TIS: Does the major processing (frame synchronization, decommutation, and extraction) of telemetry and monitor data, reading the telemetry stream, correcting obvious errors, and organizing the data for the remaining systems downstream.

CDB: Includes data base management software (CDB) and project-specific data storage facilities (Project Data Bases, PDBs). The CDB loader loads the data stream from the TIS into the PDB. Older data is archived offline to make room for newer data coming in. The PDB also contains files (ancillary data, command files, etc.) in UNIX directories.

"Stream data" is frame- or packet-based and defined by a finite time interval. An example of stream data is real-time RSC-11-11 or MON 5-15 blocks. Spool files or spoolers are files created with a fixed size limit and are specially formatted for storing stream data for use by stream data tools. Specifically, the data may be retrieved from the files by choice of parameters, rather than having to accept the entire file.

"File data" (also called bytestream file data) is any data available in a (non-spooler) file with a filename. The data in this file may be repackaged stream data, which will no longer be available to stream tools and therefore no longer accessible by individual block parameters such as creation time. The other sort of file data is that which is provided originally in a file and never as a real-time stream. Files in this category include closed-loop ATDFs, weather data files, and various navigation files. File data may be any length.

The PDB catalog keeps track of both stream data and file data. Stream data is queried through the TDS, using various block parameters (time tag, spacecraft number, data type, etc.) to specify which particular data blocks are desired. File data is queried through WOTU interface from user workstations, where the file catalog entries indicate the contents of each file available. The user can determine the file needed after finding a catalog entry describing desired data.

TDS: The primary delivery mechanism for stream data to users. The Telemetry Output Tool from the AMMOS workstation enables users to build queries for the TDS which can time-merge a data stream taking data from the real-time broadcast stream, the near-real-time spoolers (the NERT cache), and/or the PDB.

CMD: Allows authorized users to send spacecraft commands and command sequences to the DSN and to monitor and control their radiation to the spacecraft. Also supports creation of command files.

Browser: Allows users to examine and summarize stream data records at their workstations. Displays or dumps (prints) records based on Browser templates. Filters can be used to select specific records; Browser can then write selected records to spoolers or bytestream files.

DMD: Allows users to read, analyze, and display telemetry and related data in a variety of formats. Processes real-time, near-real-time, and non-real-time channelized data and displays it graphically on-screen or produces a hardcopy. Can output processed data to user programs or files.

3.3.1.2 Radio Science AMMOS Workstation

Radio Science has an AMMOS workstation located in the real-time area. This workstation, MMRS (Multi-Mission Radio Science), has all AMMOS tools for display and capture of data and can be used both to monitor the progress of on-going experiments and to retrieve data from previous experiments. The workstation will be used to support real-time Mars Observer operations just as RODAN is used to support other flight projects' activities. When fully operational, the AMMOS real-time data delivery system will allow Mars Observer data to be collected without the need for magnetic tape delivery from the station. It is currently expected that the MO occultation experiments, beginning in Fall 1993, will be supported primarily by AMMOS. The Joint Gravitational Wave Experiment (JGWE) in March 1993 will use an engineering version of the MGDS as its primary data link and will use RODAN and magnetic tape delivery as backup.

3.3.1.3 AMMOS versus RODAN

There are two main differences between the Mars Observer/AMMOS data system and the Multi-Mission Radio Science/RODAN data system. The first is the destination and preprocessing and the second is the format.

Currently, radio science data goes through the ARA at the station to be transferred to JPL, and then on as described in Section 9.0. In the transition phase, while the AMMOS real-time data delivery system is still being implemented and tested, the ARA and AMMOS (SCP->CCP->SG) data lines will exist simultaneously. For radio science data, the DSP can route to either the ARA or the AMMOS system depending on operator selection. After transition, the ARA will no longer be present and all data will flow along the SCP to CCP path. The difference then will be that AMMOS-bound data will be routed from the CCP into the SG, while other data will be routed from the CCP into NG. From the NG, the data will be relayed to RODAN, through the serial interface described in Section 9.5.

The formatting difference in the two systems is very much related to the destination. AMMOS-bound data will all have SFDU headers which RODAN and its links are presently not able to decode. The new serial interface to RODAN will be able to strip off these headers and process data as before. The new DSP software for producing these SFDUs, however, will maintain the ability to also produce non-SFDU blocks. The DSP will determine which kind of block to produce by which destination, AMMOS or non-AMMOS, it is asked to send the data. When the RODAN upgrade is carried out, all data will be produced with these headers. The formatting difference, then, will only exist until the implementation and acceptance of the RODAN upgrade, to be completed by Spring of 1993.

3.3.2 GROUND COMMUNICATIONS FACILITY

The Ground Communications Facility (GCF) provides the communication networks needed to support the communication requirements of the Radio Science System. These facilities exist at the DSCC and JPL and are briefly described in the following paragraphs.

3.3.2.1 GCF Data Subsystem

Presently, monitoring information from the DSN complexes is transported over Ground Communication Facility (GCF) data lines. The Radio Science Real-time Monitoring System (RMS) taps into these lines and feeds the data through modem lines to the PRIME. See Section 9 for a discussion of the normal configuration of these lines.

The GCF data lines transmit Radio Science open-loop tuning predicts from the NOCC to the DSS (and CTA-21) and send Radio Science, Tracking and Monitor and Control Subsystems status and configuration data from the DSCC to the NOCC in real-time. After the completion of a Radio Science recording period, the data lines can be used to send Radio Science data from the DSCC to the NOCC.

3.3.2.2 GCF Data Records Subsystem

The GCF Data Records Generator (DRG) formats the incoming closed-loop data from the DSCC and provides them to the RMDCT team which converts the Doppler and range data into computer-compatible tapes called Archival Tracking Data Files

(ATDF).

3.3.2.3 Voice Net Communications

The Ground Communications Facility voice nets provide both the means of controlling worldwide spacecraft tracking operations and for relaying information required to verify proper operation of the various ground and spacecraft subsystems. Section 6 contains a description of the voice nets as it is planned for Radio Science activities

3.3.2.4 RODAN Interface

Presently, data lines from GCF to RODAN allow the RSST to capture and display Radio Science data from the GCF lines. By March 1, 1993, an upgraded and formalized interface will replace the present system. See Section 9 for a more complete description.

3.3.3 NETWORK OPERATIONS CONTROL CENTER (NOCC)

The NOCC generates and transmits information to each DSCC prior to tracking support. It also receives, displays, logs and distributes data generated at the DSCC during tracking support.

3.3.3.1 NOCC Support Subsystem

The NOCC Support Subsystem (NSS) generates Radio Science, antenna pointing, tracking, receiver, and uplink predicts. The NSS also provides DSCC schedules and transmits a subset of the Project's SOE to be used at the stations during tracking support.

3.3.3.2 NOCC Display Subsystem

The NOCC Display Subsystem generates DTV graphic and alphanumeric status and configuration displays. The NOCC Display Subsystem provides these displays to the Network Operations Control Center and the Project's Mission Support Area. The specific subsystems involved are the NRV RTM which generates graphic displays of SSI data and alphanumeric displays of the DSP status and tuning information, the NTK RTM which generates alphanumeric displays of closed-loop data and the Video Assembly Processor (VAP) which generates graphic displays of selected data types.

The display subsystem at NOCC provides real-time visibility at JPL during real-time activities. The NRV remote SSI display, the NRV DSP status displays, the VAP Radio Science graphic displays, the NTK tracking alphanumeric displays and the NMP monitor alphanumeric displays are all expected to be used to support Radio Science experiments.

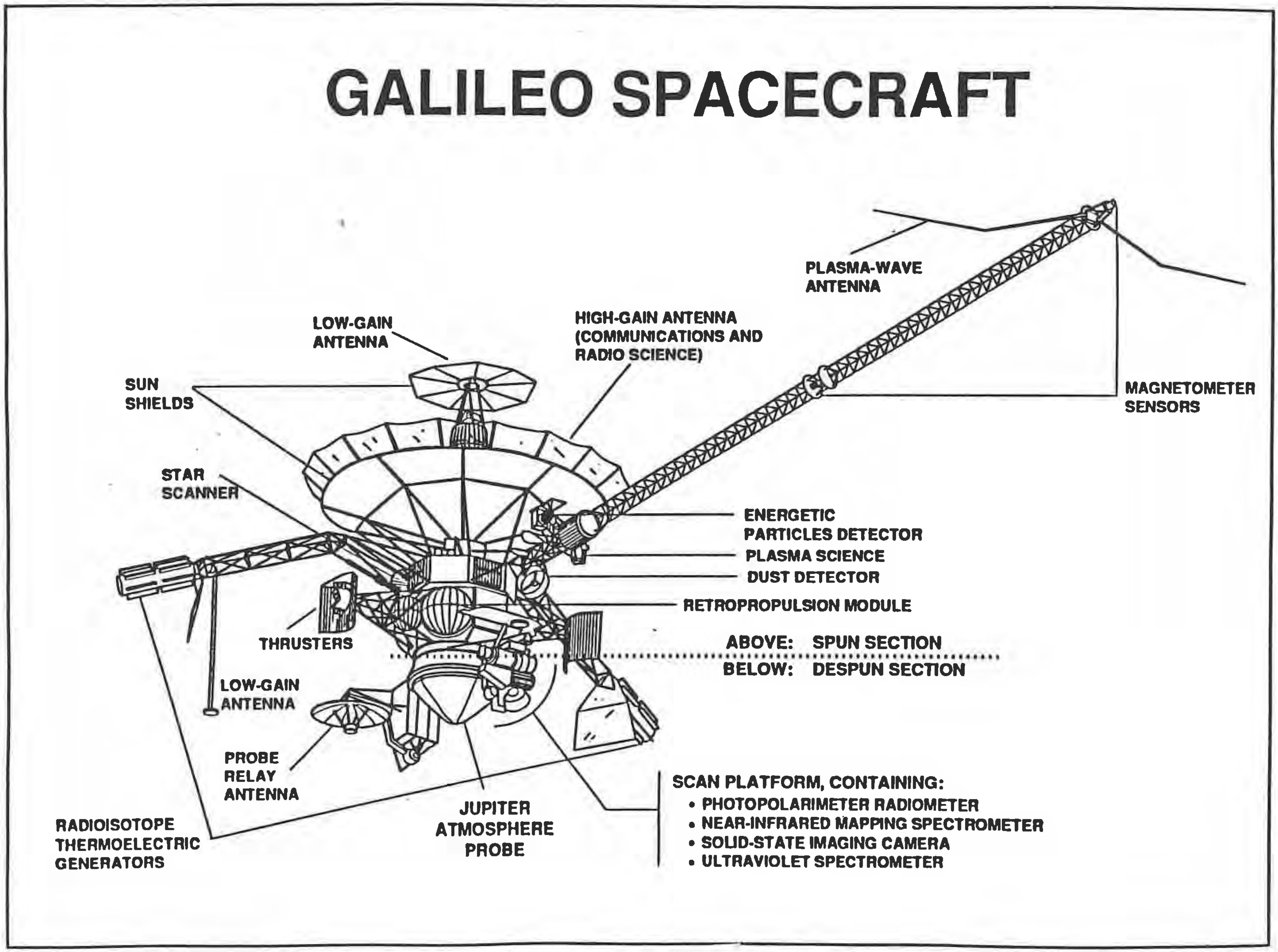
3.3.4 MISSION CONTROL COMPUTER CENTER (MCCC)

The MCCC routes all NOCC displays utilized by Radio Science and the Real Time Display System (RTDS) via its distribution system.

The MCCC RTDS provides displays of the data contained in the Monitor 5-9 blocks. These data contain system temperature, AGC and signal level estimates as well as the receiver/exciter subsystem and antenna subsystem configuration information.

3.3.5 MISSION SUPPORT AREA

The Radio Science Multi-Mission Support Area contains the real-time control center for the Radio Science System. Voice lines and DTV display capability are provided to the Project's real-time operations personnel to aid in operations monitoring. Hardcopies of displays may be requested from the NOCC.



GALILEO SPACECRAFT
PLASMA-WAVE ANTENNA
LOW-GAIN ANTENNA
HIGH-GAIN ANTENNA (COMMUNICATIONS AND RADIO SCIENCE)
SUN SHIELDS
MAGNETOMETER SENSORS
STAR SCANNER
ENERGETIC PARTICLES DETECTOR
PLASMA SCIENCE
DUST DETECTOR
RETROPROPULSION MODULE
THRUSTERS
ABOVE: SPUN SECTION
BELOW: DESPUN SECTION
LOW-GAIN ANTENNA
PROBE RELAY ANTENNA
SCAN PLATFORM, CONTAINING:
• PHOTOPOLARIMETER RADIOMETER
• NEAR-INFRARED MAPPING SPECTROMETER
• SOLID-STATE IMAGING CAMERA
• ULTRAVIOLET SPECTROMETER
JUPITER ATMOSPHERE PROBE
RADIOISOTOPE THERMOELECTRIC GENERATORS

Figure 3-1

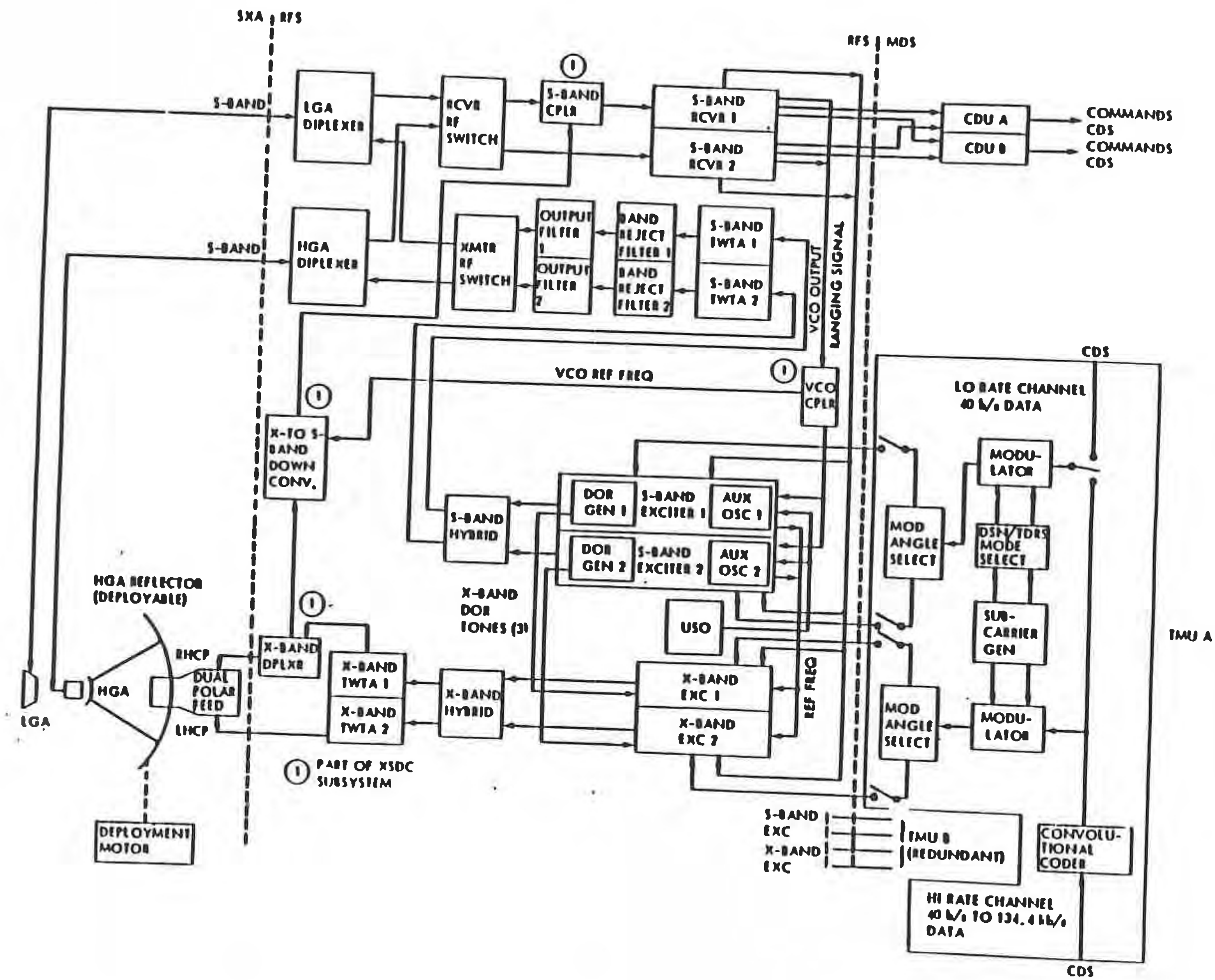


Figure 3-2 Galileo Orbiter Telecommunications System

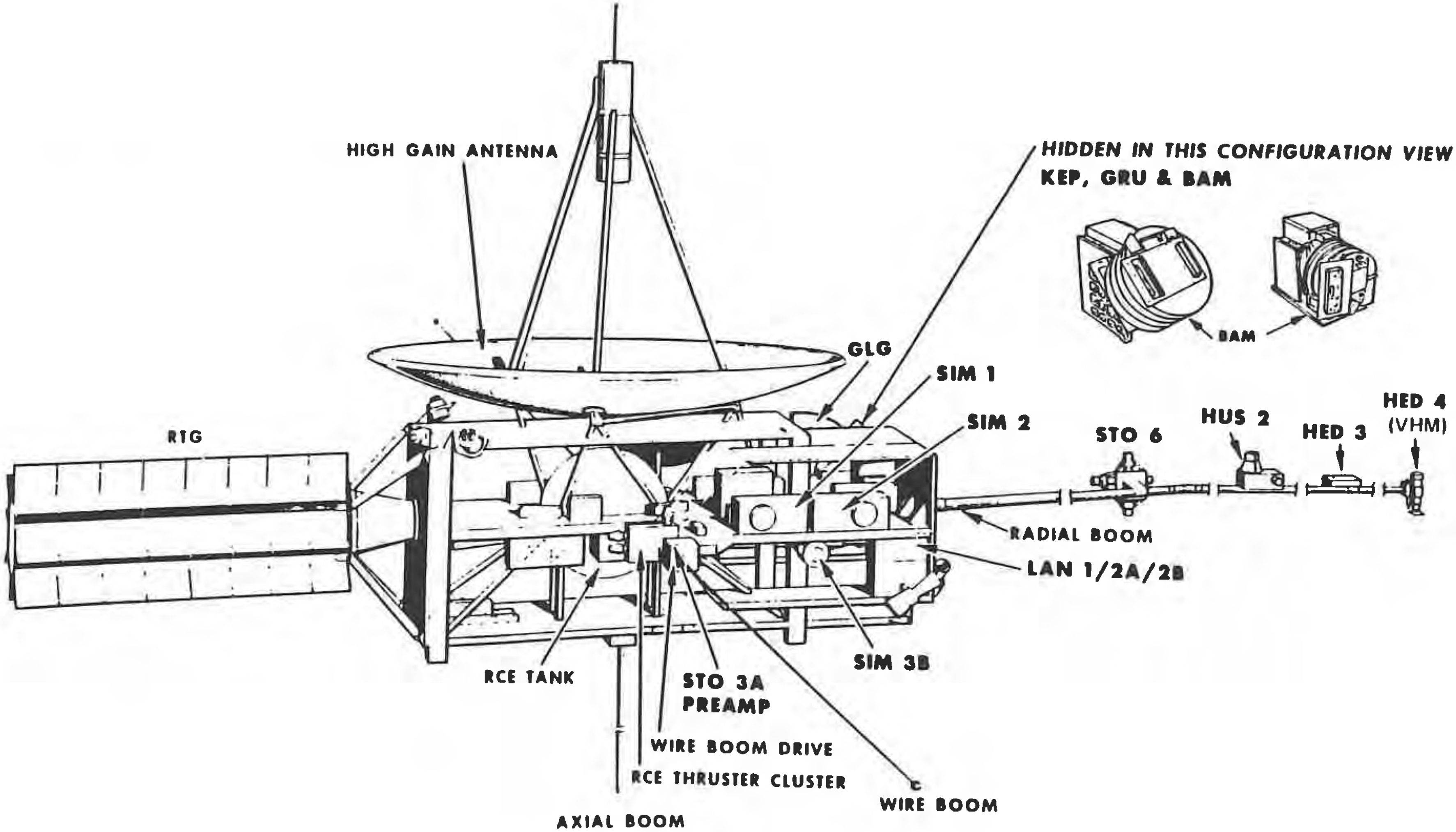


Figure 3-3 Ulysses Spacecraft

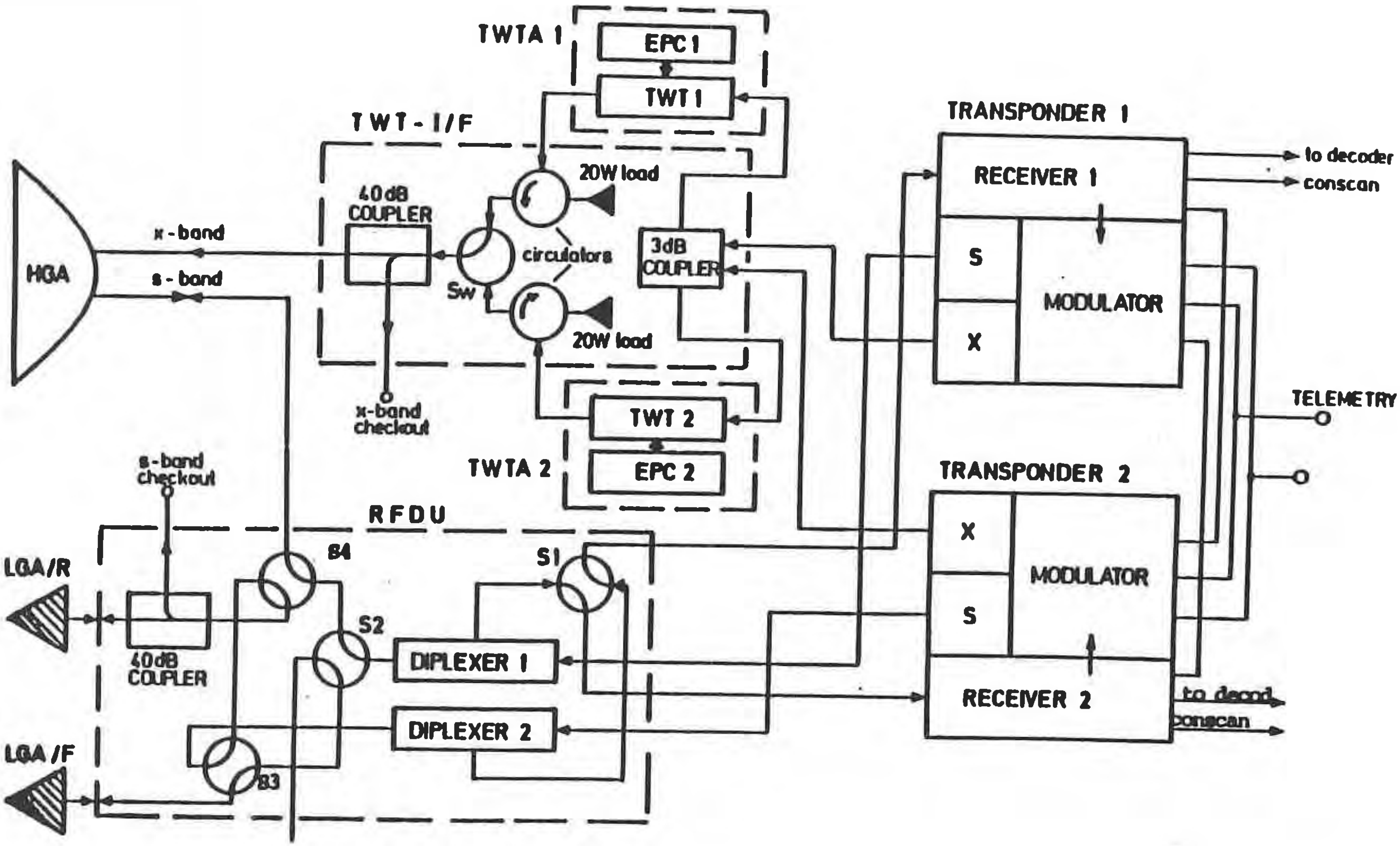


Figure 3-4 Ulysses Telecommunications Subsystem

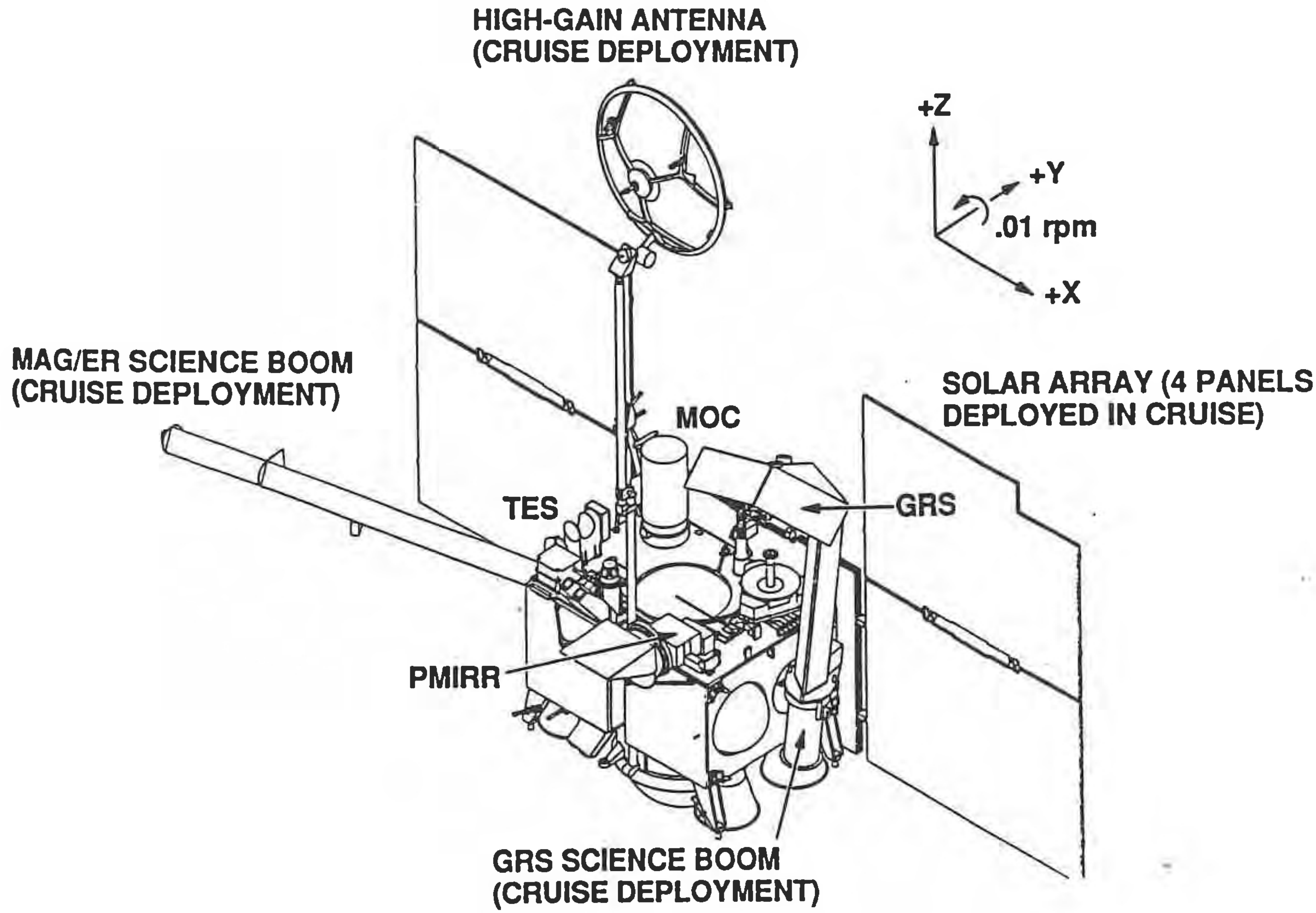


Figure 3-5 Mars Observer Spacecraft
(Cruise)

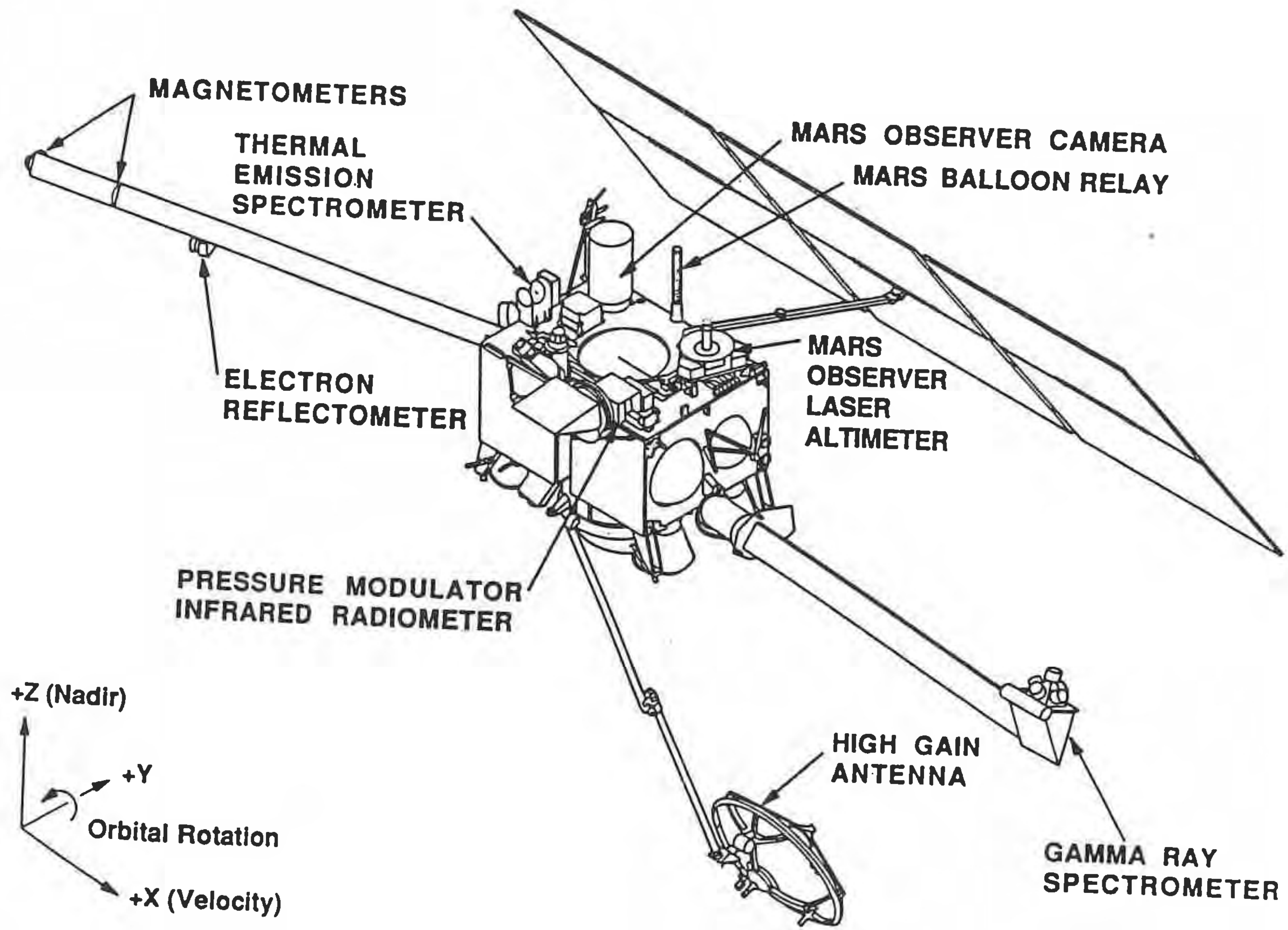


Figure 3-6 Mars Observer Spacecraft (Mapping)

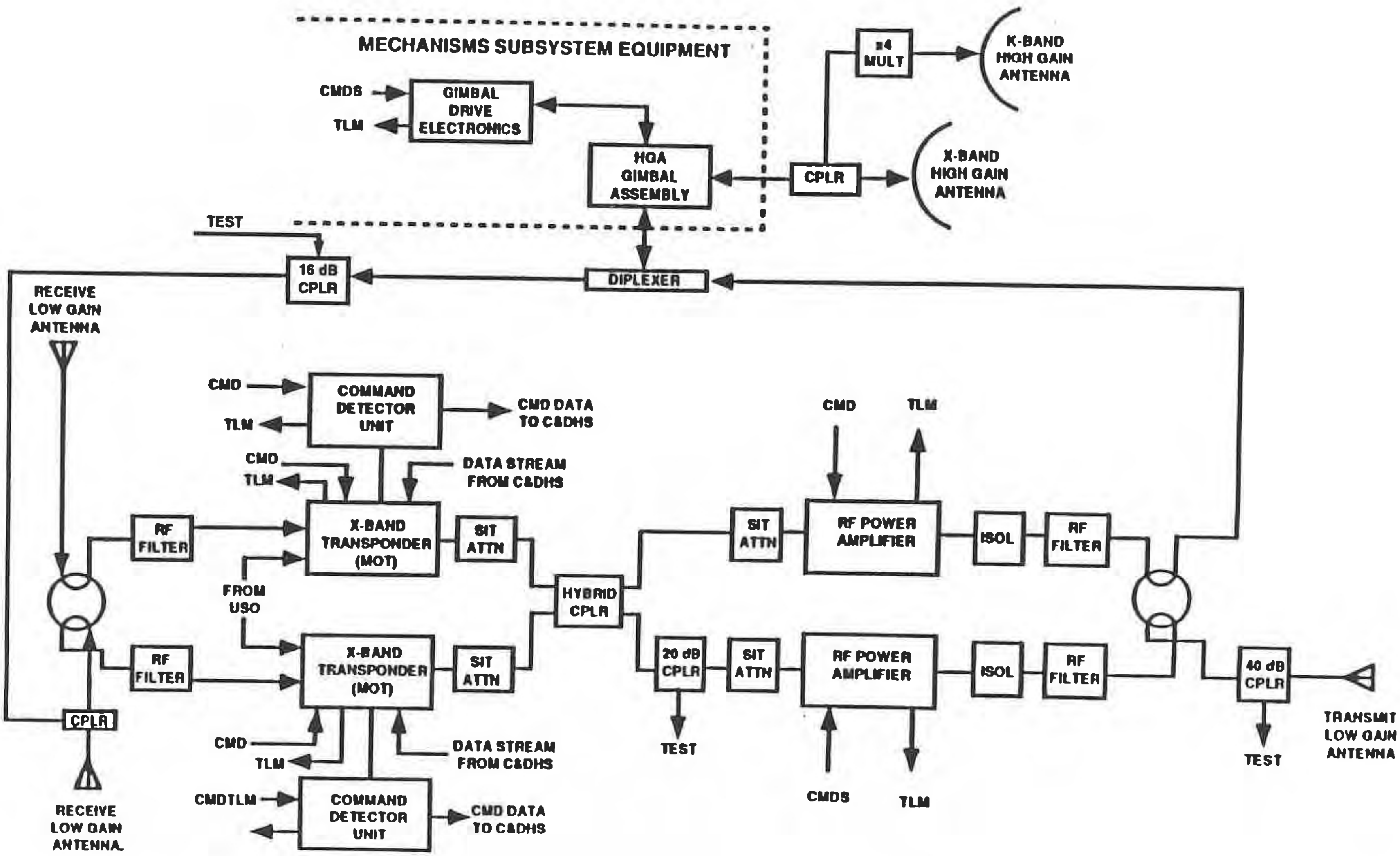


Figure 3-7 MO Telecommunications Subsystem Design

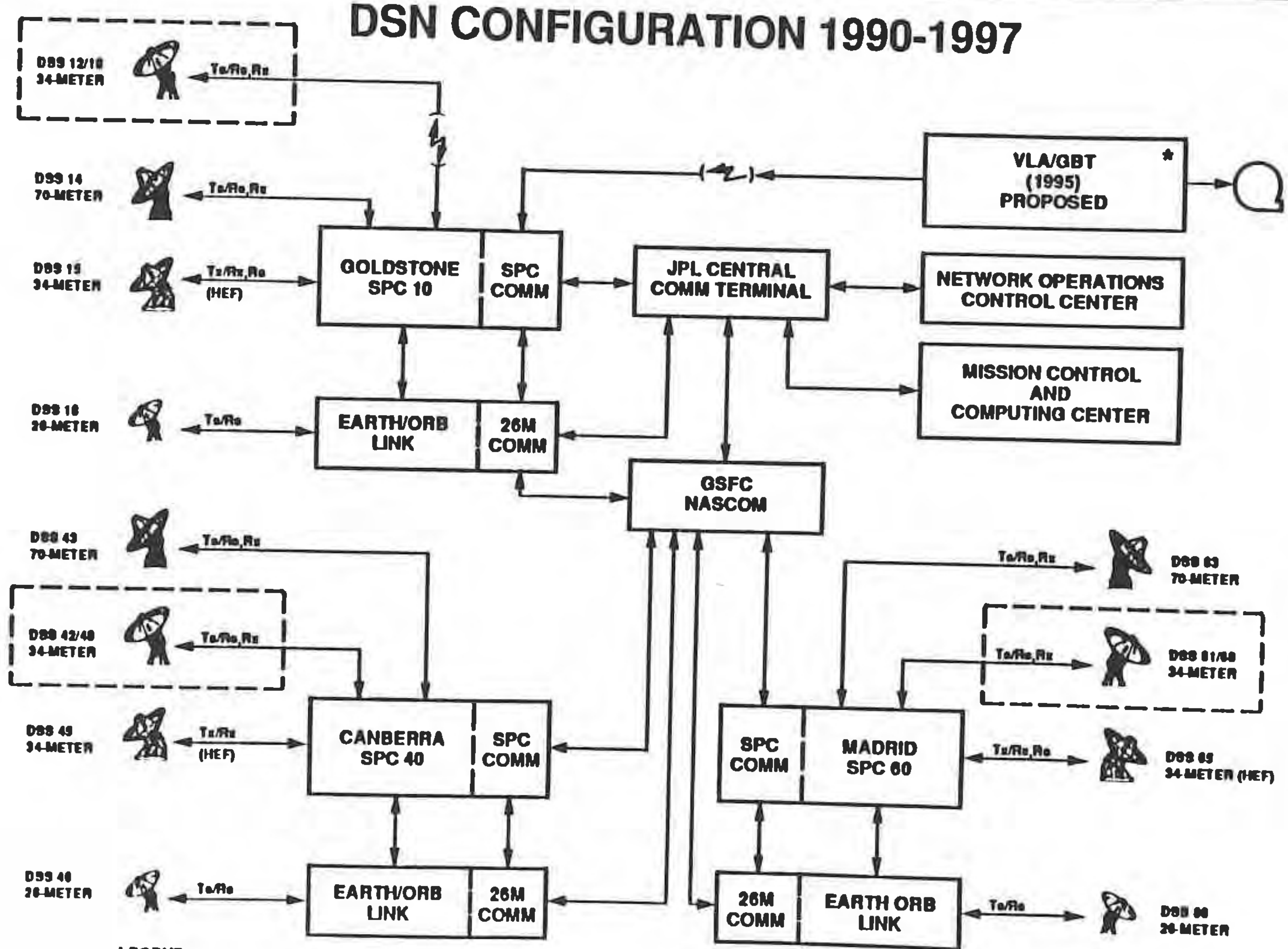
TELECOMMUNICATIONS AND DATA ACQUISITION

GALILEO MOS DELTA DESIGN REVIEW

JPL

DSN INSTITUTIONAL CHANGES WITHIN THE MOS

DSN CONFIGURATION 1990-1997



LEGEND:

COMM - GROUND COMMUNICATIONS
DSS - DEEP SPACE STATION
HEF - HIGH EFFICIENCY

M - METER
SPC - SIGNAL PROCESSING CENTER
STD - STANDARD

* PROPOSED CONCEPT - SUBJECT TO TDA/NRAO AGREEMENT

[- -] INSTITUTIONAL CHANGES

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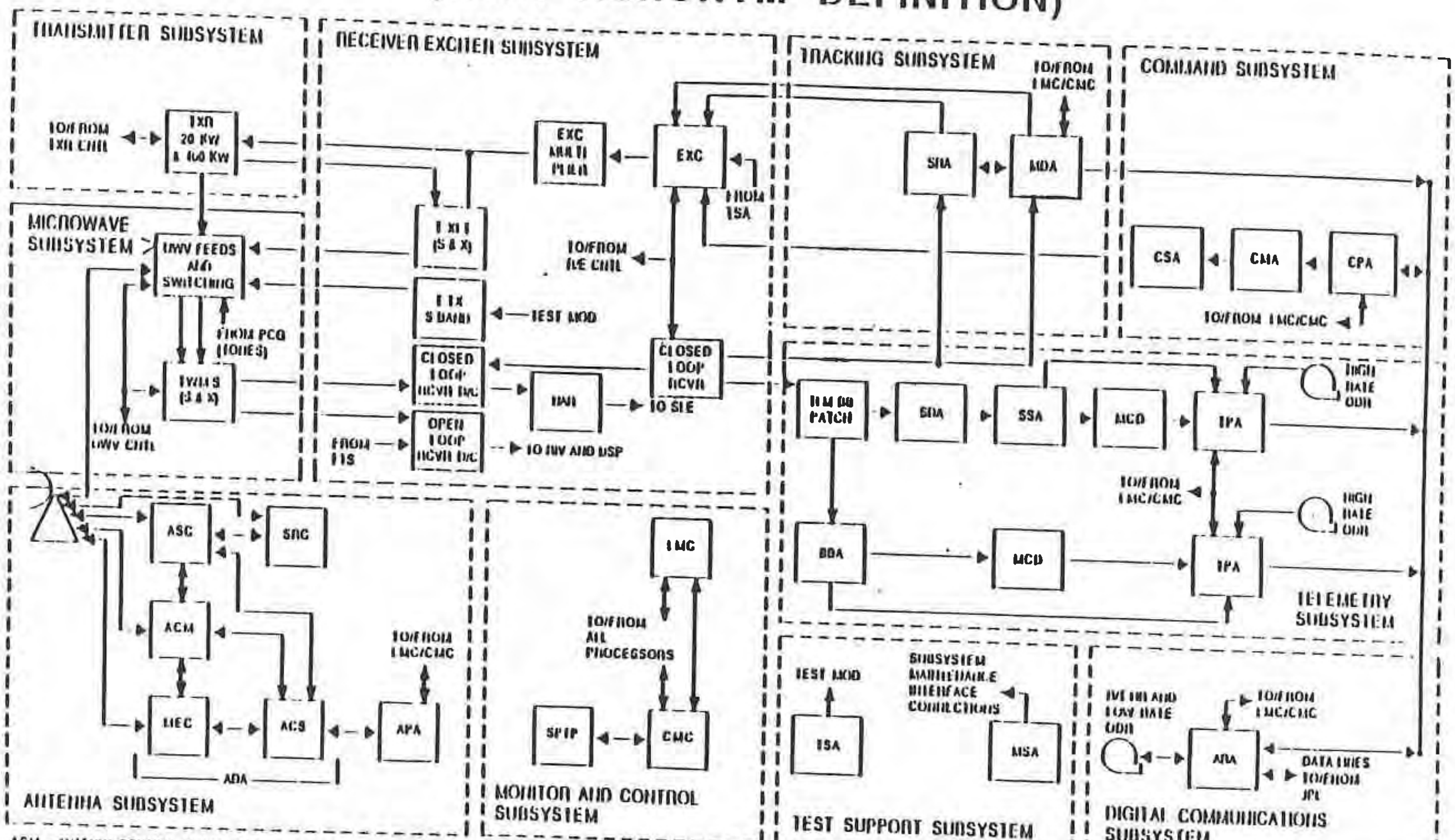
DJM-1
11-8-90

Figure 3-8

MARK IVA FUNCTIONAL BLOCK DIAGRAM
(WITH ACRONYM DEFINITION)



ACM - ANTENNA CONTROL AND MONITOR
ACS - ANTENNA CONTROL SUBASSEMBLY
ADA - ANTENNA DRIVE ASSEMBLY
APA - ANTENNA POINTING ASSEMBLY
ARA - AREA ROUTING ASSEMBLY
ASC - ANTENNA SERVO CONTROLLER
BB - BASEBAND
BBA - BASEBAND ASSEMBLY
CMA - COMMAND MODULATION ASSEMBLY
CMC - COMPLEX MONITOR AND CONTROL
CNTL - CONTROLLER
CPA - COMMAND PROCESSOR ASSEMBLY
CSA - COMMAND SWITCH ASSEMBLY

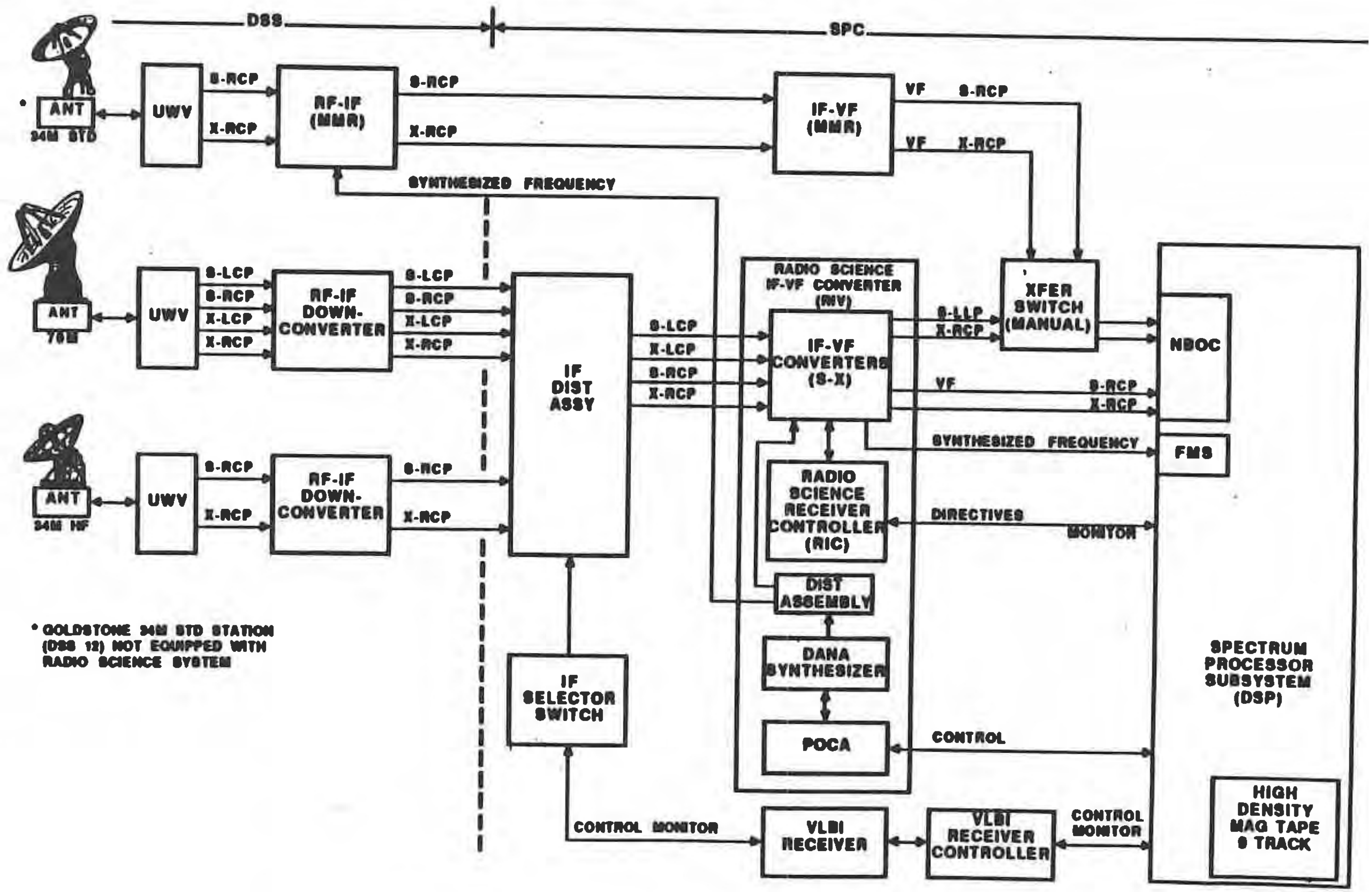
D/C - DOWNCONVERTER
DSP - DSCC SPECTRUM PROCESSING SUBSYSTEM
EXC - EXCITER
FTS - FREQUENCY AND TIMING SUBSYSTEM
LMC - LINK MONITOR AND CONTROL
MCD - MAXIMUM LIKELIHOOD CONVOLUTIONAL DECODER
MDA - METRIC DATA ASSEMBLY
MEC - MASTER EQUATORIAL CONTROLLER
MOD - MODULATION
MSA - MAINTENANCE SUPPORT ASSEMBLY
NAR - NOISE ADDING RADIOMETER
ODR - ORIGINAL DATA RECORD
PCG - PHASE CALIBRATION GENERATOR

RCVR - RECEIVER
RDA - RANGE DEMODULATION ASSEMBLY
R/E - RECEIVER EXCITER
RIV - RS IF VF DOWNCONVERTER
RS - RADIO SCIENCE
SDA - SUBCARRIER DEMODULATION ASSEMBLY
SLE - SIGNAL LEVEL ESTIMATOR
SPTP - SYSTEM PERFORMANCE TEST PROCESSOR
SRA - SEQUENTIAL RANGING ASSEMBLY
SRC - SUB REFLECTOR CONTROLLER
SSA - SYMBOL SYNCHRONIZER ASSEMBLY
TLM - TELEMETRY
TPA - TELEMETRY PROCESSOR ASSEMBLY

TSA - TELEMETRY SIMULATION ASSEMBLY
TWM - TRAVELING WAVE MASER
TXR - TRANSMITTER
T TX - TEST TRANSMITTER
T XLT - TEST TRANSLATOR
UWV - MICROWAVE

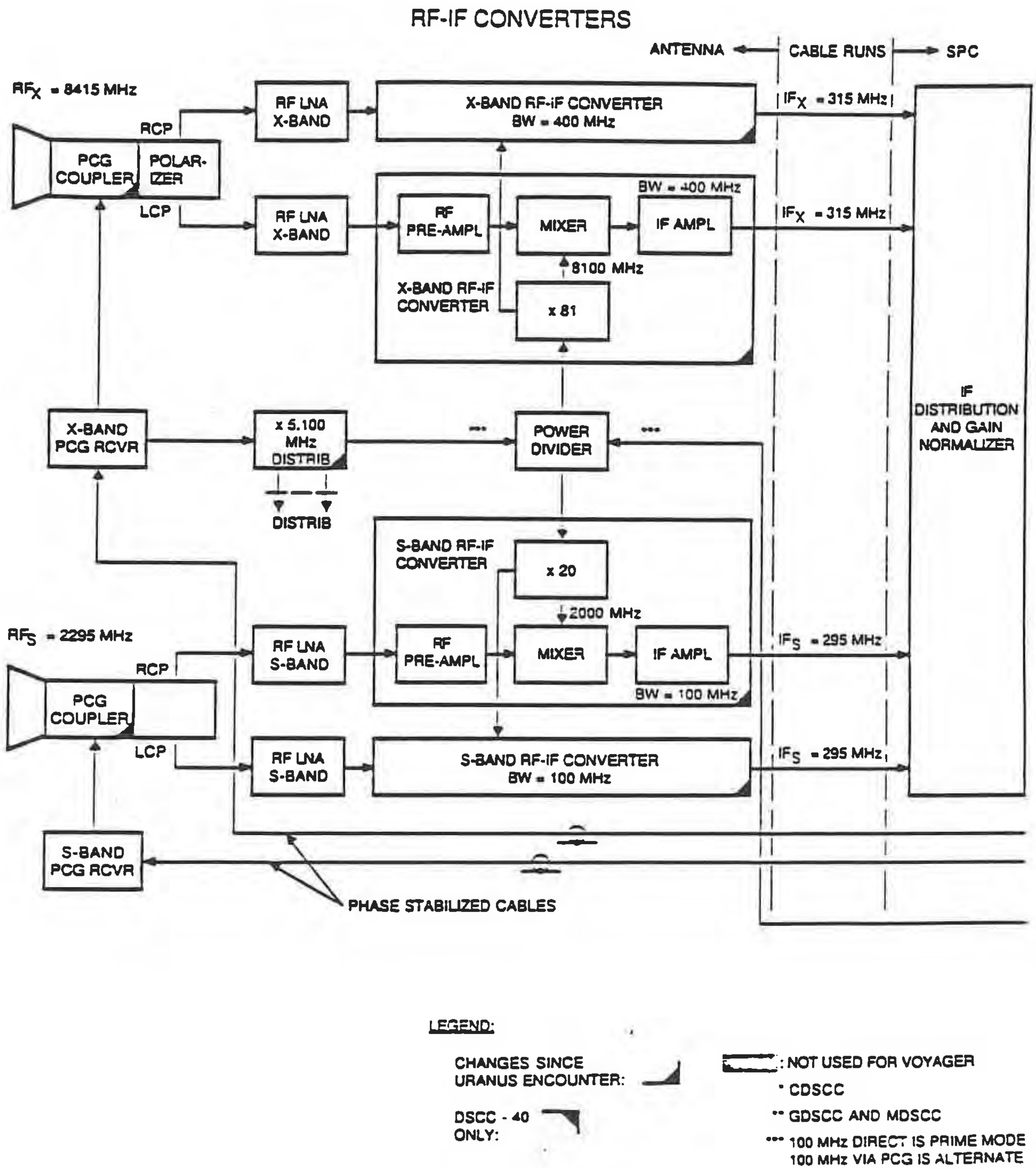
Figure 3-9

DSN RADIO SCIENCE SYSTEM



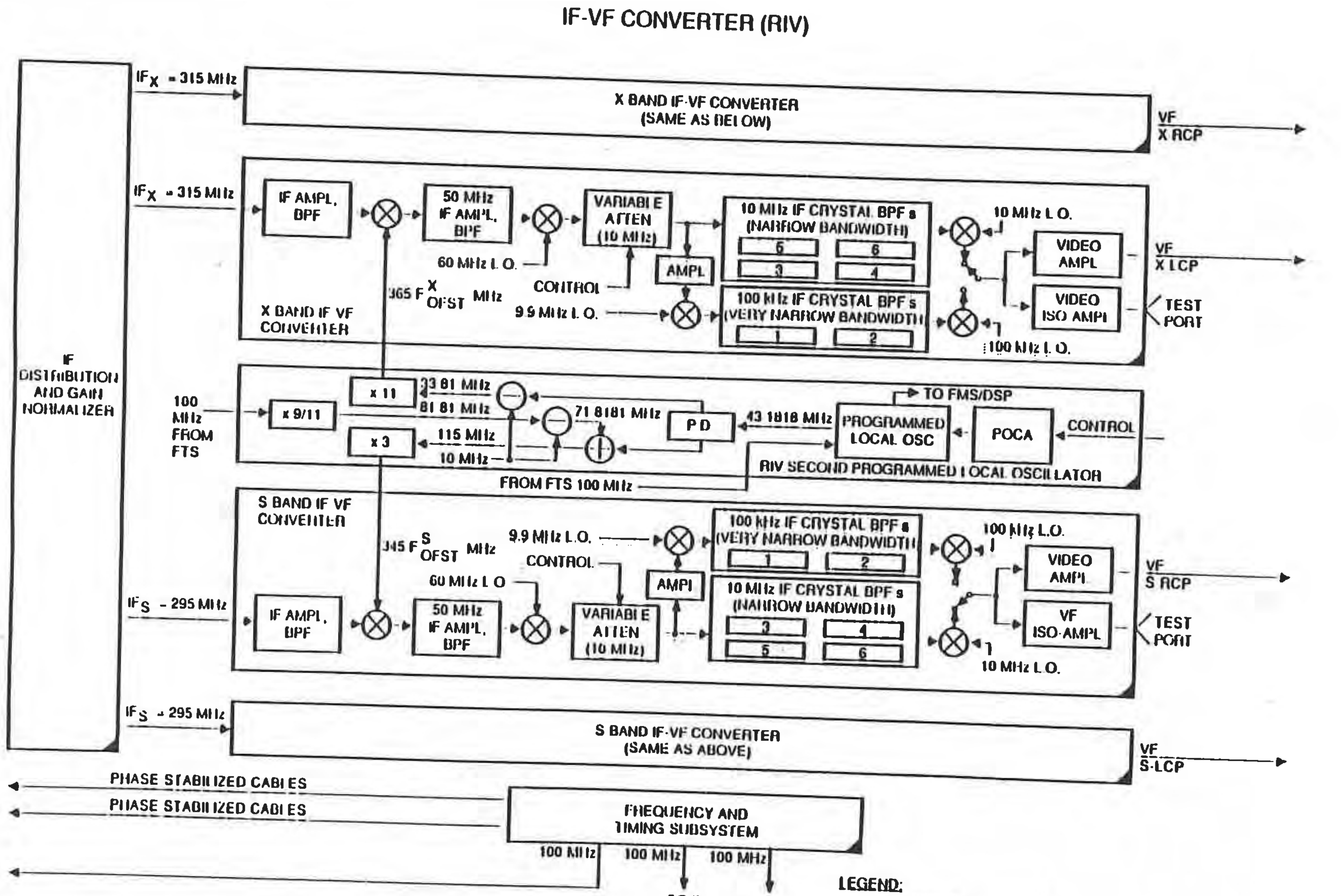
* GOLDSTONE 34M STD STATION (DSS 12) NOT EQUIPPED WITH RADIO SCIENCE SYSTEM

Figure 3-10



DSCC OPEN-LOOP RECEIVER (RF-IF)

Figure 3-11 (A)



DSCC OPEN-LOOP RECEIVER (IF-VF)

Figure 3-11 (B)

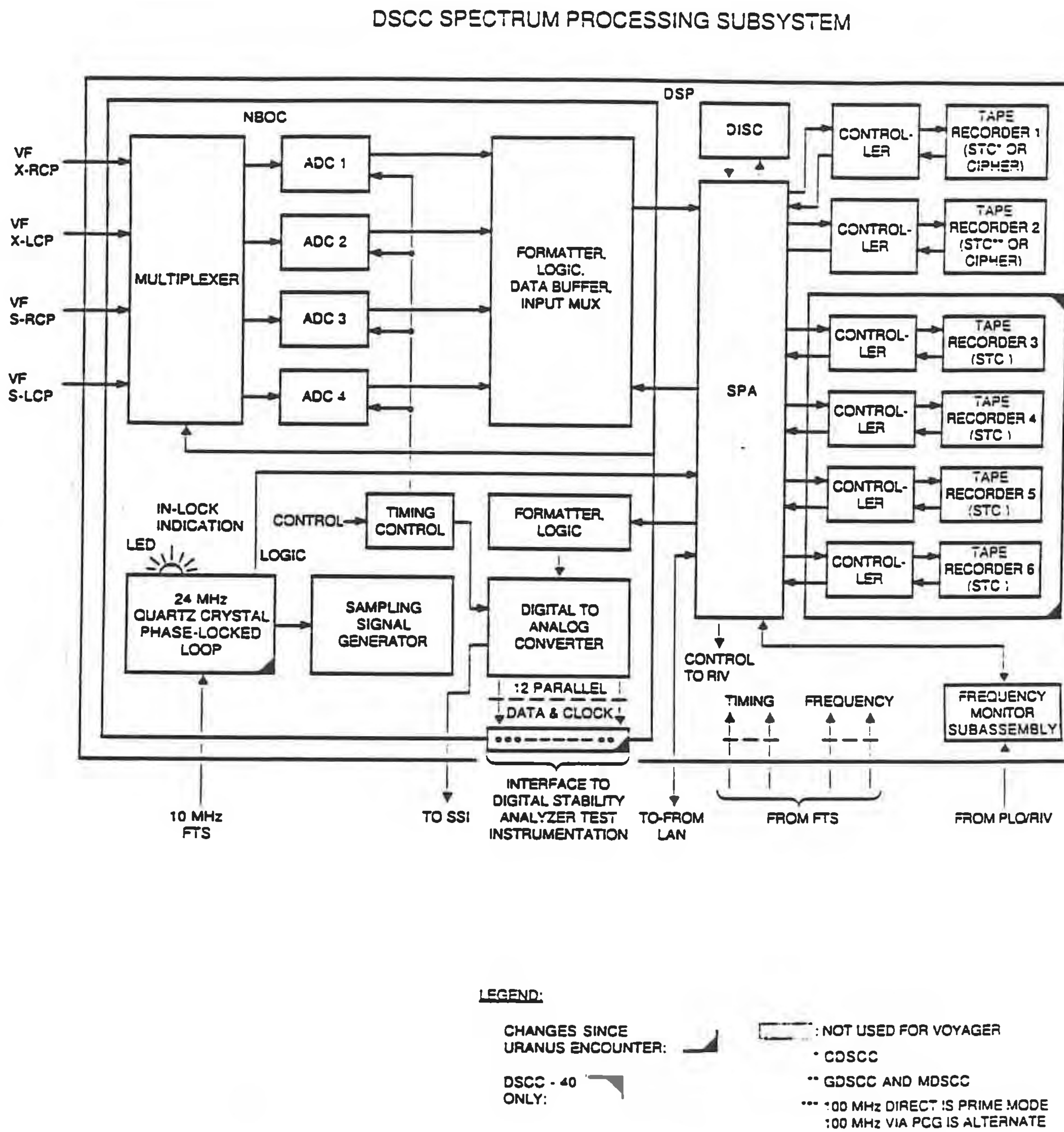

DSCC SPECTRUM PROCESSING SUBSYSTEM
DSP
NBOC
VF X-RCP
VF X-LCP
VF S-RCP
VF S-LCP
MULTIPLEXER
ADC 1
ADC 2
ADC 3
ADC 4
FORMATTER, LOGIC, DATA BUFFER, INPUT MUX
DISC
SPA
CONTROL-LER
TAPE RECORDER 1 (STC* OR CIPHER)
TAPE RECORDER 2 (STC** OR CIPHER)
TAPE RECORDER 3 (STC)
TAPE RECORDER 4 (STC)
TAPE RECORDER 5 (STC)
TAPE RECORDER 6 (STC)
IN-LOCK INDICATION
LED
CONTROL
LOGIC
TIMING CONTROL
FORMATTER, LOGIC
24 MHz QUARTZ CRYSTAL PHASE-LOCKED LOOP
SAMPLING SIGNAL GENERATOR
DIGITAL TO ANALOG CONVERTER
:2 PARALLEL
DATA & CLOCK
CONTROL TO RIV
TIMING
FREQUENCY
FREQUENCY MONITOR SUBASSEMBLY
10 MHz FTS
TO SSI
INTERFACE TO DIGITAL STABILITY ANALYZER TEST INSTRUMENTATION
TO-FROM LAN
FROM FTS
FROM PLO/RIV
LEGEND:
CHANGES SINCE URANUS ENCOUNTER:
DSCC - 40 ONLY:
: NOT USED FOR VOYAGER
* CDSCC
** GDSCC AND MDSCC
*** 100 MHz DIRECT IS PRIME MODE
100 MHz VIA PCG IS ALTERNATE

Figure 3-11 (C)

DSN TRACKING SYSTEM
70-METER DSS

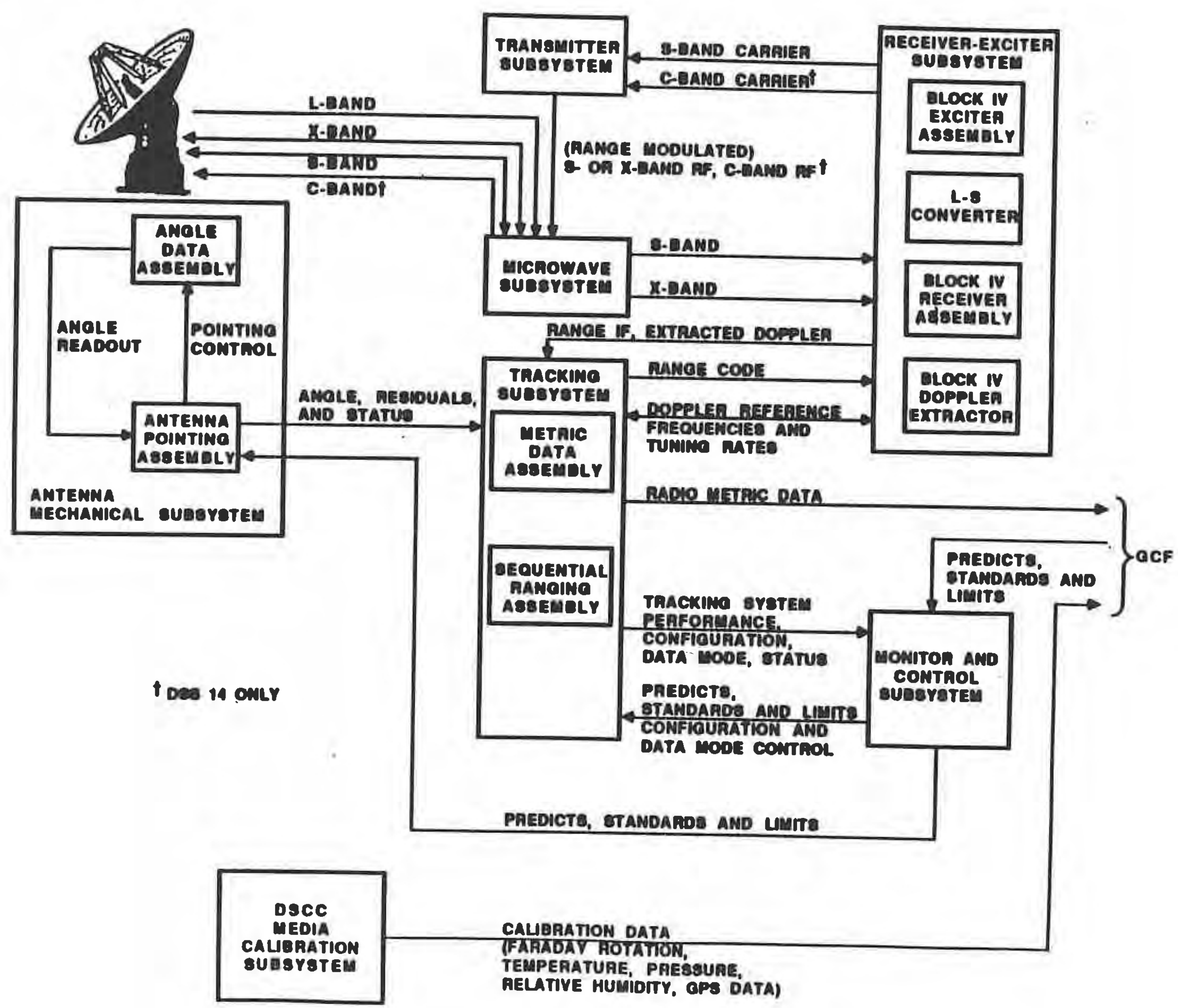
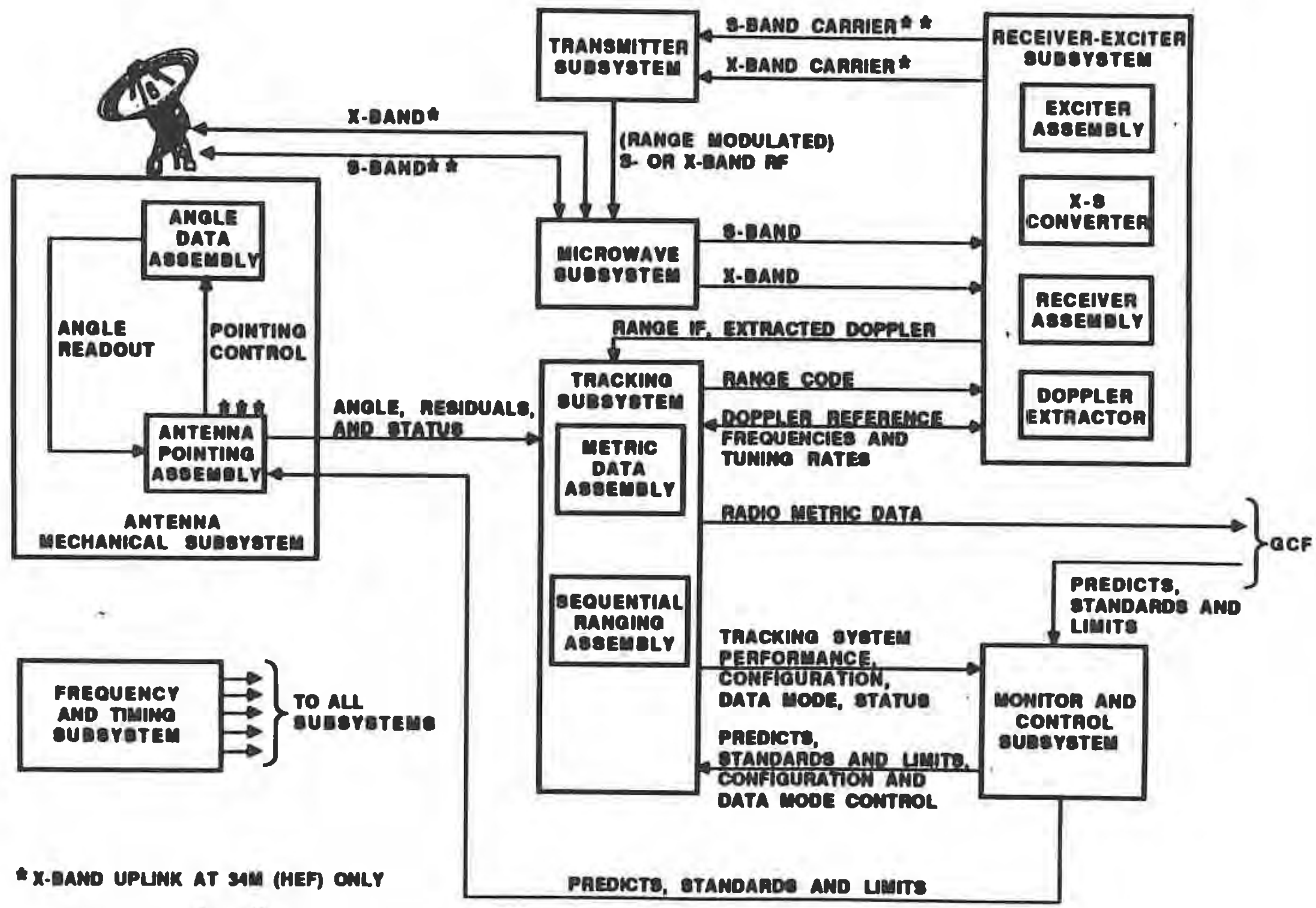


Figure 3-12

DSN TRACKING SYSTEM
34-METER DSS



* X-BAND UPLINK AT 34M (HEF) ONLY

** S-BAND UPLINK AT 34M (STD) ONLY

*** SHARED WITH 70M DSS

Figure 3-13

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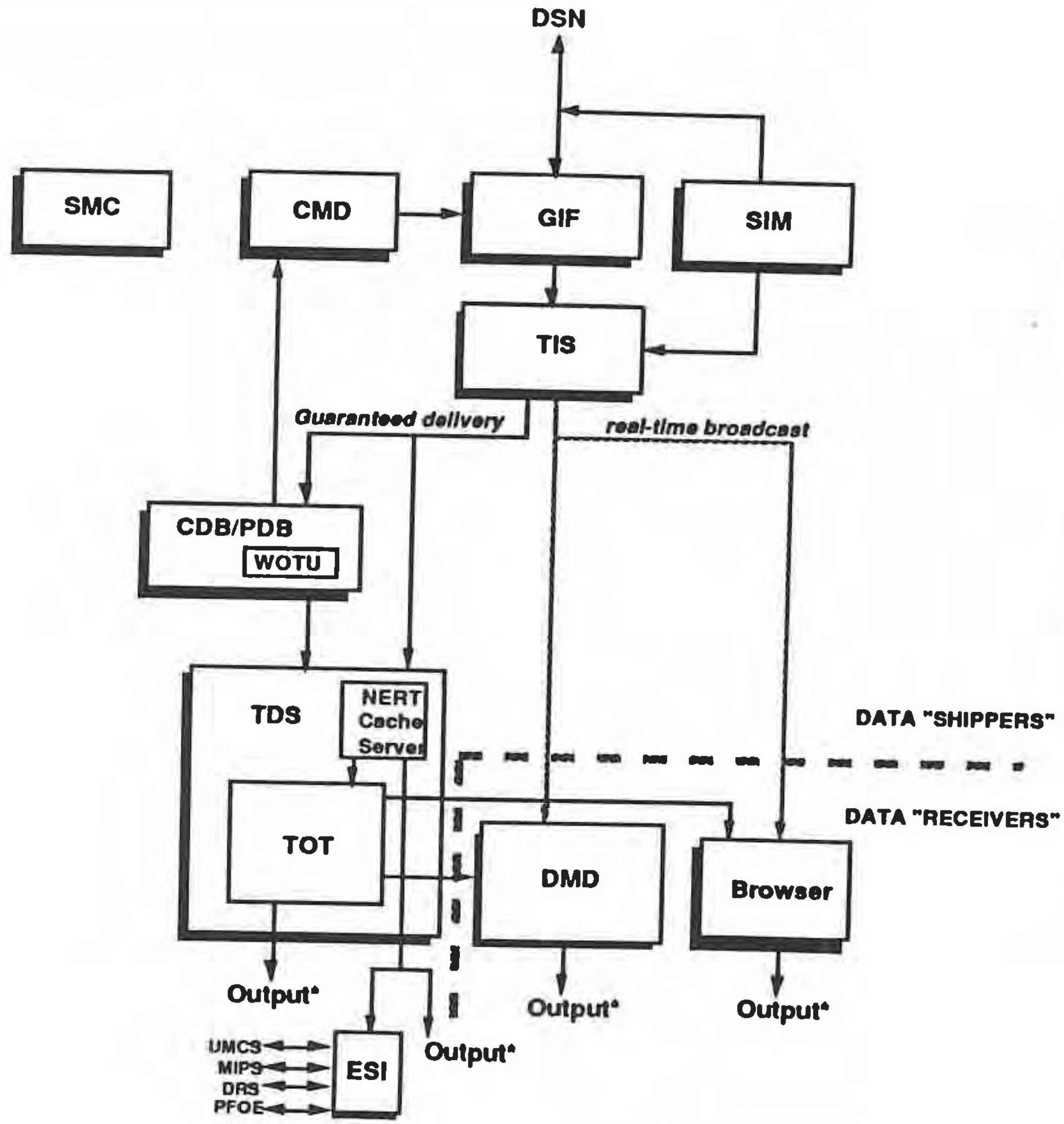
MGDS Subsystems

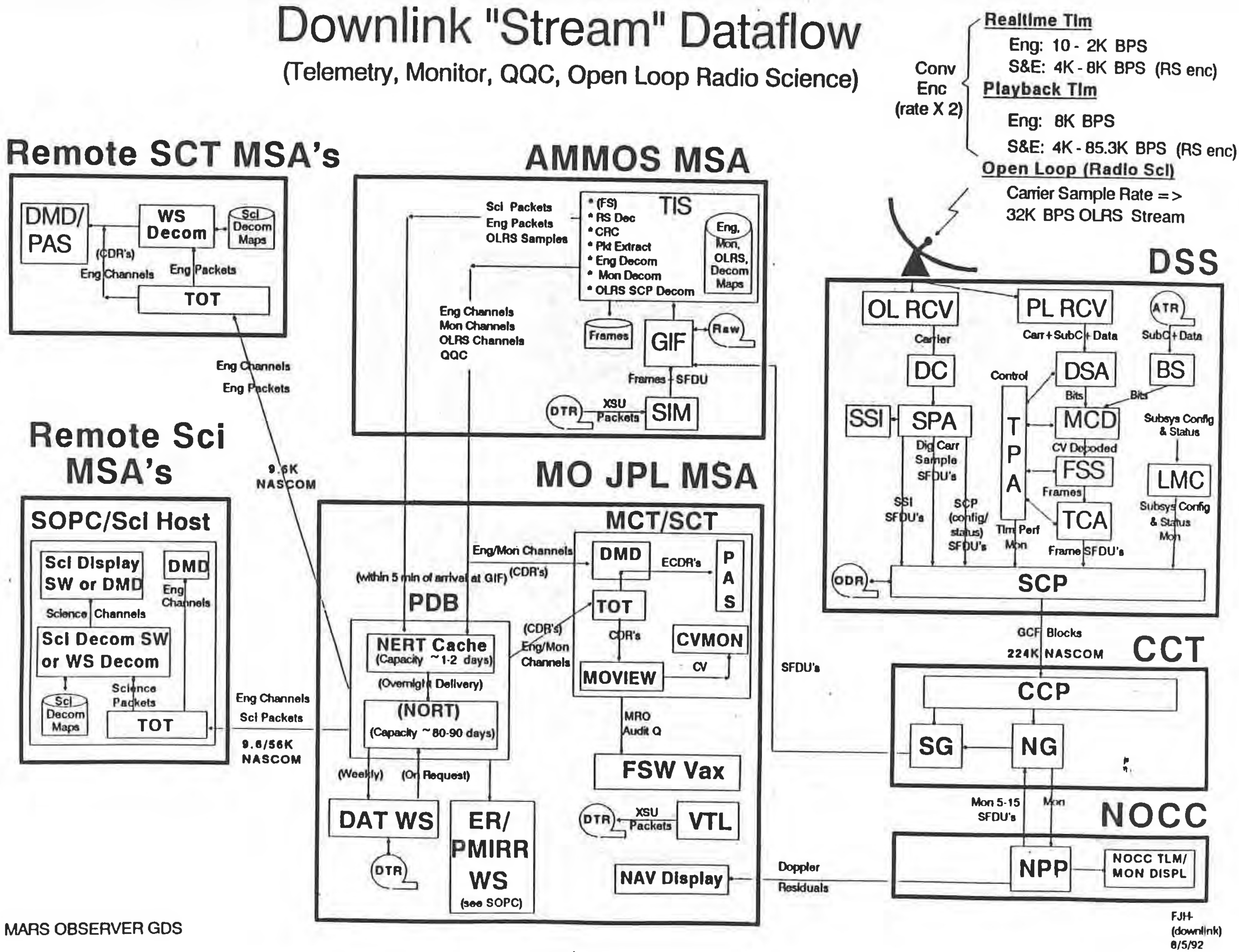


Legend:

CMD: Command Subsystem
CDB: Central Data Base
DMD: Data Monitor and Display Subsystem
DRS: Data Records System
ESI: External System Interface
GIF: Ground Comm. Facilities Interface
MIPS: Multimission Image Processing System
NERT: Near-real-time
PDB: Project Data Base
PFOE: Probe Flight Operations Equipment (Galileo)
SIM: Simulation Subsystem
SMC: System Monitor and Control Subsystem
TDS: Telemetry Delivery Subsystem
TOT: Telemetry Output Tool
UMCS: Ulysses Mission Control System
WOTU: Window on the Universe

*** Output may be in the form of displays, printouts, bytestream files, spooler files, or UNIX pipes or virtual circuits to user programs.**

Figure 3-14



Downlink "Stream" Dataflow
(Telemetry, Monitor, QQC, Open Loop Radio Science)
Conv Enc (rate X 2)
Realtime Tlm
Eng: 10 - 2K BPS
S&E: 4K - 8K BPS (RS enc)
Playback Tlm
Eng: 8K BPS
S&E: 4K - 85.3K BPS (RS enc)
Open Loop (Radio Sci)
Carrier Sample Rate =>
32K BPS OLRS Stream
Remote SCT MSA's
DMD/PAS
WS Decom
Sci Decom Maps
(CDR's)
Eng Channels
Eng Packets
TOT
AMMOS MSA
Sci Packets
Eng Packets
OLRS Samples
TIS
(FS)
RS Dec
CRC
Pkt Extract
Eng Decom
Mon Decom
OLRS SCP Decom
Eng, Mon, OLRS, Decom Maps
Eng Channels
Mon Channels
OLRS Channels
QQC
Frames
GIF
Raw
Frames
SFDU
DTR
XSU Packets
SIM
DSS
OL RCV
PL RCV
ATR
Carrier
Carr+SubC+Data
SubC+Data
DC
Control
DSA
BS
SSI
SPA
T P A
Bits
MCD
Subsys Config & Status
Dig Carr Sample SFDU's
CV Decoded
FSS
LMC
SSI SFDU's
SCP (config/status) SFDU's
Frames
Tlm Perf Mon
TCA
Frame SFDU's
Subsys Config & Status Mon
ODR
SCP
GCF Blocks
224K NASCOM
CCT
CCP
SG
NG
SFDU's
Mon 5-15 SFDU's
Mon
NOCC
NPP
NOCC TLM/MON DISPL
Doppler Residuals
Remote Sci MSA's
9.6K NASCOM
MO JPL MSA
MCT/SCT
Eng/Mon Channels
(within 5 min of arrival at GIF)
(CDR's)
DMD
ECDR's
P A S
PDB
TOT
(CDR's)
Eng/Mon Channels
CDR's
CVMON
NERT Cache (Capacity ~1-2 days)
(Overnight Delivery)
MOVIEW
CV
(NORT) (Capacity ~80-90 days)
MRO Audit Q
FSW Vax
(Weekly)
(On Request)
DAT WS
ER/PMIRR WS (see SOPC)
DTR
XSU Packets
VTL
NAV Display
SOPC/Sci Host
Sci Display SW or DMD
DMD
Eng Channels
Science Channels
Sci Decom SW or WS Decom
Sci Decom Maps
Science Packets
TOT
Eng Channels
Sci Packets
9.6/56K NASCOM
MARS OBSERVER GDS
FJH (downlink) 8/5/92

Figure 3-15

SECTION 4

TEAM ORGANIZATION & RESPONSIBILITIES

4.0 Introduction

The Radio Science Support Team (RSST) provides coordination for all flight project activities supporting Radio Science experiments. The RSST operates as a single, comprehensive focal point for experiment-related Project functions and provides long range planning for experiment interfaces with multi-mission organizations. It serves as the sole operational interface between the Radio Science investigators and the other elements of the Flight Projects and the Deep Space Network. The RSST represents the interests of the investigators (especially ones not resident at JPL) at meetings relevant to the investigation. Specifically, the RSST:

1. Plans the implementation of the Radio Science experiments along with the investigators, defines the requirements on all aspects of the experiments, and resolves (or helps to resolve) intra- and inter-experiment conflicts.

2. Submits and integrates Radio Science requirements into the plans of the flight project, DSN, MOSO, and other multi-mission organizations.

3. Provides specifications for spacecraft and DSN equipment based on the experiment's needs for hardware, software and procedures, monitors the development of the equipment and participates in testing the hardware or the output product.

4. Reviews (and, when requested, participates in the negotiations leading to) the schedule of station tracking coverage.

5. Develops and integrates spacecraft and ground operation sequences for the acquisition of experiment data by interfacing with the mission design teams, sequence teams, spacecraft engineering teams, navigation teams, mission control teams, and other elements of the projects.

6. Coordinates with the mission control teams and the DSN the process of data acquisition by conducting real-time operations and collecting the data observables.

7. Logs, archives, and validates the data products in order to prepare the data observables for scientific analysis by the investigators. (However, for Mars Observer, the RSST does not generally perform this function.)

The Radio Science Support Team is part of the Radio Science Systems Group of the Telecommunications Systems Section. The group currently supports Radio Science experiments on the Galileo, Ulysses, Mars Observer, and Cassini flight projects. The group also provides support as needed for Radio Science experiments on Voyager, Magellan, Giotto (reactivation mission) and Pioneer Venus.

Figure 4.1 shows the organization of the Radio Science Systems Group.

4.1 RSST Individual Responsibilities

4.1.1 SCIENCE COORDINATOR/EXPERIMENT REPRESENTATIVE

The Science Coordinator/Experiment Representative (SC/ER) coordinates all the RSST tasks listed above, provides overall team direction, coordinates the teams's needs and resources, and ensures that schedules and staff plans are optimized to achieve the maximum return of quality data for the Radio Science experiments. The SC/ER develops the observation strategy, performs mission analysis trade-off studies, performs inter-experiment science integration, provides sequence inputs, and monitors the progression of the uplink process. She/He is the focal point for experiment requirements to the projects, keeps abreast of upcoming and on-going spacecraft activities which could affect the Radio Science investigations, and continually updates the rest of the Support Team on the status of the mission. During real-time operations, the SC/ER monitors the progress of the experiment and provides recommendations to the operations personnel to optimize its performance.

For some flight projects, if the Science Coordinator or Experiment Representative is also an investigator he/she may be called Investigation Scientist or Coordinating Scientist.

4.1.2 INSTRUMENT ENGINEER

The Radio Science Instrument Engineer's primary responsibilities are to develop, maintain, and interpret instrument (spacecraft and Ground Data System) requirements, monitor, and, when appropriate, participate in the planning, design, scheduling, and implementation of the instrument's components by interfacing with appropriate organizations (e.g., the DSN, Project spacecraft team). The Instrument Engineer performs instrument trade-off studies, designs the instrument operation configuration and verifies that all instrument and data interfaces (including GDS) satisfy team requirements. It is also the responsibility of the Instrument Engineer to test the data products during and after instrument implementation to ensure that the quality meets team requirements. He/she, along with the Software System Engineer, develops the software tools necessary for data validation and processing. The Instrument Engineer is the lead data analyst for the USO, telecommunication subsystem, and DSN systems stability. The Instrument Engineer also assists in Radio Science real-time operations.

4.1.3 OPERATIONS ENGINEER

The Radio Science Operations Engineer's primary responsibility is the verification of the proper conduct of pre-pass, real-time, and post-pass operations of the Radio Science data acquisition activities. Specifically, he/she verifies the presence and accuracy of the activity's Sequence Of Events (SOE) and predictions required by the station based on the information provided to him/her by the SC/ER. She/He handles communications regarding action or information required from the DSN station with the Project's Mission Controller (ACE), or Ground Controller (GC), via the appropriate voice nets. He/she coordinates with the RS System Administrator the availability of data displays needed for monitoring the activity, and insures that the Radio Science real-time support area and related facilities are equipped and staffed for real-time monitoring.

4.1.4 SOFTWARE SYSTEM ENGINEER

The Radio Science Software System Engineer's primary responsibilities include evaluation of existing Radio Science software, identifying software development tasks, and overseeing development, implementation, testing, documentation and delivery of software. He reports to the various projects on the software development status via periodic presentations.

The secondary responsibilities include using the Radio Science software for data analysis and validation, and assisting in Radio Science real-time operations.

4.1.5 SYSTEM ADMINISTRATOR

The Radio Science System Administrator is responsible for the proper operation of the RSST computing equipment and peripherals. Her/His primary responsibility is the administration and upgrading of the RODAN computer facility (described in Section 9) including interfaces (e.g., RODAN-GCF lines) and the planning, implementation, and maintenance of future RSST computing facilities including PC's, workstations, and networks.

Secondary responsibilities include the proper operation of the Real-time Monitoring System (RMS) (done in coordination with the RS Operations Engineer) and, eventually, administration and upgrading of the SUN workstations. The System Administrator also assists in Radio Science real-time operations.

4.1.6 DATA PRODUCTS ENGINEER

The Radio Science Data Products Engineer's primary responsibility is to receive, log, validate, archive, and distribute to Investigators the Radio Science data products (described in Section 8). She/He also maintains data interface agreements.

Secondary responsibilities include performing system back-ups and related tasks on the RODAN computer as well as assisting in Radio Science real-time operations.

4.1.7 RADIO SCIENCE ANALYST

The Radio Science Analyst conducts specialized scientific and engineering analysis needed for the planning, implementation, or data processing of Radio Science experiments. The Analyst also assists in Radio Science real-time operations.

4.2 RST Flight Project Interfaces

4.2.1 GALILEO MDT, ULYSSES SOT, AND MO MPT

The Galileo Mission Design Team (MDT) is responsible for coordinating the spacecraft configuration for all engineering and science activities which are eventually transferred to the Mission Control Team (MCT) for generation of the Galileo SFOS and ISOE products.

The Ulysses Spacecraft Operations Team is responsible for coordinating the spacecraft configuration for all engineering and science activities which are eventually transferred to the Ulysses SEGs operator for generation of the Ulysses SFOS and ISOE products.

The Mars Observer Mission Planning Team is responsible for maintaining the Mission and Mission Sequence Plans, for leading trade studies and making recommendations to the Mission Manager, and for reviewing sequence products to ensure conformance to the Mission Sequence Plan.

4.2.2 GALILEO MCT AND ULYSSES SEGs OPERATORS

The Galileo Mission Control Team (MCT), the Ulysses SEGs Operators, and the Multi-mission Control Team (for Mars Observer) are the source of the respective SFOSs and ISOEs. It is the responsibility of the Radio Science Team to insure that these products reflect the expected Radio Science data acquisition parameters and schedules.

4.2.3 GALILEO, ULYSSES, AND MO ACEs

The Galileo ACE, Ulysses ACE, and Mars Observer ACE are the primary interface for the Radio Science Team to affect real-time changes to SOE's and station configuration for the purpose of Radio Science data acquisition.

4.3 RST DSN Interfaces

4.3.1 NETWORK OPERATIONS PROJECT ENGINEER (NOPE)

The Galileo, Ulysses, and Mars Observer NOPEs are responsible for the overall operational support of the Deep Space Network for their respective flight projects. The NOPEs prepare and issue the Network Operations Plan which defines the configuration of all DSN systems for their respective flight projects including those relevant to Radio Science.

4.3.2 SYSTEM COGNIZANT OPERATIONS ENGINEER (SCOE)

The SCOE is responsible for supporting Network Radio Science System testing, providing technical expertise on the DSN RS system, and providing technical advisory support as necessary to define system performance. He also provides backup to all those in the Radio Science Unit of the Network Advance Systems Group (NASG).

4.3.3 OTHER NASG/RADIO SCIENCE UNIT PERSONNEL

There are three other positions within the Radio Science Unit of the Network Advanced Systems Group with responsibilities related to the Radio Science System. The *Radio Science Network Operations Analyst (NOA)* provides the technical interface between real-time operations and DSN system performance, monitors and reports DSN Radio Science systems and operations performance, investigates and resolves discrepancy reports, and acts as a backup to the RS Operations Specialist and to the RS Analyst. The *Radio Science Operations Specialist* performs operations function in support of all DSN Radio Science activities, represents DSN Operations in the development of Radio Science Operations Plans, and provides assistance and backup to the RS SCOE and the RS NOA. The *Radio Science Analyst* provides testing and data analysis support for Radio Science System test activities and assists the RS SCOE and the RS Operations Specialist.

4.3.4 COMM CHIEF

The Comm Chief is responsible for the configuration and operation of the GCF communications between all DSCC's and the

NOCC. The Comm Chief is also responsible for ensuring that the proper data lines are connected to the RODAN computer at the request of the RSST.

4.3.5 NAT TRK

The NAT TRK serves as the real-time analyst for all incoming Tracking, VLBI, and Radio Science data and for all outgoing prediction data transfers for all stations and all flight projects.

4.3.6 OPS CHIEF

The Ops Chief is the DSN's lead person for all real-time DSN operations in support of flight projects.

4.3.7 TRACK CON

The Track Controller is responsible for the real-time control of one or more stations supporting a Flight Project tracking pass.

4.3.8 DSN RADIO SCIENCE DESIGN TEAM

The Radio Science Design Team (RSDT) oversees the implementation of DSN systems directly used for the acquisition of Radio Science data. It is headed by the DSN Radio Science System Engineer and has as members representatives of the Radio Science Teams for all Flight Projects as well as members of the organizations responsible for the design and implementation of hardware and software of DSN systems relevant to Radio Science.

Table 4-1

Key Radio Science Personnel

Radio Science Support Team

Sami Asmar	Ulysses Coordinating Scientist	3-0662
Mick Connally	Mars Observer Experiment Rep.	4-3826
Gina Gonzalez	Assistant Galileo Sci. Coord.	3-0681
Randy Herrera	Galileo Science Coordinator	3-0664
Ann Devereaux	Ground Instrument Engineer	4-1386
Paula Eshe	Data Products Engineer	3-0663
Tony Horton	Operations Engineer	3-1142
David Morabito	Software System Engineer	3-0665
Phyllis Richardson	Computer Engineer	3-1073

Radio Science Operations area 3-0666

Deep Space Network

Pat Beyer	Galileo TDS Manager	4-0055
Dennis Enari	Ulysses TDS Manager	4-0074
Marv Traxler	Mars Observer TDS Manager	4-0070
Michelle Andrews	Acting Galileo NOPE	584-4425
Roy Rose	Ulysses NOPE	584-4418
Thorl Howe	Mars Observer NOPE	584-4444
Sal Abbate	R.S. Sys. Cog. Ops. Eng.	584-4461

Comm Chief 3-5800
Data Chief 3-7974
NATTRK 3-7810
Ops Chief 3-7990
Ops Con 3-7907
Support Chief 3-0505
Track Controller 3-5858
"The Cave" 3-1223 3-1274 3-1401 3-1211

Flight Projects

Galileo ACE 3-5890
Ulysses ACE 3-0559
Mars Observer ACE 3-0721

Table 4-2 Radio Science Investigators & Staff

Galileo

Propagation

Taylor Howard, Team Leader	Stanford Univ.
Von Eshleman	Stanford Univ. (retired)
Arvydas Kliore*	JPL
Richard Woo	JPL
Michael Bird	Univ. Bonn, Germany
Peter Edenhofer	Univ. Bochum, Germany
Martin Pätzold	Univ. Koeln, Germany
David Hinson	Stanford Univ.

Celestial Mechanics

John Anderson, Team Leader	JPL
Frank Estabrook	JPL
John Armstrong	JPL
James Campbell	JPL (on leave)
Timothy Krisher	JPL
Eunice Lau	JPL

Ulysses

Solar Corona

Michael Bird, Principal Investigator	Univ. Bonn, Germany
Peter Edenhofer	Univ. Bochum, Germany
Martin Pätzold	Univ. Koeln, Germany
Sami Asmar	JPL

Gravitational Waves

Bruno Bertotti, Principal Investgtr.	Univ. Pavia, Italy
Sami Asmar	JPL
Luciano Iess	CNR-IFSI, Italy
Hugo Wahlquist	JPL
Gianni Comoretto	Osser Astro Arcetri, Italy
Giacomo Giampieri	JPL (RRA)
Alfonso Messeri	CNR-IFSI, Italy
Roberto Ambrosini	Ist. Radioastro., Italy
Alberto Vecchio	Univ. Pavia, Italy

Table 4-2 Radio Science Investigators & Staff - cont'd

Giotto

Peter Edenhofer, Team Leader	Univ. Bochum, Germany
Michael Bird	Univ. Bonn, Germany
Martin Pätzold	Univ. Koeln, Germany
Herbert Porsche	DLR, Germany
Hans Volland	Univ. Bonn, Germany

Mars Observer

G. Leonard Tyler, Team Leader	Stanford Univ.
Efrim L. Akim	Inst. Appl. Math., Moscow
John Armstrong	JPL
Georges Balmino	CNES, France
F. Michael Flasar	GSFC
David Hinson	Stanford Univ.
Richard Simpson	Stanford Univ.
William Sjogren	JPL
David E. Smith	GSFC
Richard Woo	JPL

Cassini

Arvydas Kliore, Team Leader	JPL
Roberto Ambrosini	Ist. Radioastro., Italy
John D. Anderson	JPL
Bruno Bertotti	Univ. Pavia, Italy
Nicole Borderies	JPL
F. Michael Flasar	GSFC
Robert G. French	Wellesley Col.
Luciano Iess	CNR-IFSI, Italy
Essam A. Marouf	SJ State Univ.
Andrew F. Nagy	Univ. Michigan
Hugo Wahlquist	JPL

Huygens Doppler Wind Experiment

Michael Bird, Principal Investigator	Univ. Bonn, Germany

Table 4-2 Radio Science Investigators & Staff - cont'd

Magellan

Occultations

Paul Steffes	Georgia Tech.
Jon Jenkins	NASA Ames
G. Leonard Tyler	Stanford Univ.

Venus Gravity Field

William Sjogren	JPL

Pioneer Venus Orbiter

Occultations

Arvydas Kliore	JPL

Voyager

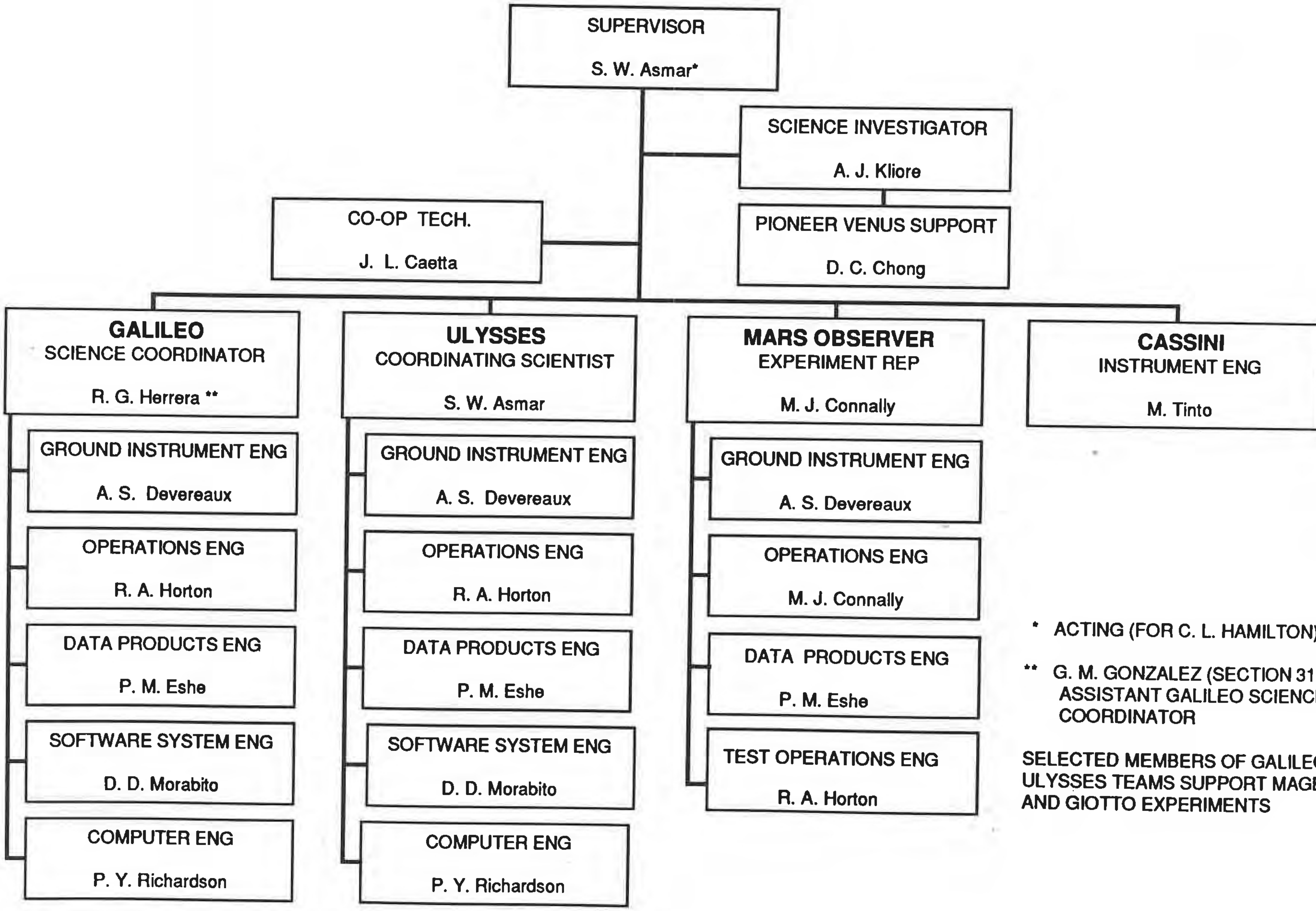
G. Leonard Tyler, Team Leader	Stanford Univ.

Voyager Neptune Celestial Mechanics Data Analysis

John D. Anderson, Team Leader	JPL

* Arvydas Kliore is Investigator for Galileo Probe Doppler Wind Experiment.

RADIO SCIENCE SYSTEMS GROUP 3394



* ACTING (FOR C. L. HAMILTON)

** G. M. GONZALEZ (SECTION 315) IS ASSISTANT GALILEO SCIENCE COORDINATOR

SELECTED MEMBERS OF GALILEO AND ULYSSES TEAMS SUPPORT MAGELLAN AND GIOTTO EXPERIMENTS

SECTION 5

PRE-PASS PREPARATIONS

5.0 Introduction

This section describes pre-pass operations for Radio Science activities. Products that are essential for real-time support will be identified. Ideally, all products relative to real-time support are ready and available several days prior to the scheduled activity. Some of these products are: Integrated Sequence of Events (ISOE), Space Flight Operation Schedule (SFOS), closed-loop receiver predictions plus open-loop Radio Science predictions (should they be required).

5.1 Predictions

The process of generating frequency tuning, tracking, and antenna pointing predictions is performed by the DSN's Network Support Subsystem (NSS). The predictions actually used at the stations are in the form of computer files which are produced on the NSS computer and transmitted to the station by the NATTRK.

Closed-loop receiver predictions will be generated for all Radio Science activities. These include standard tracking predictions which are used by the MDA to compute Doppler pseudoresiduals, and frequency tuning predictions used to tune the closed-loop receivers for initial acquisition.

Radio Science open-loop receiver (DSP) predictions will be required for those ~~Galileo,~~ Ulysses, and ~~Mars Observer~~ passes where the DSP has been allocated for open-loop recording.

The NSS generates antenna pointing predictions for all passes.

5.2 ISOE Process

The ISOE and its corresponding DSN Keyword File are the controlling documents for any Radio Science activity. The DSN Keyword File is transmitted to the station by the DSN and should contain all ground events necessary for station support during each pass.

The Mission Control Team (MCT) is responsible for supporting ISOE redline activities. Redline support may be required for unexpected events affecting the Radio Science activity.

5.3 Station Configuration & Calibration

Prior to every pass, the station dedicates a portion of time for equipment configuration and calibration. Of particular interest is the calibration of the open-loop receiver attenuation. Table 3-1 thru 3-3 contain additional information on open-loop system calibrations.

5.4 RODAN-GCF Line Activation Procedure

A very important step in the pre-pass period is the configuration of and activation of the RODAN GCF lines for real-time monitoring support using the Radio Science Real-time Monitoring System (RMS). **This procedure should be ingnored once the upgraded RODAN/GCF interface is in place.**

The procedure is as follows:

PERSON		ACTION
RSST	1.	In preparation of up-coming RS activities the SFOS and SOE must be reviewed.
	2.	As real-time support approaches, review the RODAN interface drawing to establish the required line connections for the supporting DSCCS.
	3.	Call the Comm Chief at 3-5800 or 3-5801 and the Ops Chief at 3-7990 or 3-7999 to request the connection(s). Note: Call Comm Chief first to inform him what the line configurations are. However, the Ops Chief must then be informed of the request since he and only he is to provide the direction to the Comm Chief. So, the point is to make a parallel request of the connections: first, call the Comm Chief with the configuration information, and then the OPs Chief who will then instruct the Comm Chief to carry out the directive. Asking for 56 Kb, 64 Kb, and 224 Kb line connections: For the 56 Kb line connection, ask for INBOUND DUPLEX from SPC 10, 40 or 60 on RODAN's 1, 2 and/or 4. When using RODAN 4, make sure that the modem switch in the RODAN room is set to the correct position. For 224 kb line connection ask for INBOUND SIMPLEX from SPC 10, 40 or 60 on RODAN 3 or 4. Check with Comm that the AB switch position is set to RODAN 3 (Note: RODAN 3 & 5 cannot be used simultaneously). The 64 Kb line is only for the INBOUND DUPLEX from SPC 40. The Comm Chief will know which line is to be used.
GCF/COMM	4.	Comm Chief patches the appropriate line(s) in the 230 basement with the appropriate RODAN lines.
RSST	5.	Give the Comm personnel a reasonable amount time to make these connections - say 5 to 10 minutes.

GCF/RSST 6. Both sides coordinate to verify that the Carrier and traffic lights are on at the modem. Note: The Carrier lights should always be ON. When the traffic light is ON prior to the support, this indicates that the modem may be receiving test blocks from the GCF system or is already connected to a DSCC line.

RSST/GCF 7. Troubleshooting: Once GCF verifies that the Transmit traffic light is on at his modem and all switches are set correctly, then the only thing that he can do is to seat and re-seat the patch cord or swap connections to another modem pair. On our end, we can ensure that switches are in the correct position - check behind the modem for the "Normal" operation mode. The "Digital Loopback" mode is for internal testing with Comm.

RSST/GCF 8. At the end of the RS support, an RSST person can call the Comm Chief to release the line(s) because RS activities have ended for this pass.

GCF 9. Comm normalizes the line(s) for future support.

SECTION 6

REAL-TIME OPERATIONS

6.0 Introduction

This section describes those events which occur during the real-time operations period. These involve elements of the Radio Science Team (RST), Mission Control Team (MCT), Network Operations Control Team (NOCT), and the Deep Space Station (DSS). Some activities may involve non-DSN stations as well (e.g., the Medicina VLBI station).

6.1 Radio Science Real-Time Operations

6.1.1 EVENTS PRIOR TO DATA ACQUISITION

During this period, activities include checking the correct configuration of the RODAN GCF lines, availability and correctness of the SFOS, ISOE and redlines to the ISOE, and preparing the Multi-Mission Log Sheet (see Figure 6-1).

6.1.2 EVENTS DURING THE RECORDING PERIOD

During this period, validation of the Radio Science data begins by visual inspection of the displays immediately after the data acquisition begins. The ISOE, its redlines, a predictions hardcopy (if available), the Network Operations Plan (NOP), and the Log Sheet checklist are tools to assist in the validation process. When open-loop data are being recorded, or whenever the station's Spectral Signal Indicator (SSI) is being used, the validation process should emphasize usage of the SSI, whenever possible, in the receiver mode as well as the ODAN mode. Table 6-1 describes the different configurations of the SSI for the S- and X-band receiver channels as well as the output channels of the four ADCs.

6.1.3 EVENTS FOLLOWING THE RECORDING PERIOD

Following the recording period, timely delivery of the products should begin (See Section 7). It is not always necessary, but sometimes a good idea, to remind the Track Con to remind the station personnel to mail the ODRs with the next consolidated shipment.

6.2 Voice Net Communications

A description of the voice nets is presented in Table 6-2. In order to ensure that the voice communication during the Radio Science data acquisition period proceed smoothly, all personnel using the voice nets must properly identify themselves prior to asking questions or making requests. The call sign to be used by Radio Science personnel is "Galileo Radio Science", "Ulysses Radio Science", or "Mars Observer Radio Science".

6.3 Sequence of Events Confirmations

The Integrated Sequence of Events (ISOE), its redlines, and its corresponding DSN Keyword file will be the controlling documents for the conduct of the real-time operations during all Radio Science activities. It is important that all operations groups (RSST, MCT, NOCC and the participating DSCC) follow the same script. During the pass, it is recommended that positive reporting of each item be exercised. Confirmation of each event will provide visibility into the status of the ground data system at each station.

6.4 Tracking System Operations

The MDA (closed-loop doppler and/or range) is standard for all tracks. The appropriate channel should be enabled (when applicable S- and/or X-band) and the correct Doppler sample rate should be consistent with ISOE. Whenever the Sequential Ranging Assembly (SRA) is required for the pass, it should be configured according to the NOP.

6.5 Radio Science System Operations

DSP operations are dependent upon the experiment requirements and will be scheduled on that basis. The DSP should be configured according to the NOP and verified against the SOE (the recommended configuration also appears in Section 3). The SSI will be used to monitor the performance of the Radio Science System during periods of open-loop data recording.

6.6 Graphics Displays and Pass Products

The DTV displays available to the RST in the multi-mission Radio Science area are a data source for monitoring the operations of the pass. The Operations Engineer communicates with the ACE, and/or NATTRK to coordinate the selection of displays.

Table 6 - 1

Station SSI Identification

Display	SSI Port	Signal Source
RCV1	1	Closed-Loop Receiver
RCV2	2	Closed-Loop Receiver
RCV3	3	Closed-Loop Receiver
RCV4	4	Closed-Loop Reciever
SRCP	5	S-band RCP from OLR
SLCP	6	S-band LCP from OLR
XRCP	7	X-band RCP from OLR
XLCP	8	X-band LCP from OLR
ODAN/B	9	S-band NBOC Output
ODAN/A	9	X-band NBOC Output
SP15	11	S-band from MMR
SP14	12	X-band from MMR

TABLE 6-2

VOICE NET COMMUNICATION

INTER-2:	Standard Project operational net to NOCC for communication between Mars Observer ACE and Ops Chief
INTER-5:	Standard Project operational net to NOCC for communication between Galileo ACE and Ops Chief
INTER-6:	Standard Project operational net to NOCC for communication between Magellan ACE and Ops Chief
INTER-8:	Standard Project operational net to NOCC for communication between Ulysses ACE and Ops Chief
GDSCC-1:	Standard NOCC-to-DSN Complex control net (Goldstone)
CDSCC-1:	Standard NOCC-to-DSN Complex control net (Canberra)

TABLE 6-2

VOICE NET COMMUNICATION (cont'd)

MDSCC-1:	Standard NOCC-to-DSN Complex control net (Madrid)
FAC COORD:	OPS CON - Facilities coordination
CMTRY:	Commentary (and music)

RADIO SCIENCE OPERATIONS VALIDATION SHEET

 OPERATOR (S) / /

DSS: S/C ID: PASS: DOY: DATE: SCHEDULED AOS: | LOS: |

SUPPORTING ACTIVITY:

LIST DRs:

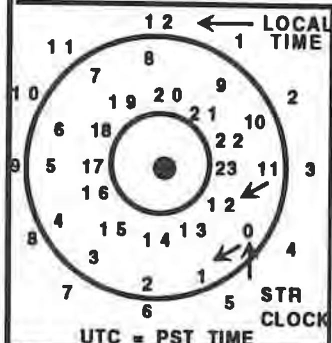
S-BAND: MASER—— RCVR:—— X-BAND: MASER—— RCVR:—— SEP ANGLE SAA

=$ W *WEATHER CONDITIONS:*

RMS STATUS: CL OR (CL & OP), CIRCLE ONE. DSP RECORD TIME: STOP

ANT MAX ELEVATION
ANGLE: TIME:

R-LINE/RATE: 1/56K—— 2/56K—— 3/224K —— 5/64K —— 4/56K 4/224K —— NOTE: #4 IS SWITCHABLE



INITIAL ACQUITION

MGN S-> S & X-BAND

RCVRS I/L: /

AGC : /

AGC/BW : /

LOOP/BW : /

SNT : /

TXR ON/OFF: /

MDA S & X-BAND

DOPP SAMP RATE: /

DOPP RESIDS: /

MDTR: /

2-WAY DOPPLER TIME:

SRA S & X-BAND

T0, T1 , T2 , T3:

\# OF COMP:

PR/NO: /

P DRVID: /

RNG MOD ON TIME:

SUN DISPLAYS:

AGC PLOT
DOPP RESIDS
DOPP NOISE
M59 SNT
SSI DISPLAY
NRV DSP RMS

DSP STATUS

CHANNEL	A	B	C	D
FILTER:				
CHN ASSIGN:				
ATT:				
RMS VOLTS:				

NBOC MODE =

SAMPLE RATE =

MIXED MODE PDX = YES / NO PREDICT CODE =

SSI CFG

FULL BW: ______ HZ

CENTER FREQ: ______ HZ

ODAN CYCLE: A , B , C , D

SIGNAL PRESENCE: YES / NO

SSI DISPLAY

NOCC OPEN-LOOP DISPLAYS

DSP STATUS F-708 & F-709 TEXTED

NOCC CLOSED-LOOP DISPLAYS

S-DOP MDA F-607 / X-DOP FORMAT F-607

S-RNG SRA F-617 / X-RNG FORMAT F-617

S/C & STA INIT CONDITIONS + (R-T COMMENTS):

RTLT = HH:MM:SS

SPACECRAFT ID NUMBERS:
GLL=77, ULS=55, MGN=18, MO=94

RAH 12/05/92

SECTION 7

POST-PASS OPERATIONS

7.0 Introduction

Post-pass operations for each Radio Science activity will begin upon completion of the Radio Science event. During this period, Radio Science related activities will consist of data product delivery (tapes, files, playback etc.) to the RSST, validation of data products, and the processing of the data. The RSST may require post-pass calibrations if problems arise during the pass. The processing and analysis of the data are discussed in Section 8. Section 7.1 specifies procedures and operation schedules for the delivery of data products. Section 7.2 describes other possible post-pass actvities.

7.1 Data Product Delivery

The Galileo USO test data product delivery strategy and schedules are given in Table 7-1. The Galileo Gravitational Wave Experiment data product delivery strategy and schedules are given in Table 7-2. The Ulysses Gravitational Wave Experiment data product delivery strategy and schedules are given in Table 7-3. Mars Observer data product delivery strategy and schedules are given in Table 7-4. These tables along with the following subsections describe each of the products as they relate to the specific activities. The format and interface agreement numbers for the data products are specified in Table 7-5 for Galileo, Table 7-6 for Ulysses and Table 7-7 for Mars Observer.

7.1.1 OPEN-LOOP DATA

The open-loop data are recorded at the DSCC site on a 9-track 6250 bpi tape known as an ODR (Original Data Record). The tape contains up to four channels of digitized receiver data from the OLR (Open-Loop Receiver) as well as POCA (Programmable Oscillator Control Assembly) tuning, timing, and configuration and status information. When applicable, the DSP ODR tape(s) will be logged and delivered to the RSST.

Upon completion of recording of each tape, the tape ID number, the start and stop recording times, the tape drive ID number, the station ID, and the pass number should be written onto the label of each tape.

Full duplication of all ODR tapes is required. The duplicates will be shipped to JPL while the original tapes will remain at the DSN complex until the duplicates are delivered to the RSST and have been validated. The tapes are to be shipped to JPL in the next available consolidated shipment. Once at JPL, the tape is to be delivered to the NDC (230-304A) to be logged, then delivered to the RSST (Attn: P. Eshe) where it will then be given an RSST tape ID.

Under special circumstances, the RSST may desire to process open-loop data immediately after a pass, rather than wait for the arrival of the open-loop ODRs. Arrangements should then be made for playback of the open-loop data after a pass. These IDRs (Intermediate Data Records) will be manufactured by the NDP and delivered to the RSST after completion of the playback.

ODR tapes will not be used for Mars Observer after May 1, 1993, and possibly earlier. The procedures described in this section can be applied to Mars Observer prior to that date (i.e., USO tests and Gravitational Wave Investigation data). After the AMMOS and DSN electronic data delivery capability is delivered to the Project, open-loop data will be sent in real-time to the Project Data Base (PDB). Playbacks will be performed when problems occur. Once on the PDB, the data will be accessed by scientests and the RSST directly. No data validation activities by the RSST are planned.

During the Joint Gravitational Wave Wxperiment, open-loop data will be delivered to Mars Observer investigators both electronically using AMMOS facilities and by ODR tape. This dual delivery is considered necessary since the AMMOS Radio Science capability will not have bee fully tested by March 22, the start of the experiment. Electronic data delivery will allow for "quick look" data analysis on a pass-by-pass basis so that problems can be detected and corrected quickly.

7.1.2 CLOSED-LOOP TRACKING DATA

Closed-loop tracking data in the form of an ATDF will be borrowed from the Radio Metric Data Conditioning Team (RMDCT) and copied.

For Mars Observer, ATDFs and Orbit Data Files (ODFs) are delivered to the PDB regularly according to the MO OIAs.

7.1.3 SPACECRAFT TRAJECTORY DATA (CRSPOSTA FILES)

The Celestial Reference Set (CRSPOSTA) file contains spacecraft trajectory vectors for use in the data processing of the Radio Science data. For each pass or set of passes, a CRSPOSTA file derived from the best available navigation solution will be required for Galileo and Ulysses.

The RSST will communicate its for the file to Project NAV via a request memo. GNAV will deliver the requested CRSPOSTA files into a permanently catalogued file on the UNISYS 1100B system. The RSST will transfer the file over to the PRIME computer using the Ethernet connection. In the event the Ethernet is down for an extended period of time, the RSST will initiate the proper tape movements to and from IPC in order to access the file. The CRSPOSTA files will not be validated by the RSST.

For Galileo, the present SIS (210-12) specifies the NAVIO format as the CRS product to be delivered to the Orbiter Engineering Team (OET) and Radio Science. However, in practice, Radio Science receives the file in an ASCII format (CRSPOSTA), and OET receives it in a different data format.

The CRSPOSTA files residing on the UNISYS B system can be transferred to the PRIME using FTP as shown below;

1) Go to the directory on the PRIME in which you want the CRSPOSTA file(s) to be copied.

2) Type "FTP<cr>". Then, type "OPEN UNIB<cr>" at the FTP prompt (note if this doesn't work, then directly use the node number "OPEN 128.149.54.2").

3) Enter the login information.

4) Get the file by typing "GET" followed by the UNISYS file name, followed by the PRIME filename, for example;

    GET CRS.RS-89-349/CRS-D1 RS-89-349/CRS-D1

5) When the FTP prompt appears after successful transfer, go back to (4) for the next file transfer, or do a "BYE" to exit.

Note that sometimes the files residing on the UNISYS are not yet in ASCII format. In this case, you must directly log onto the UNISYS B system and perform the following steps prior to the file transfer:

```
@ASG,UP filename
@EMBED CRS.navelementname,filename
```

The @EMBED command will take the delivered NAV file (which is the element "navelementname" which was placed by NAV into the Radio Science permanently catalogued file "CRS") and recover the ASCII into the assigned file named "filename" which can then be transferred. For example:

```
@ASG,UP FILE1.
@EMBED CRS.RS-89-349/CRS-D1,FILE1.
```

The CRSPOSTA files from the Ulysses NAV team (UNAV) will be made available on the development VAX, GROUCHO. UNAV will notify Radio Science via SPAN mail (or phone call) when these files are available and where they are located on GROUCHO. Since an account on GROUCHO is needed in order to use FTP, these files cannot be directly FTPed to RODAN. Therefore the following procedure must be used:

1) Log onto a VAX for which you have an account (e.g. JPLGP).

2) If you are using a VAX other than GROUCHO, transfer the file from GROUCHO to your VAX using the VAX COPY command as follows:

   COPY GROUCH::disk:[directory]filename yourfilename

   where "disk" is name of the disk (e.g. USER$DISK2), "directory" is the directory name (e.g. TPM.ULYS.CRS), and "filename" is the name of the CRSPOSTA file residing on GROUCHO, and "yourfilename" is the name of the file into which the CRSPOSTA file is to be copied.

3) FTP the file from the VAX to the desired partition in RODAN.

Mars Observer will using S and P SPICE kernals in place of CRS files. MO NAV provides these to the PDB on a regular schedule.

7.1.4 NOCC PASSFOLDER

The NOCC hardcopy data which may be requested by the RSST consists of the complete passfolder including the Controller's Log (Network Operations Log), Tracking System Pass Summary (NATTRK Log), tracking and/or Radio Science frequency predictions, etc. These logs will be made available to the RSST per request.

7.1.5 RADIOMETRIC TRACKING CALIBRATION DATA

Radiometric Tracking Calibration Data will be available on a permanently catalogued file residing on the UNISYS. These data include the changes induced in the various tracking data types based on media measurements. For MO, the calibration data are delivered to the PDB on a regular basis.

7.1.6 SMALL FORCES HISTORY FILE

A Small Forces History File (Attitude History File) will be required for the Ulysses Gravitational Wave data in order to calibrate out the effects of the spacecraft spin. This file contains delta velocities which are induced by accelerations such as those due to Precession Maneuvers which occur between provided time tags. The file also contains the right ascension and declination of the spacecraft spin axis and the spacecraft rotation spin rate as inferred from the telemetry. This file is generated by ESOC flight dynamics and is deliverable to the RSST from UNAV.

7.1.7 DPTRAJ LISTING

A DPTRAJ listing may be requested anytime before, during or after the acquisition of Ulysses Gravitational Wave data. These listings (or files) contain specifically requested quantities of interest (e.g., topocentric data).

This data product is not applicable to GLL or MO.

7.1.8 DSN WEATHER DATA

Measurements of local weather at the DSN tracking stations during Mars Observer support will be delivered to the PDB from the DSN on a monthly basis. These data can be used to model the effects of the earth's troposphere on the radio link with the spacecraft.

7.1.9 TIMING AND POLAR MOTION FILES

This file contains estimates of the position of the Earth's rotation poles and universal time from astronomical observations. The information in this file allows for the earth's rotation to be accounted in the analysis of Doppler data.

7.1.10 SPICE KERNELS

SPICE is a system for supplying scientist with necessary ancillary information for data analysis. The name "SPICE" comes from the five "kernels" in which this information is delivered. Each kernel is a file containing information which can then be manipulated using a series of software subroutines provided by JPL's Navigation and Ancillary Information Facility (NAIF), the "NAIF Toolkit". The five kernels are:

<u>S Kernel</u> This file provides information on the Spacecraft trajectory in inertial space and is provided by the spacecraft navigation teams.

<u>P Kernel</u> This file provides the ephemeris of the Planets and moons of the solar system and is also provided by the spacecraft navigation team.

<u>I Kernel</u> This file provides Instrument-specific information, such as pointing offsets. The science Team Leaders and

Principal Investigators are responsible for this file.

C Kernel This file provides the spacecraft attitude in inertial Coordinates. The AACS analyst on the Spacecraft Team is responsible for the C kernel.

E Kernel The Event kernel provides a listing of spacecraft and ground events that might affect collected scientific data. The ISOE, as provided by the MCT, and notes provided by the Science Investigation Teams will comprise this kernel.

7.1.11 ANGULAR MOMENTUM DESATURATION FILES

This is a file provided by the Mars Observer Spacecraft Team. After the angular momentum accumulated on a reaction wheel has reached a predefined limit (the wheel is saturated), the wheel will be "desaturated" using the spacecraft thrusters. A file containing a record of the time and duration of all the thruster firings occurring during that desaturation event is produced after each event.

7.1.12 NAVIGATION INFORMATION FILES

This file contains information used to model solar radiation pressure such as the configuration and orientation of the spacecraft bus, the solar array, and the HGA.

7.2 Quick Look Data Analysis During the GWE

After each Mars Observer tracking pass of the JGWE, a subset of the collected open-loop data will be analyzed quickly to determine system performance. The results of this analysis will used to locate problems and implement a solution quickly. It is anticipated that quick-look results will available as soon as two hours after a tracking pass is complete.

7.3 Other Post-pass Activities

Currently, there are no requirements for post-pass calibrations for the Radio Science passes. However, it is important that any post-pass calibrations be performed with the same equipment used during the recording period. If any equipment had changed due to failures or if spare parts were used, then that information should be obtainable through the NOPE. Any post-test calibration tapes should be included in the shipment of all other tapes (ODRs).

Playback of open-loop data will not be required under normal circumstances. However, data playback may be requested through the NOPE of the appropriate project if special circumstances warrant it. If this is the case, then the appropriate GCF wideband line along with the DSP and an LMC may be scheduled for some period following the test. The playback request would normally specify adequate playback time to include the complete playback of the Radio Science data. IDRs containing the playback data will be generated on the DRG in NDPA and will be picked up by a RSST representative.

There are no requirements for any post-pass System Performance Tests (SPTs). However, one may be requested if deemed necessary during specific passes.

The DSP may be requested after the test for any specially requested tape duplication, data playback, and/or post-pass calibrations.

TABLE 7-1

DATA PRODUCT DELIVERY STRATEGY AND SCHEDULE

GALILEO USO TESTS

PRODUCT	DELIVERY STRATEGY	DELIVERY SCHEDULE
ATDF(s)	Borrow original ATDF from RMDCT, make copy and return original.	When ATDF is made.
ODR(s)	Only if open-loop data were acquired. The station will ship the ODR(s) to JPL NDC 230-304A (Attn. P. Eshe)	Within a month after event.
CRSPOSTA FILE	A request memo is sent to J. Johanneson, GNAV. Will notify via forms delivered in mail, specifying file names and file locations.	Within a few days of request memo.
NOCC Passfolder	Written request made to Rosa Anguiano (507-215). Passfolder then mailed to P. Eshe.	Within seven working days following the pass.

TABLE 7-2

DATA PRODUCT DELIVERY STRATEGY AND SCHEDULE

GALILEO GRAVITATIONAL WAVE EXPERIMENT

PRODUCT	DELIVERY STRATEGY	DELIVERY SCHEDULE
ATDF(s)	Borrow original ATDF from RMDCT, make copy, and return original.	When ATDF is made.
CRSPOSTA FILE	A request memo is sent to J. Johanneson, GNAV. Will notify via forms delivered in mail, specifying file names and file locations.	Within a few days of request memo.
NOCC Passfolder	Phone request made to Rosa Anguiano (507-215). Passfolder then mailed to P. Eshe.	Within seven working days following the pass.

TABLE 7-3

DATA PRODUCT DELIVERY STRATEGY AND SCHEDULE

ULYSSES GRAVITATIONAL WAVE EXPERIMENT

PRODUCT	DELIVERY STRATEGY	DELIVERY SCHEDULE
ATDF(s)	Borrow original ATDF from RMDCT, make copy, and return original.	When ATDF is made.
NOCC Passfolder	Phone request made to Rosa Anguiano (507-215). Passfolder then mailed to P. Eshe.	Within seven working days following the pass.
Radio. Trk. Calib. Data	Request memo sent to H. Royden, DSN TRK.	Within one week.
Small Forces Hist. File	Request memo to T. McElrath, UNAV. Access from NAV VAX GROUCHO.	To be available within TBD days.
DPTRAJ Listing	Request memo to T. McElrath, UNAV. Can access from NAV VAX GROUCHO via FTP or request paper listings. As need basis.	Within one working day of UNAV receiving request.
CRSPOSTA FILE	A request memo is sent to Tim McElrath, UNAV. Will place files on NAV VAX GROUCHO and notify via SPAN mail.	Within a few (TBD) days of request memo.

TABLE 7-4

DATA PRODUCT DELIVERY STRATEGY AND SCHEDULE

MARS OBSERVER EXPERIMENTS - GENERIC

PRODUCT	DELIVERY STRATEGY	DELIVERY SCHEDULE
ODR(s) (Backup)	The station will ship the duplicate ODR(s) to JPL NDC (230-304A) (Attn. P. Eshe).	Within one month of end of a pass.
Playback IDR(s)	To be generated only if specially requested. Request to T. Howe. IDR(s) to be delivered to P. Eshe from DSN NOCC NDPA.	Within one week (normally two days) of end of a pass.
ATDF(s)	Delivered to PDB from MO NAV.	When ATDF is made.
ODF(s)	Delivered to PDB from MO NAV.	Approximately daily.
Radio Science Original Data Stream	Delivered to PDB from DSCC.	Real-time.
Media Calibration	File on PDB from DSN.	Tropospheric model delivered prelaunch for Cruise. Ionospheric data delivered weekly.
DSN Weather Data	File on PDB from DSN.	Monthly.
Timing and Polar Motion Files	File on PDB from DSN.	Weekly.
NOCC Passfolder	Phone request made to Rosa Anguiano (507-215). Passfolder then mailed to P. Eshe.	Within seven working days following the pass.

TABLE 7-4

DATA PRODUCT DELIVERY STRATEGY AND SCHEDULE

MARS OBSERVER EXPERIMENTS - GENERIC

PRODUCT	DELIVERY STRATEGY	DELIVERY SCHEDULE
SP SPICE Kernals	File on PDB from MO NAV	Updates as needed during Cruise, weekly during Mapping.
C SPICE Kernals	File on PDB from SCT	As requested in Cruise, every two weeks during Mapping.
Angular Momentum Desat. Files	File on PDB from SCT.	After each event.
Nav/Engr Information Files	File on PDB from SCT.	As needed.

TABLE 7-5

GALILEO

DATA PRODUCT INTERFACE AGREEMENTS

DATA PRODUCT	SOURCE	USER	FORMAT #	IFA #
Archival Tracking Data File (ATDF)	DSN	RSS	SIS 1001-14	NAV-1
Original Data Record (ODR)	DSN	RSS	DSN 820-13 RSC 11-10A SIS 233-03	DSN-22
Playback Intermediate Data Record (IDR)	DSN	RSS	DSN 820-13 IDR-12-1A SIS 233-09	DSN-21
Spacecraft Trajectory Data (CRSPOSTA)	NAV	RSS	SIS 210-12	NAV-32
Experiment Data Record (EDR)	DMT	RSS	SIS 224-04	DMT-39
NOCC Passfolder	DSN	RSS	Paper	DSN-24
Real-Time Command Hardcopy Logs	DSN?	RSS	TBD	TBD

TABLE 7-6

ULYSSES

DATA PRODUCT INTERFACE AGREEMENTS

DATA PRODUCT	SOURCE	USER	FORMAT #	IFA #
Archival Tracking Data File (ATDF)	DSN/TRK	RSS	DSN 820-13 TRK 2-25	1tm
Original Data Record (ODR)	DSN/TRK	RSS	DSN 820-13 RSC 11-10A	1taa
Playback Intermediate Data Record (IDR)	DSN/TRK	RSS	DSN 820-13 IDR-12-1A	1taa
TELECOM Performance Prediction Data (TPAP)	DSN/NSS	RSS	Listing	1td
Radiometric Track Calibration Data	DSN/TRK	RSS	7sd	1tu
NOCC Passfolder Items	DSN	RSS	Hardcopy	1tee
Small Forces History File	NAV	RSS	3sh	3tt
DPTRAJ Listing	NAV	RSS	3si	3tu
REGRES File	NAV	RSS	3sg	TBD
Spacecraft Trajectory Data (CRSPOSTA)	NAV	RSS	TBD	TBD
Spacecraft Range Delay	FLT	RSS	FR 3-500 APP. A NAV	7tb

TABLE 7-7

MARS OBSERVER

DATA PRODUCT INTERFACE AGREEMENTS

DATA PRODUCT	SOURCE	DESTINATION	SIS #	OIA #
ATDF	DSN	PDB	DACE004	DSN-I-015
ODF	DSN	PDB	DACE005	DSN-I-007
Radio Science Original Data Stream	DSN	PDB	DACE046	N/A
Media Calibration	DSN	PDB	DACE006	DSN-I-009
DSN Weather Data	DSN	PDB	DACE022	DSN-I-011
Timing and Polar Motion Files	DSN	PDB	DACE007	DSN-I-010
NOCC Passfolder Items	DSN	RSST	Hardcopy	DSN-I-022
SP SPICE Kernels	MO NAV	PDB	NAE011	NAV-I-008
C SPICE Kernels	SCT	PDB	EAE007	SPAE-I-01
Angular Momentum Desaturation Files	SCT	PDB	EAE003	NAV-I-003
Navigation Engineering Information Files	SCT	PDB	EAE011	NAV-I-004

SECTION 8

DATA PROCESSING AND VALIDATION

8.0 Introduction

This section is primarily concerned with what is done with Radio Science data after it is delivered to the RSST.

The Radio Science software system is broken down into two subsystems: the Data Records Subsystem (DRS) and the Planning and Analysis Subsystem (PAS). The DRS is concerned primarily with data archiving and validation. The PAS is primarily concerned with experiment planning and analysis of data.

There are four program sets which have been or are planned to be formally delivered to the Galileo Project (and some will also be used by Ulysses). These are RCLVAL and ROLVAL in the DRS, and STBLTY and LMSPEC in the PAS. RCLVAL was formally delivered to the Galileo project in 1990 and is described in Section 8.1.4. ROLVAL was formally delivered to the Galileo project in March 1992 and is described in Section 8.1.5. LMSPEC (used for evaluating limbtrack maneuvers for Galileo occultation events during Jupiter orbital operations in 1995-1996) was formally delivered to the Galileo project in 1984, but is not applicable for this edition of the handbook. The remaining program, STBLTY, is planned to be delivered in two phases; the first delivery scheduled for November 1993 will concentrate on performing stability analysis on cruise data, while the second delivery tentatively scheduled for December 1994 will incorporate the added capability of performing stability analysis on Radio Science data acquired during Galileo planetary orbital operations.

Note that with respect to Mars Observer, the RSST will perform *system* validation using the collected data. There will be no *data* validation done by the RSST. This is in contrast to other flight projects where the RSST validates the collected data before sending it to the investigator(s).

8.1 Data Records Subsystem (DRS)

The RSST Data Records Subsystem (DRS) includes the software and procedures required to ensure that the data collected in support of Radio Science observations are usable by the Radio Science Investigators. The following subsections describe the RSST Data Records Subsystem.

8.1.1 DATA SOURCES

The Radio Science data sources are the DSCC, the NOCC, the Multi-Mission Radio Metric Data Conditioning Team (MMNAV & RMDCT), the Galileo Navigation Team (GNAV), the Ulysses Navigation Team (UNAV), the Mars Observer Navigation Team (MONAV), and the Mars Observer Spacecraft Team (SCT). The data types generated by each of these entities are described in detail in Section 7.

8.1.2 DATA PROCESSING AND LIBRARY FACILITIES

The facilities required to transport and process the various Radio Science data types are scattered throughout the JPL organization. These facilities include the DSN Network Data Center (NDC) in Building 230-109 through which all DSN data must be released to the Project, the Information Processing Center (IPC) 1100 computer and library, the UNAV VAX GROUCHO and the Radio Occultation Data Analysis (RODAN) Facility in Building 230.

Mars Observer real-time and file data will be collected on the MO workstation, MMRS, using AMMOS PDB tools. The data is then available for RSST display, processing, and distribution.

8.1.3 DATA DESTINATIONS

After completion of all data preparation processes, the data products must be archived at JPL and copies shipped to the appropriate destination: the Galileo Radio Science Team (RST), the Ulysses Investigators, or the Mars Observer Investigators. The details of the delivery procedures for each of the Radio Science data products are described in Section 7.

8.1.4 CLOSED-LOOP TRACKING DATA VALIDATION (RCLVAL)

Validation processing for the closed-loop tracking data for both Galileo and Ulysses employs the program RCLVAL. This program was formally delivered to the Galileo Project in 1990.

The data validated include Doppler pseudo-residuals and signal strengths (AGCs). RCLVAL is also used to flag the times the data fell within or without specified tolerance limits, to flag the times of data gaps, and to flag the times and values of doppler sample rate and "flagged" signal mode changes. Plots of doppler pseudo-residuals and AGCs can also be generated by the program and archived.

For Mars Observer, closed-loop validation will be performed using a combination of RCLVAL software on RODAN and closed-loop processing maintained by John Armstrong.

8.1.5 OPEN-LOOP DATA VALIDATION (ROLVAL)

The ROLVAL software set is used to perform validation processing of open-loop data tapes (ODRs and/or playback IDRs) for Galileo and Ulysses. These programs are being developed and tested using the open-loop data acquired from some Galileo USO passes and the Ulysses First Opposition passes. ROLVAL was formally delivered to the Galileo Project in March 1992. A developmental version of ROLVAL which can read 4-mm DAT's now exists.

The programs which constitute the ROLVAL program set as well as their validation functions are described below:

ROLHDR - produces plots and header dumps of POCA frequencies, time tags, rms voltage sample values, and min max rms values. Also flags changes in various header quantities as well as the times these changes occurred.

ROLFFT - performs signal presence verification by producing plots of power spectral density according to specifications provided by the user.

ROLSMP - produces plots of digitized sample values versus time and histograms of sample values.

ROLVAL software may also be used by MO but primary open-loop validation will be done at Stanford.

8.1.6 DATA PRODUCT COPYING AND ARCHIVING

In addition to the validation programs described above, the DRS also employs utility programs to perform data product copying and archiving for all incoming data products (ODRs/IDRs, ATDFs, CRSPOSTA files, media calibration files, etc.).

ODR tapes from MO USO tests will be copied for RSST use and the originals will be sent to Stanford University for further analysis and archiving.

8.1.7 DATA TRANSFER FROM TAPE TO "OBERON"

For the Joint Gravitational Wave Experiment, the open-loop ODR tapes will be transferred to files on the RODAN computer. The files will then be electronically transferred to the Investigator's computer "OBERON" using FTP.

8.2 Planning and Analysis Subsystem (PAS)

The Planning and Analysis Subsystem (PAS) is concerned primarily with experiment planning and analysis of Radio Science data.

8.2.1 STABILITY ANALYSIS PROCESSING (STBLTY)

The ODRs/IDRs and/or ATDFs from selected Radio Science activities will be processed using the program set "STBLTY" which evaluates the frequency stability and phase noise of the signal received from the spacecraft, as well as estimating the frequency and frequency rate of the USO. The spacecraft trajectory from the CRSPOSTA files is used by the program set to estimate the "predicted" or "model" frequency which is then differenced from the observed frequency which is extracted from the open-loop or closed-loop data. The frequency stability in terms of Allan deviation is then estimated from the resulting residuals.

STBLTY is currently being used to measure the stability of Radio Science data involving the Galileo USO as the signal source, as well as estimating the USO frequency. An output file of STBLTY containing summary records for the Gravitational Redshift experiments is periodically delivered to the Experimenter.

STBLTY has also been used to process Ulysses two-way doppler residuals. In addition, it is expected to handle different open-loop data signal detection scenarios depending upon signal conditions.

STBLTY consists of several programs, each of which performs a specific task. Figure 8-1 is a block diagram illustrating the interconnection between the component programs making up the STBLTY program set as it relates to the processing of one-way (USO) data. Figure 8-2 is a block diagram for the corresponding two-way data processing case. Listed below are the descriptions of each program.

FILTER - is used to produce a filter file for input to the NBDECIM program, based on the desired filter specifications of the user. FILTER designs a linear phase finite impulse response (FIR) filter using the Remez Exchange Algorithm. The user provides the program with the desired filter center frequency, bandwidth, and decimation factor, and the program outputs the reversed ordered time series impulse response corresponding to the specified filter and decimation factor.

NBDECIM - reads the samples from an ODR or playback IDR, and then filters and decimates the data for each channel. The input time series is convolved with the appropriate impulse response time series output from FILTER in order to get the output filtered/decimated time series. The first N samples of each interval of input data are processed this way and the output series is written onto a file.

DETPHS - performs detection of the signal from the open-loop data file output from NBDECIM. It uses a least-squares algorithm to get estimated parameters. It is appropriate to use DETPHS on data where there are dynamic signal conditions such as occultation events.

PLLDEC - is a digital phase-locked-loop program which reads either ODRs or playback IDRs, and performs signal detection. It is operationally easier to use then NBDECIM/DETPHS. It is appropriate to use PLLDEC on data from events with strong and relatively static signal conditions.

GETTRAJ - reads input file containing spacecraft centered trajectory EME50 vectors delivered from NAV, and outputs a file containing heliocentric position and velocity vectors of a specified earth-based DSN station and spacecraft.

OCEP - combines, displays and edits all Radio Science data. Inputs include closed-loop tracking data from ATDFs, or open-loop data output from the digital filtering and detection programs (NBDECIM-DETPHS or PLLDEC). OCEP reconstructs the observed sky frequencies from the doppler counts (from an input ATDF) or from the detected open-loop baseband frequencies and POCA tuning frequencies (from input files generated by the open-loop detection software which in turn use the ODR tapes as input).

RESID - computes frequency residuals from observed frequencies (OCEP output) and predicted frequencies (estimated from GETTRAJ output trajectory file).

STBLTY - reads in residuals computed from RESID and performs stability analysis. Computes Allan variance, phase noise, absolute frequency, and frequency drift rate. Writes summary information onto a database for one-way data.

FITUSO - allows one to fit and remove an aging model from the estimated spacecraft transmitted frequencies from a set of USO passes.

USOSMRY - displays parameters and statistics from the USO data base.

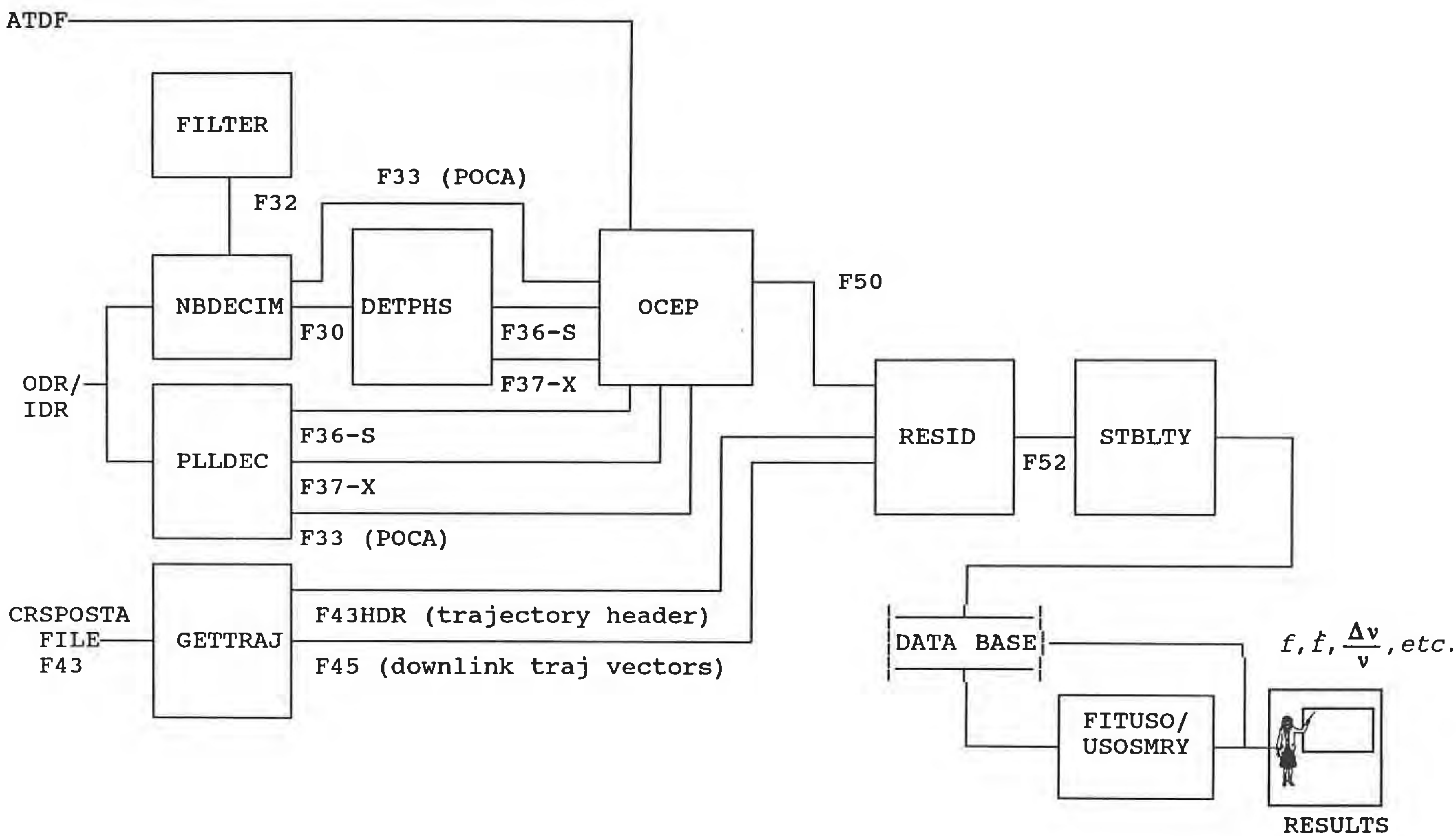


FIGURE 8-1 - STBLTY PROGRAM SET (for one-way data)

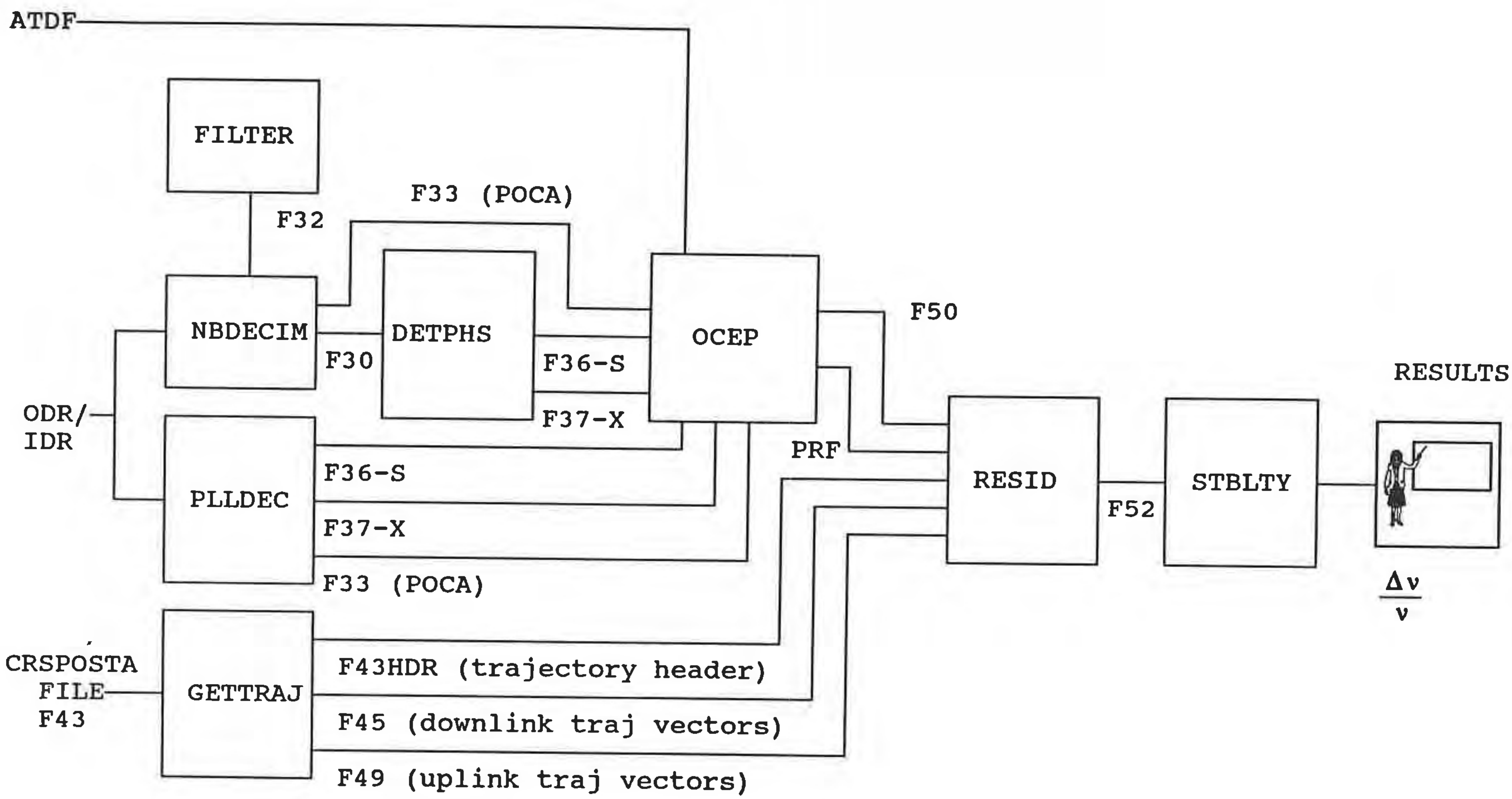


FIGURE 8-2 - STBLTY PROGRAM SET (for two-way data)

SECTION 9

REAL-TIME COMPUTER SUPPORT

9.0 Introduction

The Radio Science Real-time Monitoring System (RMS) displays real-time information necessary for monitoring the instrument and the experiment. Presently, the Radio Science Team depends primarily on a PRIME 4050 Computer and a SUN 4/330 workstation to run the various data collection and display programs. In January and February of 1993, an upgraded RMS will be installed that will display the same information but will run significantly different from previous implementations.

Sections 9.1 thru 9.4 discuss the present RMS system. The proposed new RMS system is discussed in Section 9.5. Computer security is discussed in Section 9.6.

9.1 Overview

The present overall structure of the RODAN computer system is shown in Figure 9-1. This multi-mission computing facility is used to support Radio Science experiments. The personnel who administer this facility are provided by the Radio Science Systems Group in Section 339. The heart of the RODAN is a PRIME 4050 computer and its peripheral devices which include two 6250/1600 bpi tape drives, a 1.3 Gbyte DAT drive, two disks of 496 and 315 MB memory capacity, a laser printer and an array processor. The array processor is a Floating Point Systems AP-120B (64 kiloword memory) vector hardware processor and math library software package. The PRIME computer supports 15 PCs/user terminals located in buildings 230 and 161.

The Real-time Monitoring System (RMS) receives data sent from one or more DSN stations. The data arrive into the basement of building 230 over the GCF lines and, from there thru splitters, are sent to the first floor Radio Science area where RODAN is located. The data are sent to RODAN on five receive-only lines at either 56, 64, or 224 kb/s. An HP 9220 computer functions as RODAN's front-end data acquisition filter and transfers the selected data to the PRIME via an IEEE 488 parallel interface. The data can be displayed on various terminals hooked up to the PRIME and can be sent over the Radio Science subnet to be picked up by the Radio Science workstations, a SUN 4/60 and a SUN 4/330 both sharing 654 Mb of mass storage.

9.1.1 GCF LINES TO RODAN

The lines which carry real-time data into the RMS from the DSN's GCF are "receive only" and are tapped off of Data Set lines right before the Digital Matrix Switch and the ECS Computer.

The tapped lines go directly to modems in the Building 230 basement which are hard-wired via twisted pair lines to a second set of modems located in the RODAN computer room. These modems conform to EIA RS-449/422A standards. The second set of modems are connected to the input ports of RODAN's front-end data acquisition/filter computer. The data flow is described below.

9.1.1.1 HP Serial Interface

Five Programmable Serial Interfaces (Hewlett-Packard 98691As) have been programmed for use with the DSN's communication protocols. Each interface includes a Z80 microprocessor which manages twenty 4800-bit blocks in a shared circular buffer with the MC68000 CPU in the HP 9220 computer.

9.1.1.2 HP 9220

A Hewlett-Packard 9220 computer reads data from the interfaces and checks to see if the data type is one of interest to RODAN. If so, it is then transferred to RODAN via a IEEE-488 parallel interface. The data types of interest are DOP (doppler), ANG (antenna angles), M59 (Monitor 5-9), RNG (ranging), SSI (spectral signal indicator), and NRV (DSP status).

9.1.1.3 HPIN

HPIN is a phantom process (non-interactive background process) in the PRIME computer that receives data from the IEEE interface. HPIN places these data blocks into a 100 block circular buffer in shared memory to allow access by the FARMER and ROUTERTCP processes. It generates warning messages if no data are received.

9.1.2 INSIDE RODAN AND BEYOND

Two processes that run on RODAN are key to the real-time displays: FARMER and ROUTERTCP. These programs sort through the data being sent by the HP and do two things, respectively: (1) store them in a disk file on the PRIME, or (2) broadcast them via TCP packets over the subnet to the SUN workstations.

9.1.2.1 FARMER and ROUTERTCP

Both the FARMER and the ROUTERTCP processes have configuration files associated with them. Each configuration file lists the spacecraft number, the station ID, and the type of data which the user wishes to capture. The file for ROUTERTCP also includes start and stop times for the capture period. FARMER identifies the selected data from the incoming stream and unpacks and archives them to a userdesignated disk file on the PRIME. ROUTERTCP, likewise, identifies selected data for the workstations and sends these data out on the Radio Science subnet to the workstations in a broadcast format.

9.1.2.2 PRIME Displays

See Section 9.3 for a complete description on how to run the display software on the PRIME. Note also that a procedure can be written using PRIME's Command Procedure Language (CPL) to setup often-used display configurations.

9.1.2.3 Radio Science Workstations

Two SUN workstations, the 4/330 (GODZILLA) and the 4/60 (GAMURA), are connected to the Radio Science subnet. Each can execute the RMS Workstation Display software independently. A user may have up to ten graphics windows open at any one time. For further information on the the number and types of displays available, see Section 9.4.

9.2 Startup and Takedown Procedures

This section describes how to start up the data acquisition portion of the RMS, and how to take it down at the end of the pass. If you intend to run only the display generators and are not responsible for starting and stopping the RMS, then skip this section for now. (Note that emergency startup and shutdown procedures for the PRIME are provided in a white notebook labeled "RODAN Handbook" which resides next to the console in the RODAN computer room.)

On the PRIME computer, HPIN must be started first followed by FARMER and then any display programs. Each process shares a system resource with the preceding process; moreover, the former initializes the shared resource. Hence, the order in which these processes are started is essential for successful RMS startup.

9.2.1 STARTUP SEQUENCE

To startup the data acquisition portion of the RMS, one must start two processes on the PRIME (HPIN and FARMER) and one on the HP front-end (FILTER). Although either the HP front-end or PRIME can be started first, it is recommended that the HPIN process on the PRIME be activated first, followed by the HP front-end.

If the HP front-end is started first, it will hang as soon as it tries to send packets to the PRIME via the IEEE-488 interface. Once HPIN on the PRIME is started, normal operations will commence.

9.2.1.1 HPIN

The preferred startup procedure begins with ensuring that the HPIN phantom process is running on the PRIME. Normally, the HPIN process is always running (as a system phantom) so there would be no need to start it. To check on its status, the PRIMOS command STAT US will display all logged-on users and running processes. Should "SYSTEM (HPIN.CPL)" NOT appear as a running process, the user should attach to the TSS directory (A TSS) at the system console and enter the following command: PH HPIN. This will start the HPIN process. (WARNING!: Do not start HPIN without first verifying that it is not currently running on the PRIME. A duplicate HPIN process could hang up the system. If you are not sure what to do, call the System Administrator.)

HPIN initializes the IEEE-488 controller and begins depositing data from the HP front-end into a circular buffer in the PRIME. If there is no data available on the IEEE-488 bus either because the front-end has not been started, because data are not being received by the modems, or because the HP has not been configured correctly, the HPIN process will generate DMA timeout warning messages to user FARMER until such data are received or the HP is correctly configured. (NOTE: HPIN generated DMA timeout messages are also generated if data are coming in slowly).

If HPIN should, for some reason, log itself out, the COMO file TSS>HPIN.COMO should be examined to identify the reason for the logout. This file should also be renamed and/or printed out prior to restarting the process in order to preserve the information documented in this file.

9.2.1.2 HP Setup

The next step in the startup procedure is to check and adjust, if necessary, the status of the HP front-end. The Hewlett-Packard 9220 computer is located at the bottom of the FPS Array Processor rack.

9.2.1.2.1 *Power Switches*

If the HP is powered OFF, turn on the power switches for the floppy disk drives, the printer and the monitor and continue with the next section. Otherwise, skip to 9.2.1.2.3

9.2.1.2.2 *TSS Operational Disk*

Insert the 3 1/2 inch disk with the blue label that says

"TSS: stand alone T.S.S. Operational Disk" into the disk drive (HP 9122) with the label facing up and then power up the main box. This will initiate a cold boot. Wait for the cold boot to finish (the screen will show "Command:. . . ." in the top left, and the disk activity light will go out).

If the HP is already on but the system needs rebooting for any reason, then press "SHIFT RST" while the disk is in the drive. This will reboot the system from the disk. If the H.P. does not boot properly, then try cycling power.

The disk should stay in the drive or next to it at all times. (The RODAN System Administrator has backup copies of this disk.) These disks should always be write protected. (The red thingy should be pushed down so that it is NOT visible through the hole from the top).

9.2.1.2.3 *G.C.F. Lines*

Figure 9-2 is a block diagram description of the interconnection of the RODAN lines between the GCF in 230/B3 and the Radio Science RODAN computer system located in 230/103B. Five GCF lines are routed to RODAN, with the following descriptions and codes:

RODAN	DESCRIPTION	CODE
1	56K DUPLEX	20
2	56K DUPLEX	21
3	224K SIMPLEX	22
4	56K/224K SWITCHABLE	23
5	64K DUPLEX DSCC 40 ONLY	24

RODAN-4 is a switchable link with a dual position switch at the front of the modem, 56 Kbps/224 Kbps. The RODAN 3 and RODAN 5 lines both connect to GCF but only one can carry data to the Radio Science computer at a time. The choice depends on the toggle setting of an AB switch located behind a steel plate in a rack in the COM area in the Building 230 basement.

The configuration of each line can be confirmed or modified for any of the three DSN complexes by calls to the COM Chief (X35800) and/or the OPS Chief (X37990). Refer to Section 6 for specific details of the procedure for setting up RODAN lines. One can verify that the proper lines are connected by checking the FARMER display on the PRIME or by running MONITOR on the HP as described in the next section.

9.2.1.2.4 *Program Startup*

Start the FILTER program by pressing "X" (execute) at the "Command:. . . . " prompt and then type "FILTER [CR]". When prompted, type the three codes which correspond to the RODAN/GCF lines which are to be used (e.g., "20 [CR] 21 [CR] 22 [CR]"). See Section 9.2.1.2.3 for the correspondence between the lines and the codes. For RODAN-4, be sure to set the toggle to either 224 Kbps or 56 Kbps depending on what was negotiated with the COM Chief and/or OPS Chief.

If you choose an unconnected interface, or if there is a hardware problem you will immediately get a message:

"! NO RECEIVE CLOCK !!!!!!!!"

Check to make sure that you have entered the correct line codes. Also, check the LED's on the modems. These LED's indicate whether data and clock are present on the GCF line. Both Carrier and Traffic LED's must be lit for proper operation.

If a problem cannot be located locally and an attempt has been made to work it with the COM Chief, only then should one call the OPS Chief and report that the line is not working properly. If the HP is set up properly, the most likely problem is that a patch cord in the COM area is not making good contact.

If you wish, you may execute the MONITOR program on the HP to get some indication of the kind of data blocks present on all of the lines. Execute it the same way as FILTER. Programs are stopped by pressing the "SHIFT" key simultaneously with the "STOP" key. This returns you to the same command line you get after a cold boot. (Note that data will not be logged by FARMER if MONITOR is running on the HP.)

9.2.1.3 FARMER

Login at a Tektronix 4107 terminal as user "FARMER". After you are logged in, type "FARMER[CR]" to start this process.

The program will ask the user for the name of a configuration file. Enter the filename. The configuration file is a listing of parameters that FARMER uses to determine which data it should accept. These files which reside in the TSS directory have names such as GLL_14, GLL_43, GLL_63 and GLL_ALL. The first three files will accept data from a single 70-m station tracking Galileo. The last file will accept data from all 70-m stations which are tracking Galileo. These files will only accept data related to Galileo passes. Other files are set up (or will be) to accept data for Ulysses or Mars Observer Radio Science activities or other spacecraft passes. This is an example of a configuration file:

```
77 SSI  40
77 NRV  40
77 DOP  43 S
77 ANG  43
77 M59  43
```

Note that there are no start or end times associated with the configuration file.

FARMER will then prompt for the name of the subdirectory into which the data will be logged. Type in an appropriate subdirectory name (e.g., GLL23343 would be for a Galileo pass on DOY 233 at station 43).

9.2.1.4 Display Startup

See Section 9.3 for a detailed description of the setting up and running of the DISPLAY software on the PRIME.

See Section 9.4 for a detailed description of setting up and operating the display system on the SUN workstations.

9.2.2 TAKE-DOWN PROCEDURES (PRIME ONLY)

Display programs can be stopped by entering the appropriate response given in the menus. See Section 9.3. At the end of a pass, the FARMER process should be halted by typing control-P, followed by "LO" to logout the terminal. HPIN normally runs continuously as a system phantom, so it need not be stopped. If applicable, the proper notification for the release of RODAN lines should be communicated to the COM Chief or OPS Chief.

9.3 PRIME DISPLAY Software

This section describes how to run the DISPLAY program on the PRIME.

Once the FARMER process has begun to collect and archive data in the disk database, either an NEC graphics terminal, or a Tektronix 4107 terminal can be used to run the DISPLAY program on the PRIME.

The procedures for the NEC and Tektronix 4107 terminals are identical, and are described in Section 9.3.1.

The PRIME DISPLAY software may be modified in the future to function on the IBM PCs using PCPLOT with Tek 4105 terminal emulation.

9.3.1 NEC/TEKTRONIX 4107 CONSIDERATIONS

This section describes running the DISPLAY software with an NEC terminal using a specially modified real-time version of the ESC140 terminal emulator. This is due to the one graphics page limitation of the Tektronix 4107 terminal; however, viewing multiple pages on the Tektronix 4107 terminals is still possible.

In the case of NEC terminals, eight-inch floppy disks configured to auto-load the proper version of ESC140 are available. Labels for the special function keys on the keyboard are also available.

The NEC has internal display memory for three graphics displays, and a text display, all completely independent. The user can select any one graphics display and/or the text display without affecting the running of the display program.

The Tektronix 4107 terminal has only one graphics display page as previously mentioned; to view other pages, the user must use the "V" option discussed in Section 9.3.3.3.

9.3.2 BASIC PROGRAM OPERATION

To start the program, type in "DISPLAY" while attached to the top level TSS directory. DISPLAY will ask a few basic questions such as what spacecraft ID (77 for Galileo; 55 for Ulysses) and station or complex the user wishes to view. These questions are self-explanatory and will not be described in detail. Table 9-1 provides a list of all available data types along with the corresponding data number. The data number is one of the inputs which DISPLAY will request.

After entering all the required data specifications, DISPLAY will set up the text and/or graphic pages, and then backfill each of the graphs to the present point (real-time). After initially backfilling each of the grids, real-time display processing resumes. If the user does not wish to wait for the backfilling to complete, then enter a control-P (to cancel the backfilling), and enter the real-time command (R) and all graphs will start displaying immediately in real-time. The control-P break always resets any backfilling in progress.

9.3.3 PLOT CONTROL

Once a display program has been started and configured, you can control what data are displayed and what portion of the data file is plotted.

9.3.3.1 General

Display programs spend their time trying to update the display, rather than waiting for commands. Before a display will accept a command from the keyboard, you must attract its attention with the break key, or control-P. It will respond by printing a menu of available commands in the top left corner of the screen. Once you have the menu displayed, you can type any one of the commands described later (9.3.3.3). Note however, that the display will not update while the program is waiting for a command.

9.3.3.2 NEC/ESC140 Display Control

There is a row of special function keys across the top of the NEC keyboard. Only three of them are used by the RMS. These control the local displays on the NEC and do not affect the PRIME.

The key labeled "TEXT ON/OFF" toggles visibility of the text page on/off. On the Tektronics 4107, the "Dialog" key provides a similar function.

The key labeled "GRAPH ON/OFF" toggles visibility of all graphs on/off. On the Tektronics 4107, the "Graph" command toggle after a control-P provides a similar function.

The key labeled "ALT GR PAGE" cycles through the three graphics pages on the NEC (The Tektronics 4107 requires use of the "V" command). This key is purely a local display function. It has no effect on program operation.

DO NOT hit the "RESET" key during RMS program execution or you will have to quit the current program and start it over again to get the proper displays.

9.3.3.3 Command Menu

The following describes the commands that the user may enter after getting the attention of the program with the "BREAK" key or control-P. The arguments enclosed in brackets "[*]" need not be entered if the command applies to the current graphics page, chosen by a "V" command.

C CONTINUE - tells the program to return to display processing and exit the command window.

Q QUIT - stops the program

F [n] FRAME - provides a blow-up of an existing grid(s). To change the page format, set "n" to:
0: original page format (two grids)
1: select grid #1, disregard #2
2: select grid #2, disregard #1
A space is required before the n-value. Use the left button on the mouse to select the opposite corners of the desired rectangular, blow-up region in the grid. If you wish not to change a grid, press the middle button on the mouse.

L [n] LIMIT - specify grid limits. n has the same meaning as in Frame. Enter "/" to use the current limit. When specifying an X-axis time-range, the day (DOY) of the first time limit by default is the day of the last data point updated prior to entering the command mode. A space is required before the n-value.

M MOVE - specify a time to which the displays are to move. The user will be prompted for the desired time in year, day of year and then hour, minutes, and seconds.

R REAL-TIME - similar to the "CONTINUE" command except that all displays are brought quickly to real-time.

P [x] PRINT - produces hardcopy on the QMS laser writer of text or graph at the current page. For text copy, use the command "P t". For a copy of a graph, set "x" to the number of the grid desired, "1" or "2". If only one grid is on the graph page, then no "x" specification is necessary. A space is required before the x-value.

V p VIEWPAGE - specifies the graphics page for which the subsequent user commands apply. "p" is set to the number of the desired graphics page; 1, 2 or 3.

Cgtc COLOR - specifies the color to use for a particular trace on a grid. "g" specifies the grid number, "t" specifies the trace number on the specified grid, and "c" is the number of the desired color 0-9, e.g., "C113"

Dgts DISCRETE SYMBOL - specifies the symbol to use for discrete point plotting. "g" specifies the grid number, "t" specifies the trace number. "s" is the desired symbol, such as a plus sign, e.g., "D11+"

D[n] DISCRETE - toggles the grid in/out of discrete plotting mode. "n" specifies a particular grid on a page. If two grids exist on a page and "n" is not specified, then both grids are toggled.

T[n] TIC - toggle the grid tic marks on/off. This only takes effect when a grid is refreshed. "n" has the same meaning as in "D[n]" above.

A[n] AUTO-Y - toggles the auto-scaling on/off for a particular grid. If this is set and a data point falls out of range, then the grid will be erased and the vertical limits reset to accommodate the new point. "n" has the same meaning as it does in "D[n]" above.

Y[n] Y-VALUE - toggles the y-value report function on/off. If "on", the y-value of every point plotted is reported in the grid on the left side in the same data color as the data trace. "n" has the same meaning as in "D[n]"

B BELL - toggles the terminal audible bell on/off.

9.4 SUN Workstation "display" Software

This section discusses how to set up and run the "display" software on the Sun workstations.

9.4.1 THINGS TO DO BEFORE RUNNING THE DISPLAYS

1) On RODAN, attach to the "router" subdirectory. Edit the configuration file (e.g., "gll_all") to specify exactly the data being requested. The following is an example of a configuration file:

```
90/045/23:30:00
90/046/12:00:00
 77 DOP  14 X
 77 DOP  14 S
 77 ANG  14
 77 M59  14
 77 DOP  43 X
 77 DOP  43 S
 77 ANG  43
 77 M59  43
 77 DOP  63 X
 77 DOP  63 S
 77 ANG  63
 77 M59  63
 77 SSI  40
```

```
77 NRV  40
```

Note two spaces between data type and station/complex ID

Line 1: specifies the YEAR/DAY/HOURS:MINUTES:SECONDS - this is the start time of the database collection run.

Line 2: specifies the YEAR/DAY/HOURS:MINUTES:SECONDS - this is the end time of the database collection run.

Line 3-14: Specify the data types that are desired for collection. These can be in any order and any number of data types (please observe proper spacing between fields). The first item is the spacecraft ID (77 for Galileo, 55 for Ulysses). The next item is the data block type (see Table 9-1 for the data types contained in each block type). The next item is station or complex ID. Then the last item is frequency band (S or X) for applicable data block types.

2) On GODZILLA, go to the /home/tss subdirectory (i.e., cd /home/tss). Edit the configuration file (e.g., gll_all). An example is given below:

```
90/045/23:30:00
90/046/12:00:00
 77 DOP 14 X
 77 DOP 14 S
 77 ANG 14
 77 M59 14
 77 DOP 43 X
 77 DOP 43 S
 77 ANG 43
 77 M59 43
 77 DOP 63 X
 77 DOP 63 S
 77 ANG 63
 77 M59 63
 77 SSI 40
 77 NRV 40
```

Note one space between data type and station/complex ID

9.4.2 INVOKING AND RUNNING THE "display" SOFTWARE

1) Login as user "tss" at GODZILLA.

2) Enter the proper password (obtain from workstation system administrator).

3) The computer will place the user in the directory containing all of the executable code, configuration files, and utilities necessary for running the "display" software.

   (Unusual condition: When running the "display" software for the very first time or after a boot-up, the program will detect that the "virtual memory" space is empty or is uninitialized. The "display" software will automatically invoke "Data Base Utilities" to allow the user to proceed with data base initialization. Skip to Part 6) of this section for an explanation on how to use "get live data" or see Section 9.4.3 for an explanation on how to use the other options.)

4) A window titled "STARTUP MENU" will be displayed which contains two options (See Figure 9-3). Select "new display" by pointing the mouse to this item and clicking the LEFT mouse button. This will invoke "display".

5) A menu will appear in the upper right hand corner of the display titled "Main Selection Menu" (see Figure 9-4). To initiate a "live" monitoring session, select "Data Base Utilities" with the mouse (LEFT button). Upon selecting "Data Base Utilities", the user will be presented with the following choices (see Figure 9-5):

   "get live data"
   "load from tape/disk"
   "save to tape/disk"
   "list sub-directories"
   "Report about present data base"
   "Quit"

6) Select "get live data" with the LEFT mouse button. (If the user wishes to use an old data base, she/he should see Section 9.4.3.1 ("load from tape/disk") for details on bringing one up.)

   If the database already contains data, the user will be prompted to make a decision:

   "Do you wish to resume using the same data base? (y or n only)"

   If the user selects "y", then the database will not be cleared and new data will be appended to the existing data base. Please note that every data base is configured to accept data for a specific time range. If the new data falls beyond the specified time limits of the data base, then data will be lost.

If the user selects "n", the user is prompted:

"Is it OK to delete the existing data base? (y or n only)".

If "n" is selected, the program displays:

"Save the data base and try again".

The "get live data" option will then terminate. This is a safety step and lets the user save data before destroying or clearing the data base. The user should now make a new selection from the "Data Base Utilities" panel.

If "y" is selected, then the database will be cleared and the following message will appear:

"Enter name of stream file which specifies desired GCF data: (for example:ws_40)"

Enter a configuration filename (e.g., "gll_all").

The software then proceeds to calculate space allocation based on the specified data types and requested time span in the configuration file. If the "virtual memory" limits are exceeded, the user will be presented with an error message:

"(init, data): shmget : Not enough memory "

The user must either reduce the time span coverage (modify the start and end times to include a shorter span) or reduce the number of data types. After the configuration file is edited, the user may try again. When the program is satisfied with the configuration file parameters, it will proceed with creating, initializing and partitioning the "virtual memory" to accommodate the data monitoring. A socket communication link will be initiated that will enable the reception of data from the PRIME computer across the Radio Science subnet and an infinite loop will execute waiting for data to commence transmitting.

7) The user must now set up the data transfer from the PRIME to GODZILLA.

a) Login to RODAN through a shell window in "sunview".

Point the mouse to the background (grey) and select the RIGHT mouse button. A menu will appear. Select "Shells" (see Figure 9-6). A window ("Shelltool") will appear in the middle of the screen. Type the following:

"telnet rodan [CR]"

The computer will respond as follows:

```
Trying 128.149.43.57 ...
Connected to rodan.
Escape character is '^]'.

Telnet Rev. 2.1-22.0 connected

You are connected to the Network Terminal Server
Copyright (c) 1987, Prime Computer, Inc., All Rights
Reserved.
OK,
```

Type the following: login router[CR]

Computer responds: Password?

Type the following: Password (Obtain from the RODAN System Administrator.)

Computer responds:

```
ROUTER (user 32) logged in Monday, 14 May 90 21:44:52.
Welcome to PRIMOS version 22.0
Copyright (c) Prime Computer, Inc. 1988.
Last login Friday, 11 May 90 19:40:36.

OK,
```

Type the following:

a router[CR] (attach to directory "router")

b) Initiate ROUTERTCP on the PRIME.

At the next OK prompt, type the following:

routertcp[CR]

Computer responds:

Enter name of file containing stream parameters

Type:

gll_all[CR] (for example)

(Note that you can interrupt or cancel execution of any program on the PRIME by typing <cntl>p.)

The PRIME should start sending data packets. The response on the Shelltool should be something similar to the following:

```
SOURCE INET ADDRESS 80952B39
SETUP_SOCKET 1
SOCKET 0
BIND 0
ADDRES  -2137707759
"  "  "        "
```

(See Figure 9-7 for remainder of message.)

The "Data Base Utilities window sould display reception of those data packets. You are now on your way to receiving Great Science Data (GSD)!

c) ROUTERTCP error-handling.

In case ROUTERTCP aborts on the PRIME, do the following at the ER! prompt:

c all[CR]	(close all. Close all open files.)
rls -all[CR]	(release unneeded resources)
delete doyxxx[CR]	(delete file)

ROUTERTCP attempts to create a subdirectory named "DOYXXX" everytime it is invoked (where xxx is the day-of-year). If there were several attempts to start up the program, there may be a leftover subdirectory of the same name. The above "delete" command will remove these files so that the PRIME software can create the intended files.

If things appear to be really fouled-up, type in the following sequence:

ice[CR]	(reinitialize the command environment)
a router[CR]	(attach back to router directory)

(Note: ROUTERTCP is configured to send data to GODZILLA only - the present host for "display". If a different host or computer is required to run "display", then the ROUTERTCP software needs to be modified and recompiled.)

8) Once the system is functioning normally, the user can close the Shelltool to reduce clutter in the Sun display. (Note: do not "quit" the window, just "close" it.) This can be done by pointing the mouse pointer at the top black bar of the window and clicking the RIGHT button on the mouse. A menu

shall appear with one of the choices being "close". Select that and the window will be reduced to an icon.

9) A stand-alone utility called "gauge" can be invoked by entering "gauge &" in one of the open Sun windows. A window displaying the data types and the amount of "captured" data will open up. "gauge" acts the same way as a "fuel gauge"; it shows how much of the allocated data space in the "virtual memory" is filled. This can also serve as a warning in case the space is filling up for a particular data type.

10) When done with any monitoring activities, the user can then quit or close out each window. If the user wants to terminate the "display" software and log out, he/she should first click on "Exit Program" under the "Main Selection Menu". Next, the user should click on the background with the RIGHT mouse button. Another menu will appear. Move the mouse to the EXIT SUNVIEW item and click the mouse (see Figure 9-8). This will return the user to the operating system. The user can then log out by typing "exit" followed by a "CR".

9.4.3 OTHER "Data Base Utilities" OPTIONS

The other options in Data Base Utilities" (besides "get live data") will be discussed in detail in this section.

9.4.3.1 <u>"load from tape/disk"</u>

This option allows the user to access a previously saved data base for perusal or examination. Select this option by pointing the mouse pointer to this choice and clicking the LEFT button. A summary of the existing data base in the "virtual memory" will be displayed and the user will be prompted:

"Do you wish to delete the existing data base? (y or n only)" (Question 1)

An "n" response will give the user further prompting:

"Want to add to the existing data base? (y or n only) "

A "y" answer will add a user-specified file from tape or from the disk drive to the present data base. An "n" response will terminate the option. A message "Try again" will appear. This is a safety measure to give the user a chance to save the existing data base into a file or a directory on disk. This can be done by exercising the "save to tape/disk" option. Once the user has saved the present data base, the "load from tape/disk" option can be tried again.

Returning to Question 1, if the user responds with "y", the "virtual memory" is initialized. The user is prompted:

"Extract data base from TAPE or FILE? (t or f only) " (Q #2)

If "f" is selected, the user is prompted for the name of the subdirectory which contains the desired archived data. The "f" or FILE response indicates that the user desires a data base that is stored on the hard disk. The data base files are actually separate files with distinctly coded file names for each data type. For example /home/tss/gl123343 contains the following data files:

```
  51 ANG.sc77.dss43
 184 M59.sc77.dss43
 832 NRV.sc77.dss40
1784 SDOP.sc77.dss43
1104 SSI.sc77.dss40
   1 XDOP.sc77.dss43
```

After the user specifies the subdirectory name, the data base is loaded into the "virtual memory" and the program displays:

"This process is completed, and the window can now be destroyed."

The user can now destroy the "Data Base Utilities" window by pointing the mouse to the top black bar of the window and pressing the RIGHT mouse button. A menu will appear. Select the "quit" option to destroy the window. Alternatively, the window can be destroyed by pointing the mouse to the "quit" item in the "data base utilities" menu and clicking the LEFT button.

Returning to Question #2, if "t" is selected, the program will prompt the user:

"Install tape and press RETURN when ready "

When the user presses the return key, the files will be extracted from the tape and placed into the "virtual memory". The files will also be placed onto the hard disk in a subdirectory with the same name as the tape files.

9.4.3.2 <u>"save to tape/disk"</u>

The data may be archived to either a hard disk subdirectory or onto a tape. When this choice is selected, the user is prompted:

"give new name for a sub-directory to put archive:" (e.g. gll_run)

All data in "virtual memory" will be archived into the subdirectory specified by the user. Next, the user has a choice to backup the files onto tape. The user will be prompted:

"do you wish to put (gll_run) archive on tape? (y or n only)"

An "n" response will terminate this option and the user can make another selection on the "Data Base Utilities" panel.

A "y" response will initiate a program prompt:

"install tape and press RETURN when ready "

The database files will be backed up onto the tape cartridge. If there is no tape present or the tape drive is not responding, the following error message will be displayed:

"tar: /dev/rst8: I/O error
Wish to try tar... again? (y or n only) "

"tar" (tape archiving and restoring utility) is the name of the backup utility supplied with the UNIX operating system. Depending on the user response, the archiving utility will try again to back-up the data files on to the tape. The tar utility will list on the screen each file that is successfully recorded on tape.

If it is desired to examine the contents of a tape after tape writing completes, the following command will list the contents of the tape:

```
tar -tvf /dev/rst0
```

9.4.3.3 <u>"list sub-directories"</u>

This option will list all of the sub-directories which may contain data. It is usually desired to invoke this option first to see what data directories are available on the disk prior to invoking any of the other options.

9.4.3.4 <u>"Report about present data base"</u>

This option displays the status of the current "virtual memory" data base.

9.4.3.5 "Quit"

This option will terminate the "Data Base Utilities" window.

9.4.4 CREATING PLOTS

1) After the user has setup a "live" monitoring session using "get live data" or an archived data base has been retreived into "virtual memory", the user can select the option "CREATE A NEW PLOT" from the "Main Selection Menu" (see Figure 9-4).

2) When the "Data Type Selection Menu" appears, the user can select from among the various data types. This menu is automatically set according to what data types are available in the "virtual memory" (see Figure 9-9).

3) After selecting a data type, the user can select from the various "Plot Types" (see Figure 9-10).

4) After the plot is created and appears on the screen, the "Main Selection Menu" will appear again. The user can then choose another quantity to plot by repeating steps 1-3. The various plots created can be moved around or manipulated by using the mouse commands described in Section 9.4.5.

9.4.5 MANIPULATING WORKSTATION DISPLAYS USING THE MOUSE

After logging onto the workstation and setting up the displays, the following more commonly used mouse commands can be utilized to manipulate the display windows (see the "Display Test Software Operations Manual" by G. Benenyan for a description of the full set of WS commands):

1) To make a plot larger or smaller: Position mouse to corner or edge of plot. Hold down "control" key and click & hold CENTER mouse button simultaneously. Move mouse to desired location. Release "control" key and CENTER mouse button.

2) To move a plot: Position mouse to corner or side of plot. Click & hold CENTER mouse button. Move mouse to desired location. Release CENTER mouse button.

3) To change start time: Move mouse to the "START" bar at the top of the window. Press the LEFT mouse button to move the bar to the desired location. Release LEFT mouse button. To take effect, click on 'jump'.

4) To change time span: Move mouse to the "SPAN" bar at the top

of the window. Press the LEFT mouse button to move the bar to the desired location. Release LEFT mouse button. To take effect, click on 'jump'.

5) To change the vertical scale of a plot: Point the mouse to the top black bar of the plot, click the RIGHT mouse button. Click on "modify graph" with the RIGHT mouse button. Point the mouse to the value for which a change is desired and click the LEFT mouse button. To change the value, use the delete key and enter the desired value. Repeat with any other values that are to be changed. To implement the modifications, click on "accept parameters" with the LEFT button.

6) To display the values for a particular data point (X,Y): Point the mouse to the top black bar of the plot and click the RIGHT mouse button. Click on "Compute XY" with the RIGHT mouse button. Point the mouse to the desired place on the plot and click the LEFT mouse button.

7) To bring a plot forward: Point the mouse on the edge of the plot and click the LEFT mouse button.

8) To obtain a hardcopy of a plot: Point the mouse to the top black bar and click the RIGHT button. Click on "Print" with the RIGHT button. The plot window will be resized to full screen, temporarily making the plot monochrome. A snapshot of the screen will then be taken. It will take approximately three minutes to get a hardcopy. The window will then be restored to its original location and state after the "snapshot" is taken.

9) To plot discrete points instead of a continuous line (or vice versa): Point the mouse to the top black bar of the plot and click the RIGHT mouse button. Click on "modify plot" with the RIGHT mouse button. The plot parameters window will appear. Point the mouse to the value displayed next to "Plot-mode" and click the LEFT mouse button. Use the delete key appropriately, then enter the desired value ("-1" for continuous line, "43" for "+" sign, or any other ASCII decimal equivalent for desired plotting symbol). Click the mouse on "Accept parameters" with the LEFT mouse botton to implement the change.

9.5 RODAN Upgrade

By February 1993, the RODAN interface with the DSN will be changed from five modem lines to two (prime and backup)

RS-449/442 lines using the X.25 protocol. This interface affects all multi-mission Radio Science activities, especially the upcoming Galileo and Ulysses Gravitational Wave Experiment in mid-March 1993 (see overall structure of the upgraded RODAN system in Figure 9-1A). Also included in the RODAN upgrade will be the phasing out of the 9 track tapes drives with EXABYTE tape drives which will fulfill a multi-mission interface agreement in accordance with the DSN.

The incoming lines will be RS-449/442 using the transport protocol X.25. The front end processor to be used to receive the data will be Gamura (a Sun SPARC station 1). Gamura will be modified with a serial port to accept this interface.

The data will be transported to RODAN with SFDU headers. RODAN is not equipped to handle data with SFDU headers; therefore, the headers will be stripped from the data as it is received.

The data delivered to RODAN will be copies of data streams generated by the NOCC gateway. All communication with RODAN will be one-way only, from the DSN to RODAN. The key functions performed by RODAN will include synchronizing and capturing incoming blocks using the X.25 protocol and demultiplexing and constructing the seperate data streams.

SSI Spectrum data, monitor data, and tracking data blocks will continue to be the data types passed across the RODAN interface from the DSN.

The interface will be configured to run a clock rate of 224 Kbps. The maximum aggregate rate shall not exceed 90Kbps for all complexes. The maximum rate from a single complex shall not exceed 45 Kbps.

Key parameters necessary for operation of the X.25 protocol on this interface are shown in Table 9-2. Data encapsulation for X.25 protocol are shown in Figure 9-11.

9.6 Computer Security

The following computer security practices must be adherred to:

1) Passwords

   a) Avoid trivial passwords like your names, user id, or a keyboard character sequence.

   b) Passwords should be at least six characters long.

   c) Preferably, passwords should be formed of two random alphanumeric words separated by a special character (e.g., &, *, $, #, @).

d) They should not be revealed to or used by anyone other than the assignee.

e) Passwords are not to be displayed on terminal screens when entered. Passwords are to be prompted for during each log on. Passwords should not be specified in any automated logon files.

f) Passwords should be changed at least every 90 days.

2) Terminals are not to be left unattended while logged on. If possible, terminals should have an "auto logout" implemented.

3) Do not attempt unauthorized access of computer systems or networks for any purpose.

4) Floppy disks and other removable media containing sensitive (i.e., important) data are to be locked up when not in use.

5) Backup protection is to be provided for all sensitive or critical files and programs. If possible, automated backup should be implemented.

6) Leased and purchased microcomputer program products that are proprietary are to be protected against unauthorized use (e.g., execution on an unauthorized computer system) and illegal duplication.

7) All terminals should be locked up during off-hours or a keyboard lockout (physical switch) should be put in place.

TABLE 9-1

AVAILABLE DATA TYPES FOR RMS

Data Number	Data Type
0	TEXT: NRV TIME TAGS
1	TEXT: DSP/SSI STATUS DISPLAY
2	TEXT: M59 REPORT OF CONSCAN MODE/LOOP
000	DOP: AGC
001	DOP: PSEUDO RESIDS
002	DOP: DOPPLER COUNT
003	DOP: DIFFERENTIAL DOPPLER COUNT
004	DOP: DOPPLER REFERENCE FREQUENCY
005	DOP: NOISE
006	DOP: # CYCLE SLIPS
007	DOP: INTEGRATED DIFFERENTIAL DOPPLER FREQ (SB)
008	DOP: PSEUDO DOPPLER FREQUENCY
009	DOP: RECEIVED FRENQUENCY
010	DOP: RF RESIDS
011	DOP: CUMULATIVE PHASE DIFF
100	ANG: AZIMUTH ANGLE
101	ANG: ELEVATION ANGLE
102	ANG: AZIMUTH RESIDUALS
103	ANG: ELEVATION RESIDUALS
500	SSI: SPECTRUM, ALL INPUTS
501	SSI: SPECTRUM, ALL ODAN INPUTS
506	SSI: SPECTRUM, ALL RIV INPUTS
511	SSI: SPECTRUM, ALL "SPXX" INPUTS
530	SSI: PEAK FREQ HIST, ALL INPUTS
531	SSI: PEAK FREQ HIST, ALL ODAN INPUTS
536	SSI: PEAK FREQ HIST, ALL RIV INPUTS
541	SSI: PEAK FREQ HIST, ALL "SPXX" INPUTS
560	SSI: PEAK POWER HIST, ALL INPUTS
561	SSI: PEAK POWER HIST, ALL ODAN INPUTS
566	SSI: PEAK POWER HIST, ALL RIV INPUTS
571	SSI: PEAK POWER HIST, ALL "SPXX" INPUTS
590	SSI: STACKED RIGHT, ALL INPUTS
591	SSI: STACKED LEFT, ALL INPUTS
600	NRV: MIN/MAX, ALL 4 CHANNELS
601	NRV: DSP RMS, ALL 4 CHANNELS
602	NRV: RIC RMS, ALL 4 CHANNELS
603	NRV: POCA READBACK
604	NRV: DSP RMS: CHS 1,3 (X-BAND)
605	NRV: DSP RMS: CHS 2,4 (S-BAND)
800	M59: SYSTEM NOISE TEMP, RCVR A

TABLE 9-1

(CONTINUED)

Data Number	Data Type
801	M59: SYSTEM NOISE TEMP, RCVR B
802	M59: SIGNAL LEVEL INDICATOR, RCVR A
803	M59: SIGNAL LEVEL INDICATOR, RCVR B
804	M59: AZIMUTH ANGLE
805	M59: ELEVATION ANGLE
806	M59: AGC SIGNAL LEVEL, RCVR A
807	M59: AGC SIGNAL LEVEL, RCVR B
808	M59: SNT VERSUS ELEV. ANGLE, RCVR A
809	M59: SNT VERSUS ELEV. ANGLE, RCVR B

TABLE 9-2

Key Parameters for X.25 Protocol Operation

Parameter	Value	Description
Modulo	8	Allowable Frames Outstanding
N1	1027 Bytes	Maximum Length of Information Frame
N2	5	Number of Retransmission Retries
T1	2 seconds	Frame Response Time (Acknowledgement)
T3	40 seconds	Inactivity Time-Out (Time Between Transmissions)
CRC Formula	$X^{16} + X^{15} + X^2 + 1$	
Levels Protocol	PVC=1	Permanent Virtual Circuit
Command/Response Address	NG=3, RODAN=1	

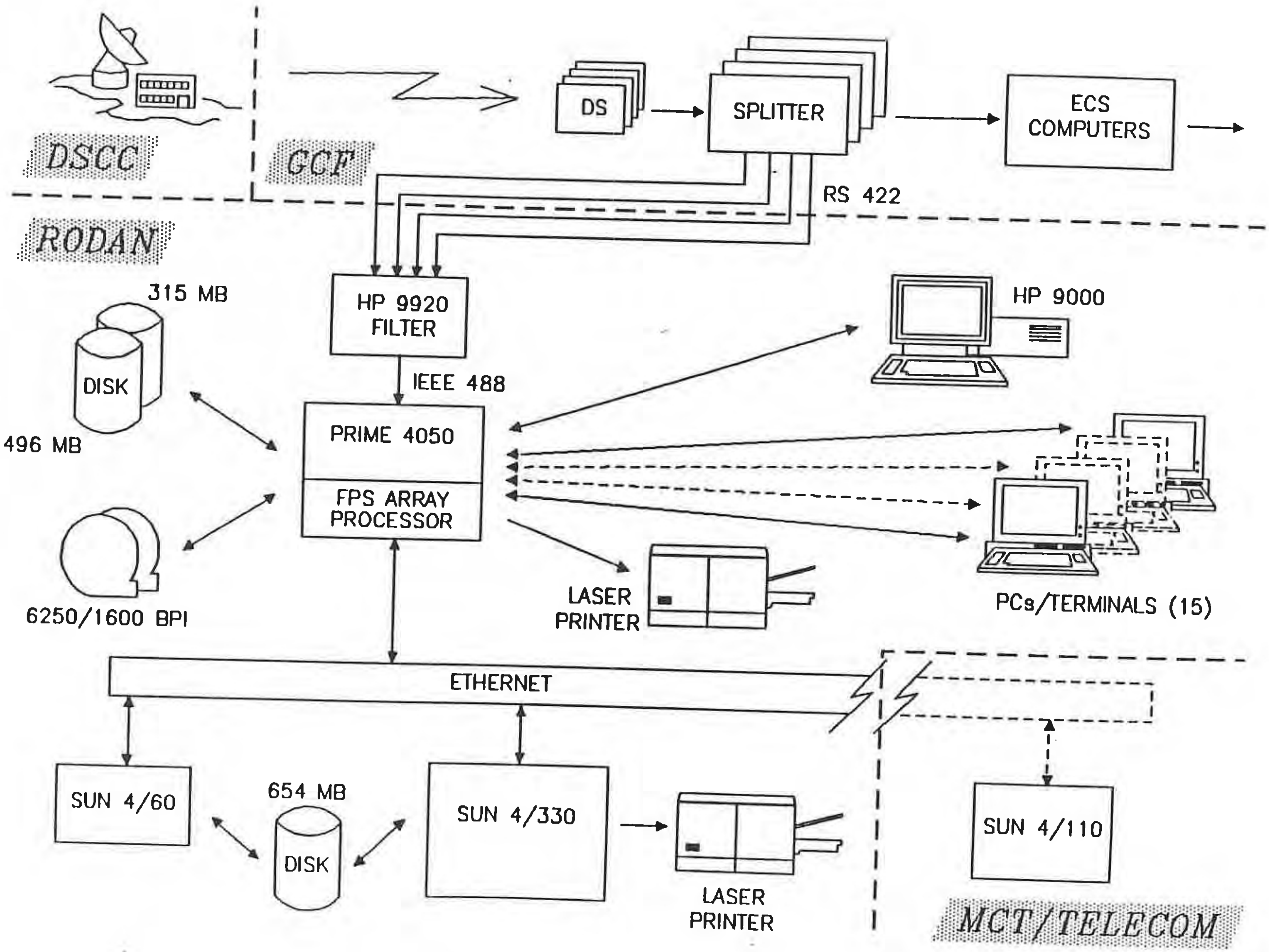

DSCC
GCF
DS
SPLITTER
ECS COMPUTERS
RS 422
RODAN
315 MB
DISK
496 MB
HP 9920 FILTER
IEEE 488
PRIME 4050
FPS ARRAY PROCESSOR
HP 9000
6250/1600 BPI
LASER PRINTER
PCs/TERMINALS (15)
ETHERNET
SUN 4/60
654 MB
DISK
SUN 4/330
LASER PRINTER
SUN 4/110
MCT/TELECOM

Figure 9-1

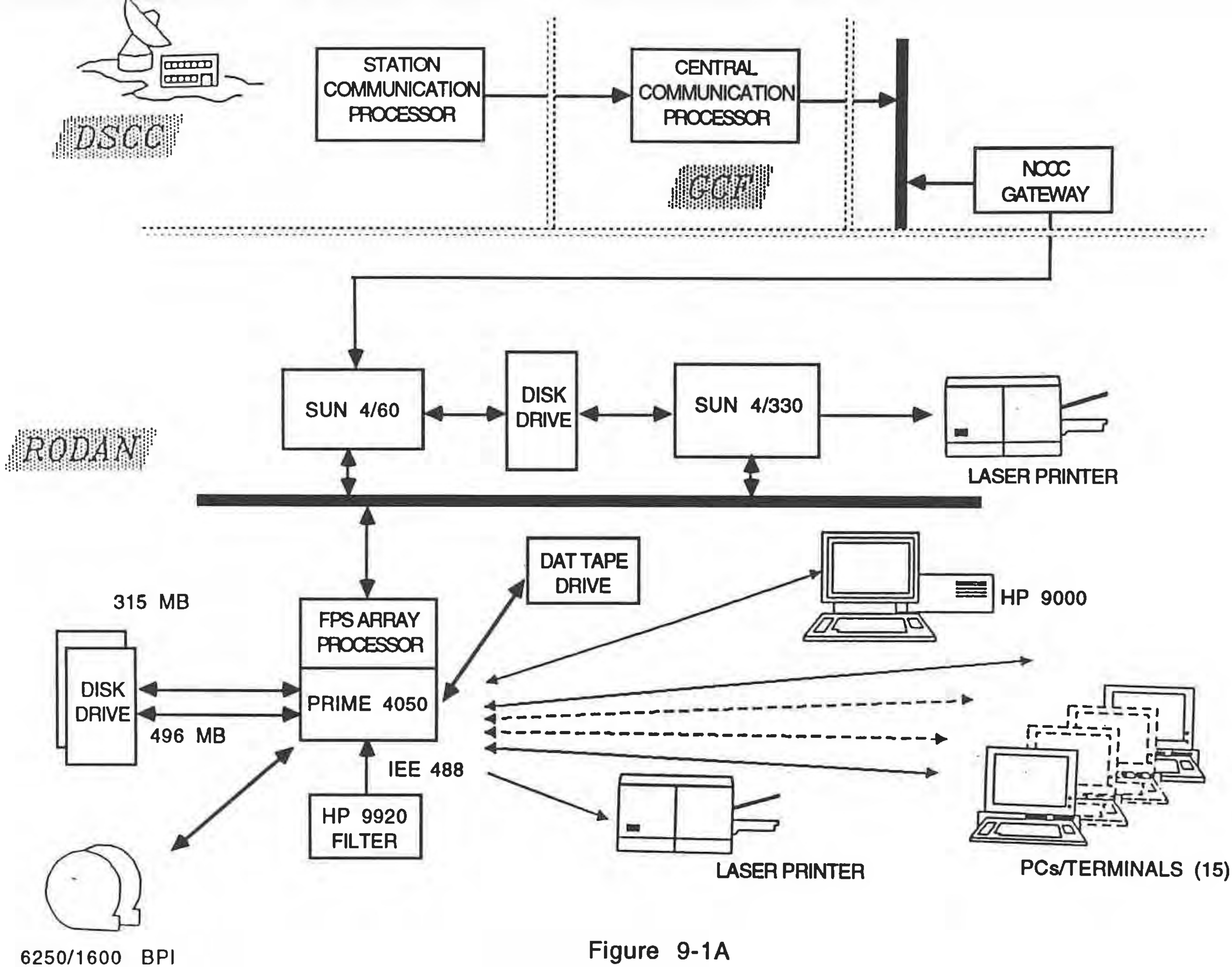
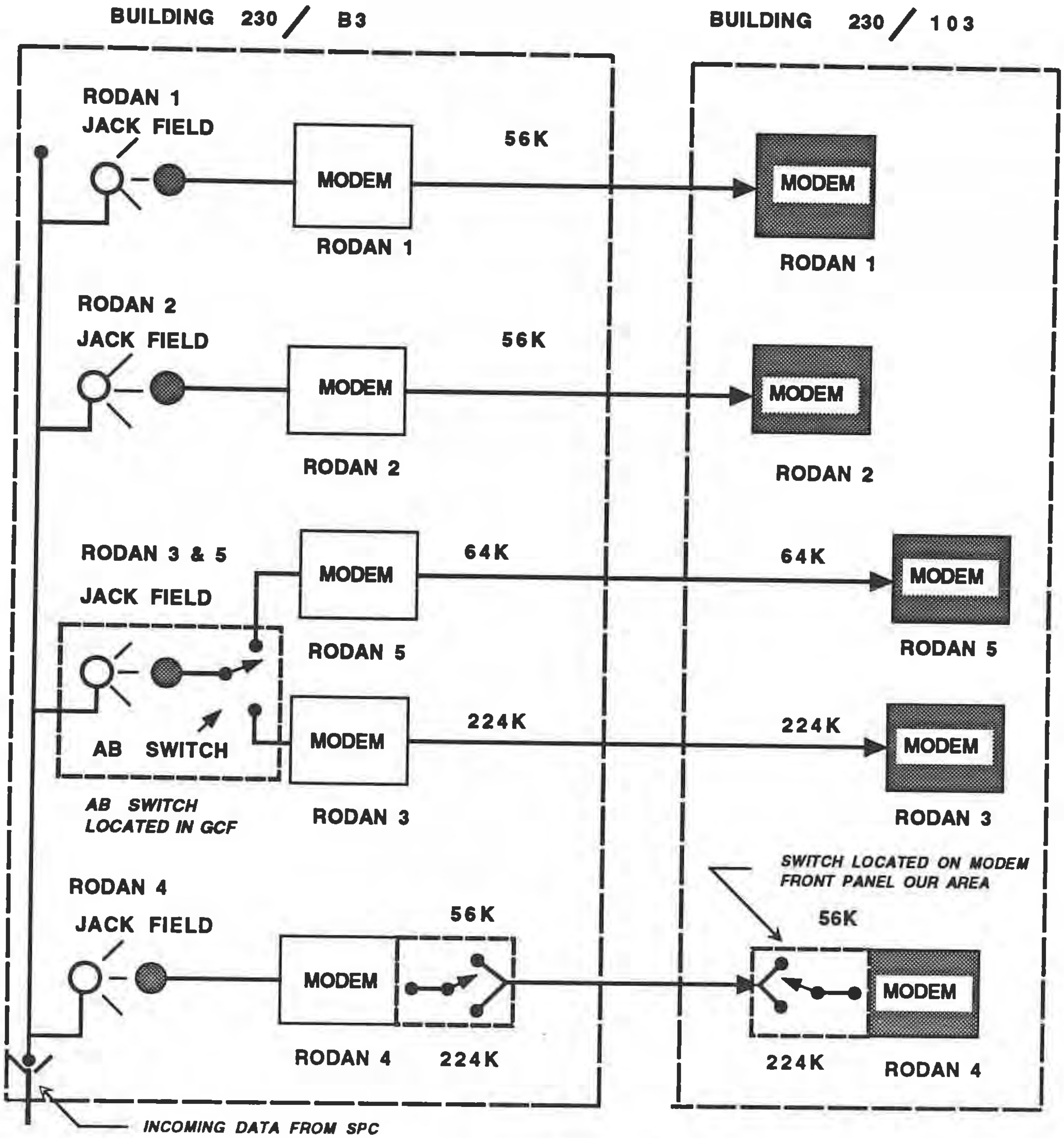

DSCC
STATION COMMUNICATION PROCESSOR
CENTRAL COMMUNICATION PROCESSOR
GCF
NOCC GATEWAY
RODAN
SUN 4/60
DISK DRIVE
SUN 4/330
LASER PRINTER
DAT TAPE DRIVE
HP 9000
315 MB
FPS ARRAY PROCESSOR
PRIME 4050
DISK DRIVE
496 MB
IEE 488
HP 9920 FILTER
LASER PRINTER
PCs/TERMINALS (15)
6250/1600 BPI

Figure 9-1A

RODAN GCF CONFIGURATION FOR MULTI-MISSION RADIO SCIENCE ACTIVITIES



RODAN GCF lines configuration are as follows: There is no standard configuration for these modems other than the constrint on modem #5 for SPC-40 alone. It is the SPC using the 64Kb clock / 64Kb line at the date of this drawing.

Figure 9 - 2

Effective: 11/26/92

RAH

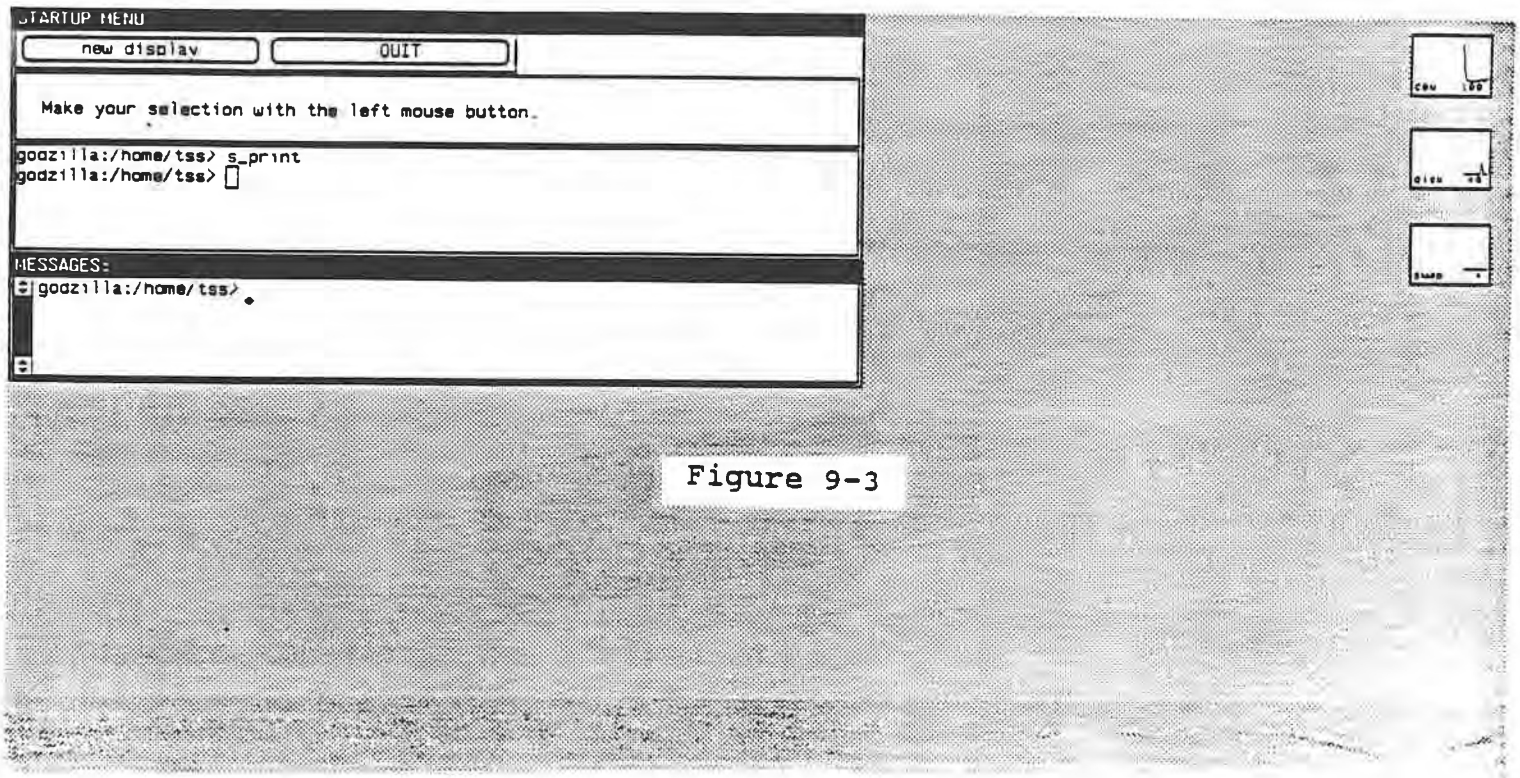


Figure 9-3

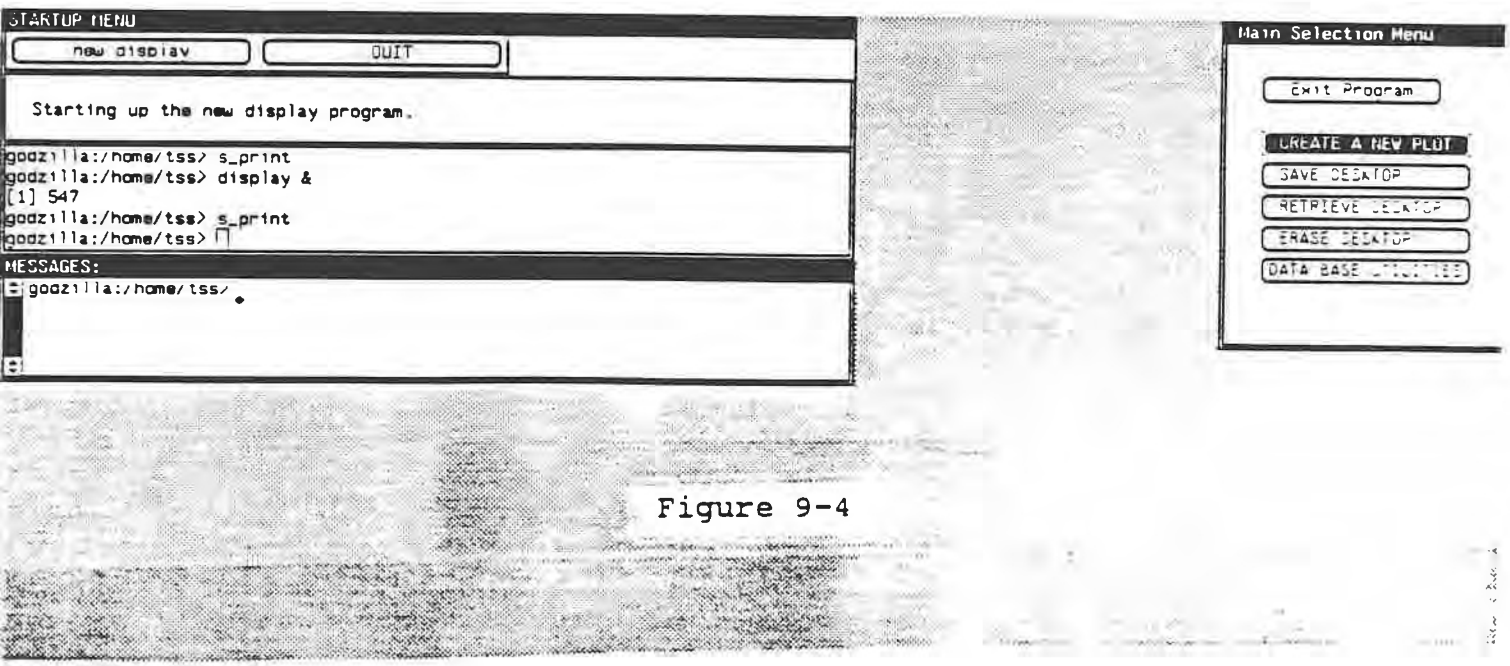


Figure 9-4

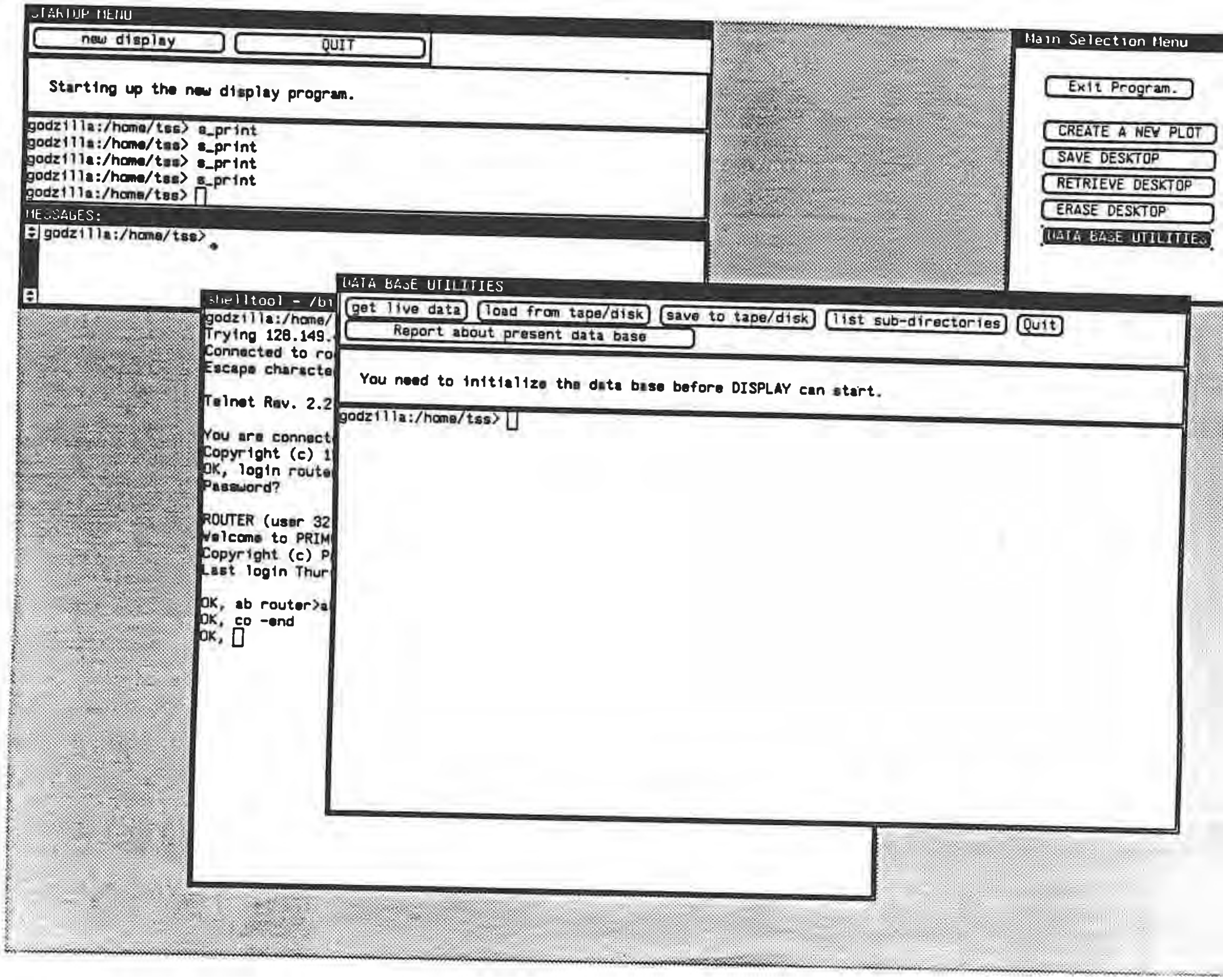

STARTUP MENU
new display
QUIT
Starting up the new display program.
godzilla:/home/tss> s_print
godzilla:/home/tss> s_print
godzilla:/home/tss> s_print
godzilla:/home/tss> s_print
godzilla:/home/tss>
MESSAGES:
godzilla:/home/tss>
Main Selection Menu
Exit Program.
CREATE A NEW PLOT
SAVE DESKTOP
RETRIEVE DESKTOP
ERASE DESKTOP
DATA BASE UTILITIES
shelltool - /bi
godzilla:/home/
Trying 128.149.
Connected to ro
Escape characte
Telnet Rev. 2.2
You are connect
Copyright (c) 1
OK, login route
Password?
ROUTER (user 32
Welcome to PRIM
Copyright (c) P
Last login Thur
OK, ab router>a
OK, co -end
OK,
DATA BASE UTILITIES
get live data
load from tape/disk
save to tape/disk
list sub-directories
Quit
Report about present data base
You need to initialize the data base before DISPLAY can start.
godzilla:/home/tss>

Figure 9-5

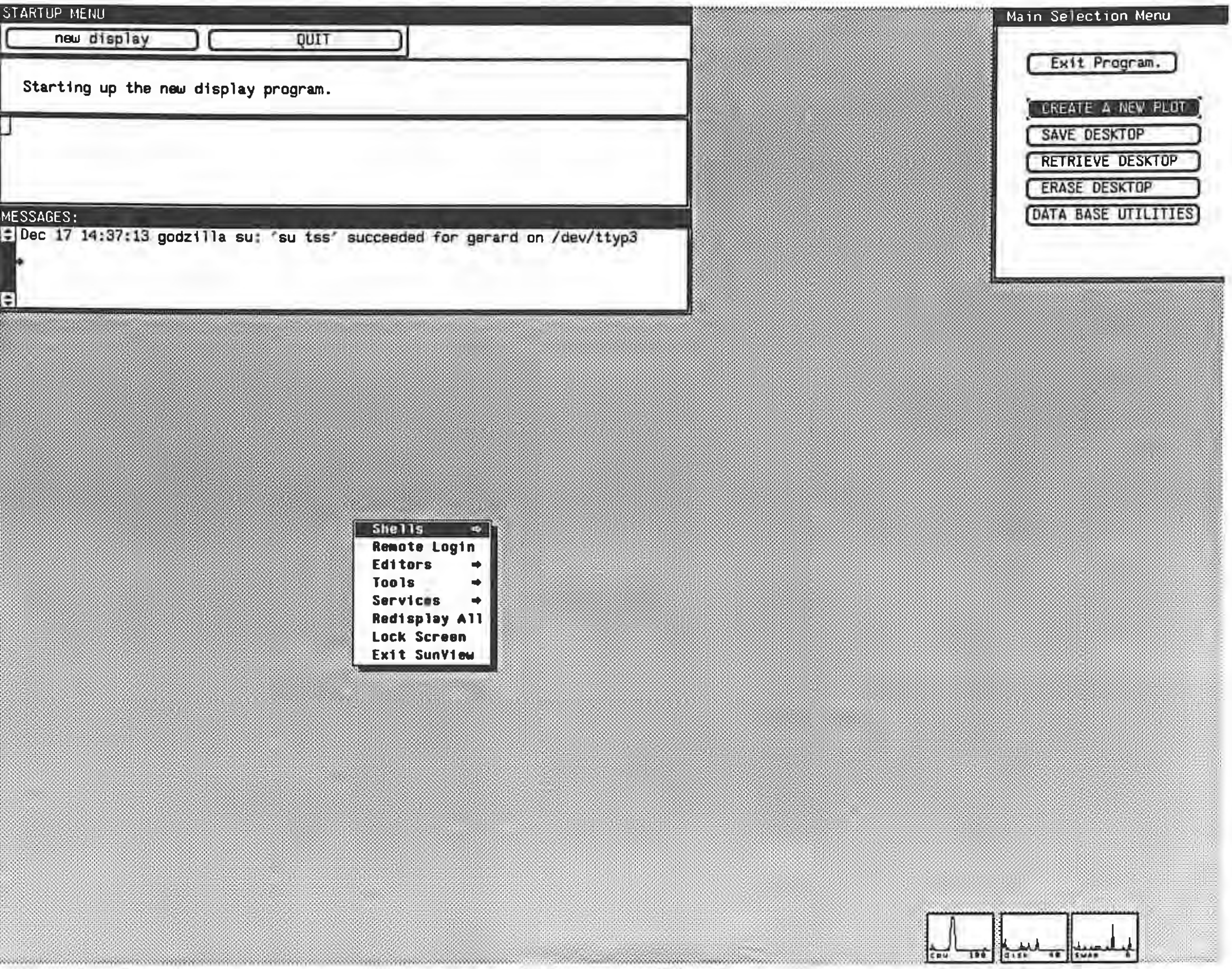

STARTUP MENU
new display
QUIT
Starting up the new display program.
MESSAGES:
Dec 17 14:37:13 godzilla su: 'su tss' succeeded for gerard on /dev/ttyp3
Main Selection Menu
Exit Program.
CREATE A NEW PLOT
SAVE DESKTOP
RETRIEVE DESKTOP
ERASE DESKTOP
DATA BASE UTILITIES
Shells
Remote Login
Editors
Tools
Services
Redisplay All
Lock Screen
Exit SunView

Figure 9-6

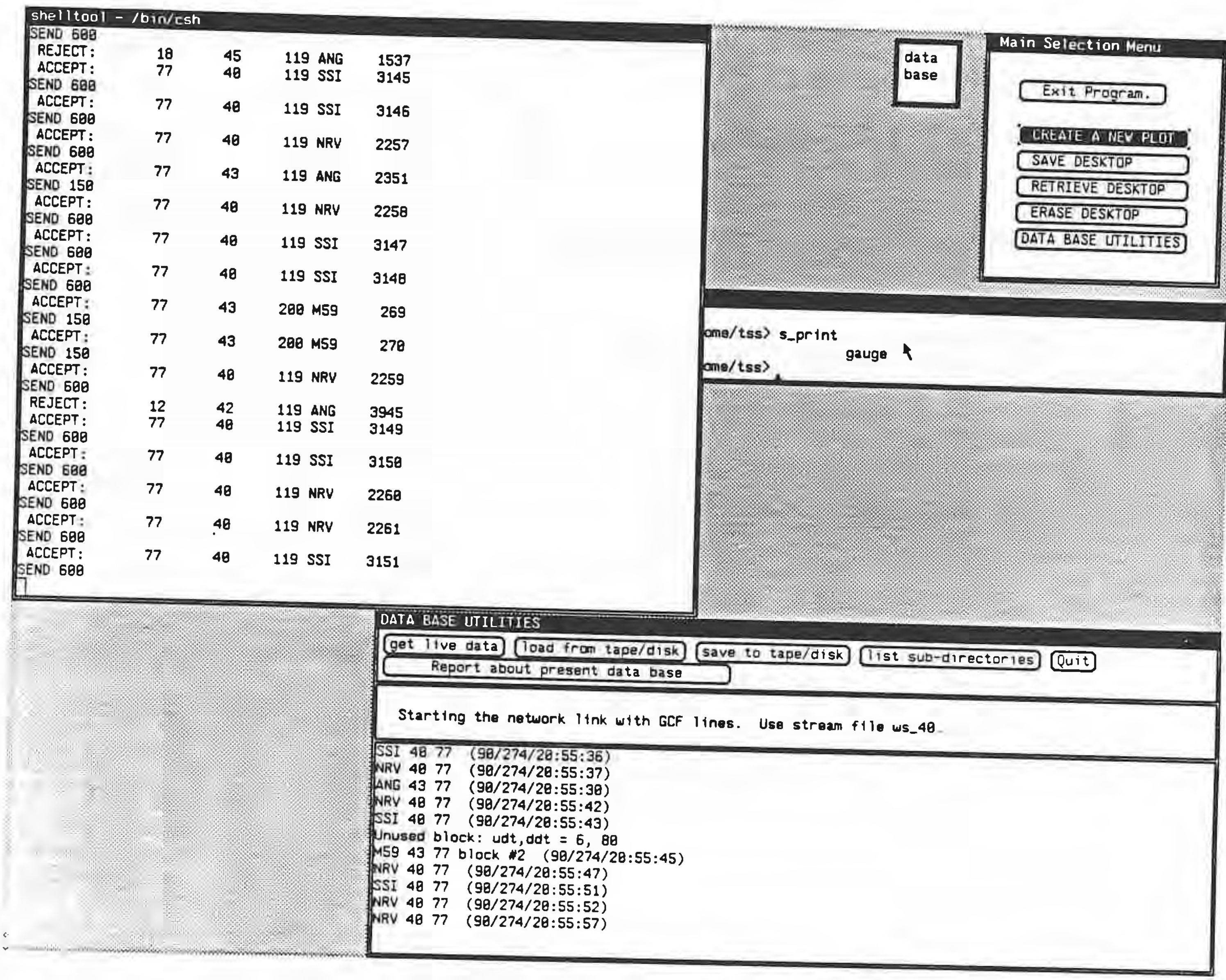

shelltool - /bin/csh
SEND 600
REJECT: 18 45 119 ANG 1537
ACCEPT: 77 40 119 SSI 3145
SEND 600
ACCEPT: 77 40 119 SSI 3146
SEND 600
ACCEPT: 77 40 119 NRV 2257
SEND 600
ACCEPT: 77 43 119 ANG 2351
SEND 150
ACCEPT: 77 40 119 NRV 2258
SEND 600
ACCEPT: 77 40 119 SSI 3147
SEND 600
ACCEPT: 77 40 119 SSI 3148
SEND 600
ACCEPT: 77 43 200 M59 269
SEND 150
ACCEPT: 77 43 200 M59 270
SEND 150
ACCEPT: 77 40 119 NRV 2259
SEND 600
REJECT: 12 42 119 ANG 3945
ACCEPT: 77 40 119 SSI 3149
SEND 600
ACCEPT: 77 40 119 SSI 3150
SEND 600
ACCEPT: 77 40 119 NRV 2260
SEND 600
ACCEPT: 77 40 119 NRV 2261
SEND 600
ACCEPT: 77 40 119 SSI 3151
SEND 600
data base
Main Selection Menu
Exit Program.
CREATE A NEW PLOT
SAVE DESKTOP
RETRIEVE DESKTOP
ERASE DESKTOP
DATA BASE UTILITIES
ome/tss> s_print
gauge
ome/tss>
DATA BASE UTILITIES
get live data
load from tape/disk
save to tape/disk
list sub-directories
Quit
Report about present data base
Starting the network link with GCF lines. Use stream file ws_40.
SSI 40 77 (90/274/20:55:36)
NRV 40 77 (90/274/20:55:37)
ANG 43 77 (90/274/20:55:38)
NRV 40 77 (90/274/20:55:42)
SSI 40 77 (90/274/20:55:43)
Unused block: udt,ddt = 6, 80
M59 43 77 block #2 (90/274/20:55:45)
NRV 40 77 (90/274/20:55:47)
SSI 40 77 (90/274/20:55:51)
NRV 40 77 (90/274/20:55:52)
NRV 40 77 (90/274/20:55:57)

Figure 9-7

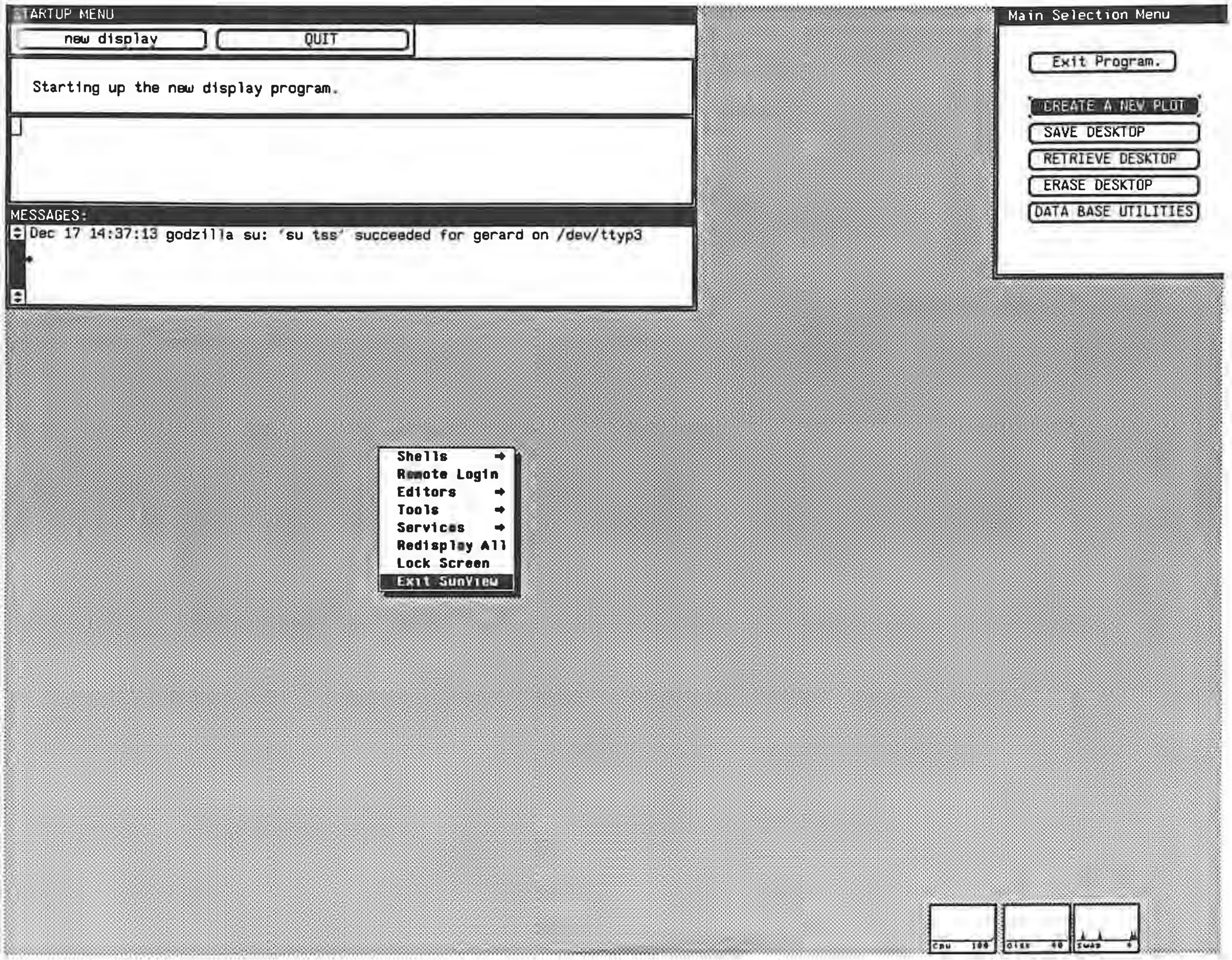

STARTUP MENU
new display
QUIT
Starting up the new display program.
MESSAGES:
Dec 17 14:37:13 godzilla su: 'su tss' succeeded for gerard on /dev/ttyp3
Main Selection Menu
Exit Program.
CREATE A NEW PLOT
SAVE DESKTOP
RETRIEVE DESKTOP
ERASE DESKTOP
DATA BASE UTILITIES
Shells
Remote Login
Editors
Tools
Services
Redisplay All
Lock Screen
Exit SunView

Figure 9-8

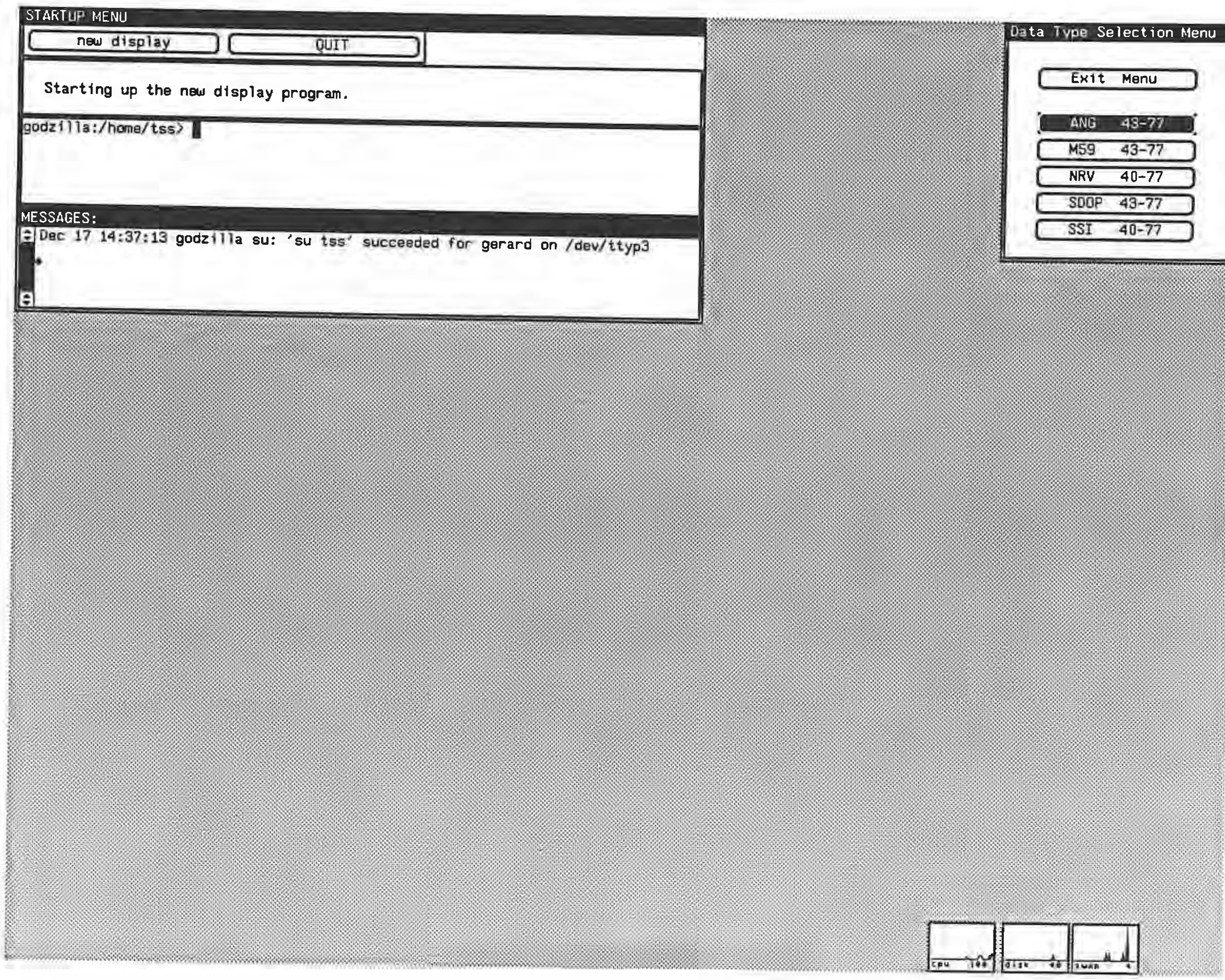

STARTUP MENU
new display
QUIT
Starting up the new display program.
godzilla:/home/tss>
MESSAGES:
Dec 17 14:37:13 godzilla su: 'su tss' succeeded for gerard on /dev/ttyp3
Data Type Selection Menu
Exit Menu
ANG 43-77
M59 43-77
NRV 40-77
SDOP 43-77
SSI 40-77

Figure 9-9

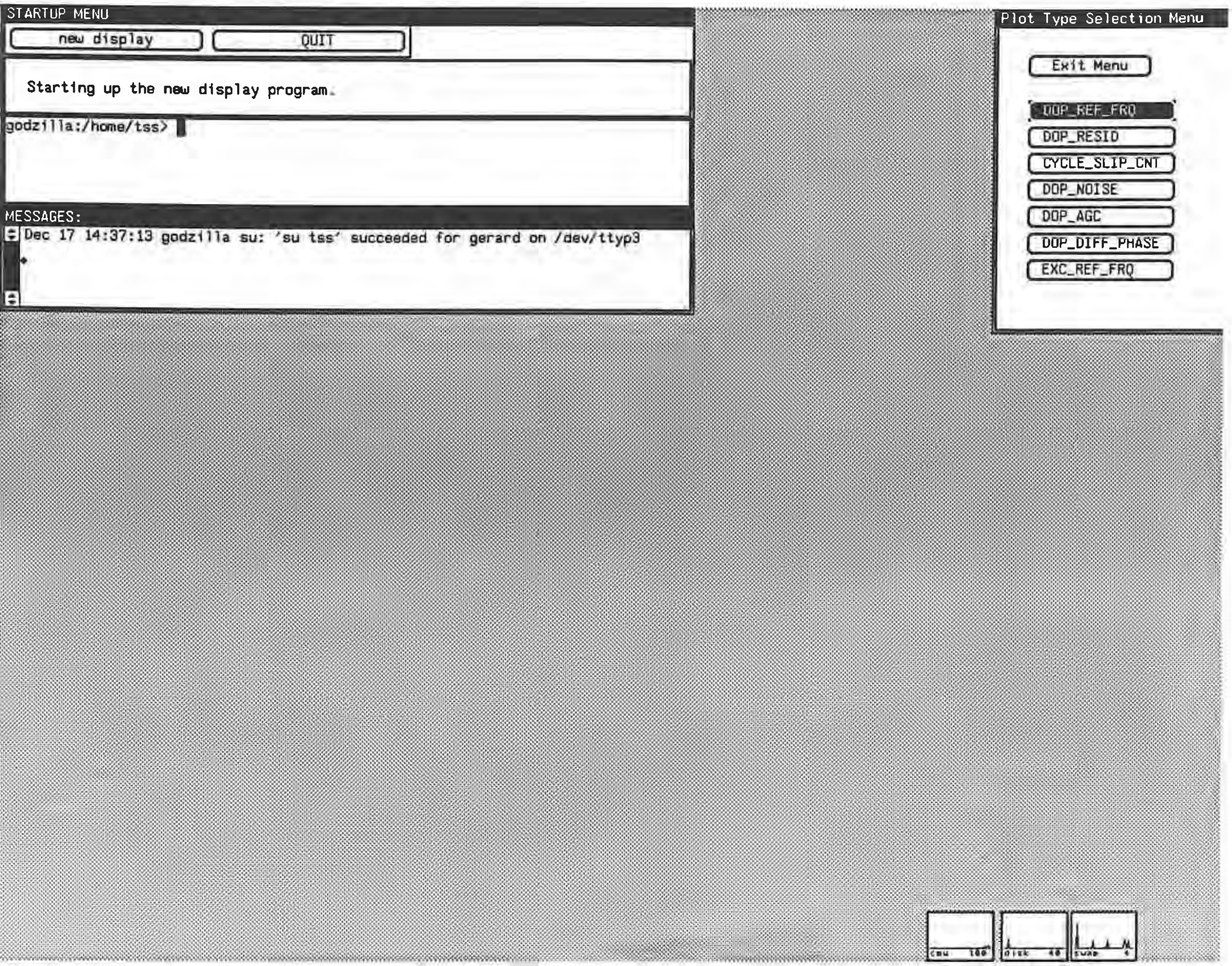

STARTUP MENU
new display
QUIT
Starting up the new display program.
godzilla:/home/tss>
MESSAGES:
Dec 17 14:37:13 godzilla su: 'su tss' succeeded for gerard on /dev/ttyp3
Plot Type Selection Menu
Exit Menu
DOP_REF_FRQ
DOP_RESID
CYCLE_SLIP_CNT
DOP_NOISE
DOP_AGC
DOP_DIFF_PHASE
EXC_REF_FRQ

Figure 9-10

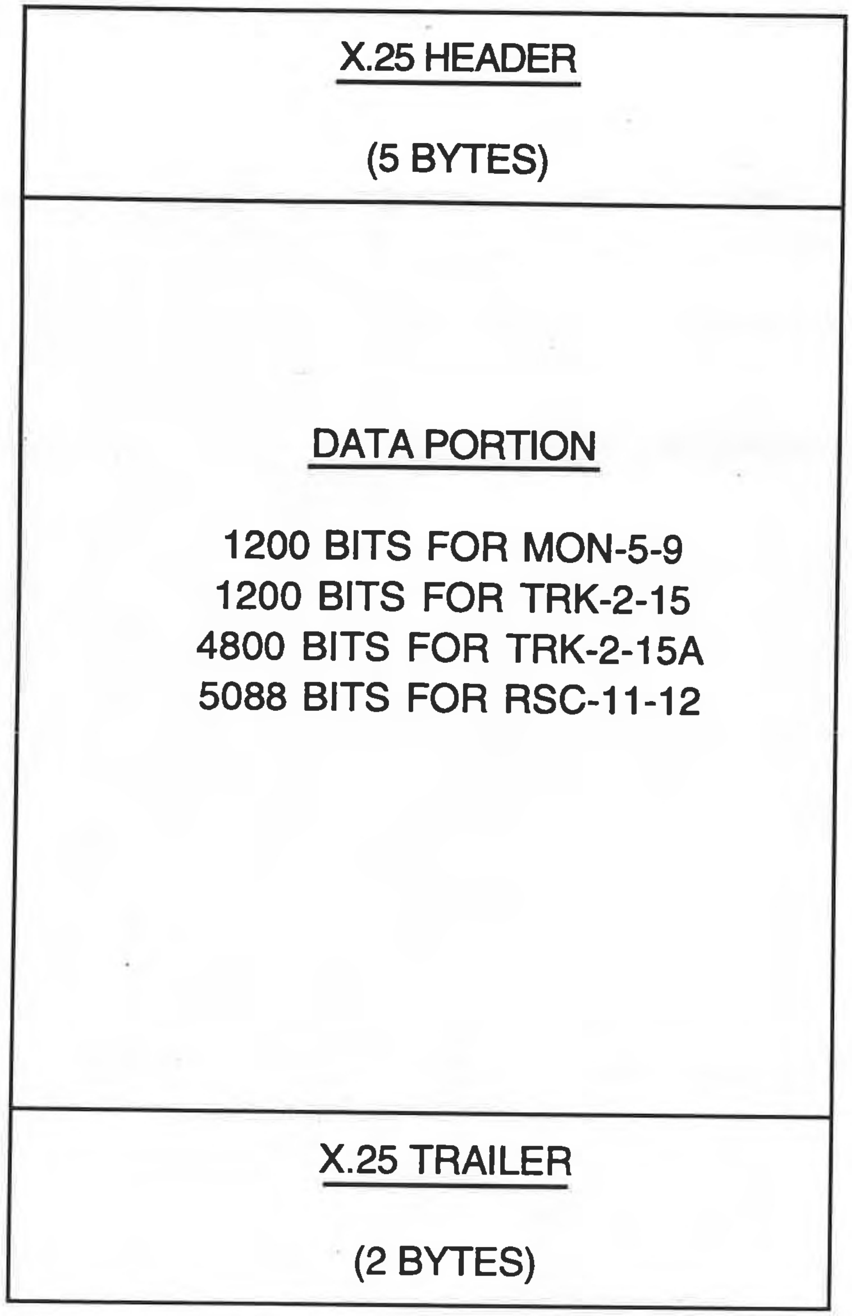


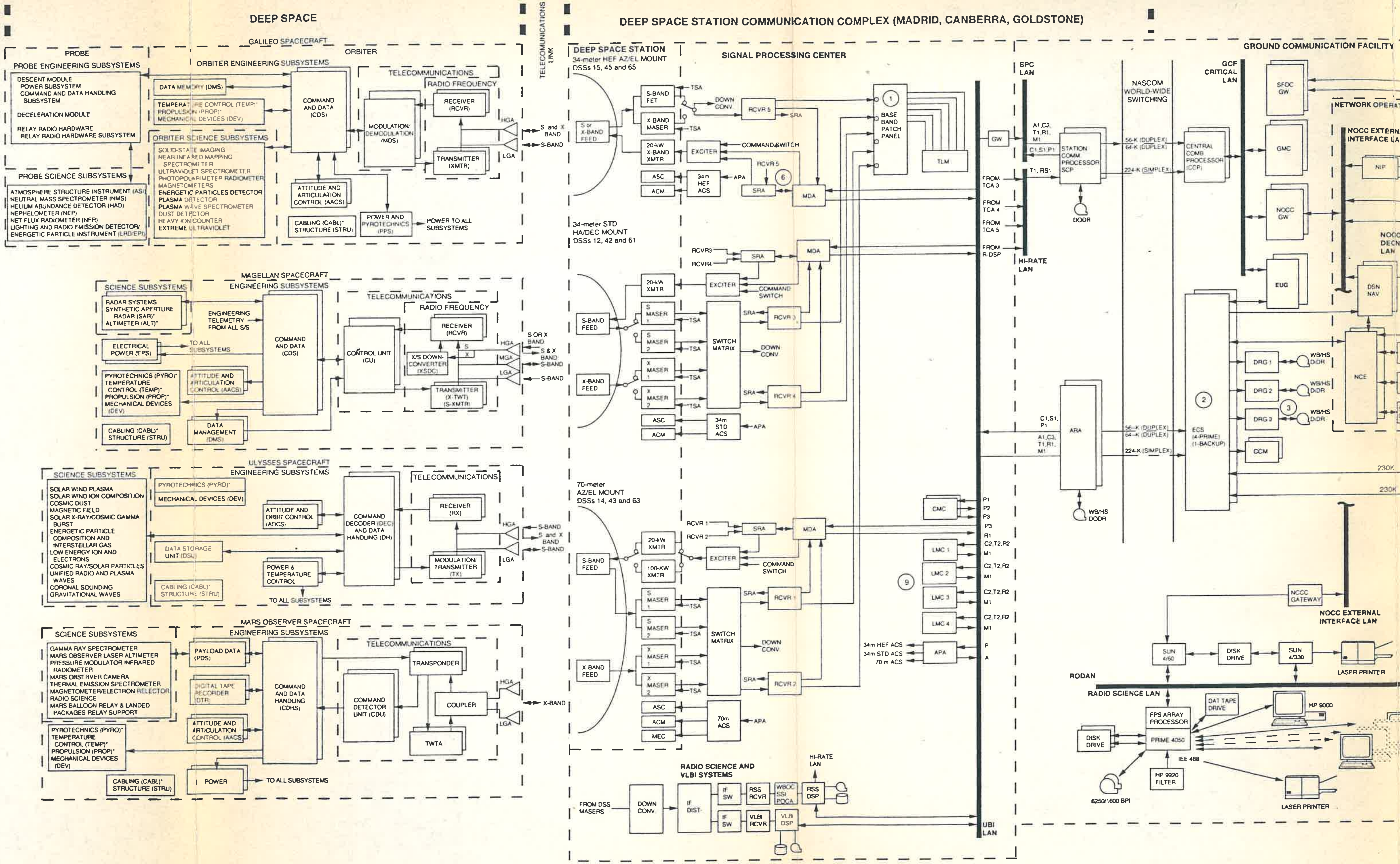
FIGURE 9-11

Data Encapsulation for X.25 Protocol

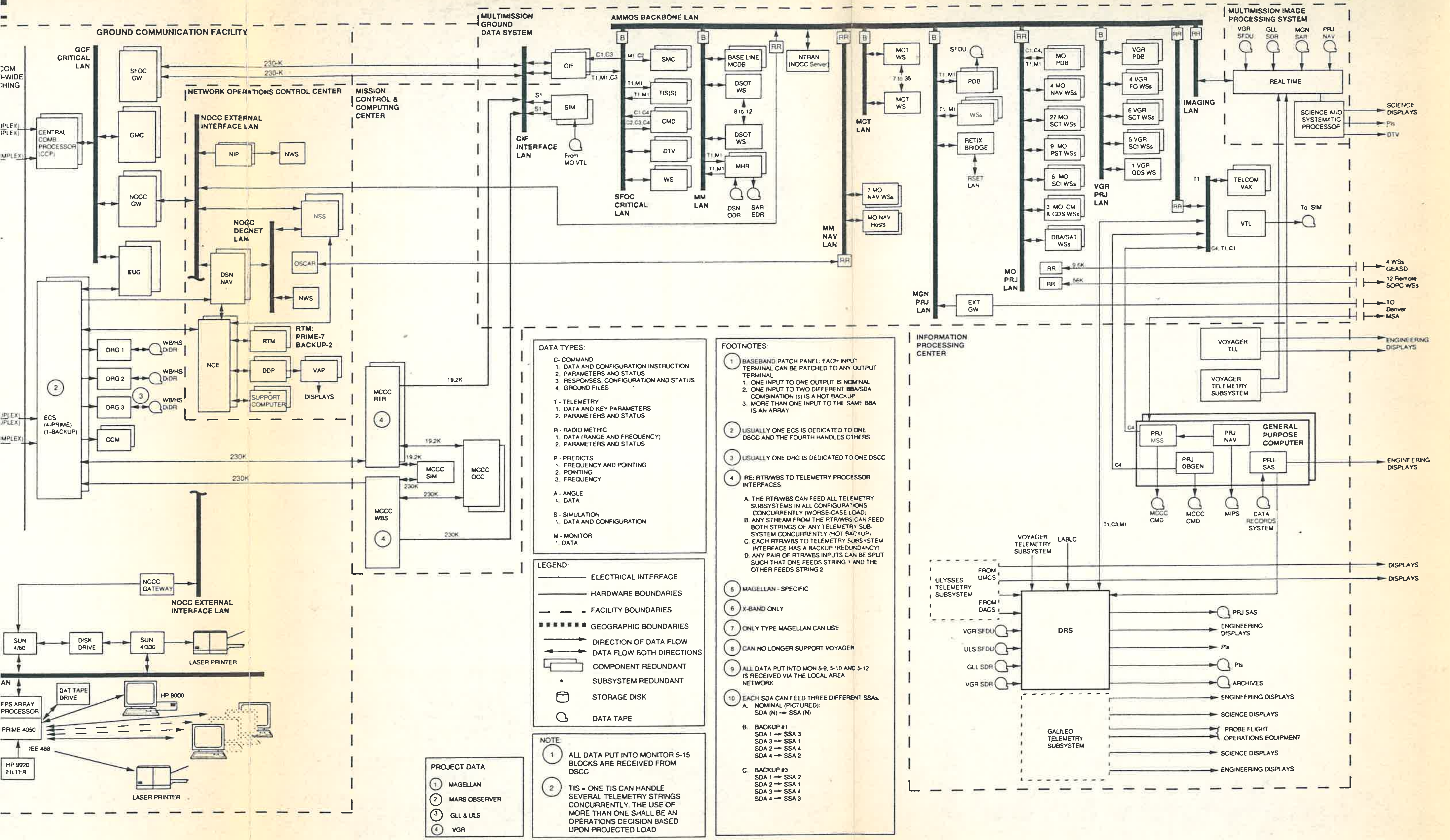
APPENDIX A

END-TO-END SYSTEM DIAGRAMS

MULTIMISSION END-TO-END INFORMATION SYSTEM DA



ND-TO-END INFORMATION SYSTEM DATA FLOW DIAGRAM (LEVEL II 8/20/92)



DATA TYPES:

C- COMMAND
1. DATA AND CONFIGURATION INSTRUCTION
2. PARAMETERS AND STATUS
3. RESPONSES, CONFIGURATION AND STATUS
4. GROUND FILES

T - TELEMETRY
1. DATA AND KEY PARAMETERS
2. PARAMETERS AND STATUS

R - RADIO METRIC
1. DATA (RANGE AND FREQUENCY)
2. PARAMETERS AND STATUS

P - PREDICTS
1. FREQUENCY AND POINTING
2. POINTING
3. FREQUENCY

A - ANGLE
1. DATA

S - SIMULATION
1. DATA AND CONFIGURATION

M - MONITOR
1. DATA

LEGEND:
- ELECTRICAL INTERFACE
- HARDWARE BOUNDARIES
- FACILITY BOUNDARIES
- GEOGRAPHIC BOUNDARIES
- DIRECTION OF DATA FLOW
- DATA FLOW BOTH DIRECTIONS
- COMPONENT REDUNDANT
- SUBSYSTEM REDUNDANT
- STORAGE DISK
- DATA TAPE

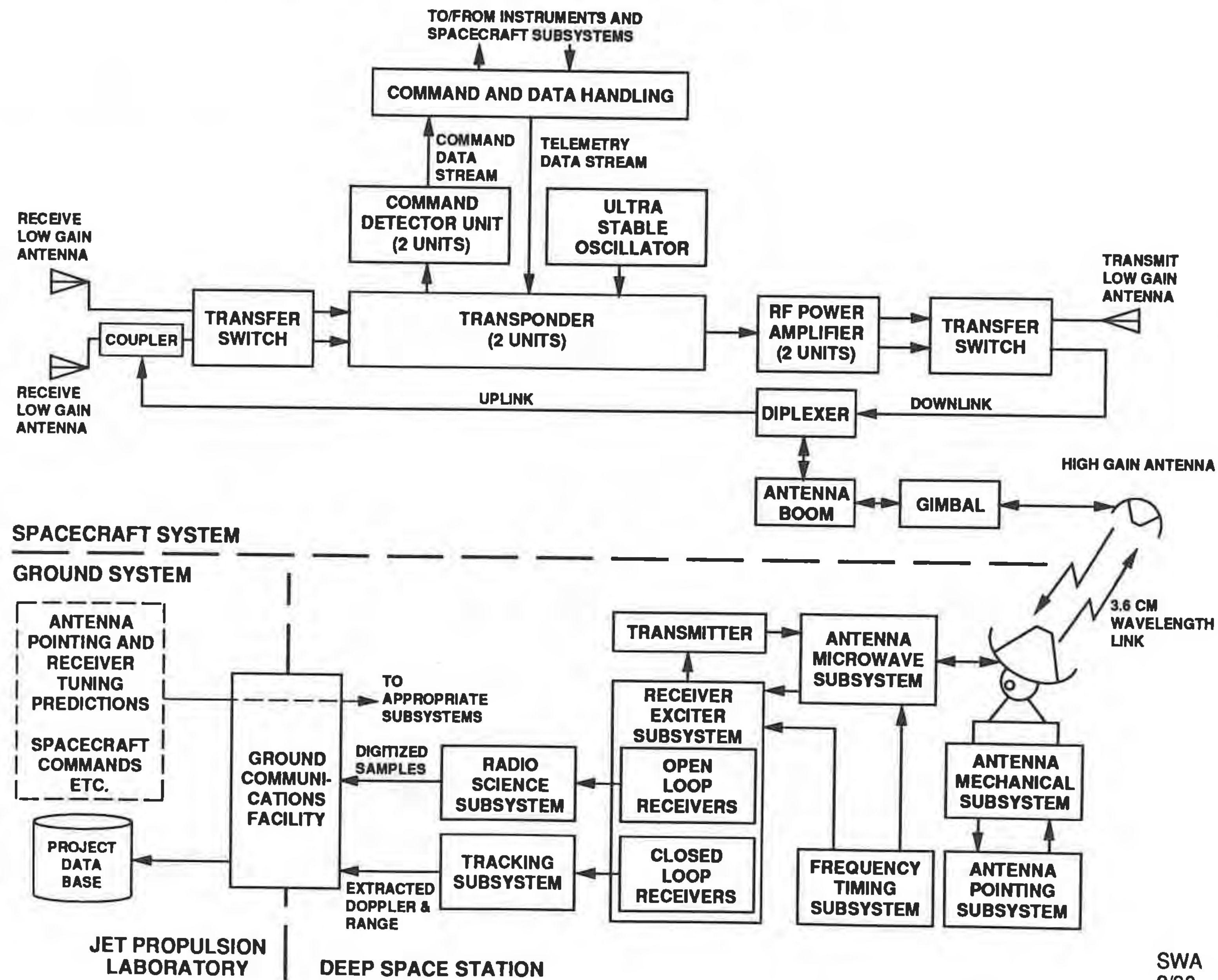
NOTE:
1. ALL DATA PUT INTO MONITOR 5-15 BLOCKS ARE RECEIVED FROM DSCC
2. TIS = ONE TIS CAN HANDLE SEVERAL TELEMETRY STRINGS CONCURRENTLY. THE USE OF MORE THAN ONE SHALL BE AN OPERATIONS DECISION BASED UPON PROJECTED LOAD

PROJECT DATA
1. MAGELLAN
2. MARS OBSERVER
3. GLL & ULS
4. VGR

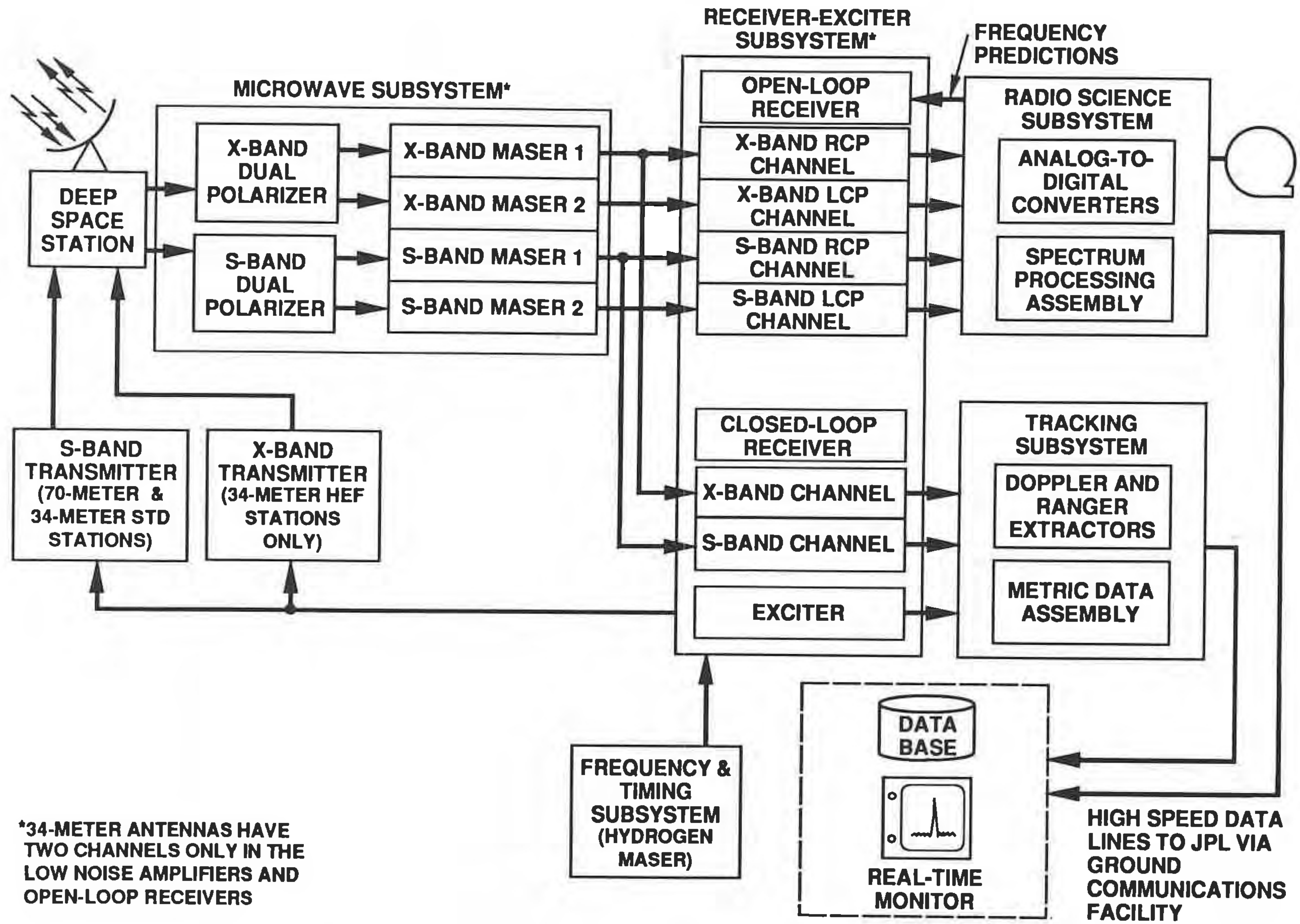
FOOTNOTES:

1. BASEBAND PATCH PANEL: EACH INPUT TERMINAL CAN BE PATCHED TO ANY OUTPUT TERMINAL
   1. ONE INPUT TO ONE OUTPUT IS NOMINAL
   2. ONE INPUT TO TWO DIFFERENT BBA/SDA COMBINATION (s) IS A HOT BACKUP
   3. MORE THAN ONE INPUT TO THE SAME BBA IS AN ARRAY
2. USUALLY ONE ECS IS DEDICATED TO ONE DSCC AND THE FOURTH HANDLES OTHERS
3. USUALLY ONE DRG IS DEDICATED TO ONE DSCC
4. RE: RTR/WBS TO TELEMETRY PROCESSOR INTERFACES
   A. THE RTR/WBS CAN FEED ALL TELEMETRY SUBSYSTEMS IN ALL CONFIGURATIONS CONCURRENTLY (WORSE-CASE LOAD)
   B. ANY STREAM FROM THE RTR/WBS CAN FEED BOTH STRINGS OF ANY TELEMETRY SUBSYSTEM CONCURRENTLY (HOT BACKUP)
   C. EACH RTR/WBS TO TELEMETRY SUBSYSTEM INTERFACE HAS A BACKUP (REDUNDANCY)
   D. ANY PAIR OF RTR/WBS INPUTS CAN BE SPLIT SUCH THAT ONE FEEDS STRING 1 AND THE OTHER FEEDS STRING 2
5. MAGELLAN - SPECIFIC
6. X-BAND ONLY
7. ONLY TYPE MAGELLAN CAN USE
8. CAN NO LONGER SUPPORT VOYAGER
9. ALL DATA PUT INTO MON 5-9, 5-10 AND 5-12 IS RECEIVED VIA THE LOCAL AREA NETWORK
10. EACH SDA CAN FEED THREE DIFFERENT SSAs.
    A. NOMINAL (PICTURED):
       SDA (N) → SSA (N)
    B. BACKUP #1
       SDA 1 → SSA 3
       SDA 3 → SSA 1
       SDA 2 → SSA 4
       SDA 4 → SSA 2
    C. BACKUP #3
       SDA 1 → SSA 2
       SDA 2 → SSA 1
       SDA 3 → SSA 4
       SDA 4 → SSA 3

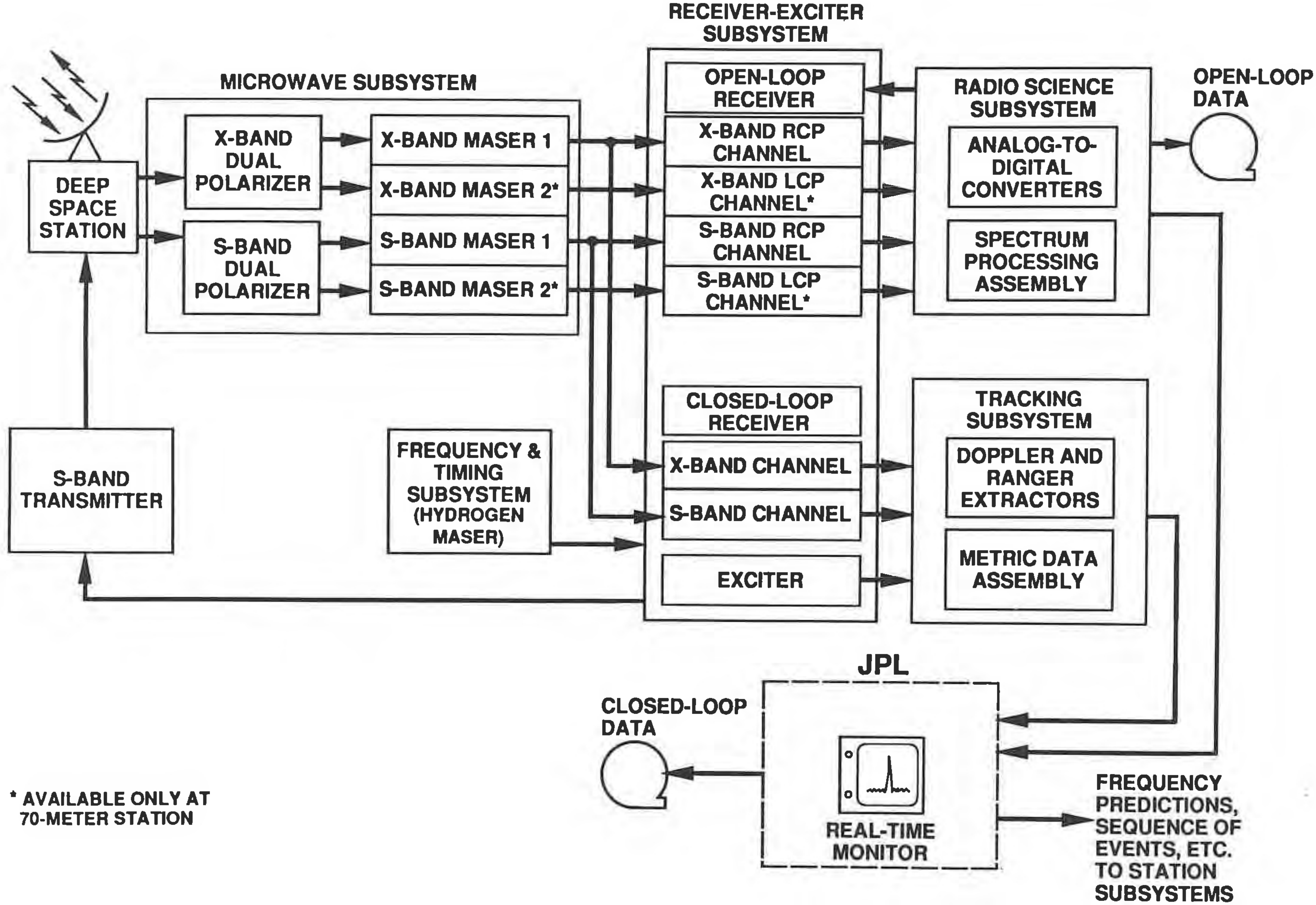
MARS OBSERVER RADIO SCIENCE INSTRUMENT
FUNCTIONAL BLOCK DIAGRAM



SWA
8/90



Galileo Radio Science Ground Data System Functional Block Diagram



Ulysses Radio Science Ground Data System Functional Block Diagram

APPENDIX B

USEFUL FORMULAE

B-1: Reconstruction of the antenna frequency from the recorded frequency using the open-loop receiver filters:

RIV RECEIVERS (70-m and 34-m HEF)

$$F_{antenna}^{S\text{-}band} = 3\left(F_{poca} + \frac{790}{11} \times 10^6\right) + 1950 \times 10^6 - F_{SampRate} - F_{Reco}$$

$$F_{antenna}^{S\text{-}band} = 11\left(F_{poca} - 10 \times 10^6\right) + 8050 \times 10^6 - 3F_{SampRate} + F_{reco}$$

MMR RECEIVERS (34-m STD / DSS 42 & 61)

$$F_{antenna}^{S\text{-}band} = 48F_{poca} + 300 \times 10^6 - \frac{3}{4}F_{SampRate} + F_{reco}$$

$$F_{antenna}^{X\text{-}band} = \frac{11}{3}\left(48F_{poca} + 300 \times 10^6 - \frac{3}{4}F_{SampRate}\right) + F_{reco}$$

B-2: Estimation of POCA frequency from the predicted S-band frequency and estimation of the S-band frequency from the predicted POCA frequency:

$$F_{poca} = \frac{F_{predicted}^{S\text{-}band} - FO}{3} - \frac{7940}{11} \times 10^6$$

$$F^{S\text{-}band} = 3F_{poca} + \frac{23820}{11} \times 10^6 + FO$$

B-3: Calculation of the signal position in the SSI:

RIV OUTPUT

$$F_{SSI}^{S\text{-}band} = 1950 \times 10^6 + 3\left(F_{poca} + \frac{790}{11} \times 10^6\right) - F_{received}^{S\text{-}band} + TBD$$

$$F_{SSI}^{X\text{-}band} = 8050 \times 10^6 + 11\left(F_{poca} - 10 \times 10^6\right) - F_{received}^{X\text{-}band} + TBD$$

ODAN OUTPUT

$$F_{SSI}^{S\text{-}band} = 1950 \times 10^6 + 3\left(F_{poca} + \frac{790}{11} \times 10^6\right) - F_{received}^{S\text{-}band} + TBD$$

$$F_{SSI}^{X\text{-}band} = 8050 \times 10^6 + 11\left(F_{poca} - 10 \times 10^6\right) - F_{received}^{X\text{-}band} + TBD$$

B-4: SSI update interval:

$$Update\ Interval\ (\mathrm{sec}) = \frac{XFORM \times NAVG}{5.12 \times BW}$$

where

XFORM = SSI transform size
NAVG = the number of averages
BW = SSI bandwidth (Hz)

B-5: Spacecraft downlink and uplink frequencies:

1) PREDICTED SPACECRAFT TRANSMITTED FREQUENCIES (S-BAND):

NONCOHERENT (Pre-launch estimate):

$$F_{USO} = 2294997701\ Hz$$

COHERENT:

$$F_{COH} = \frac{240}{221} \times FR$$

2) PREDICTED FREQUENCY DIFFERENCE BETWEEN COHERENT AND NONCOHERENT DOWNLINK (S-BAND) AT RECEIVING STATION

COHERENT TO NONCOHERENT:

$$\Delta F_{COH \rightarrow NCOH} = \left[F_{USO} - \frac{240}{221} \times FR\right]\left[1 - \frac{\dot{\rho}}{c}\right]$$

NONCOHERENT TO COHERENT:

$$\Delta F_{NCOH \rightarrow COH} = \left[\frac{240}{221} \times FR - F_{USO}\right]\left[1 - \frac{\dot{\rho}}{c}\right]$$

3) PREDICTED UPLINK FREQUENCY (at spacecraft)

$$FR = FT + Doppler$$

where:

FO = *Filter offset*

c = *speed of light* (2.9979×10^5 *km*/sec)

$\dot{\rho}$ = *range rate at station* (*km*/sec)

F_{USO} *is the predicted USO frequency*

$\Delta F_{COH-NCOH}$ = *Positive downlink frequency difference at S-band (can be used directly as DSP FRO)*

$\Delta F_{NCOH-COH}$ = *Negative downlink frequency difference at S-band (can be used directly as DSP FRO)*

FR = *Frequency of signal received by the spacecraft*

FT = *Frequency of signal transmitted to the spacecraft*

Doppler = *Doppler contribution between station and spacecraft*

NOTE: All frequencies are in Hz.

APPENDIX C

Abbreviations and Acronyms

A/D	Analog-to-Digital Converter
ACE	Galileo/Ulysses/MO Mission Controller
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control signal level
AMMOS	Advanced Multi-Mission Operations System
AOS	Acquisition Of Signal at a DSS
APA	Antenna Pointing Assembly
APC	Advanced Personal Computer (NEC Computer)
ARA	Area Routing Assembly
ARD	Antenna Reference Distribution
ASAP	Standard Radio Science Time Requirement
ATDF	Archival Tracking Data File (closed-loop data tape)
ATR	All The Rest
AUX OSC	Auxiliary oscillator in a spacecraft
BLK III	Closed-loop receiver (design phase III)
BLK IV	Closed-loop receiver (design phase IV)
BOA	Beginning of Activity
BOT	Beginning of Track
BPI	Bits Per Inch
BPF	Band Pass Filter
C/A	Closest Approach
CBM	Cured By Magic (see DR)
CCR	Closed Cycle Refrigerator (for the maser)
CCS	Computer Command Subsystem
CDU	Command Detector Unit
CEP	Critical Events Period
CMC	Complex Monitor and Control
COH	Coherent downlink
CONSCAN	Conical Scanning of a Radio source used to accurately point the Antenna
CPL	Command Procedure Language (for PRIME computer)
CRG	Coherent Reference Generator
CRS	CTA-21 Radio Science Subsystem
CRS	Celestial Reference Set (Spacecraft Trajectory Vectors)
CRSPOSTA	CRS ASCII Format
CUL	Clean Up Loop
D/A	Digital-to-Analog Converter
DAC	Digital-to-Analog Converter
DAS	Data Acquisition System
dBc	Decibel relative to carrier
dBc/Hz	dBc per Hertz, magnitude relative to carrier spectral density
DC	Direct Current (frequency equals zero)

DCO	Digitally Controlled Oscillator
DDP	Digital Display Processor
DL	Predicted one-way downlink frequency
DMC	DSCC Monitor and Control
DMD	Data Monitor and Display
DMT	Data Management Team
DOY	Day Of Year (UTC)
DR	Discrepency Report (see CBM)
DRA	Digital Recording Assembly
DRG	Data Records Generator
DRS	Radio Science Software Data Records Subsystem
DSCC	Deep Space Communications Complex
DSN	Deep Space Network
DSP	DSCC Spectrum Processor
DSS	Deep Space Station
DTK	DSCC Tracking Subsystem
DTR	Digital Tape Recorder (spacecraft)
DTV	Digitial TV monitoring display device
EOA	End of Activity
EOT	End of Track
ER	Experiment Representative
ERT	Earth Received Time
FDS	Flight Data System
FFT	Fast Fourier Transform
FPS	Floating Point Systems (maker of the Array Processor used by the RSST)
FRO	Frequency Offset
FTP	File Transfer Protocol
FTS	Frequency and Timing Subsystem
GC	Ulysses Ground Controller (Ulysses ACE)
GCF	Ground Communications Facility
GCR	Group Coded Recording
GDS	Ground Data System
GIF	GCF Interface Subsystem
GLL	Galileo Project
GNAV	Galileo Navigation Team
GPS	Global Positioning System
GSD	Great Science Data!
GUI	Graphic User Interface
GWE	Gravitational Wave Experiment (Ulysses)
HB	Radio Science HandBook
HGA	High-Gain Antenna (spacecraft)
IA	Interface Agreement
ICD	Interface Control Document
IDR	Intermediate Data Records tape (playback tape)

IF	Intermediate Frequency
IMOP	Integrated Mission Operations Profile (Galileo)
IMOP	What I do after I spill something.
IOM	InterOffice Memorandum
IPC	Information Processing Center (JPL computer facility)
IPS	Inches Per Second
ISOE	Integrated Sequence of Events
IVC	IF Selection Switch
JPL	Jet Propulsion Laboratory
L(f)	Single sideband phase noise spectral density as a function of offset frequency (f) from carrier
LAN	Local Area Network
LCP	Left-handed Circularly Polarized
LGA	Low Gain Antenna (Spacecraft)
LMC	Link Monitor and Control
LNA	Low Noise Amplifier
LO	Local Oscillator
LOS	Loss Of Signal at a DSS
LPF	Low Pass Filter
MCA	Master Clock Assembly
MCCC	Mission Control Computer Center
MCT	Mission Control Team
MDA	Metric Data Assembly
MGC	Manual Gain Control
MGDS	Multi-Mission Ground Data System (AMMOS)
MI	Modulation Index
MISD	Mission Director's Voice Net
MMR	Multi-Mission Receiver (at 34-m STD stations)
MO	Mars Observer
MO	Modus Operandi (the way we do things)
MONIDR	Monitor Intermediate Data Record
MOSO	Mission Operations Support Office
MOU	Memorandum of Understanding
MSA	Mission Support Area
MTS	MCCC Telemetry Subsystem
NAIF	Navigation and Ancillary Information Facillity
NAR	Noise Adding Radiometer
NATTRK	Network Analysis Team Tracking Analyst
NAV	Project Navigation Team
NB	Narrow-Band
NBOC	Narrow-Band Occultation Converter
NCOH	Non-Coherent downlink
NDC	Network Data Center

NDPA	Network Data Processing Area
NDPT	Network Data Processing Team
NDS	Network Display Subsystem
NIU	Network Interface Unit
NMP	Network Monitor Processor display system
NOA	Network Operations Analyst
NOCC	Network Operations Control Center
NOCG	Network Operations Control Group
NOCT	Network Operations Control Team
NOP	Network Operations Plan
NOPE	Network Operations Project Engineer
NOSG	Network Operations Scheduling Group
NRV	NOCC Radio Science/VLBI Display Subsystem
NRZ	Non-Return to Zero
NSP	NASA Support Plan
NSS	NOCC Support Subsystem
NTK	Network Tracking Display System
OCI	Operator Control Input
OD	Orbit Determination by the Project's Navigation Team
ODF	Orbit Data File
ODR	Original Data Record
OEA	Operations Engineering Analysis
OIA	Operational Interface Agreement
O/L	Open-Loop
OLR	Open-Loop Receiver
OOPS	Technical term used by RSST for errors in HB
OPCH	DSN Operations Chief
ORT	Operational Readiness Test
ORT	a morsel left over from a meal
OVT	Operational Verification Test
OWLT	One-Way Light Time
PAS	Radio Science Software Planning and Analysis Subsystem
PBNBIDR	Playback Narrow Band Intermediate Data Records
PC	Personal Computer
PDB	Project Data Base
PE	Phase Encoded
PIDR	Parkes Intermediate Data Record
PLL	Phase-Lock Loop
PLO	Programmed Local Oscillator
POCA	Programmable Oscillator Control Assembly
PPM	Precision Power Monitor
PRA	Planetary Ranging Assembly
RASM	Remote Access Sensing Mailbox
RAYPATH	DSN program used to generate light-time file modeling atmospheric effects and used as an

	input for the generation of predictions
RCP	Right-handed Circularly Polarized
RF	Radio Frequency
RFS	Radio Frequency Subsystem (spacecraft)
RIC	RIV Controller
RIV	Radio Science IF-VF Converter Assembly
RMDCT	Radio Metric Data Conditioning Team
RMS	Real-time Monitoring System (formally TSS)
RODAN	Radio Occultation Data Analysis Computer Facility
ROLS	Radio Occultation Limbtrack Systems
ROVER	Wide-band backup recording system (obsolete)
RSWG	Radio Science Working Group
RSS	Radio Science System
RSST	Radio Science Support Team (Not Galileo Remote Sensing Science Teams; SSI, NIMS PPR and UVS)
RSSS	Radio Science Support System (alias RODAN)
RST	Radio Science Team (Investigators and RSST)
RTDS	Real-Time Display System
RTLT	Round-Trip Light-Time
RTM	Real-Time Monitor (supplies data to NOCC graphics/display systems)
SCE	Solar Corona Experiment (Ulysses)
SCET	SpaceCraft Event Time
SCOE	System Cognizant Operations Engineer
SCT	SpaceCraft Team
SDT	Science Data Team
SEF	Sequence of Events File
SEG1	Sequence of Events Generation program (generates SFOS, ISOE and DSN keyword file)
SEL	Station Event List
SEP	Sun-Earth Probe Angle
SEQGEN	SEQuence of events GENeration program (generates SEFs)
SFOS	Space Flight Operations Schedule
SIRD	Support Instrumentation Requirements Documents
SIS	Software Interface Specification
SLE	Signal Level Estimator
SNR	Signal-to-Noise Ratio
SNT	System Noise Temperature
SOE	Sequence of Events
SOM	Software Operations Manual
SOP	Standard Operations Procedures
SPA	Spectrum Processor Assembly
SPC	Signal Processing Center
SPD	S-band Polarization Diversity (microwave subsystem)
SPE	Static Phase Error
SPR	System Performance Record

SPT	System Performance Test
SRA	Sequential Ranging Assembly
SRD	Science Requirements Document
SSA	Solid State Amplifier (spacecraft S-band downlink)
SSB	Single Sideband
SSI	Spectral Signal Indicator (not Solid-State Imaging!)
SSS	SSI Input Channel Selection (DSP OCI)
TBD	To Be Determined, since we don't know the answer
TBS	To Be Subjected to further scrutiny
TCG	Time Code Generator
TCM	Trajectory Correction Maneuver
TCT	Time Code Translator
TDS	Telemetry Delivery Subsystem
TIS	Telemetry Input Subsystem
TLC	Tracking Loop Capacitor
TMO	Time Offset (OCI)
TMU	Telemetry Modulation Unit
TOT	Telemetry Output Tool
TSS	Test Support System (now called RMS)
TWM	Traveling Wave Maser
TWNC	Two-Way Non-Coherent switch (spacecraft)
TWNC	Too Wishy-washy, Nebulous and Confusing
TWT	Traveling Wave Tube
TWTA	Traveling Wave Tube Amplifier (spacecraft)
TWX	Teletype message
TXR	DSS transmitter
ULS	Ulysses Project
UNAV	Ulysses Navigation Team
USO	Ultra-Stable Oscillator
UTC	Universal Time, Coordinated
VAP	Video Assembly Processor
VCO	Voltage Controlled Oscillator
VEEGA	Venus-Earth-Earth-Gravity-Assist
VF	Video Frequency
VTR	Video Tape Recorder
WOTU	Window on the Universe
XA	Doppler-compensated ground-transmitter DCO frequency for spacecraft receiver's best-lock frequency
XRO	X-band receiver only (microwave subsystem) determination experiment

APPENDIX D

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APPENDIX E

Medicina & Kashima And RASM File Transfer

E.1 Doppler Tracking from A VLBI Antenna

Simultaneous Doppler tracking of the same spacecraft from two widely separated stations on the ground can be profitably used in space experiments for the detection of low-frequency gravitational waves. The downlink signal received at the two stations has different and uncorrelated contributions from the local noise sources (troposphere, ionosphere and ground electronics), so that it is more difficult to mistake a noise spike for a gravitational wave signal.

Every VLBI station can in principle be used for precision Doppler tracking of a spacecraft, provided that additional instrumentation is available for the extraction of a side tone from the transmitted spacecraft carrier signal. This task is accomplished by a device called the Digital Tone Extractor (DTE).

E.2 The VLBI Station of Medicina and Kashima

The Medicina station is equipped with a 32-m el-az parabola, a cooled S-X band receiver (built for geodynamical observations), a H-maser frequency standard and a MARK III VLBI terminal. The spacecraft signal is preamplified and mixed with a signal of known frequency (LO1 = 8080 MHz for X-band), generated by the H-maser standard. After the IF amplification stage, a second mixage occurs with a second signal, generated again by the H-maser, whose frequency is programmable with a resolution of 10 kHz. At this stage, the spacecraft signal has been down-converted to the so-called video-band (0-2 MHz).

The video signal is sent to the MARK III terminal, which samples it at 4 MHz with 1-bit quantization. The data are clipped and formatted, together with timing information. The resulting stream of digital data can be sent to the digital tone extractor and to a VLBI recorder, for off-line analysis.

Kashima is a 26-meter VLBI station in Japan. It will be equiped with digital tone extractors provided by the Italian GWE team and will track (in listen-only mode) the Ulysses signal uplinked from Canberra.

E.3 The Digital Tone Extractor

The DTE is an instrument that can extract a tone of known frequency from a noisy signal, measuring its phase and amplitude. It is composed of a programmable digital oscillator, a coherent complex correlator, and a complex integrator. The input signal, coming from the MARK III formatter, is multiplied in phase and in quadrature with the local oscillator output and the resulting signal is integrated for a period ranging from 100 ms to 60 s.

This task is controlled by a Z80 microprocessor.

For each integration, the content of the two accumulator registers and start-stop times are sent to an HP1000 computer, which controls the DTE and the data acquisition. The computer extracts the signal phase at two times and then calculates the frequency offset of the input signal vs. the programmed frequency. The oscillator can then be reprogrammed in such a way to follow the input signal, so that the DTE and the computer that reprograms it act together as a high-precision Phase-Locked-Loop. In order to increase the SNR, the DTE bandwidth is kept as narrow as possible (<= 2 Hz). The signal is first searched in a relatively large frequency interval (100 Hz, typically) centered around the predicted frequency, using an algorithm controlled by the HP1000 computer. Once the signal is located and locked, the offset between predicted and observed frequency is computed and used to correct the frequency predictions. In order to closely follow the signal, the observed frequency is low-passed and compared with the predicted one after every integration cycle. If for some reason, the signal is lost, all previous steps are repeated. The signal is continuously monitored in the video-band by means of a spectrum analyzer.

The frequency predictions for the Madrid station are provided by JPL using the DPODP (Double Precicion Orbit Determination Program). They are converted to frequencies referenced to the location of the Medicina antenna (known with an accuracy of 0.9 cm), taking into account only the rotation of the baseline vector. The resulting expected frequencies at Medicina are fitted with a six-parameter function which is actually used to drive the DTE.

E.4 Predicts for Medicina

For the Bologna Station (Medicina) predicts will be downloaded onto a PC from the NSS computer reformatted and uploaded to the GPVAX computer and sent by way of SPAN to Italy. The RASM to GPVAX file transfer is described in Section 5.5.

E.5 JPL-Medicina Operational Agreement

Since the Medicina VLBI Tracking station is not part of the DSN where tracking predict information are routinely transmitted to each station, this section (originally a memorandum of understanding) describes products and media to be delivered to Medicina. These products are still generated by the DSN and will be transferred as soon as they become available

The following products will sent to Medicina by the RSST via E-mail or FAX prior to tracking periods.

1. Receiver predicts generated for one of the Madrid Stations.

Medicina will bias them.

2. MDA Text predicts generated for one of the Madrid Stations. The text predicts must contain 20 data points which span most of the pass.

3. Planetary pointing predicts which span 3 days of data and 3 points per day if possible.

4. Edited SOE if time permits, otherwise just send the entire SOE file.

5. All products delivered approximately 1 week prior to support but no later than 1 day before.

6. STATRAJ file available at JPL during high support periods.

The following should be noted: where indicated (S-band) is representative of S-band sky frequency; "TFREQ" means the S/C frequency downlink with no doppler; "XMTREF" means the S/C receiver best lock frequency with no doppler.

E.6 Medicina Pre-Pass Preparations

Prior to a track the following operations must be completed. The times given are relative to the BOT, and represent the last time at which these operations can be started.

E.6.1 -6 HOURS: PREPARATION OF PX FILE

The predictions for Madrid are edited and written in a uniform format on a file named PX_ddd_ss_b_m; ddd is the day-of-year number for the passage (3 digits), ss is the S/C identification number (2 digits), b is the band (S or X), and m is the mode (1 for one-way, 0 for 2 or 3 way). The file is to be stored on directory /COMORETTO/DTE/DAT.

E.6.2 -4 HOURS: PREPARATION OF POINTING FILE

Extract the satellite pointing information from the Madrid predict data. Interpolate them to have a point every 3 hours, and write them in the format hhmmss.sss +/-ddmmss.sss. These data will not be read directly by the pointing software, but have to be entered manually every 3 hours.

E.6.3 -4 HOURS: PREPARATION OF PARM FILE

The prediction data in the PX file are used to compute the predict parameter file for Medicina, for the S or X band as appropriate. This is done running the program PREDIZ5 from the directory /COMORETTO/DTE. The program must be run twice, one time to produce the parameter file for the S-band, and a second time for the X-band. The program optionally produces a printout of the frequencies computed using the 6-parameter fit. These frequencies must be checked against those specified in the PX file, and translated to Medicina, for possible fit errors.

E.6.4 -1:30 HOURS: PREPARATION OF THE ANTENNA

Check the following:

A. If the HP-1000 computer is not turned on, bootstrap it and log the following sessions: FIELD.OPER on the MARKIII Field System terminal (LU 64), USER.OPER on other two terminals. One terminal will be used to run the program TRACK, the other to run the monitor program PRINTNOW.

B. Check connections of the DTE cables. If cables are correctly connected, the "DAT VALID" LED's on the DTE's must be on.

C. Check antenna functionality.

D. Check GO-1000 synchronization against the maser clock.

E. Check disk space available on the HP-1000. A dual frequency track requires at least 6Mbytes of disk space.

F. Check connections of the FFT spectrum analyzer.

G. Plug the calibrated cable into the VLBI calibration ground unit, and record the variation in the CABLE measurement (with sign). Remove the calibrated cable.

H. Switch off and on the VLBI tone cal, and check whether a signal is visible on the FFT spectrum analyzer.

I. Select a proper 2nd LO frequency for each band (S and X), and program them using the MARKIII Field System terminal.

J. Check total power level on the MARKIII receiver, and adjust IF attenuators accordingly.

K. Check that both the small printer (LU 32) and the large printer (LU 6) are powered and on-line.

L. Perform a test integration with each DTE on the VLBI calibration tone.

Appendix E

RASM FILE TRANSFER

The Remote Access Schedule Mailbox (RASM) provides an interface to the Network Support System (NSS) for schedule information to remote users that do not have normal access.

For Radio Science, RASM will provide a means of file transfer from the NSS to the General Purpose VAX (GPVAX) minicomputer. From the GPVAX we can mail the predicts and other information directly to Bologna. The file transfer will be initiated using a Macintosh SE/30 computer which will interface with both systems. It should be noted that because The NSS/RASM VAX has such an extensive security system; VAX-TO-VAX transfer from NSS to GPVAX is not possible which is the reason for using RASM with the Macintosh.

Below are the steps involved with file transfer from RASM -Macintosh-GPVAX:

A. A member of the RSST must notify the Ulysses NOPE when predicts and other Tracking information are needed. ***Our products are not placed on the system automatically. The NOPE must be informed of our needs for predicts and other information for Bologna several days in advance.***

B. Log onto RASM from the Macintosh computer and select the files to be transfered. After completing this, Log Off RASM.

C. Edit and Reformat file (s) on the Macintosh for uploading to the GPVAX.

D. Log onto the GPVAX and prepare the system to receive file (s) from the MAC.

E. Verify that the file (s) have reached the GPVAX followed by mailing them using SPAN.

F. Log Off the GPVAX.

Each phase of this procedure is clearly expressed in the texts that follows. At the end of each section is a summary regarding important areas to recall while following these procedures.

Notifying Ulysses NOPE of Desired Products to be loaded on RASM

The first step in the file transfer procedure is to notify the Ulysses NOPE which predicts are needed and for which station, when the predicts are needed, and the time span they should be generated. To best follow up this request is to provide the NOPE with a table or list indicating exactly the products desired. A member of the RS team should prepare a Table of start and stop times , Stations, and Passes needed for the RS sampling period. (See Table R-1 below as an example) Once this is accomplished, the NOPE will place the requested products on RASM

NOTE: Bologna should receive MDA Text predicts from each DSS due to possible periods where over lapping view periods may occur and additional recording time may be taken as a result.

TABLE R-1
SUMMARY OF THIS SECTION

DOW	DATE	DOY	DSS	BOA	BOT	EOT	EOA	CODE	RS PASS	RSST SUPPORT
FRI	DEC. 07	341	12	2:55	4:25	11:30	11:45	408G		
	DEC. 07	341	42	9:30	11:00	19:15	19:30	408G		
	DEC. 07	341	61	17:30	18:45	3:30	3:45	408G		
SAT.	DEC. 08	342	12	0:25	3:00	11:45	12:00	408G		
	DEC. 08	342	42	8:15	11:15	6:20	6:35	408G		
	DEC. 08	342	61	15:20	18:20	20:30	20:45	408G		
	DEC. 08	342	12	19:00	20:40	21:25	21:40	408G		
SUN.	DEC. 09	343	61	5:10	6:40	12:55	13:10	408G		
	DEC. 09	343	12	12:00	13:30	20:30	20:45	408G		
	DEC. 09	343	42	18:30	20:00	6:10	6:40	408G		

SUMMARY OF THIS SECTION

1. A hard copy of the products is always the best way to indicate specifically what is requested.
2. This process initiates the production and placement of the predicts to RASM.
3 Bologna should receive MDA Text from each DSS.

RASM LOG ON PROCEDURE AND FILE (S) CAPTURE

The communication software package for the Macintosh SE/30 is "Microphone II". It provides computer-to-computer interface for both RASM and GPVAX. Both systems have common communication settings with one exception: RASM can use either 1200 or 2400 Baud rates. All other communication settings are common such as; 8 bits per character, one stop bit, no parity.

The Following explains access procedures to RASM:

1. To initiate access to RASM locate the little apple on the top line of the Mac display, upper left hand corner of the display. Click on it and drag the arrow down using the mouse to the word " CHOOSER " which appears within the window. SEE A COPY OF THE CHOOSER DISPLAY IN THE SUMMARY SECTION.

2. Four rectangles within the window " CHOOSER " will appear. The top left corner window displays four icons with a controlling scroll bar attached to the right. Manipulate the arrow using the mouse to the bottom of the window. Observe the icon that looks like an alien animal and says "NetSerial". (It will be located in the lower right hand corner of that window). Click On it and continue.

NetSerial™

3. Observe the right top window which was previously blank and now displays "Select a NetSerial"on top of the rectangle. Look inside the window for **"339 Modem 9600 line"**. To select this line which is the hard line for the moden communication, click on it. Now, close the window by clicking on the little rectangle in the upper left hand corner of the CHOOSER window.

   The above action has configured the hardline mode of communication to RASM. The Mac has shored all settings and protocols for communication.

4. On the hard disk display look for the large icon labeled RASM. Double click on it and the software will load Microphone II. Then type **ATDT48400** to invoke computer response from RASM, and standby for instructions given below:

RASM

HELLO, PLEASE ENTER USER NAME: **2ULYS**
PASSWORD: **xxxx.xx**
Then RASM will say "YOU WILL BE CALLED BACK, GOOD BYE"
The RASM security system, checks your first Password and ID then calls you back for a second ID which is the same, but askes for a different Password. See the following RASM response:

HOST ACCESS PERMITTED
Username: **2ULYS**
Password different than the first **yyyyyy.**
Then the opening response will be:

```
*******************************************************************************
*       You are connected to a U.S. Government computer system               *
*       Any unauthorized ATTEMPT to gain access to this system,              *
*       and/or its programs or data, may subject you to a fine               *
*       and/or imprisonment.                                                 *
*******************************************************************************
```

* Welcome to the Remote Access Scheduling Mailbox (RASM) Version 1.1.
It is Wednesday, 14-NOV-1990 at 16:46 UTC. Enter a question mark (?) at any time for help.
Remote Access Schedule Mailbox Version 1.1

RASM is totally a menu driven system,so just select the available options provided by the system. Please see an example of a session below:

Main Menu
(1) **Transfer Files**
(2) Invoke Mail
(3) System Utilities
(4) Exit
* Choose [4]: **1**

Remote Access Schedule Mailbox Version 1.1
Transfer Files

(1) Transfer To RASM
(2) **Transfer From RASM**
(3) Select Kermit or XModem
(4) Exit
* Choose [4]: **3**

Remot Access Schedule Mailbox Version 1.1
Select Kermit or XModem
(1) **Select Kermit**
(2) Select XModem
(3) Exit
* Choose [3]: **1**
Select Kermit as the default protocol TO RASM, FROM RASM, or Both T[0]/F{rom]/B[oth] []: B

Kermit is now the default protocol for transfers to RASM.
Kermit is now the default protocol for transfers from RASM.
Remote Access Schedule Mailbox Version 1.1
Select Kermit or XModem
(1) Select Kermit
(2) Select XModem
(3) **Exit**
* Choose [3]: **3**

Continued File Transfer Procedure

Remote Access Schedule Mailbox Version 1.1
Transfer Files
(1) Transfer To RASM
(2) **Transfer From RASM**
(3) Select Kermit or XModem
(4) Exit
* Choose [4] : **2**

Remote Access Schedule Mailbox Version 1.1
Transfer Files From RASM
(1) TPAP Text Predicts
(2) **Tracking and R/S Predicts**
(3) View Periods
(4) 7-Day Schedule
(5) 7-Day Forcast
(6) 7-Day Strawman
(7) Administration Message
(8) Ohter Text File
(9) Exit
* Choose [9]: **2**

Directory USER: [RASMDBS.PDX]

055120026.VUX;1	055120089.DSP;1	055120089.RCV;1	055120089.REC;1
055120090.DSP;1	055120090.RCV;1	055120090.REC;1	055140026.VUX;1
055140088.DSP;1	055140088.RCV;1	055140088.REC;1	055140090.DSP;1
055140090.RCV;1	055140090.REC;1	055150052.VUX;1	055305363.PLN;1
055349031.PLN;1	055420027.VUX;1	055420052.DSP;2	055420052.DSP;1
055420089.DSP;1	055420089.RCV;1	055420089.REC;1	055420090.DSP;1
055420090.RCV;1	055420090.REC;1	055430027.VUX;1	055430091.DSP;1
055430091.RCV;1	055430091.REC;1	055450027.VUX;1	055610026.VUX;1
055610039.EXC;1	055610039.PX6;1	055610039.RCV;1	055610039.REC;1
055610039.RMT;1	055610039.RSC;1	055610039.TPA;2	055610064.DSP;1
055610064.RCV;1	055610067.DSP;1	055610067.RCV;1	055610068.DSP;1
055610068.RCV;1	055610069.DSP;1	055610069.RCV;1	055610088.DSP;1
055610088.RCV;1	055610088.REC;1	055610089.DSP;1	055610089.RCV;1
055610089.REC;2	055610089.REC;1	055610091.DSP;1	055610091.RCV;1
055610091.REC;1	055630026.VUX;1	055630074.DSP;2	055630074.DSP;1
055630074.RCV;1	055630090.DSP;1	055630090.RCV;1	055630090.REC;1
055650026.VUX;1	MDATEST.TXT;1	VODTM_LIST.TPA;1	

Total of 67 files
Select a file to transfer: **055610039.RSC;1**

Do you wish to transfer, or examine, USER: [RASMDBS.PDX] **055610039.RSC;1**
* T[ransfer]/**E[xamine]**, or <cr> to reject []: **E** **(READ ON BEFORE SELECTING THE E OPTION)**

Continued File Transfer Procedure

Wait Wait !! Before selecting the E option , go to the word **File** on top line of the Mac display and drag down to **Open New Capture File (See example in summary)**. Open it by clicking on the words and in the rectangle provided there make up a file name for all the file (s) to be captured during your session. After a nameis entered, just press "return" on the keyboard. Now, you 've created a capture file which will be saved after you exit the RASM system.

NOTE 1: There is no need to close this file between looking through files on the system and pulling them off. The reason for leaving the file open is that the entire file may be lost as a result of a premature close. Just leave it alone throughout the session.

Once a name has been given to the file ,select "E" for examine and that file will be displayed on the screen as well as become a captured file within the Mac under the name given.

NOTE 2: EXPLANATION OF THE PREDICTS FILES ABOVE;
EXC represents Exciter predicts. **RMT** are MDA binaries. **PX6** are APA binary predicts. **RSC** are Radio Science Text. **RCV** are the MDA Text (DCO). **TPA** are telecom Link, AGC, and SNR parameters. **REC** are the Sky Frequencies (Receiver). **PLN** are the planetary predicts (RA DEC.) VUX are particular station view periods. **DSP** are theOpen-Loop predicts radio science predicts. The interface says that Bologna will need: RCV (MDA), DSP (OPEN-LOOP), PLN planetaries. The RST member should send only PLN, RCV, and DSP. All other products are mainly for operational planning.

Exit RASM

After all the files are copied on the Mac, exit RASM by the option **EXIT** for each menu set that appears. When asked if you are sure; state **Yes** and RASM will place you off the system.

Summary of the File Transfer Section

1. RASM is totally a menu driven system so, just select the available options provided by the system.

2. Top line display changes for each application but follow the instructions and it should be simple

3. When ready to Capture files from RASM make sure that a file has been named.

4. While Capturing files off RASM recall **NOTE 1.**

5. Not all of the Predicts should be sent to Bologna.

6. The USERNAME **"2ULYS"** never changes The first PASSWORD never changes. However; the second PASSWORD must be updated every 90 days.

Continued Summary of the File Transfer Section

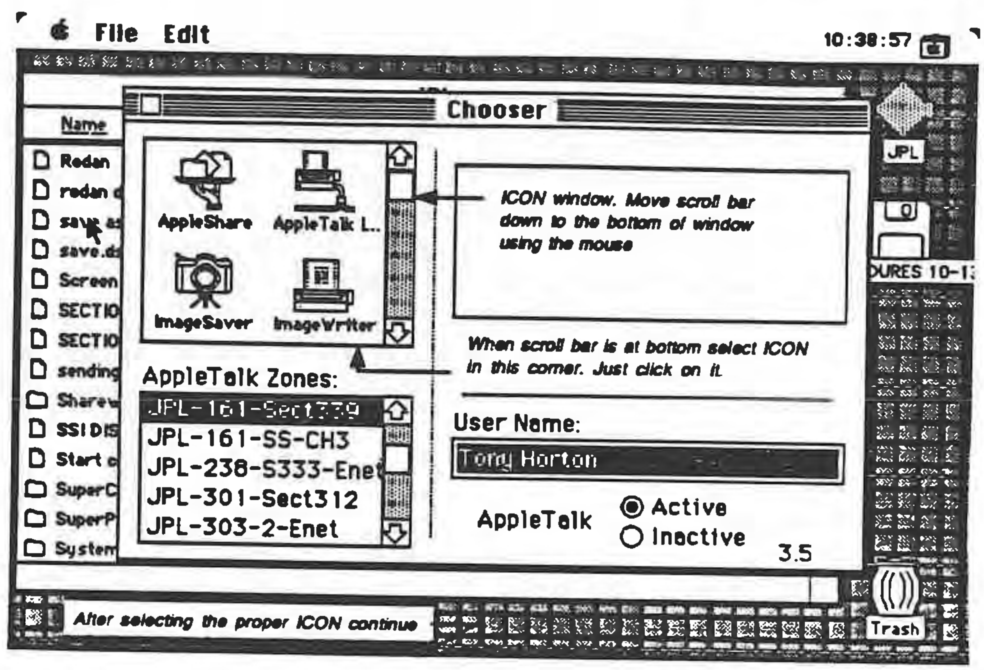
HOW TO GET THE CHOOSER WINDOW

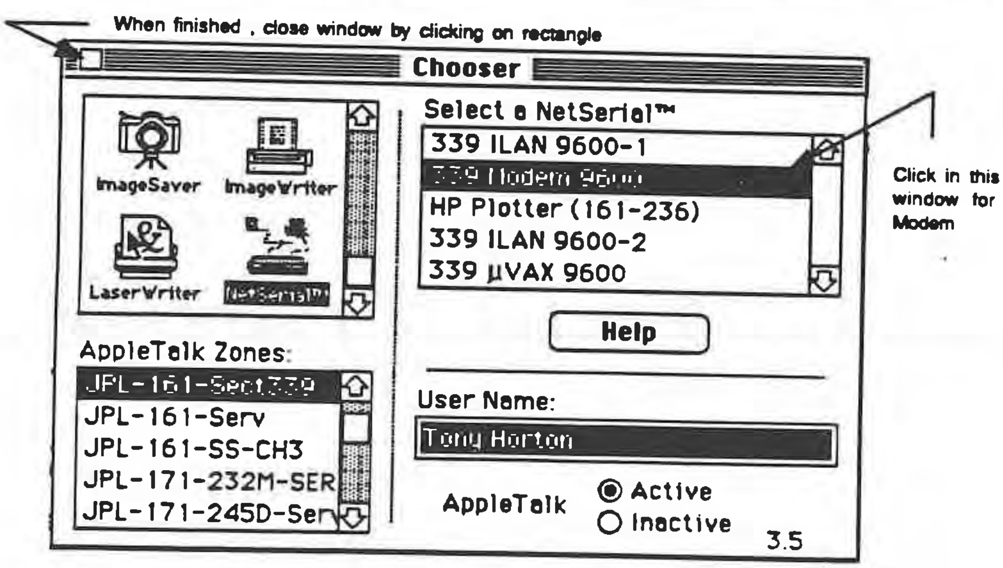
Look for the little apple icon in upper left hand corner of the hard disk display. Click on the apple, and drag down to the word Chooser and click again.The following window will open:

Example of Little Apple Window and Top line Display:

File Edit View Special 5:56:53

ACCESS PRIVILEGES
ALARM CLOCK
CALCULATION
CHOOSER ---------------->
CONTROL PANEL
CONVERT
CONTROL PANEL
CONVERT
dcad CALCULATOR
DEVELOPERS TOOLS
FIND FILE
KEY CAPS
SCRAPBOOK
SMART ALARMS
WORD FINDER
End Window





Continued Summary of the File Transfer Section

Example of the Open Capture File Window

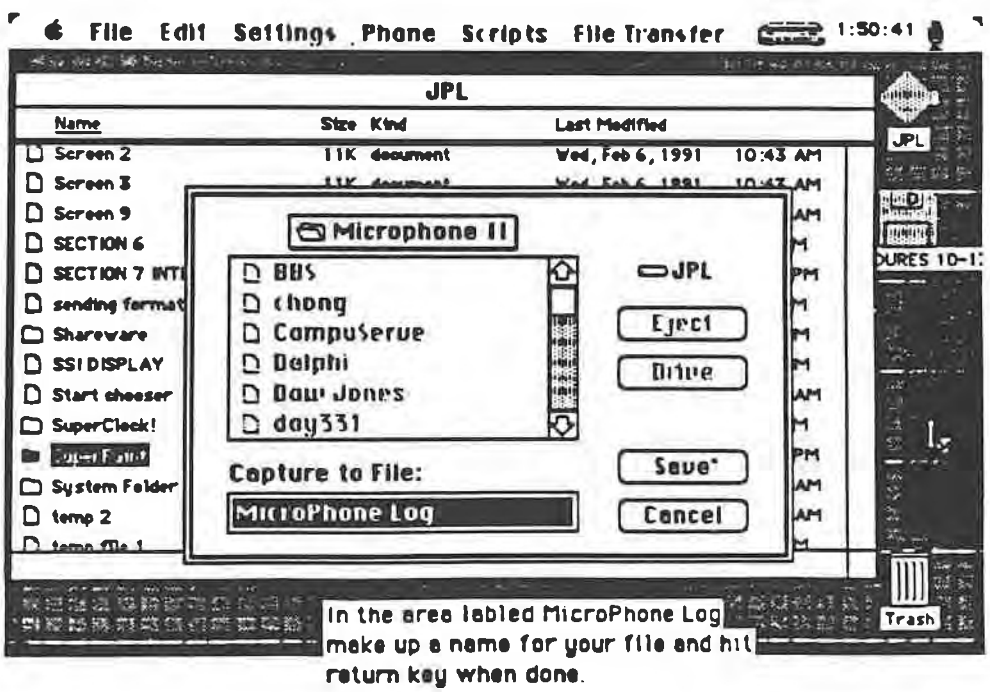
NEW SETTINGS
OPEN SETTINGS
CLOSE SETTINGS
SAVE SETTINGS
SAVE SETTINGS AS

OPEN NEW CAPTURE FILE... **Click on this line then observe the window below**
APPEND TO CAPTURE FILE
CAPTURE OFF

PRINTER ON

SAVE SELECTION AS...
APPEND SELECTION TO...
PRINT SELECTION

LAUNCH
LAUNCH AND RETURN
QUITE



EDIT and Reformat Captured Files From RASM

Once transferred predict files and/or other files reside on the Hard Disk of the Mac, they must be edited and reformatted for uploading to the GPVAX computer. This is accomplished in the following way:

1. Go through the file manually and delete all unnecessary information that may only confuse station personnel in Bologna.

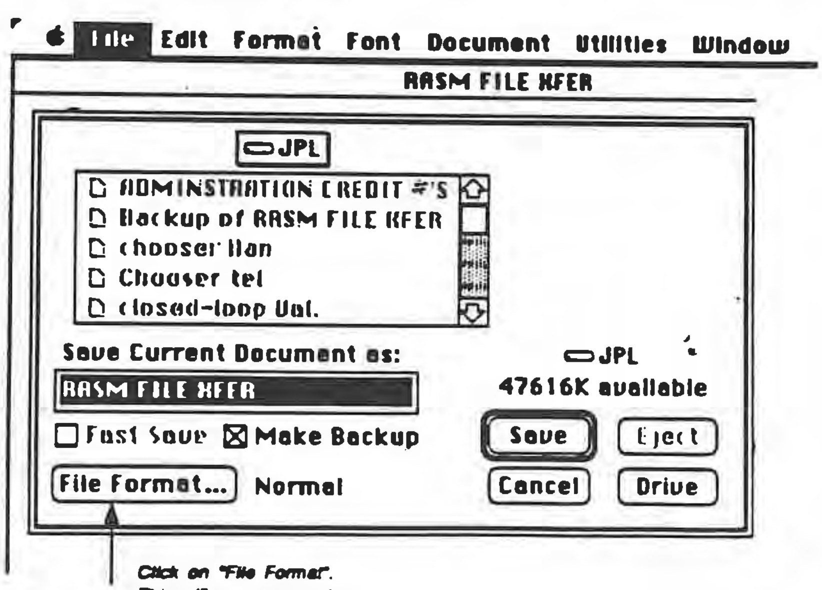
2. Then mark the beginning and end of the file using the mouse "shift key and click function together". This will mark the file so that reformatting is accomplished all at once.

3 Select **File** on the top line of the Mac and drag down to the word **"SAVE AS..."**and click.

4. Within the "SAVE AS.. " window at the bottom will be , **"FILE FORMAT..."**, which is displayed also. Click On the word and another window will open with a set of options. See examples of these windows below.

5. Select the **Text Only** by clicking on the option just in front of it. Close the window by clicking on the **"OK"**. Now, click on **Save** seen on the SAVE AS.. window. This window re-open due to your previous click. Because you have marked the beginning and end of the file it will reformat before your eyes. At this point reformatting has been completed.

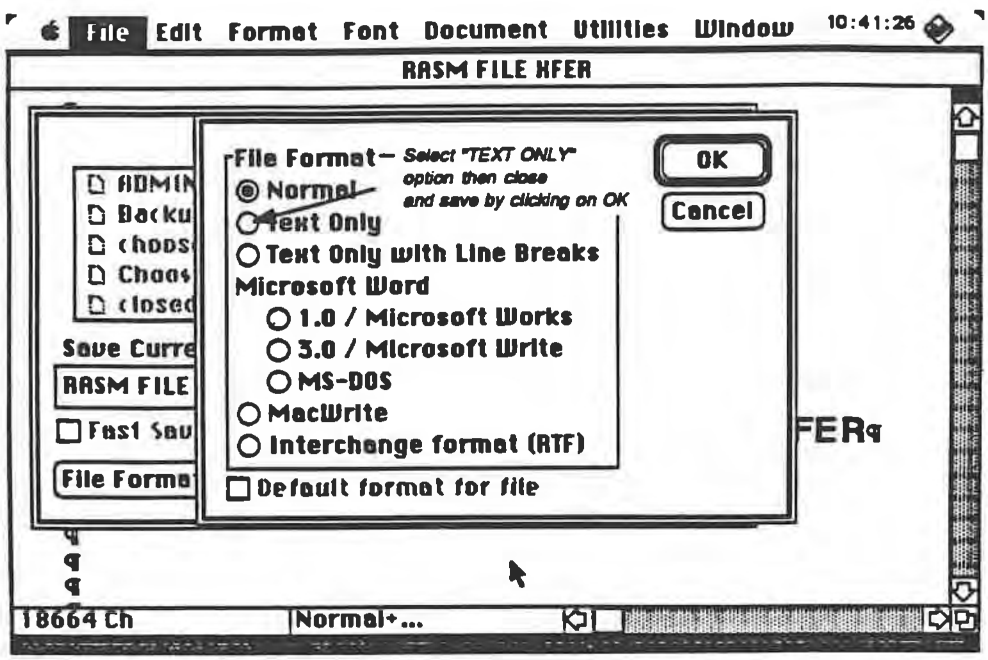
<u>Example of the "SAVE AS.." Window and the File Format Window:</u>



Click on "File Format". This will open up another window for reformatting your file. Please continue

Continued Example for File Format window

File Format... Window



Summary of Edit and Reformat Procedure

1. To mark the beginning and end of a file for reformatting the Mouse and Shift key are used together. Click on the start and end of the created file When done correctly the entire file will become dark.

LOGGING ON THE GPVAX AND PREPARE THE MAC FOR UPLOADING

To Log On the GPVAX please return to the **CHOOSER** display under the little apple, deselect the **339 Modem 9600 line** and select a **ILAN 9600 line**. This is done by simply clicking on the line you want. Deselection selection is accomplished this way. REVIEW SECTION B the RASM 339 Telebit line selection. Once the proper ILAN line is selected do the following:

1. On the Hard Disk select the ICON labeled **GPVAX**.
   This loads Microphone II and establishes communication with the outside world.

2. Type the following: **c GPVAX**

3. GPVAX will respond with:

   Connecting .. (1) 36208A3 Success


GPVAX

This means that you've reached the GPVAX and it come back with:

5. USERNAME: **THORTON**

6. PASSWORD: **xxxxxxx**

Header information regarding security of the system will display. Additional information will also display regarding assistence to problems during any session. Please continue.

FILE (s) TRANSFER FROM MAC TO GPVAX

To initiate the file transfer from Mac-to-GPVAX do the following:

After the prompt $ please type **Kermit**

then

type **receive**

This prepares the GPVAX to receive a file that is configured under Kermit protocol.

The GPVAX is now waiting to receive file (s) from your Mac. To continue the transfer please go to the top line on of the Mac display and click on **File Transfer.** This action will open another window. Drag down to the word **send Kermit** and click. See examples of these windows that follow:

Continued Mac Transfer to GPVAX Procedures

Example of FILE TRANSFER WINDOW

1. Send File (Text)...
2. Send Xmodem
3. **Send Kermit**
4. Send File to Macterminal 1.1 ...

---

1. Receive Xmodem
2. Receive Kermit

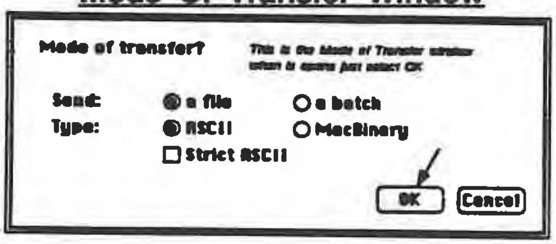
---

1. Create Batch
2. Kermit Server
3. Select Receive Folder

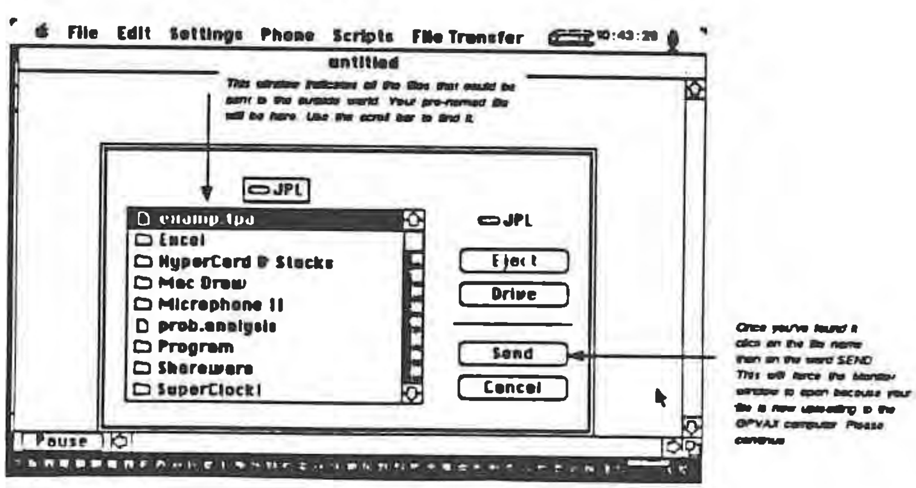
End File Transfer Window

With the mouse double click on Send Kermit. This action will prompt you with the following window:

Mode Of Transfer Window

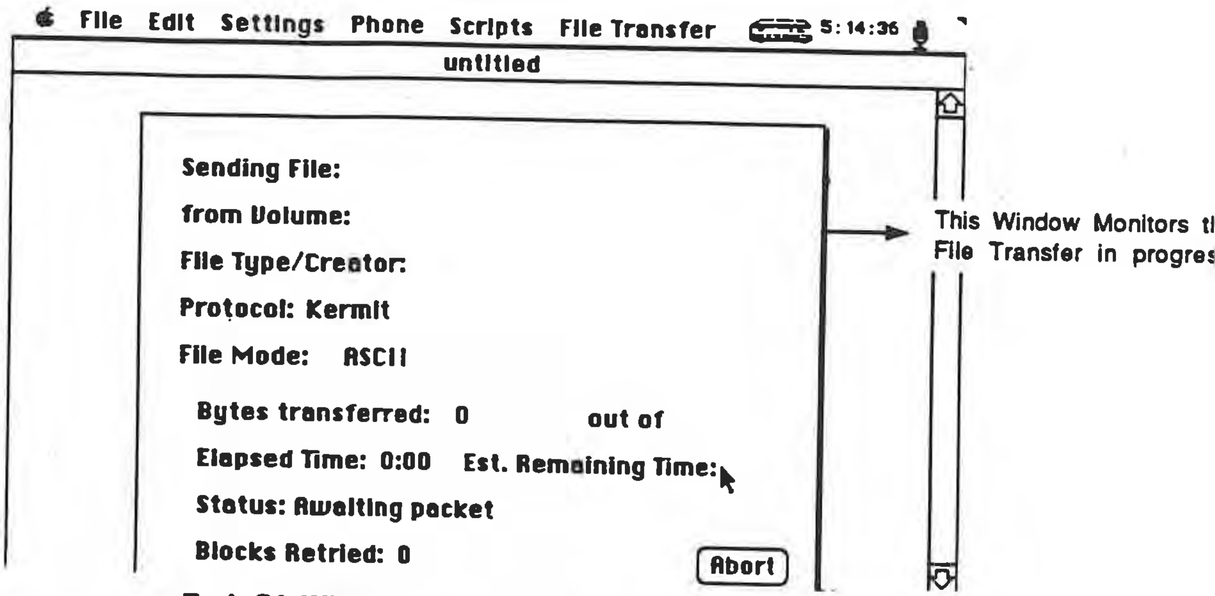


At this point select the file that was previously named and reformatted by you on the Mac. The window to make this selection will automatically appear after you select **OK** on the Mode Of Transfer window. See example below. Once you have selected your file and clicked on **Send** it will start uploading to the GPVAX and a Monitoring window will open also automatically while the transfer is in progress. See an example of this window below.



Continued Mac To GPVAX File Transfer Procedure

Example of File Transfer Window



End Of Window

When the file is completed, the window will indicate completion as well as a sound will come from the Mac to get your attention. Depending on how many files you want to transfer, this will complete uploading steps.

Summary of the Mac-GPVAX File Transfer

1. Examples of the windows providing support information to the text are provided within the section. Once on the GPVAX however, ensure that you have indicated KERMIT and have also stated RECEIVE so that the system is ready to receive files.

Exit the Transfer Process and Verify GPVAX File (s)

Type **Exit** to escape Kermit and continue:

1. Type **DIR** (Directory)
   Allows your Directory on GPVAX to be scanned.

2. Type the files name. (the command in **TYPE** followed by file name)
   After typing the file name the system will display it on the screen. (Note: this only works for ASCII files, not for binary files.)

3. Now the file is printing out on the screen and you can tell that it is all there.
   So, do a **Control C** this will stop the output. **Control S** will also stop the scrolling and **Control Q** will continue the scrolling. Please continue.

Mail File (s) to Bologna

1. Type **Mail.** This calls up the Mailing function. The computer will come back with

   MAIL>

2. You type **send "file name"**

   TO:

   You type **ULYSMAIL.DIS;1**

The file "ULYSMAIL.DIS;1" has been created with all the necessary addresses of people who will receive the predicts in Italy. See the summary which has each specific mail address. While mailing any information, an error message may appear stating that one or more of the Nodes was not reachable. Instruct the Mail function to SEND anyway and those nodes that are working will get the predicts. The other can be sent at a later time.

To Exit GPVAX

After mailing all the files exit the GPVAX with **"LO"** (logging Off) command.

SUMMARY OF THIS SECTION

GPVAX Mail Directory:
29581::IESS
ASTBO1::GIOVANNI
ASTRFI::COMORETTO
28582::WINS% MESSERI
28581::MESSERI

This completes the entire process of File Transfer from start to finish. Thank You

APPENDIX F

SCHEDULE OF ACTIVITIES

WEEK	SPACECRAFT	DOY	STATION	BOT	EOT	STAHAND	COMMENTS PAGE 1 01/11/93
11	MO	80	15	0:25	9:05		
	ULYS	80	12	1:25	10:10		
12	ULYS	81	42	6:30	18:05	(12 > 42) @ 0800Z	
	MO	81	45	7:50	13:05	(15 > 45) @0900Z	
	MO	81	65	12:50	0:35	(45 > 65) @ 1305Z	
	GLL	81	63	17:15	2:30		
	ULYS	81	61	20:45	2:10	(42 > 61) @ 1755Z	
	MO	82	15	0:40	8:00	(65 > 15) @ 0035Z	
	ULYS	82	12	1:40	7:30	(61 > 12) @01:40Z	
	GLL	82	14	3:45	11:45		
	ULYS	82	42	7:00	18:00		
	MO	82	45	7:45	13:05	(15 > 45) @ 0800Z	
	MO	82	65	12:50	1:35	(45 > 65) @ 1305Z	
	GLL	82	63	17:00	2:30		
	ULYS	82	61	20:45	1:30		
	ULYS	83	12	1:00	7:30	(61 > 12) @ 0150Z	
	MO	83	15	1:20	8:00	(65 > 15) @ 0135Z	
	GLL	83	14	2:10	11:45	(63 > 14) @ 0230Z	
	ULYS	83	42	7:00	16:30	(12 > 42) @ 0750Z	
	MO	83	45	7:45	13:00	(15 > 45) @ 0800Z	
	MO	83	65	12:45	1:35	(45 >65) @ 1300Z	
	ULYS	83	61	17:25	24:00		
	GLL	83	63	17:00	2:10		
	ULYS	84	12	0:45	7:30		
	MO	84	15	1:20	6:45	(65 > 15) @ 0135Z	
	GLL	84	14	1:50	11:45	(63 > 14) @0210Z	
	MO	84	45	6:30	13:00	(15 > 45) @ 0645Z	
	ULYS	84	42	6:45	17:50	(12 > 42) @ 0745Z	
	MO	84	65	12:45	0:30	(45 > 65) @ 1300Z	
	ULYS	84	61	17:20	1:45	(42 > 61) @17:50Z	
	GLL	84	63	16:50	3:25		10BPS MRO
	MO	85	15	0:15	8:55	(65 > 15) @ 0030Z	
	ULYS	85	12	1:15	8:00	(61 >12) @ 0140Z	
	GLL	85	14	3:05	9:45	(63 > 14) @0325Z	
	MO	85	45	8:40	12:55	(15 > 45) @ 0855Z	
	MO	85	65	12:40	0:55	(45 > 65) @ 1255Z	DOR 15/65
	ULYS	85	42	11:15	16:30		
	ULYS	85	61	17:15	2:20		
	GLL	85	63	16:50	2:30		
	MO	86	15	0:15	7:55	(65 > 15) @0030Z	DOR 15/65
	ULYS	86	12	1:50	7:50	(61 > 12) @0135Z	
	GLL	86	14	2:10	11:35	(63 > 14) @0230Z	
	ULYS	86	42	7:20	16:30	(12 > 42) @ 0735Z	
	MO	86	45	7:40	12:55	(15 > 45) @ 0755Z	
	MO	86	65	12:40	1:30	(45 > 65) @ 1255Z	
	ULYS	86	61	17:10	2:15		
	GLL	86	63	16:45	2:10		
	MO	87	15	1:15	7:50	(65 > 15) @ 0155Z	
	ULYS	87	12	1:45	7:55	(61 > 12) @ 0130Z	
	GLL	87	14	1:50	10:05		
	MO	87	45	7:35	12:55	(15 > 45) @ 0750Z	
	ULYS	87	42	7:25	16:30	(12 > 42) @ 0730Z	
	MO	87	65	12:40	0:25	(45 > 65) @ 1255Z	
	ULYS	87	61	17:05	0:35		
	GLL	87	63	16:35	2:25		
	MO	88	15	0:10	7:50	(65 >15) @ 0025Z	
	ULYS	88	12	0:05	7:30	(61 > 12) @ 0125Z	
	MO	88	15	1:10	7:50	(65 > 15) @ 0045Z	
13	GLL	88	14	2:05	11:35	(63 > 14) @ 0225Z	
	ULYS	88	42	7:00	17:30	(12 > 42) @ 0725Z	
	MO	88	45	7:35	12:50	(15 > 45) @ 0750Z	
	MO	88	65	12:35	0:25	(45 > 65) @ 1250Z	
	ULYS	88	61	17:00	0:45	(42 > 61) @ 1720Z	
	GLL	88	63	16:40	2:00		
	ULYS	89	12	0:15	7:30	(61 > 12) @00:45	
	GLL	89	14	1:40	11:30	(63 > 14) @ 0200Z	
	ULYS	89	42	7:00	17:30		
	MO	89	45	7:35	12:50	(15 >45) @0750Z	
	MO	89	65	12:35	1:00	(45 > 65) @ 1250Z	
	ULYS	89	61	17:00	0:45	(42 > 61) @ 1715Z	
	GLL	89	63	16:30	2:00		
	ULYS	90	12	0:15	6:45	(61 > 12) @ 0115Z	

WEEK	SPACECRAFT	DOY	STATION	BOT	EOT	STAHAND	COMMENTS PAGE 2 01/11/93
	MO	90	15	0:45	8:45	(65 > 15) ● 0100Z	
	GLL	90	14	1:40	11:25	(63 > 14) ● 0200Z	
	ULYS	90	42	6:15	17:15	(12 > 42) ● 0715Z	
	MO	90	45	8:30	12:50	(15 > 45) ● 0845Z	
	MO	90	65	12:35	1:20	(45 > 65) ● 1250Z	
	ULYS	90	61	16:45	1:25		
	GLL	90	63	16:35	2:00		
	MO	91	15	1:05	8:45	(65 > 15) ●0120Z	
	ULYS	91	12	0:55	7:00	(61 > 12) ● 0110Z	
	GLL	91	14	1:40	11:20	(63 > 14) ● 0200Z	
	ULYS	91	42	6:30	17:15	(12 > 42) ● 0710Z	
	MO	91	45	8:30	12:45	(15 > 45) ● 0845Z	
	MO	91	65	12:30	0:20	(45 > 65) ● 1245Z	
	ULYS	91	61	16:45	1:25	(42 > 61) ● 1705Z	
	GLL	91	63	16:30	1:50		
	MO	92	15	0:05	7:40	(65 > 15) ● 0020Z	
	ULYS	92	12	0:55	7:30	(61 > 12) ● 0101Z	
	GLL	92	14	1:30	10:10	(63 > 14) ● 0150Z	
	ULYS	92	42	7:00	17:15	(12 > 42) ● 0705Z	
	MO	92	45	7:25	12:45	(15 > 45) ● 0740Z	
	MO	92	65	12:30	0:40	(45 > 65) ● 1245Z	
	ULYS	92	61	17:00	1:15	(42 > 61) ● 1700Z	
	GLL	92	63	16:30	1:50		
	MO	93	15	0:25	5:40	(65 > 15) ● 0040Z	DOR 15/45
	ULYS	93	12	0:45	7:00	(61 > 12) ● 0100Z	
	GLL	93	14	1:30	11:15	(63 >14) ● 0150Z	
	MO	93	45	5:00	12:45	(15 >45) ● 0520Z	
	ULYS	93	42	6:30	17:10	(12 > 42) ● 0705Z	
	MO	93	65	12:30	1:15	(45 > 65) ● 1245Z	
	ULYS	93	61	16:40	0:15	(42 > 61) ● 1655Z	
	GLL	93	63	16:25	1:30		
	ULYS	93	12	23:45	7:00	(61 > 12) ● 0055Z	
	MO	94	15	1:00	8:30	(65 > 15) ● 0115Z	
	GLL	94	14	1:10	8:50	(63 > 14) ● 0130Z	
	ULYS	94	42	6:30	17:00	(12 > 42) ● 0700Z	
	MO	94	45	8:15	12:40	(15 > 45) ● 0830Z	
	MO	94	65	12:25	0:30	(45 > 65) ●1240Z	
	ULYS	94	61	16:30	0:05	(42 >61) ● 1650Z	
	GLL	94	63	16:10	1:30		
	MO	95	15	0:15	7:30	(65 >15) ●2350Z	
	ULYS	94	12	23:30	6:00	(61 >12) ● 0050Z	
14	GLL	95	14	1:10	11:05	(63 > 14) ● 0130Z	
	ULYS	95	42	5:15	17:00	(12 > 42) ● 0655Z	
	MO	95	45	7:15	12:40	(15 > 45) ● 0730Z	
	MO	95	65	12:25	0:05	(45 > 65) ● 1240Z	
	ULYS	95	61	16:30	0:30	(42 > 61) ● 1645Z	
	GLL	95	63	16:10	1:15		
	MO	95	15	23:50	7:35	(65 > 15) ● 0005Z	
	ULYS	96	12	0:00	6:00	(61 > 12) ● 0050Z	
	GLL	96	14	0:55	11:05	(63 > 14) ● 0115Z	
	ULYS	96	42	5:15	16:45	(12 > 42) ● 0650Z	
	MO	96	45	7:20	12:40	(15 > 45) ● 0735Z	
	MO	96	65	12:25	0:10	(45 > 65) ● 1240Z	
	ULYS	96	61	16:15	0:30	(42 > 61) ● 16:40Z	
	GLL	96	63	16:10	2:10		
	MO	96	15	23:55	8:30	(65 > 15) ● 0010Z	
	ULYS	97	12	0:00	5:45	(61 > 12) ● 00:45Z	
	GLL	97	14	2:55	11:00	(63 > 14) ● 0210Z	
	ULYS	97	42	5:00	16:45	(12 > 42) ● 0650Z	
	MO	97	45	8:15	121:35	(15 > 45) ● 0830Z	
	MO	97	65	12:20	·1:05	(45 > 65) ● 1235Z	
	ULYS	97	61	16:15	23:50	(42 > 61) ● 1635Z	
	GLL	97	63	16:10	1:10		
	ULYS	97	12	23:15	7:00	(61 > 12) ● 0040Z	
	MO	98	15	0:50	7:30	(65 > 15) ● 0105Z	
	GLL	98	14	0:50	10:55	(63 > 14) ● 0110Z	
	ULYS	98	42	6:00	16:45	(12 > 42) ● 0645Z	
	MO	98	45	7:15	12:35	(15 > 45) ● 0730Z	
	MO	98	65	12:20	0:05	(45 > 65) ● 1235Z	
	ULYS	98	61	16:15	23:45	(42 > 61) ● 1635Z	
	GLL	98	63	16:10	1:15		
	ULYS	98	12	23:15	6:00	(61 > 12) ● 00:35Z	

WEEK	SPACECRAFT	DOY	STATION	BOT	EOT	STAHAND	COMMENTS PAGE 3 01/11/93
	MO	98	15	23:50	7:30	(65 > 15) @ 0005Z	
	GLL	99	14	0:55	9:10	(63 > 14) @ 0115Z	
	ULYS	99	42	5:00	16:30	(12 > 42) @ 0640Z	
	MO	99	45	7:15	12:35	(15 > 45) @ 0730Z	
	MO	99	65	12:20	0:30	(45 > 65) @ 1235Z	DOR 15/65
	ULYS	99	61	16:15	23:45	(42 > 61) @ 1630Z	
	GLL	99	63	16:10	1:10		
	MO	99	15	23:50	7:25	(65 > 15) @ 0030Z	DOR 15/65
	ULYS	99	12	23:15	5:45	(61 > 12) @ 0030Z	
	GLL	100	14	0:50	10:50	(63 > 14) @ 0110Z	
	ULYS	100	42	5:15	16:30	(12 > 42) @ 0635Z	
	MO	100	45	7:10	12:35	(65 > 15) @0710Z	
	MO	100	65	12:20	24:00	(45 > 65) @1235Z	
	ULYS	100	61	16:00	23:45	(42 > 61) @ 1625Z	
	GLL	100	63	16:10	1:10		
	ULYS	100	12	23:15	6:45	(61 > 12) @ 0025Z	
	MO	100	15	23:45	7:25	(65 > 15) @ 0000Z	
	GLL	101	14	0:50	10:00	(63 > 14) @ 0110Z	
	ULYS	101	42	6:15	16:30	(12 > 42) @ 0635Z	
	MO	101	45	7:10	12:30	(15 > 45) @ 0725Z	
	MO	101	65	12:15	24:00	(45 > 65) @ 1230Z	
	ULYS	101	61	16:00	23:50	(42 > 61) @ 1620Z	
	GLL	101	63	16:45	3:15		USO
	ULYS	101	12	23:20	7:30	(61 > 12) @ 0020Z	
	MO	101	15	23:45	8:20		

GALILEO USO ACTIVITIES

LOAD	EVENT	PST DOW	PST BEGIN	PST DATE	UTC DATE	UTC DOY	UTC BEGIN	UTC END	DSS	PASS #	CL DOPP	OL DATA	ATDF	OL ODR	P-FLD	CL VALID	OL VALID	SC SPIN	COMMENTS PAGE 1 LUD 12/13/92
1989	USO-ON	Mon.	16:34	4-Dec	5-Dec	339	00:34	00:45	14		Good	NA	GA0001	NA			NA	DLSP	USO Tuned ON 56 mins. early by real-time cmd.
	launch date?																		1/sec Doppler taken near end of DSS 14 pass
	USO-Tst	Thur	13:30	7-Dec	7-Dec	341	21:30	23:28	14	51	Good	Good	GA0001	GAO0001		Good	Good	DLSP	Joe B. and Dave M. at DSS 14. Did not acquire
																			first 30 mins of OL data
	RFS TLC	Fri.	15:37	8-Dec.	8-Dec.	342	23:37	01:29	14		Good	NR	GA0002	NA		Good	NA	DLSP	1/sec. Doppler only, may have started late.
	USO Tst	Fri.	16:00	15 Dec	16-Dec	350	00:00	01:58	14	59	Good	Good	GA0003	GAO0002	YES	Good		DLSP	Good 1/sec Doppler + OL data. Luciano less
																			observed operations.
EV-4	RFS TLC	Thur.	13:02	21-Dec	21-Dec	355	21:02	22:55	14	70	Good	NR	GA0004			Good	NA	DLSP	1/sec. Doppler only- Started about 15 min late.
	USO Tst	Tue.	14:31	26-Dec	26-Dec	360	22:31	00:01	14	77	Good	Bad	GA0004	GAO0003-5		Good	NA	DLSP	No OL data acquired due to DSP problem.
																			DR F5493
1990																			
	USO Tst	Tue.	09:05	2-Jan	2-Jan	2	17:05	18:59	14		Good	Good	GA0004	GAO0006		Good		DLSP	Good 1/sec Doppler + OL data. DSP Config ?
X	RSF TLC	Thur.	11:02	4-Jan	4-Jan	4	19:02	20:55	14		Good	NR	GA0002	NA		Good	NA	ALSP	NIMS COVER DEPLOY
EV-5	USO Tst	Tue.	09:31	9-Jan	9-Jan	9	17:31	19:29	14	84	Good	NA	GA0002	NA	YES	Good	NA	DLSP	No, DSP Scheduled for this pass. Delta DOR
	USO Tst	Mon.	09:31	15-Jan	15-Jan	15	17:31	19:29	14	90	Good	?	GA0002	GAO0007-8	YES	Good		DLSP	SSI Rcd. No RT OL data displays. Possible wrong
																			Configuration. DR F5279.
X	RFS TLC	Tue.	12:19	16-Jan	16-Jan	16	20:19	22:11	14		None	NR	None	NA		NA	NA	ALSP	RFS Test aborted due to S/C anomaly.
																			X IN FIRST COLUM. FIRST S/C SAFING ANOMALY
X	USO Tst	Thur.	09:31	18-Jan	18-Jan	18	17:31	19:29	14		None	None	None	NA		NA	NA	ALSP	USO Test aborted.
X	USO Tst	Fri.	08:00	19-Jan	19-Jan	19	16:00	18:00	14		Good	NA	GA0002	NA		Good	NA	ALSP	DSS 14 Transmitter off to acquire 1-way data.
X	USO Tst	Fri.	08:01	26-Jan	26-Jan	26	16:01	17:59	14		None	None	None	NA		NA	NA	ALSP	USO Test aborted.
X	USO Tst	Sun	08:00	28-Jan	28-Jan	28	16:00	18:00	14		Good	NA	GA0002	NA		Good	NA	ALSP	DSS 14 Transmitter off.
X	USO Tst	Tue.	11:22	30-Jan	30-Jan	30	19:22	21:20	14		None	None	None	NA		NA	NA	ALSP	USO Test aborted.
X	USO Tst	Thur.	07:30	1-Feb	1-Feb	32	15:30	17:30	14	107	Good	NA	GA0008	NA	YES	Good	NA	ALSP	DSS 14 Transmitter off
X	USO Tst	Fri.	07:32	2-Feb	2-Feb	33	15:32	17:30	14		None	None	None	NA	YES	NA	NA	ALSP	USO Test aborted
	USO Tst	Sun.	07:30	4-Feb	4-Feb	35	17:30	19:30	14		None	NR	None	NA		NA	NA	DLSP	DSS 14 Transmitter off. Test aborted.
X	USO Tst	Tue.	02:45	6-Feb	6-Feb	37	10:45	12:45	63		Good	NA	GA0004	NA		Good	NA	DLSP	DSS 63 Transmitter off. No R/T Monitor.
EV-6	USO Tst	Mon.	09:32	5-Feb	5-Feb	36	17:32	19:30	14		None	NA	None	NA		NA	NA	DLSP	USO test was aborted.
X																			
	RFS TLC	Tue.	10:50	6-Feb	6-Feb	37	18:50	20:43	14		None	NR	None	NA		NA	NA	DLSP	RFS TLC Test was aborted.
	1-Way	Sat.	01:20	10-Feb	10-Feb	41	09:20	11:40	63	115	Good	NA	GA0004	NA	YES	Good	NA	DLSP	1/5 sec. One-way Doppler during Venus Encounter
																			Day.
	USO Tst	Mon.	19:00	12-Feb	13-Feb	44	03:00	05:20	43	118	Good	Good	GA0007	GAO0009		Good		DLSP	Late in pass. Low Elevation data
	USO Tst	Wed.	16:02	14-Feb	15-Feb	46	00:02	02:00	43	120	Good	Good	GA0005	N	YES	Good		DLSP	RST Demonstration. Woo and Estabrook observed
	USO Tst	Sun.	11:33	18-Feb	18-Feb	49	19:33	21:31	43	124	Good	Good	GA0007	N	YES	Good		DLSP	I/F lost with MDA/SRA required reload, no DR issued.

NA- NOT AVAILABLE NR- NOT REQUIRED N- NEED ODRs D= DSP SCHED N =DSP NOT SCHED - = DSP NOT APPL

GALILEO USO ACTIVITIES

LOAD	EVENT	PST DOW	PST BEGIN	PST DATE	UTC DATE	UTC DOY	UTC BEGIN	UTC END	DSS	PASS #	CL DOPP	OL DATA	ATDF	OL ODR	P-FLD	CL VALID	OL VALID	SC SPIN	COMMENTS PAGE 2 LUD 12/13/92
VE-1 -	CDU SNR	Wed	08 20	21-Feb	21-Feb	52	16:02	17:09	14		Bad	NR		NA		Bad	NA	DLSP	No RT Monitor. 1/60 sec Doppler
	RSF TLC	Wed.	13 57	21-Feb	21-Feb	52	21:57	23:51	43		Bad	NR		NA		Good	NA	DLSP	No RT Monitor
	RFS AGC	Thur.	12:08	22-Feb.	22-Feb.	53	20:08	21:39	14		Good	NR	GA0006	NA		Good	NA	DLSP	
	USO Tst	Sat.	18:03	24-Feb	25-Feb.	56	02:03	03:32	43	130	Good	Good	GA0006	GAO0010	YES	Good		DLSP	
	USO Tst	Tue.	15:03	27-Feb	27-Feb	58	23:03	01:02	43	133	Good	Good	GA0006	GAO0011	YES	Good		DLSP	
	USO Tst	Thur.	16:03	1-Mar	2-Mar	61	00:03	02:32	43	135	Good	Good	GA0006	GAO0012	YES	Good		DLSP	Short Pre-cal.
	RFS TLC	SUN.	17:39	4-Mar	5-Mar	64	01:39	03:33	43	138	Good	NR	GA0006	NA	YES	Good	NA	DLSP	
	CDU SNR	Mon.	13:25	5-Mar	5-Mar	64	21:25	22:31	43	139	Good	NR	GA0006	NA	YES	Good	NA	DLSP	
	RFS AGC	Mon.	15:10	5-Mar	5-Mar	64	23:10	00:31	43		Good	NR		NA		Good	NA	DLSP	No RT Monitor.
	USO Tst	Thur.	18:04	8-Mar	9-Mar	68	02:04	03:48	43	142	Good	Good	GA0009	N	YES	Good		DLSP	
	USO Tst	Fri.	18:05	16-Mar	17-Mar	76	02:05	03:33	43	150	Good	Good	GA0007	N	YES	Good		DLSP	LGA -2 Switch 10/18/89 - 03/15/90
	USO Tst	Sun.	16:35	18-Mar	19-Mar	78	00:35	02:34	43	152	Good	Good	GA0007	N	YES	Good		DLSP	
	USO Tst	Sat.	11:05	24-Mar	24-Mar	83	19:05	21:04	43	158	Good	Good	GA0008	N	YES	Good		DLSP	
VE-2	USO Tst	Thur.	16:08	29-Mar	30-Mar	89	00:08	02:04	43	163	Good	Good	GA0007	N	YES	Good		DSLP	TSS Demonstration
	CDU SNR	Sun.	15:59	1-Apr	1-Apr	91	22:59	00:05	43	166	Bad	NR	GA0007	NA	YES	Good	NA	DLSP	Telecomm RT Monitor
	RFS TLC	Sun.	17:29	1-Apr	2-Apr	92	00:29	02:23	43	166	Marg	NR	GA0007	NA	YES	Good	NA	DLSP	Telecomm RT Monitor.
	RFS AGC	Mon.	18:09	2-Apr	3-Apr	93	01:09	02:30	43	167	Good	NR	GA0007	NA		Good	NA	DLSP	No RT Monitor
	USO Tst	Sat.	15:06	7-Apr	7-Apr	97	22:06	00:05	43	172	Good	Good	GA0009	N	YES	Good		DLSP	
	USO Tst	Sat.	15:07	14-Apr	14-Apr	104	22:07	00:05	43	179	Good	?	GA0009	N	YES	Good		DLSP	
	USO Tst	Thur	17:37	19-Apr	20-Apr	110	00:37	02:38	43	184	Good	?	GA0010		YES			DLSP	Mis-placed Pass, found by Paula ,thanks !!!!
VE-3	USO Tst	Mon.	16:07	23-Apr	23-Apr	113	20:07	22:06	43	184	Good	NA	GA0010	NA	YES		NA	DLSP	
	USO Tst	Tue.	16:07	1-May	1-May	121	23:07	01:06	43	196	Good		GA0009	NA	YES	Good	NA	DLSP	
	USO Tst	Tue.	02:08	8-May	8-May	128	09:07	11:07	63	202	Good	?	GA0009	N	YES	Good		DLSP	No RT Monitor
	USO Tst	Wed.	16:17	16-May	16-May	136	23:17	01:17	43	211	Good	?	GA0009	GAO0013	YES	Good		DLSP	No RT Monitor
	USO Tst	Sat.	12:53	19-May	19-May	139	19:53	21:51	43	214	Good	NA	GA0009	NA	YES	Good	NA	DLSP	Post USO High Power Ranging Test.
	RFS TLC	Fri.	11:17	25-May	25-May	145	18:17	20:11	14	220	None	NR	NA	NA	YES	NA	NA	DLSP	MDA crashed DRF7834 . Lost all Data.
	USO Tst	Tue.	12:08	29-May	29-May	149	19:08	21:06	43	224	Good		GA0009	GAO0014	YES	Good		DLSP	Predicts not loaded in DSP DR F7865
	CDU SNR	Thur.	10:43	31-May	31-May	151	17:43	18:49	43	226	Good	NR	GA0009	NA	YES	Good	NA	DLSP	Low Elevation
	RFS AGC	Fri.	14:12	1-Jun	1-Jun	152	21:12	22:34	43	227	Good	NR	GA0009	NA	YES	Good	NA	DLSP	

NA- NOT AVAILABLE NR- NOT REQUIRED N- NEED ODRs D= DSP SCHED N =DSP NOT SCHED - = DSP NOT APPL

LOAD	EVENT	PST DOW	PST BEGIN	PST DATE	UTC DATE	UTC DOY	UTC BEGIN	UTC END	DSS	PASS #	CL DOPP	OL DATA	ATDF	OL ODR	P-FLD	CL VAILD	OL VAILD	SC SPIN	COMMENTS PAGE 3 LUD 12/13/92
	USO Tst	Mon.	12:06	4-Jun	4-Jun	155	19:06	21:06	43	230	Good	NA	GA0009	NA	YES	Ugly	NA	DLSP	
VE-5	USO Tst	Mon	11:11	11-Jun	11-Jun	162	18:11	19:44	14	237	Good		GA0011		YES			DLSP	Low Elevation. No SSI Data DR F8002
	USO Tst	Thur	08:07	21-Jun	21-Jun	172	15:07	17:09	14	247	Good	?	GA0010	GAO0020	YES			DLSP	No SSI Displays
	USO Tst	Mon	09:07	25-Jun	25-Jun	176	16:07	18:09	14	251	Good	?	GA0010		YES			DLSP	No SSI displays DR F8135
	USO Tst	Mon	11:07	2-Jul	2-Jul	183	18:07	20:09	43	256	Good	?	GA0010	GAO0015	YES			DLSP	No RT Monitor
	RFS TLC	Thurs.	14:51	5-Jul	5-Jul	186	21:51	23:45	43	261	Good	NR	GA0010	NA	YES		NA	DLSP	
	CDUSNR	Wed	13:11	11-Jul	11-Jul	192	20:11	22:17	43	267	Good	NR	GA0010	NA	YES		NA	DLSP	Italian GWE Demo.
	RFS AGC	Wed	16:26	11-Jul	12-Jul	192	23:26	00:47	43	267	Good	NR	GA0010	NA	YES		NA	DLSP	Low Elevation. GWE Demo.
	USO Tst	Thurs	07:37	12-Jul	12-Jul	193	14:37	16:36	14	266	Good	NA	GA0010	NA	YES		NA	DLSP	Italian GWE Demo.
	USO Tst	Mon	11:12	16-Jul	16-Jul	197	18:12	20:13	43	272	Good	NA	GA0010	NA	YES		NA	DLSP	DSP POCA red for support DRF8566.
	USO Tst	Wed.	14:06	25-Jul	25-Jul	206	21:06	23:06	43	281	Good	Good	GA0010	GAO0016	YES			DLSP	SSI not enabled and recording started late DRF8810
	USO Tst	Wed.	14:06	1-Aug	1-Aug	213	21:06	23:06	43	288	N/A	Good	GA0011	GAO0017	YES			DLSP	Stowed Antenna at 22:08z for High Winds DR F8890
	USO Tst	Thurs.	13:35	9-Aug	9-Aug	221	20:35	22:37	43	296	Marg		GA0011	GAO0018	YES			DLSP	
	USO Tst	Thurs.	11:05	16-Aug	16-Aug	228	18:05	20:07	43	303	Good		GA0011	GAO0019	YES			DLSP	
	USO Tst	Tue.	08:05	21-Aug	21-Aug	233	15:05	17:07	14	308	Good		GA0011		YES			DLSP	
	RFS TLC	Fri.	13:11	24-Aug	24-Aug	236	20:11	22:05	43	311	Marg		GA0011		YES			DLSP	
	RFS AGC	Mon.	11:41	27-Aug	27-Aug	239	18:41	20:02	43	314	Good		GA0011		YES			DLSP	
	USO Tst	Fri.	12:34	31-Aug	31-Aug	243	19:34	21:36	43	318	Good		GA0011		YES			DLSP	
	USO Tst	Thurs.	18:34	6-Sept.	7-Sep	250	01:34	03:36	63	324	Marg		GA0011		YES			DLSP	
	USO Tst	Mon.	12:04	10-Sept.	10-Sept.	253	19:04	21:05	43	326	Good		GA0011		YES			DLSP	
	USO Tst	Wed	12:18	19-Sept.	19-Sept.	262	19:18	21:20	43	337	Good		GA0012		YES			DLSP	
	USO TST	Mon.	15:30	24-Sept.	24-Sept.	268	00:30	03:40	63	342	Good		GA0012		YES			DLSP	
	USO Tst	Mon	11:47	01-Oct.	01-Oct.	274	18:47	20:49	43	349	Good		GA0012	GAO0021	YES			DLSP	
	USO Tst	Mon.	10:02	08-Oct.	08-Oct.	281	17:04	19:04	43	356	Good		GA0012		YES			DLSP	
	RSF AGC	Fri.	07:40	19-Oct.	19-Oct.	292	14:40	15:55	43	367	Good		GA0012					DLSP	
	RFS TLC	Fri.	09:30	19-Oct.	19-Oct.	292	16:30	16:24	43	367	Marg		GA0012					DLSP	
	USO Tst	Mon.	17:31	31-Oct.	31-Oct.	303	01:31	03:32	63	377	Good		GA0012					DLSP	
	USO Tst	Wed.	17:00	07-Nov.	07-Nov	312	01:00	03:02	63	386								DLSP	

NA- NOT AVAILABLE NR- NOT REQUIRED N- NEED ODRs D= DSP SCHED N =DSP NOT SCHED - = DSP NOT APPL

GALILEO USO ACTIVITIES

LOAD	EVENT	PST DOW	PST BEGIN	PST DATE	UTC DATE	UTC DOY	UTC BEGIN	UTC END	DSS	PASS #	CL DOPP	OL DATA	ATDF	OL ODR	P-FLD	CL VAILD	OL VAILD	SC SPIN	COMMENTS PAGE 4 LUD 12/13/92
	USO Tst	Fri.	19:00	18-Nov.	18-Nov.	321	03:00	05:02	63	395			GA0016	GAO0022	YES			DLSP	
														GAO0023					GAO0023
														GAO0024					GAO0024
	USO Tst	Sun	17:00	25-Nov.	25-Nov.	330	01:00	03:01	63	404			GA0016		YES			DLSP	
	USO Tst	Mon.	01:54	10-Dec	10-Dec.	345	01:54	03:45	42	420			GA0016		YES			DLSP	LGA -1 Switch 3/15/90 - 12/08/90
	USO Tst	Wed.	08:00	12-Dec	12-Dec.	346	08:00	11:00	63	421			None		YES			DLSP	
	USO Tst	Sun.	08:14	16-Dec.	16-Dec.	350	08:14	10:16	61	425			GA0016		YES			DLSP	
	USO Tst	Wed.	17:00	26-Dec.	26-Dec.	360	17:00	19:01	43	438			GA0016	GAO0043	YES			DLSP	
1991																			
	USO Tst	Thur.	07:30	3-Jan	3-Jan	4	07:30	09:32	63	444			GA0016		YES			DLSP	First USO Test for Year 1991
	USO Tst	Sun.	18:00	6-Jan	6-Jan	6	18:00	20:02	43	447			GA0016	GAO0044	YES			DLSP	
	CDU SNR	Wed.	16:56	9-Jan	9-Jan	9	16:56	17:49	43	450			GA0016		YES			DLSP	
	RFS AGC	Wed.	18:28	9-Jan	9-Jan	9	18:28	19:49	43	450			GA0016		YES			DLSP	
	RFS TLC	Thurs.	20:48	10-Jan	10-Jan	10	20:48	22:42	43	451			GA0016		YES			DLSP	
	USO Tst	Mon.	18:45	14-Jan	14-Jan	14	18:45	18:47	43	455			GA0017	GAO0045	YES			DLSP	
	USO Tst	Wed.	17:01	16-Jan	16-Jan	16	17:01	19:02	43	457			GA0017	GAO0046	YES			DLSP	
	USO Tst	Sat.	16:01	19-Jan	19-Jan	19	16:01	18:03	43	460			GA0017	GAO0047	YES			ALSP	
	USO Tst	Mon.	18:01	21-Jan	21-Jan	21	18:01	20:03	43	462			GA0017	GAO0048	YES			ALSP	
	USO Tst	Sat.	16:01	26-Jan	26-Jan	26	16:01	18:03	43	467			GA0017	GAO0049	YES			ALSP	
	USO Tst	Mon.	06:01	29-Jan	29-Jan	29	06:01	08:03	63	469			GA0017	GAO0050	YES			ALSP	
	USO Tst	Sat.	15:46	2-Feb	2-Feb	33	15:46	17:48	43	474			GA0017	GAO0051	YES			ALSP	LGA - 2 Switch 12/08/90 - 01/31/91
	USO Tst	Mon.	06:01	4-Feb	4-Feb	36	06:01	08:03	63	476			GA0017		YES			ALSP	
	USO Tst	Thurs.	06:01	7-Feb	7-Feb	39	06:01	08:03	63	479			GA0017		YES			ALSP	
	USO Tst	Tue.	15:02	12-Feb	12-Feb	43	15:02	17:03	43	484			GA0017	GAO0052	YES			ALSP	
	USO Tst	Mon	21:17	18-Feb	18-Feb	49	21:17	23:19	43	490			GA0017	GAO0053	YES			ALSP	
	USO Tst	Sun.	15:32	24-Feb	24-Feb	55	12:50	16:15	43	496			GA0018	GAO0054	YES			ALSP	
	RFS TLC	Thurs.	16:16	28-Feb	28-Feb	59	16:16	18:10	43	500			GA0018		YES			DLSP	
	USO Tst	Tue.	14:03	5-Mar	5-Mar	64	14:02	16:04	43	505			GA0018	GAO0055	YES			DLSP	
	RFS AGC	Wed.	22:31	6-Mar	6-Mar	65	22:31	23:53	43	508			GA0018		YES			DLSP	
	USO Tst	Thurs.	16:17	14-Mar	1'4-Mar	73	16:17	18:19	43	514			GA0018	GAO0056	YES			DLSP	
	USO Tst	Fri.	15:02	22-Mar	22-Mar	81	15:02	17:04	43	522			GA0018	GAO0057	YES			DLSP	
																			CDS Bus Reset A and Reset B 03/26/91
																			CDS Bus Reset A and Bus Reset B 03/26/91

NA- NOT AVAILABLE NR- NOT REQUIRED N- NEED ODRs D= DSP SCHED N =DSP NOT SCHED - = DSP NOT APPL

LOAD	EVENT	PST DOW	PST BEGIN	PST DATE	UTC DATE	UTC DOY	UTC BEGIN	UTC END	DSS	PASS #	CL DOPP	OL DATA	ATDF	OL ODR	P-FLD	CL VAILD	OL VAILD	SC SPIN	COMMENTS PAGE 5 LUD 12/13/92
	USO Tst	Thurs.	13:02	28-Mar	28-Mar	87	13:02	15:04	43	528			GA0020		YES			ALSP	
	USO Tst	Wed.	16:02	3-Apr	3-Apr	93	16:02	18:04	43	534			GA0020		YES			ALSP	
	USO Tst	Tue.	16:00	9-Apr	9-Apr	99	16:00	18:00	43	540			GA0020		YES			DLSP	
	USO Tst	Fri.	13:45	19-Apr	19-Apr	109	13:45	15:30	43	550			GA0020		YES			ALSP	
	USO Tst	Sat.	00:00	27-Apr	28-Apr	118	00:00	02:00	63	558			GA0020		YES			ALSP	
	USO Tst	Mon	00:00	21-May	21-May	141	00:00	02:00	63	581			GA0021	GAO0058	YES			ALSP	
	USO Tst	Mon	23:00	3-Jun	3-Jun	154	23:00	01:00	61	595			GA0021	GAO0059	YES			ALSP	
																			CDA BUS RESET A AND BUS RESET B 07/08/91
	USO	Mon		5-Aug	5-Aug	217	0645-1155		43									DLSP	USO WAS SWITCHED OFF FOR COLD TURN
																			#2. TWTA-1 LOW PWR AT 10BIT WAS
																			SELECTED
																			USO SWITCHED ON 228/013112
X	USO Tst	Wed	18:30	4-Sep	4-Sep	247	00:00	18:30	63	688			GA0029		YES			ALSP	
	HGA ANOMALY																		
X	USO Tst	Mon	21:15	16-Sep	16-Sep	259	21:15	23:15	14	701			GA0030	GAO0060	YES			DLSP	
X	USO Tst	Wed	00:45	2-Oct	2-Oct	275	00:45	02:45	43	716			GA0031	GAO0061	YES			DLSP	
X	USO Tst	Sat	15:00	19-Oct	19-Oct	292	15:00	17:00	63	733			GA0032		YES			DLSP	
X	USO Tst	Thur	03:30	14-Nov	14-Nov	318	03:30	05:30	43	759			GA0033		YES			DLSP	
X	USO Tst	Sat	20:15	30-Nov	30-Nov	334	20:15	22:14	14	778			GA0034		YES			DLSP	
																			FUTURE EVENTS
																			Cooling Turn #5 2/24/92-3/06/92
																			Cooling Turn #6 04/06/92- 04/17/92
1992	USO Tst	Tue	03:25	10-Mar	10-Mar	70	03:25	05:25	43	876			GA0048		YES			DLSP	
	USO Tst	Wed	15:44	1-Apr	1-Apr	92	15:44	17:54	14	899			GA0049	GAO0062-64	YES			ALSP	Warming Turn #6 03/18/92-03/22/92
	USO Tst	Wed	19:32	22-Apr	22-Apr	113	19:32	21:42	43	920			GA0049		YES			ALSP	
	USO Tst	Thur	11:49	14-May	14-May	135	11:49	13:50	14	942			GA0051	GAO0065-68	YES			DLSP	
	USO Tst	Wed	19:17	3-Jun	3-Jun	155	19:17	21:17	43	962			GA0051						
	USO Tst	Wed	20:45	24-Jun	24-Jun	176	20:45	22:44	43	983			GA0051	GAO0069	YES			DLSP	
	USO Tst	Wed	03:12	15-Jul	15-Jul	196	03:12	05:12	63	1004			GA0053	GAO0070	YES			DLSP	
																			Warm / Cool Turns #7 07/20/92 - 07/31/92
	USO Tst	Sun	18:50	2-Aug	2-Aug	215	18:50	20:50	43	1022			GA0054	GAO0071	YES			DLSP	
	USO Tst	Thur	03:35	26-Aug	26-Aug	240	03:35	05:35	63	1046	Good	Good	GA0057	GAO0072	YES			DLSP	Channels 2 & 4 attu adjusted for 1 volt peak-to-peak
	USO Tst	Wed	06:30	17-Sep	17-Sep	262	01:30	06:30	63	1068	Good	Marginal	GAO058	GAO0073-76	YES			DLSP	DR # H2671 DSP halted 0130-0145z. reloaded
																			DR # H2672 CH 4 indicates filter 0 instead of 1.
																			Sta unable to change 0145 - 0330z.
																			Warm/Cool Turns #8 0831/92- 0911/92
																			Warm / Cool Turns # 9 09/21/92 - 10/02/92

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GALILEO USO ACTIVITIES

LOAD	EVENT	PST DOW	PST BEGIN	PST DATE	UTC DATE	UTC DOY	UTC BEGIN	UTC END	DSS	PASS #	CL DOPP	OL DATA	ATDF	OL ODR	P-FLD	CL VAILD	OL VAILD	SC SPIN	COMMENTS PAGE 6 LUD 12/13/92
	USO Tst	Mon	04:30	5-Oct	5-Oct	279	23:30	01:30	63	1066	Good	Good	GA0058	GAO0077-78	YES				
																		DLSP	DR # H2882 18 min Tracking outage 2135Z TO
																			2153Z. MDA Halted no impact to USO TEST
																			DR # H2885 Ant went to brake due to pedestal brake
																			being activated from 0735 to 0737z . Also no impact
																			to the USO Test.
																			Cold Turn #10 & Spin-up 10/19/92- 10/23/92
	USO Tst	Wed	01:30	28-Oct	28-Oct	302	21:30	23:30	63				GA0060	NONE	YES			DLSP	DSP RED DR#???

NA- NOT AVAILABLE NR- NOT REQUIRED N- NEED ODRs D= DSP SCHED N =DSP NOT SCHED - = DSP NOT APPL

CRUISE TEST SCHEDULE

(* schedule to be updated when final DSN allocations become available)

Test	Date	Time	Sequence
USO TESTS			
USO Test #1	10/22/92	11:00	C3
USO Test #2	11/7/92	11:30	C3
USO Test #3 (Occfig)	11/20/92	08:30	C4
USO Test #4	12/5/92	07:30	C4
USO Test #5	12/19/92	12:13	C5
USO Test #6	*1/14/93	21:00:00	C6
USO Test #7	*2/17/93	18:00:00	C7
USO Test #8	*3/4/93	22:00:00	C7
USO Test #9	*3/15/93	20:00:00	C8
USO Test #10 (Occfig)	*4/15/93	20:00:00	C8
USO Test #11	*4/26/93	20:00:00	C9
USO Test #12 (Occfig)	*5/11/93	20:00:00	C9
USO Test #13	*5/26/93	20:00:00	C10
USO Test #14	*6/10/93	20:00:00	C11
USO Test #15	*6/26/93	20:00:00	C11
USO Test #16 (Occfig)	*7/10/93	20:00:00	C12
USO Test #17	*7/23/93	20:00:00	C12
USO Test #18	*9/23/93	20:00:00	T4
USO Test #19	*11/3/92	20:00:00	T4

CRUISE TEST SCHEDULE (CONTINUED)

Test	Date	Time	Sequence
TRACKING SYSTEM CALIBRATION TESTS			
TSC Test #1	12/22/92	22:00:00	C5
TSC Test #2	*3/9/93	18:00:00	C7
TSC Test #3	*6/7/93	?	C11
TSC Test #4	*8/6/93	?	T2
GWE PERFORMANCE TESTS			
GWEPT #1	11/17/92	15:00:00	C4
GWEPT #2	12/1/92	14:00:00	C4
GWEPT #3	12/14/92	6:30:00	C4
OTHER TESTS TBD			
RADIO SCIENCE OPERATIONS READINESS TESTS			
RSORT #1	*5/7/93	20:00:00	C10
RSORT #2	*6/4/93	04:00:00	C10
RSORT #3	*6/25/93	12:00:00	C11