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Radio Science Handbook

Volume 2: 1991

Ulysses Solar Corona Experiment

Galileo Redshift Observation/ Ultrastable Oscillator Tests

June 14, 1991

Prepared by

Radio Science Support Team

JPL

Jet Propulsion Laboratory
California Institute of Technology

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Ulysses ACE
Galileo ACE
Ops Chief

DSCC 10 Director
DSCC 40 Director
DSCC 60 Director

Vellum File

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This document was prepared by members of the Radio Science Support Team. Team membership is listed in Table 4-1.

The Galileo Gravitational Wave Experiment description was provided by Drs. J. Armstrong and F. Estabrook. The Ulysses Gravitational Wave Experiment description was provided by Prof. B. Bertotti and information on the Medicina station were provided by L. Iess, A. Messeri and G. Comoretto. Assistance in preparing the description of the Ulysses Solar Corona Experiment was provided by Dr. M. Bird. Assistance in preparing the description of the Galileo Redshift observation was provided by Dr. T. Krisher.

Mardy Wilkins typed several portions of this document.

SECTION 1

INTRODUCTION

1.0 Scope

The Radio Science Handbook is an internal reference document used by the Radio Science 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 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 (RSST).

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.

Currently, the Radio Science Systems Group supports a number of Radio Science experiments on at least four flight projects (Galileo, Ulysses, Mars Observer, and Cassini). Experiments not addressed in this volume (e.g., Galileo Jupiter Orbital activities, Ulysses Gravitational Wave Experiment at the second opposition, etc.) will be described in future volumes of the Handbook.

1.1 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.

Shown in Figure 1-2 is a Galileo Mission Overview which is used to further assist in the planning of Radio Science activities for the Galileo Project.

1.2 Related Documents & Literature

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

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

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

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

For additional information on Gravitational Waves, see:

9. B. Bertòtti, 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, in press.

10. Berotti, B. 1983 "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.

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

For additional information on Redshift experiments, see:

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

For evaluation of the USO performance, see:

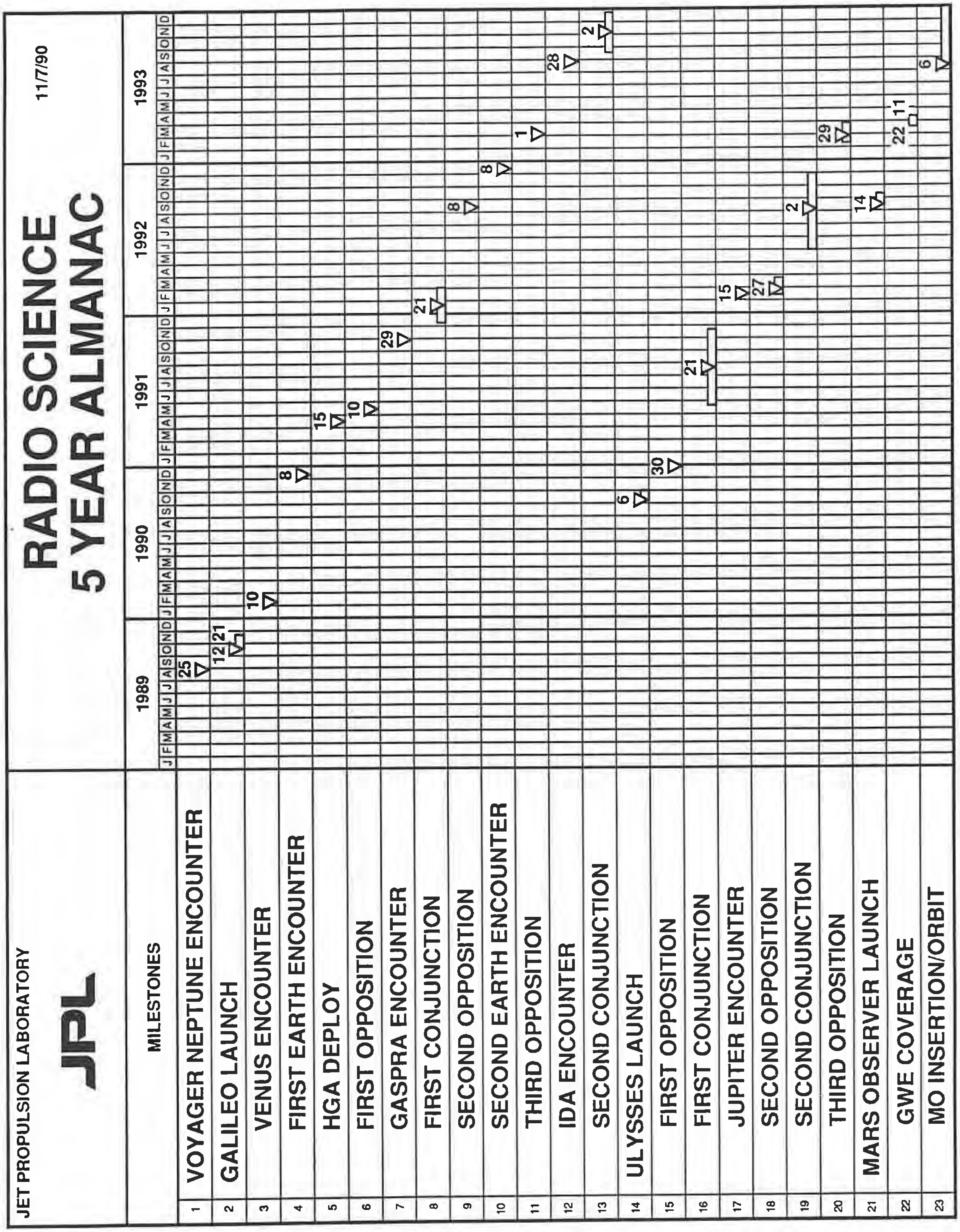
13. S. W. Asmar, P. Eshe, D. Morabito, "Evaluation of Radio Science Instrument: A Preliminary Report on the USO Performance, 10

August 1990, JPL IOM 3394-90-061.

For additional information on the Ulysses Solar Corona Experiment, see

14. M. K. Bird, S. W. Asmar, J. P. Brenkle, P. Edenhofer, M. Patzold, and H. Volland, "The Coronal-Sounding Experiment," Astronomy and Astrophyiscs, in press.

Figure 1-1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JPL
RADIO SCIENCE
5 YEAR ALMANAC
11/7/90
MILESTONES
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1990
1991
1992
1993
J F M A M J J A S O N D
1 VOYAGER NEPTUNE ENCOUNTER
2 GALILEO LAUNCH
3 VENUS ENCOUNTER
4 FIRST EARTH ENCOUNTER
5 HGA DEPLOY
6 FIRST OPPOSITION
7 GASPRA ENCOUNTER
8 FIRST CONJUNCTION
9 SECOND OPPOSITION
10 SECOND EARTH ENCOUNTER
11 THIRD OPPOSITION
12 IDA ENCOUNTER
13 SECOND CONJUNCTION
14 ULYSSES LAUNCH
15 FIRST OPPOSITION
16 FIRST CONJUNCTION
17 JUPITER ENCOUNTER
18 SECOND OPPOSITION
19 SECOND CONJUNCTION
20 THIRD OPPOSITION
21 MARS OBSERVER LAUNCH
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25
12 21
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29
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28
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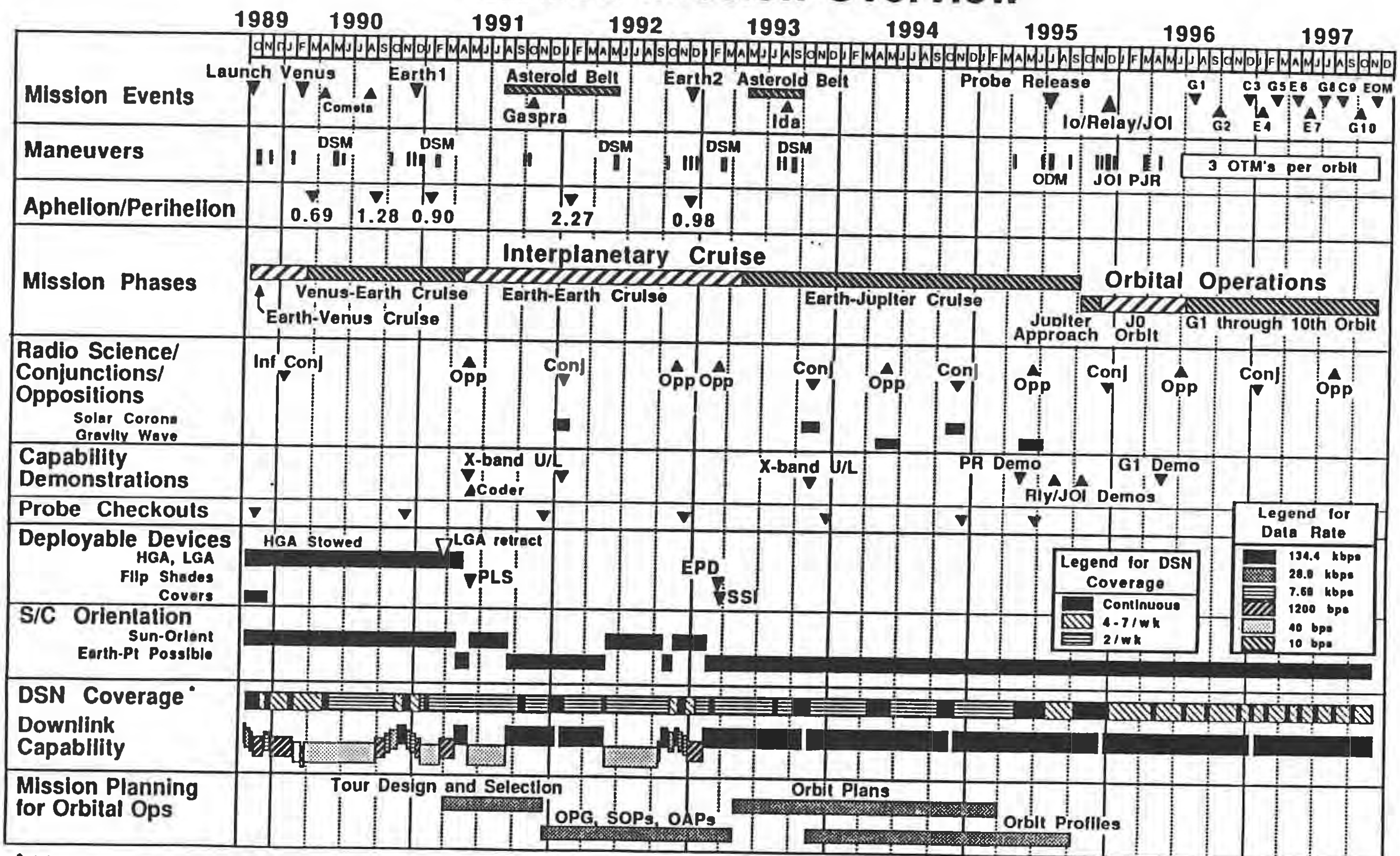
Figure 1-2

Galileo Mission Overview



* GSOC coverage of Cruise Science (5 tracks/week) starts in Sept 91 and continues through Sept 95.

JL
15 Sept 88

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 atmospheric and ionospheric structure of planets and satellites, planetary gravitational fields, shapes, and masses, planetary rings, ephemerides of planets, solar plasma and magnetic fields, gravitational wave search, and aspects of the theory of general relativity (e.g., gravitational redshift).

The Radio Science experiments described below have been implemented, are in progress, or are planned for the near future for the Galileo and Ulysses projects. Mars Observer and Cassini Radio Science experiments will be described in future volumes of this document. Section 4 list investigators involved in these experiments.

2.1 Galileo Gravitational Wave Experiment

The Galileo Gravitational Wave Experiment will be the most sensitive attempt to date to detect low frequency (i.e., less than ~0.1 Hz) gravitational waves. These gravitational waves are propagating gravitational fields, "ripples" in the curvature of space-time that carry energy and momentum and propagate away from their sources at finite speed. All relativistic theories of gravity agree on the existence of these waves. Theories differ, however, regarding essential properties of the radiation (e.g., number of polarization states, propagation speed). In Einstein's General Relativity, gravitational waves have two polarization states, propagate at the speed of light, and have space-time curvature (or apparent change of relative distances) transverse to the wave propagation direction.

The strength of a gravitational wave is characterized by the fractional distance change between test masses caused by the wave: the dimensionless "strain amplitude", $h = \Delta\ell/\ell$. Gravitational waves can in principle be produced in the laboratory (e.g., by a massive bar spinning about an axis perpendicular to its length) but the resulting signal is far too weak to be detectable with any foreseeable technology.

Much stronger gravitational waves are produced by astrophysical sources where there is coherent motion of very massive objects under extremely violent dynamical conditions. These astrophysical gravitational waves are still difficult to detect because they interact so weakly with matter. This property--the extremely weak interaction with matter--means, however, that they propagate unchanged from their sources:

detailed information about the time evolution of sources during violent events is preserved, unconfused by subsequent absorption or scattering. (This contrasts with electromagnetic waves, which can be screened or scattered by intervening matter. Even neutrinos produced in supernovae are scattered many times while leaving the cores of those explosions.) Relativistic motion of bulk matter and strong gravitational fields are central to most theoretical views about violent activity in supernovae, galactic nuclei, and quasars. When gravitational waves from these objects are detected, we will have the first observations of the interiors of strong-gravity, high-velocity regions.

Different astrophysical sources produce gravitational waves with different temporal behavior. Bursts (which last for at most a few cycles) are produced on a variety of time scales by, e.g., formation or collisions of black holes. Periodic waves (superpositions of one or more sinusoids that are approximately constant in amplitude and frequency over a typical observing time) could be produced, e.g., by binary neutron stars or black holes. Stochastic waves (random fluctuations that persist for times long with respect to the observing interval) could have been produced as a relic of inhomogeneity in the structure of the Big Bang itself.

Different detection methods are used, depending on the time scale of the radiation. Various noise sources (notably seismic noise) cause ground-based detectors to be most sensitive to high-frequency (kilohertz) waves. In contrast, space-based detectors are sensitive at low-frequencies because of the large characteristic scale of the experiments (mass separations ~astronomical units) and because of the relatively low "environmental noise" in space. This means that space-based detectors are sensitive to very different astrophysical sources than are laboratory detectors. On these ~10-10,000 second time scales the relevant sources are, e.g., background gravitational waves from the Big Bang, formation and vibrations of supermassive holes in galactic nuclei, and coalescence of massive binary black holes.

The Galileo Gravitational Wave Experiment uses the earth and the Galileo spacecraft as free test masses. The Doppler tracking system of the NASA Deep Space Network, driven by an ultra-high-quality frequency standard on the ground, monitors a coherently transponded X-band microwave link with Galileo. In doing so it continuously measures the relative dimensionless velocity ($\Delta v/c$) between the Earth and spacecraft. A gravitational wave passing through the solar system produces strain ($\Delta \ell/\ell$) on the earth-spacecraft system. The result is that the gravitational waveform is replicated three times in the Doppler tracking time series. This three-pulse response is an important signature of a gravitational wave and allows discrimination against phase noise sources in the Doppler measurement system that have different response functions.

To maximize the sensitivity of the Galileo Gravitational Wave Experiment to cosmic gravitational waves, extreme care must be taken to minimize effects of perturbing noise sources. These considerations lead to the following experimental requirements:

(1) Tracking should be done near solar opposition where the effects of charged particles on the solar wind which randomly perturb the phase of the radio signal ("solar wind phase scintillations") are minimized.

(2) Tracking should be done with the X-band uplink capability of the DSN and Galileo. Since solar wind phase scintillation noise scales as $(1/\text{radio frequency})^2$, use of X-band uplink and downlink reduces the plasma noise by more than a factor of 10 compared with previous generation (S-band) experiments.

(3) Tracking should be done with hydrogen-maser-quality frequency reference systems. Clock stability is crucial to the sensitivity of the overall experiment and the highest-quality frequency standard should be used to drive the electronics at the stations.

(4) Tracking should be two- or three-way, and as continuous as possible. The Doppler mode should be 2- or 3-way so as to reference the experiment to the high-precision ground frequency standard. The tracking should be as continuous as possible to maximize the chance of being "on" during a burst and to give long, relatively complete, records to use in the search for periodic or stochastic waves.

(5) Stations should be chosen and configured for maximum sensitivity. This means using the 34-m HEF stations and adjusting tracking operations so as to make the data as stable as possible.

(6) Both open- and closed-loop data should be taken. The open-loop data allow the Doppler to be extracted in post-processing in several different ways, building confidence in the reality of candidate events.

(7) When possible, there should be an independent, real time assessment of station performance, e.g., with the stability analyzer. This independent assessment of station stability can be used as a "veto" signal, if it detects transient stability problems in the station. Also, the sensitivity of searches for gravitational wave backgrounds can be improved when there is an independent assessment of station stability.

(8) The spacecraft should be in as quiet a mode as is feasible. Spacecraft dynamics or perturbations in the radio system that cause

noise in the measurements and should be minimized.

(9) Engineering telemetry relating to spacecraft events, spacecraft spin rate, and state of the radio system need to be taken for correlation with candidate events in the Doppler time series. The Galileo spacecraft and the 34-m HEF X-band uplink combine to make this experiment much more sensitive than previous searches. The improved sensitivity means that candidate noise sources that were ignorable in previous generation experiments now need to be considered. Spacecraft events that affect the Doppler observable need to be recorded and integrated with the Doppler data to act as "veto signals" in the analysis.

(10) Tropospheric and ionospheric calibration data, to the extent available, should be gathered to assess the effect of these propagation noise sources and, if possible, calibrate and remove them.

(11) "Calibration signals" should occasionally be introduced into the data to verify performance. A possible way to do this is to occasionally (perhaps once per pass, for a duration of about 5 minutes), introduce known, systematic variations in the phase by moving the subreflector to a new position and then moving it back to its (fixed) position for the rest of the pass.

2.2 Ulysses Gravitational Wave Experiment

The Ulysses Gravitational Wave Experiment is designed to attempt detection of low frequency (i.e., in the mHz band) gravitational waves. (for references see Section 1.2 Related Documents). Possible astrophysical sources in this frequency band are: collapse and collisions of black holes in the nuclei of galaxies and quasars; periodic wave trains emanating from massive orbiting binary black holes; or an isotropic background of cosmological origin. For this experiment, Doppler tracking is most sensitive to waves whose characteristic time scale τ is shorter than the round-trip-light-time, T. Since one expects all the above sources to be stronger at lower frequencies, it is important to extend the measurement to as low a frequency as possible. Also, at frequencies lower that 1/T, the effect of the fluctuations in the interplanetary plasma are better compensated by the incomplete radio frequency link available on Ulysses. These considerations point to two crucial experimental requirements

(1) The tracking should be divided in continuous periods of longest possible duration by overlapping station passes. Particular care must be taken in the station handover procedures to minimize gaps in the data.

(2) Both X- and S-band should be available during the test to partially eliminate the plasma noise, which is greater at lower frequencies. This will be done also by using a special algorithm being developed which allows a prediction of uplink plasma content from the measured downlink content.

Several of the First Opposition Test objectives listed above address the evaluation of the different contributors to the error budget. This is particularly important in view of the fact that the spacecraft's transponder has not been completely tested prior to launch. The error budget will be realized after complete analysis of the opposition data from the participating stations and at both frequency bands, along with information gathered from ionospheric and ground weather data.

The distance of the spacecraft at first opposition, corresponding to a round-trip-light-time T of 72 seconds does not allow a good sensitivity in the mHz band (indeed the bare sensitivity of Doppler tracking, before filtering, is proportional to T up to $T = \tau$ and stays approximately constant beyond τ). However, the available data will be analyzed with the purpose of extracting all the information (in particular, upper limits in the time and frequency domains) concerning gravitational waves of different sorts.

The Ulysses Radio Science experiments will use the 70-m (DSS 14, 43, 63) and 34-m STD (DSS 12, 42, 61) stations (will **not** use 34 meter HEF stations because Ulysses does not utilize X-band uplink and the Radio Science experiments will be in the two-way mode). The strategy of the First Opposition Test was to cycle through all the 70-m and 34-m STD station subnets in order to test the system using each of these stations.

The data observables are closed-loop Doppler, range, DRVID, and open-loop data from each station; except for DSS 12 which is not equipped with open-loop data acquisition capability. The first opposition test was described in volume 1 of this handbook.

2.3 Galileo Faraday Rotation Experiment

See volume 3 of this handbook.

2.4 Ulysses Solar Corona Experiment

The Ulysses Solar Corona Experiment (SCE), conducted during the solar conjunctions, performs coronal-sounding measurements (see reference in section 1.2). The SCE utilizes dual frequency (S- and X-bands) Doppler and range data to determine the density, velocity, and turbulance spectrum of the Sun's atmosphere to distances well below 10 solar radii. Radio-sounding observations are sensitive to plasma parameters in the main acceleration regime of the solar wind.

The Doppler and ranging data will be used to derive the three dimensional distribution of the coronal electron density. The large scale structure can be inferred from the total electron content obtained from the dual frequency ranging. The dual-frequency Doppler is more sensitive to relative changes in the electron content. The dual-frequency Doppler data will also be used to characterize the level and spectral index of coronal turbulence. Another plasma parameter obtained from radio sounding is the velocity. The most reliable measurements of this type are obtained from cross correlation of radio scintillation using multiple signal ray paths. It is anticipated that the interplanetary vestiges of a coronal mass ejection will be occasionally detected as significant perturbation in the ranging and Doppler data.

2.5 Ulysses Io Plasma Torus Occultation Experiment

See volume 3 of this handbook.

2.6 Galileo Redshift Observations & USO Tests

The Ultrastable Oscillator Redshift Observations (USORSO) are performed to measure the frequency shift caused by the motion of the spacecraft as it moves in and out of the solar (or any 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) 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 USORSO observations 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.

The USORSO experiment measures the spacecraft USO-referenced frequency shift caused by the motion of the Galileo spacecraft while it flies into and out of any gravitational field it may encounter.

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 USORSO 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.

The attached table shows an up-to-date list of USORSO passes.

2.7 Galileo Earth/Gaspra Mass Determination

See volume 1 of this handbook for the Earth 1 flyby (Dec. '90) and a future volume for Earth 2 flyby (Dec. '92).

GALILEO USO ACTIVITIES

LOAD	EVENT	PST DOW	PST BEGIN	PST DATE	UTC DATE	UTC DOY	UTC BEGIN	UTC END	DSS	PASS #	CL DOP	OL DATA	ATDF	OL ODR	P-FLD	CL VALID	OL VALID	RS EDR	COMMENTS PAGE 1 LUD 06/05/91
EV-3	USO-ON	Mon.	16:34	4-Dec	5-Dec	339	00:34	00:45	14		Good	NA	GA0001	NA			NA		USO Tuned ON 56 mins. early by real-time cmd. 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		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		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			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		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		No OL data acquired due to DSP problem. DR F5493
	USO Tst	Tue.	09:05	2-Jan	2-Jan	2	17:05	18:59	14		Good	Good	GA0004	GAO0006		Good			Good 1/sec Doppler + OL data. DSP Config. ?
	RSF TLC	Thur.	11:02	4-Jan	4-Jan	4	19:02	20:55	14		Good	NR	GA0002	NA		Good	NA		
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		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			SSI Red, No RT OL data displays. Possible wrong Configuration. DR F5279.
	RFS TLC	Tue.	12:19	16-Jan	16-Jan	16	20:19	22:11	14		None	NR	None	NA		NA	NA		RFS Test aborted due to S/C anomaly.
	USO Tst	Thur.	09:31	18-Jan	18-Jan	18	17:31	19:29	14		None	None	None	NA		NA	NA		USO Test aborted.
	USO Tst	Fri.	08:00	19-Jan	19-Jan	19	16:00	18:00	14		Good	NA	GA0002	NA		Good	NA		DSS 14 Transmitter off to acquire 1-way data.
	USO Tst	Fri.	08:01	26-Jan	26-Jan	26	16:01	17:59	14		None	None	None	NA		NA	NA		USO Test aborted.
	USO Tst	Sun	08:00	28-Jan	28-Jan	28	16:00	18:00	14		Good	NA	GA0002	NA		Good	NA		DSS 14 Transmitter off.
	USO Tst	Tue.	11:22	30-Jan	30-Jan	30	19:22	21:20	14		None	None	None	NA		NA	NA		USO Test aborted.
	USO Tst	Thur.	07:30	1-Feb	1-Feb	32	15:30	17:30	14	107	Good	NA	GA0008	NA	YES	Good	NA		DSS 14 Transmitter off
	USO Tst	Fri.	07:32	2-Feb	2-Feb	33	15:32	17:30	14		None	None	None	NA	YES	NA	NA		USO Test aborted
	USO Tst	Sun.	07:30	4-Feb	4-Feb	35	17:30	19:30	14		None	NR	None	NA		NA	NA		DSS 14 Transmitter off. Test aborted.
	USO Tst	Tue.	02:45	6-Feb	6-Feb	37	10:45	12:45	63		?	NA	GA0004	NA		Good	NA		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		USO test was aborted.
	RFS TLC	Tue.	10:50	6-Feb	6-Feb	37	18:50	20:43	14		None	NR	None	NA		NA	NA		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		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			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			RST Demonstration. Woo and Estabrook observed RODAN and SFOF operations.
	USO Tst	Sun.	11:33	18-Feb	18-Feb	49	19:33	21:31	43	124	Good	Good	GA0007	N	YES	Good			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	RS EDR	COMMENTS PAGE 2 LUD 06/05/91
VE-1 -	CDU SNR	Wed	08:20	21-Feb	21-Feb	52	16:02	17:09	14		?	NR		NA		Bad	NA		No RT Monitor. 1/60 sec Doppler
	RSF TLC	Wed.	13:57	21-Feb	21-Feb	52	21:57	23:51	43		?	NR		NA		Good	NA		No RT Monitor
	RFS AGC	Thur.	12:08	22-Feb.	22-Feb.	53	20:08	21:39	14		Good	NR	GA0006	NA		Good	NA		
	USO Tst	Sat.	18:03	24-Feb.	25-Feb.	56	02:03	03:32	43	130	Good	Good	GA0006	GAO0010	YES	Good			
	USO Tst	Tue.	15:03	27-Feb	27-Feb	58	23:03	01:02	43	133	Good	Good	GA0006	GAO0011	YES	Good			
	USO Tst	Thur.	16:03	1-Mar	2-Mar	61	00:03	02:32	43	135	Good	Good	GA0006	GAO0012	YES	Good			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		
	CDU SNR	Mon.	13:25	5-Mar	5-Mar	64	21:25	22:31	43	139	Good	NR	GA0006	NA	YES	Good	NA		
	RFS AGC	Mon.	15:10	5-Mar	5-Mar	64	23:10	00:31	43		?	NR		NA		Good	NA		No RT Monitor.
	USO Tst	Thur.	18:04	8-Mar	9-Mar	68	02:04	03:48	43	142	Good	Good	GA0006	N	YES	Good			
	USO Tst	Fri.	18:05	16-Mar	17-Mar	76	02:05	03:33	43	150	Good	Good	GA0007	N	YES	Good			
	USO Tst	Sun.	16:35	18-Mar	19-Mar	78	00:35	02:34	43	152	Good	Good	GA0007	N	YES	Good			
	USO Tst	Sat.	11:05	24-Mar	24-Mar	83	19:05	21:04	43	158	Good	Good	GA0008	N	YES	Good			
VE-2	USO Tst	Thur.	16:06	29-Mar	30-Mar	89	00:06	02:04	43	163	Good	Good	GA0007	N	YES	Good			TSS Demonstration
	CDU SNR	Sun.	15:59	1-Apr	1-Apr	91	22:59	00:05	43	166	?	NR	GA0007	NA	YES	Good	NA		Telecomm RT Monitor
	RFS TLC	Sun.	17:29	1-Apr	2-Apr	92	00:29	02:23	43	166	?	NR	GA0007	NA	YES	Good	NA		Telecomm RT Monitor
	RFS AGC	Mon.	18:09	2-Apr	3-Apr	93	01:09	02:30	43	167	?	NR	GA0007	NA		Good	NA		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			
	USO Tst	Sat.	15:07	14-Apr	14-Apr	104	22:07	00:05	43	179	?	?	GA0009	N	YES	Good			
	USO Tst	Thur	17:37	19-Apr	20-Apr	110	00:37	02:36	43	184	?	?	GA0010		YES				Mis-placed Pass, found by Paula ,thanks !!!!
VE-3	USO Tst	Mon.	18:07	23-Apr	23-Apr	113	20:07	22:06	43	184	Good	NA	GA0010	NA	YES		NA		
	USO Tst	Tue.	16:07	1-May	1-May	121	23:07	01:06	43	196	NA		GA0009	NA	YES	Good	NA		
	USO Tst	Tue.	02:08	8-May	8-May	128	09:07	11:07	63	202	?	?	GA0009	N	YES	Good			No RT Monitor
	USO Tst	Wed.	16:17	16-May	16-May	136	23:17	01:17	43	211	?	?	GA0009	GAO0013	YES	Good			No RT Monitor
	USO Tst	Sat.	12:53	19-May	19-May	139	19:53	21:51	43	214		NA	GA0009	NA	YES	Good	NA		Post USO High Power Ranging Test.
	RFS TLC	Fri.	11:17	25-May	25-May	145	18:17	20:11	14	220	Bad	NR	NA	NA	YES	NA	NA		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			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		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		

NA- NOT AVAILABLE NR- NOT REQUIRED N- NEED OD ?= 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	RS EDR	COMMENTS PAGE 3 LUD 06/05/91
	USO Tst	Mon.	12:08	4-Jun	4-Jun	155	19:08	21:06	43	230	Good	NA	GA0009	NA	YES	Ugly	NA		
VE-5	USO Tst	Mon	11:11	11-Jun	11-Jun	162	18:11	19:44	14	237	Good		GA0011		YES				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				No SSI Displays
	USO Tst	Mon	09:07	25-Jun	25-Jun	176	16:07	18:09	14	251		?	GA0010		YES				No SSI displays DR F8135
	USO Tst	Mon	11:07	2-Jul	2-Jul	183	18:07	20:09	43	258	?	?	GA0010	GAO0015	YES				No RT Monitor
	RFS TLC	Thurs.	14:51	5-Jul	5-Jul	186	21:51	23:45	43	261	?	NR	GA0010	NA	YES		NA		
	CDUSNR	Wed	13:11	11-Jul	11-Jul	192	20:11	22:17	43	267	Good	NR	GA0010	NA	YES		NA		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		Low Elevation. GWE Demo.
	USO Tst	Thurs	07:37	12-Jul	12-Jul	193	14:37	16:38	14	268	Good	NA	GA0010	NA	YES		NA		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		DSP POCA red for support DRF8588.
	USO Tst	Wed.	14:06	25-Jul	25-Jul	206	21:06	23:08	43	281	Good	Good	GA0010	GAO0016	YES				SSI not enabled and recording started late DRF8819
	USO Tst	Wed.	14:06	1-Aug	1-Aug	213	21:06	23:08	43	288	Good	Good	GA0011	GAO0017	YES				Stowed Antenna at 22:08z for High Winds DR F8899
	USO Tst	Thurs.	13:35	9-Aug	9-Aug	221	20:35	22:37	43	296			GA0011	GAO0018	YES				
	USO Tst	Thurs.	11:05	16-Aug	16-Aug	228	18:05	20:07	43	303			GA0011	GAO0019	YES				
	USO Tst	Tue.	08:05	21-Aug	21-Aug	233	15:05	17:07	14	308			GA0011		YES				
	RFS TLC	Fri.	13:11	24-Aug	24-Aug	236	20:11	22:05	43	311			GA0011		YES				
	RFS AGC	Mon.	11:41	27-Aug	27-Aug	239	18:41	20:02	43	314			GA0011		YES				
	USO Tst	Fri.	12:34	31-Aug	31-Aug	243	19:34	21:36	43	318			GA0011		YES				
	USO Tst	Thurs.	18:34	6-Sept.	7-Sep	250	01:34	03:36	63	324			GA0011		YES				
	USO Tst	Mon.	12:04	10-Sept.	10-Sept.	253	19:04	21:05	43	328			GA0011		YES				
	USO Tst	Wed	12:18	19-Sept.	19-Sept.	262	19:18	21:20	43	337			GA0012		YES				
	USO TST	Mon.	15:30	24-Sept.	24-Sept.	268	00:30	03:40	63	342			GA0012		YES				
	USO Tst	Mon	11:47	01-Oct.	01-Oct.	274	18:47	20:49	43	349			GA0012	GAO0021	YES				
	USO Tst	Mon.	10:02	08-Oct.	08-Oct.	281	17:04	19:04	43	356			GA0012		YES				
	RSF AGC	Fri.	07:40	19-Oct.	19-Oct.	292	14:40	15:55	43	367			GA0012						
	RFS TLC	Fri.	09:30	19-Oct.	19-Oct.	292	16:30	18:24	43	367			GA0012						
	USO Tst	Mon.	17:31	31-Oct.	31-Oct.	303	01:31	03:32	63	377			GA0012						
	USO Tst	Wed.	17:00	07-Nov.	07-Nov.	312	01:00	03:02	63	386									

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	RS EDR	COMMENTS
	USO Tst	Fri.	19:00	16-Nov.	16-Nov.	321	03:00	05:02	63	395			GA0016	GAO0022	YES				
														GAO0023					
														GAO0024					
	USO Tst	Sun	17:00	25-Nov.	25-Nov.	330	01:00	03:01	63	404			GA0016		YES				
	USO Tst	Mon.	01:54	10-Dec	10-Dec.	345	01:54	03:45	42	420			GA0016		YES				
	USO Tst	Wed.	08:00	12-Dec	12-Dec.	346	08:00	11:00	63	421			None		YES				
	USO Tst	Sun.	08:14	16-Dec.	16-Dec.	350	08:14	10:16	61	425			GA0016		YES				
	USO Tst	Wed.	17:00	26-Dec.	26-Dec.	360	17:00	19:01	43	436			GA0016	GAO0043	YES				
1991																			
	USO Tst	Thur.	07:30	3-Jan	3-Jan	4	07:30	09:32	63	444			GA0016		YES				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				
	CDU SNR	Wed.	16:58	9-Jan	9-Jan	9	16:58	17:49	43	450			GA0016		YES				
	RFS AGC	Wed.	18:28	9-Jan	9-Jan	9	18:28	19:49	43	450			GA0016		YES				
	RFS TLC	Thurs.	20:48	10-Jan	10-Jan	10	20:48	22:42	43	451			GA0016		YES				
	USO Tst	Mon.	16:45	14-Jan	14-Jan	14	16:45	18:47	43	455			GA0017	GAO0045	YES				
	USO Tst	Wed.	17:01	16-Jan	16-Jan	16	17:01	19:02	43	457			GA0017	GAO0046	YES				
	USO Tst	Sat.	16:01	19-Jan	19-Jan	19	16:01	18:03	43	460			GA0017	GAO0047	YES				
	USO Tst	Mon.	18:01	21-Jan	21-Jan	21	18:01	20:03	43	462			GA0017	GAO0048	YES				
	USO Tst	Sat.	16:01	26-Jan	26-Jan	26	16:01	18:03	43	467			GA0017	GAO0049	YES				
	USO Tst	Mon.	06:01	29-Jan	29-Jan	29	06:01	08:03	63	469			GA0017	GAO0050	YES				
	USO Tst	Sat.	15:46	2-Feb	2-Feb	33	15:46	17:48	43	474			GA0017	GAO0051	YES				
	USO Tst	Mon.	06:01	4-Feb	4-Feb	36	06:01	08:03	63	476			GA0017		YES				
	USO Tst	Thurs.	06:01	7-Feb	7-Feb	39	06:01	08:03	63	479			GA0017		YES				
	USO Tst	Tue.	15:02	12-Feb	12-Feb	43	15:02	17:03	43	484			GA0017	GAO0052	YES				
	USO Tst	Mon	21:17	18-Feb	18-Feb	49	21:17	23:19	43	490			GA0017	GAO0053	YES				
	USO Tst	Sun.	15:32	24-Feb	24-Feb	55	12:50	18:15	43	496			GA0018	GAO0054	YES				
	RFS TLC	Thurs.	16:16	28-Feb	28-Feb	59	16:16	18:10	43	500			GA0018		YES				
	USO Tst	Tue.	14:03	5-Mar	5-Mar	64	14:02	16:04	43	505			GA0018	GAO0055	YES				
	RFS AGC	Wed.	22:31	6-Mar	6-Mar	65	22:31	23:53	43	506			GA0018		YES				
	USO Tst	Thurs.	16:17	14-Mar	1`4-Mar	73	16:17	18:19	43	514			GA0018	GAO0056	YES				
	USO Tst	Fri.	15:02	22-Mar	22-Mar	81	15:02	17:04	43	522			GA0018	GAO0057	YES				

NA- NOT AVAILABLE NR- NOT REQUIRED N- NEED OD 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	RS EDR	COMMENTS PAGE 5 LUD 06/05/91
	USO Tst	Thurs.	13:02	28-Mar	28-Mar	87	13:02	15:04	43	528					YES				
	USO Tst	Wed.	16:02	3-Apr	3-Apr	93	16:02	18:04	43	534					YES				
	USO Tst	Tue.	16:00	9-Apr	9-Apr	99	16:00	18:00	43	540									
	USO Tst	Fri.	13:45	19-Apr	19-Apr	109	13:45	15:30	43	550									
	USO Tst	Sat.	00:00	27-Apr	28-Apr	118	00:00	02:00	63	558									
	USO Tst	Mon	00:00	21-May	21-May	141	00:00	02:00	63	581									
	USO Tst	Mon	23:00	3-Jun	3-Jun	154	23:00	01:00	61	595									
	USO Tst	Thurs	12:59	6-Jun	6-Jun	157	12:59	15:00	43	598									

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

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 Galileo Spacecraft

The Galileo spacecraft is shown on Figure 3-1. The Galileo telecommunications subsystem is shown is 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 perform Radio Science observations. The subsystem is equipped with two redundant transponders with dual frequency (S- and X-bands) uplink and downlink capabilities.

The subsystem may be operated in the coherent mode, in which the downlink signal is referenced to the uplink signal, or the non-coherent mode, where 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. Commands to the spacecraft also determine the mode as well as the selection one of the following: 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.

3.2 The Ulysses Spacecraft

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 antennae are coupled to two redundant transponders, 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 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 manoeuver 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 onboard 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.

3.3 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 3-5 through 3-10 show the various systems relevant to the Radio Science activities.

3.3.1 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 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.

3.3.2 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 a 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 RA and DEC three points 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.

3.3.3 DSCC ANTENNA MICROWAVE SUBSYSTEM

3.3.3.1 70-m Anetennas

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.

3.3.3.2 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.

3.3.3.3 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.

3.3.4 DSCC RECEIVER-EXCITER SUBSYSTEM

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.

3.3.4.1 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 could 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, 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.

3.3.4.2 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 IFs from the 70-m and 34-m HEF stations. It also switches between the Radio Science and VLBI systems.

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 Table 3-3.

3.3.4.3 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 spectra 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 downlnk 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%.

3.3.5 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.

3.3.6 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 3-9 and 3-10.

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 DSN Multi-Mission NAV group 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.

3.3.7 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 computer compatible 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 Table 3-2.

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.

3.3.8 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.

3.4 Other Facilities

3.4.1 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.

3.4.2 GCF DATA SUBSYSTEM

Communication with DSN complexes takes place over the Ground Communication Facility (GCF) data lines. See section 9 for a discussion of the normal configuration of these lines.

These lines transmit Radio Science open-loop tuning predicts from the NOCC to the DSS (and CTA-21) and sends 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, this subsystem can be used to send Radio Science data from the DSCC to the NOCC.

3.4.3 GCF DATA RECORDS SUBSYSTEM

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

3.4.4 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 planed for the Radio Science activities

3.4.5 RODAN INTERFACE

Data lines from GCF to RODAN allow the RSST to capture and display Radio Science data from the GCF lines. See Section 9 for a more complete description.

3.4.6 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.

3.4.7 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.

3.4.8 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 the experiments.

3.4.9 MISSION CONTROL COMPUTER CENTER (MCCC)

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

3.4.10 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 displays with hardcopy capability are provided to the Project's real-time operations personnel to aid in operations monitoring.

Table 3-1

Radio Science Station Capabilities

DSCC:

Antenna Mechanical Subsystem	ANT
Antenna Control Subsystem	ACS
Antenna Pointing Subsystem	APA
Microwave Subsystem	UWV
Receiver-Exciter Subsystem	RCV
Block IV Receivers	
Open-Loop Receiver	OLR
Block IV Exciter Assembly	EXC
Precision Power Monitor	PPM
Spectral Signal Indicator	SSI
Noise Adding Radiometer	NAR
Signal Level Estimator	SLE
DSCC Tracking Subsystem	DTK
SIM Synthesizer	
Block IV Extractors	
Metric Data Assembly	MDA
Sequential Ranging Assembly	SRA
DSCC Spectrum Processing Subsystem	DSP
Complex Monitor and Control Assembly	CMC
Link Monitor and Control Assembly	LMC
Frequency and Timing Subsystem	FTS
Area Routing Assembly	ARA
Local Area Network	LAN

JPL:

NOCC:	NSS, VAP, NRV, NTK
GCF:	Voice Comm., Data lines, DRG
MCCC:	RTDS
MSA:	Display terminal
RSSS:	RMS, DRS, PAS

Table 3-2

Station Configuration

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.

Ulysses Solar Corona Experiment Configuration:

The Doppler sample rate is one per second for priority 1 (6 August to 25 August) and one per 10 seconds for other times. The required frequency and timing reference is the Hydrogen maser. The ranging parameters are shown in the NOP.

The DSP should be configured as shown in Table 3-2a below, **except** for periods of small SEP angles (approximately one week before loss of signal and one week after recovery of signal) where the DSP will be configured as in Table 3-2b. The RSST will inform the NOPE of the exact times to use the modified configuration.

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 the Table 3-2a.

Table 3-2a: Galileo/Ulysses Radio Science DSP Configuration

Parameter	DIRECTIVE	Setting	Notes
70-m (DSS: 14, 43, or 63) Galileo or Ulysses spacecraft			
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 = 1	XRCP
		B = 2	SRCP
		C = 3	XLCP
		D = 4	SLCP
Output to SSI	SSS	B	
Bit resolution	NBRES	8	
Tape density, bpi	DENS	6250	458.3 min/tape
34-m HEF (DSS: 15, 45, or 65) Galileo spacecraft			
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 = 2	SRCP
		C = 1	XRCP
		D = 2	SRCP
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) Galileo or Ulysses spacecraft			
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 = 3	XRCP
		B = 4	SRCP
		C = 3	XRCP
		D = 4	SRCP
Output to SSI	SSS	B	
Bit resolution	NBRES	8	
Tape density, bpi	DENS	6250	458.3 min/tape

Table 3-2b: Ulysses SCE DSP Configuration at Small SEP Angles

Parameter	DIRECTIVE	Setting	Notes
70-m (DSS: 14, 43, or 63)			
Filter number	DEFFL	3 3 3 3	2000 Hz BW
Filter offset	RIVOF	-3750	in Hz
NBOC mode	MODE	1	
Sample rate	NBRAT	5000	samp/sec
IVC switch	CFG	PRIME	
Chan. assignment	NBCHN		NBOC ch=RIV ch
		A = 1	XRCP
		B = 2	SRCP
		C = 3	XLCP
		D = 4	SLCP
Output to SSI	SSS	B	
Bit resolution	NBRES	8	
Tape density, bpi	DENS	6250	80 min/tape

Table 3-3

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.

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

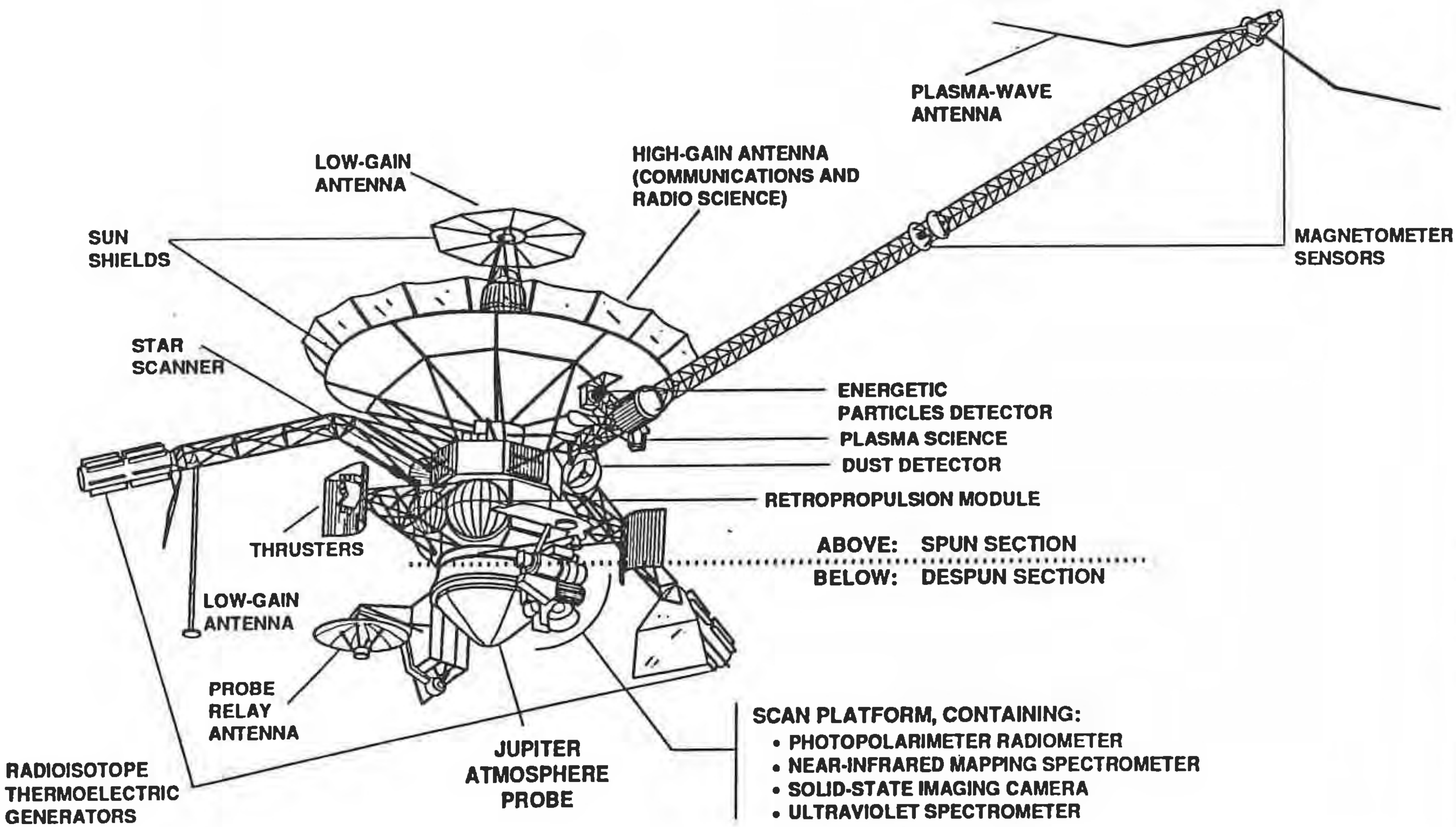
$$SNR = P_S - P_N$$

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

To compute changes in RMS voltage levels, use:

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

GALILEO SPACECRAFT



F' ure 3-1

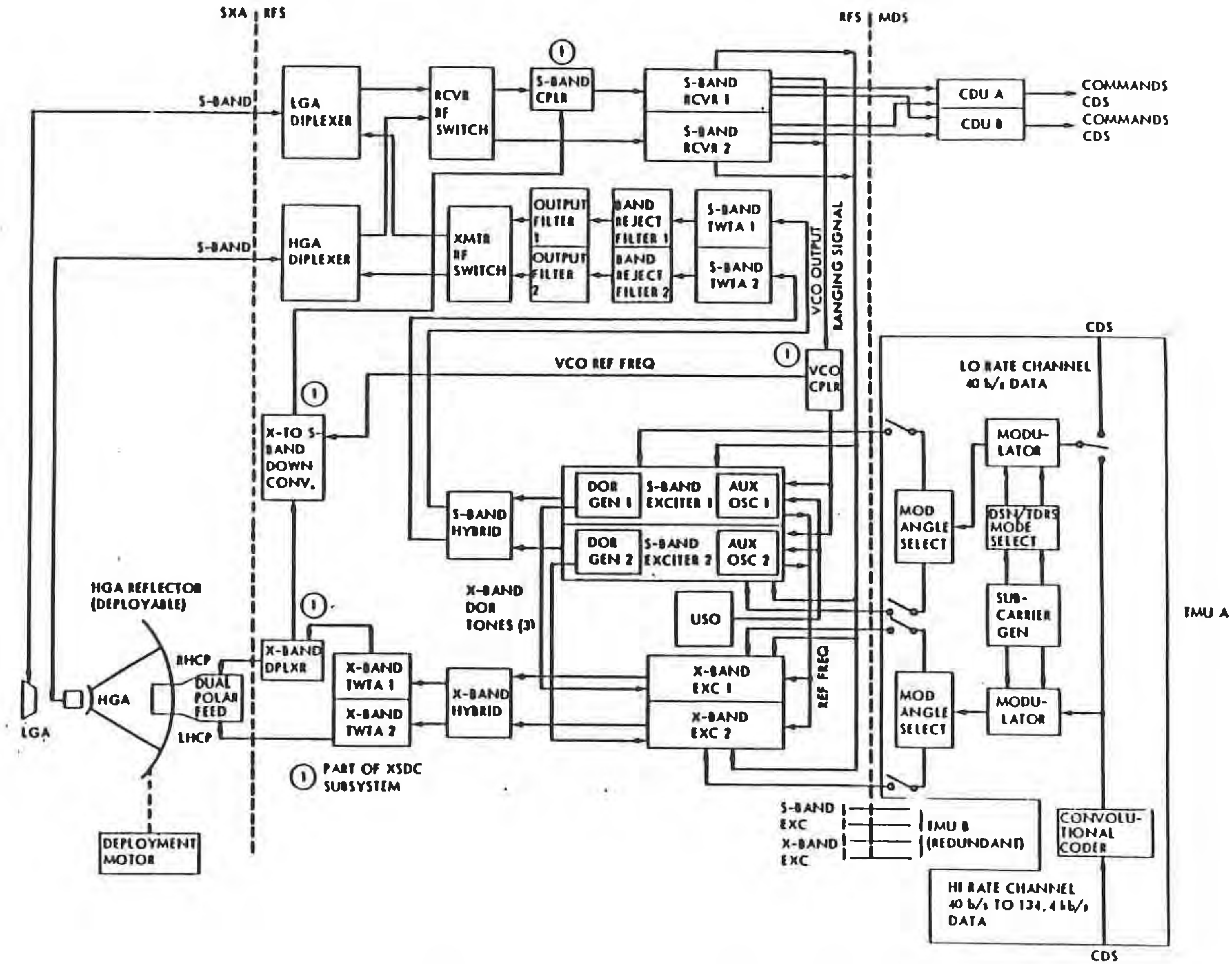
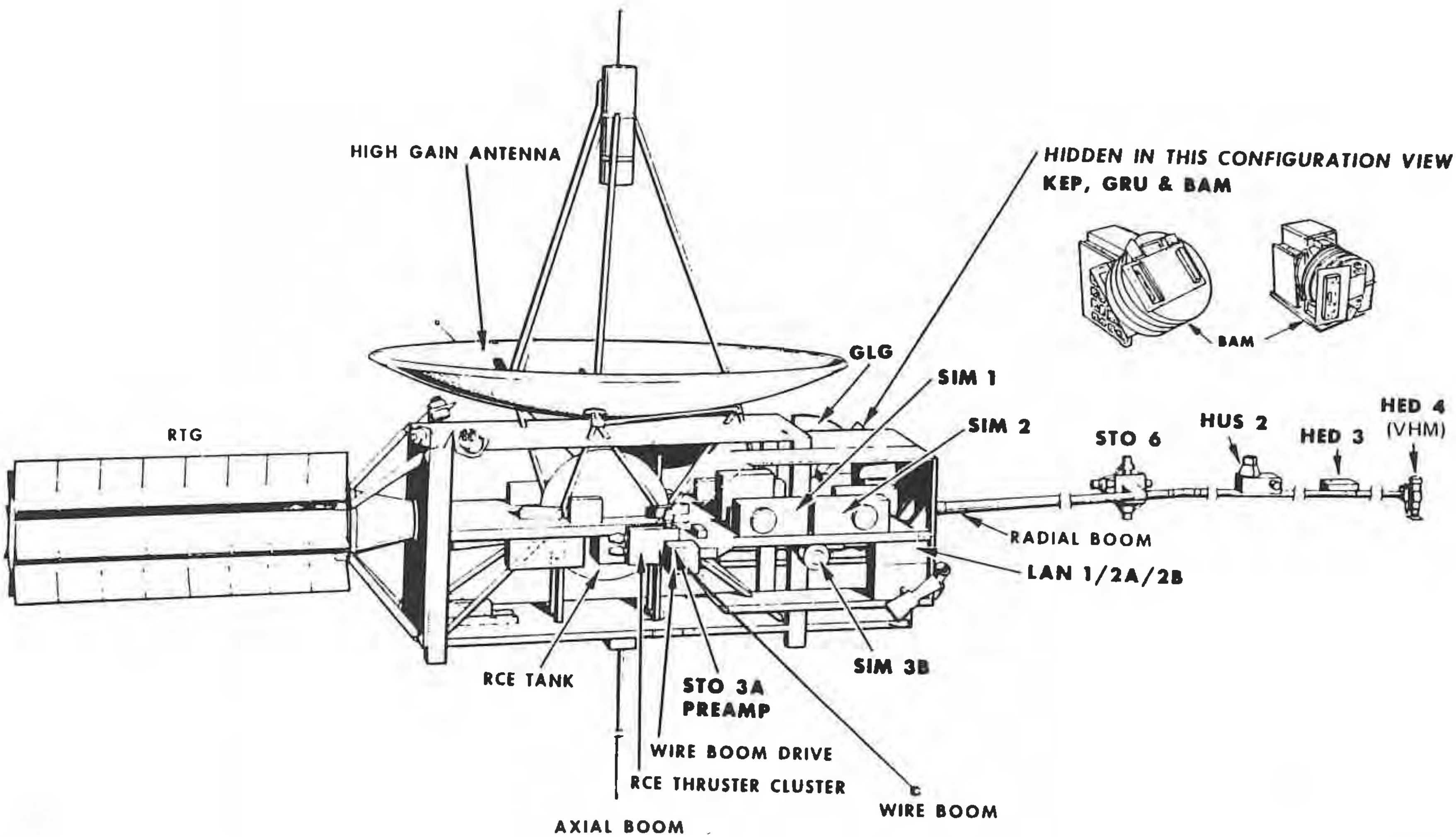


Figure 3-2 Galileo Orbiter Telecommunications System

Figure 3-3

JPL

OVERVIEW PRESENTATION
ULYSSES SPACECRAFT CONFIGURATION



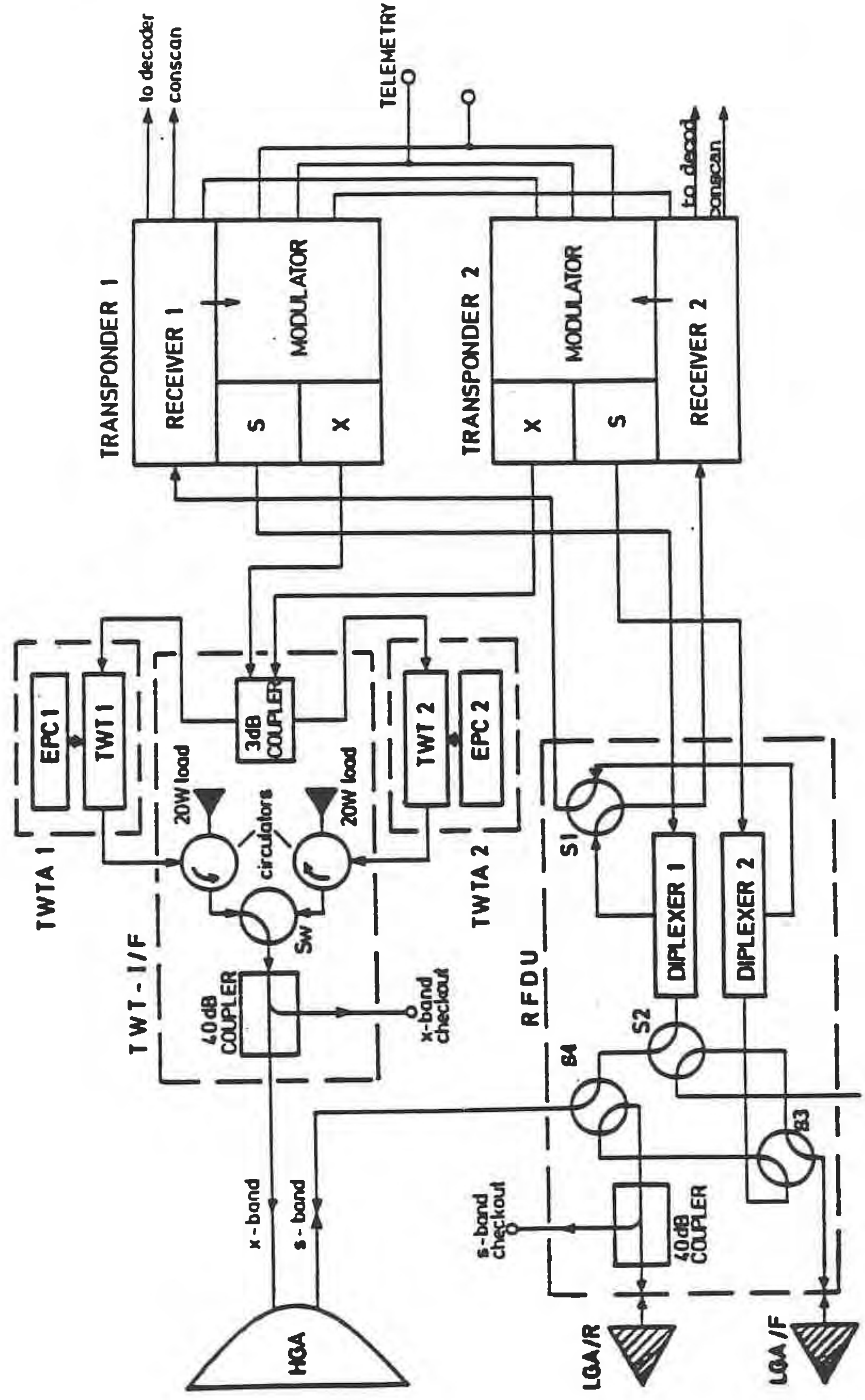
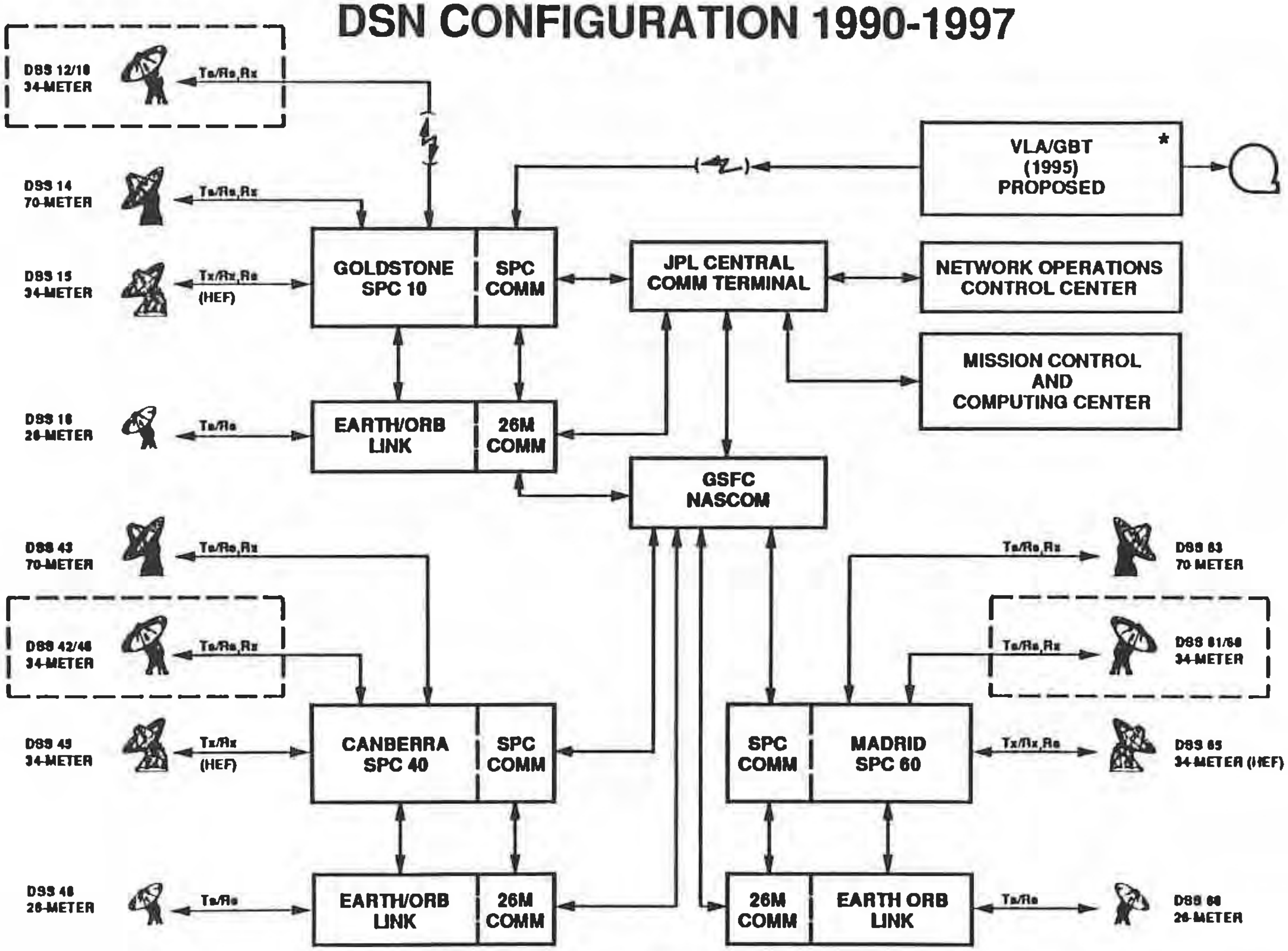


Figure 3-4 Telecommunications subsystem Block Diagram

DSN CONFIGURATION 1990-1997



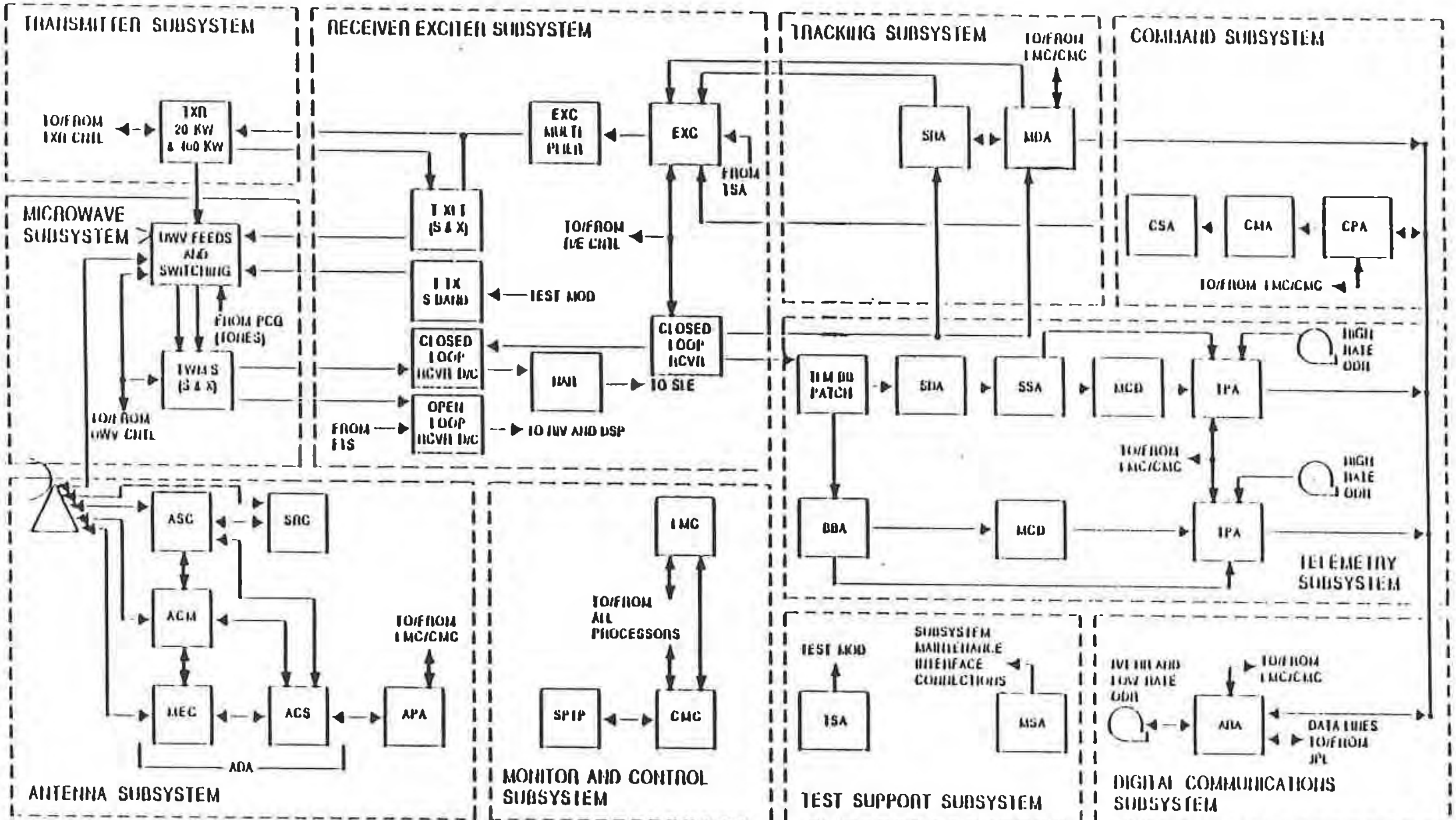
LEGEND:
COMM - GROUND COMMUNICATIONS
DSS - DEEP SPACE STATION
HEF - HIGH EFFICIENCY
M - METER
SPC - SIGNAL PROCESSING CENTER
STD - STANDARD
[dashed box] INSTITUTIONAL CHANGES
* PROPOSED CONCEPT - SUBJECT TO TDA/NRAO AGREEMENT

6485-23767as

DJM-1
11-8-90

Fi‹ ›re 3-5

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

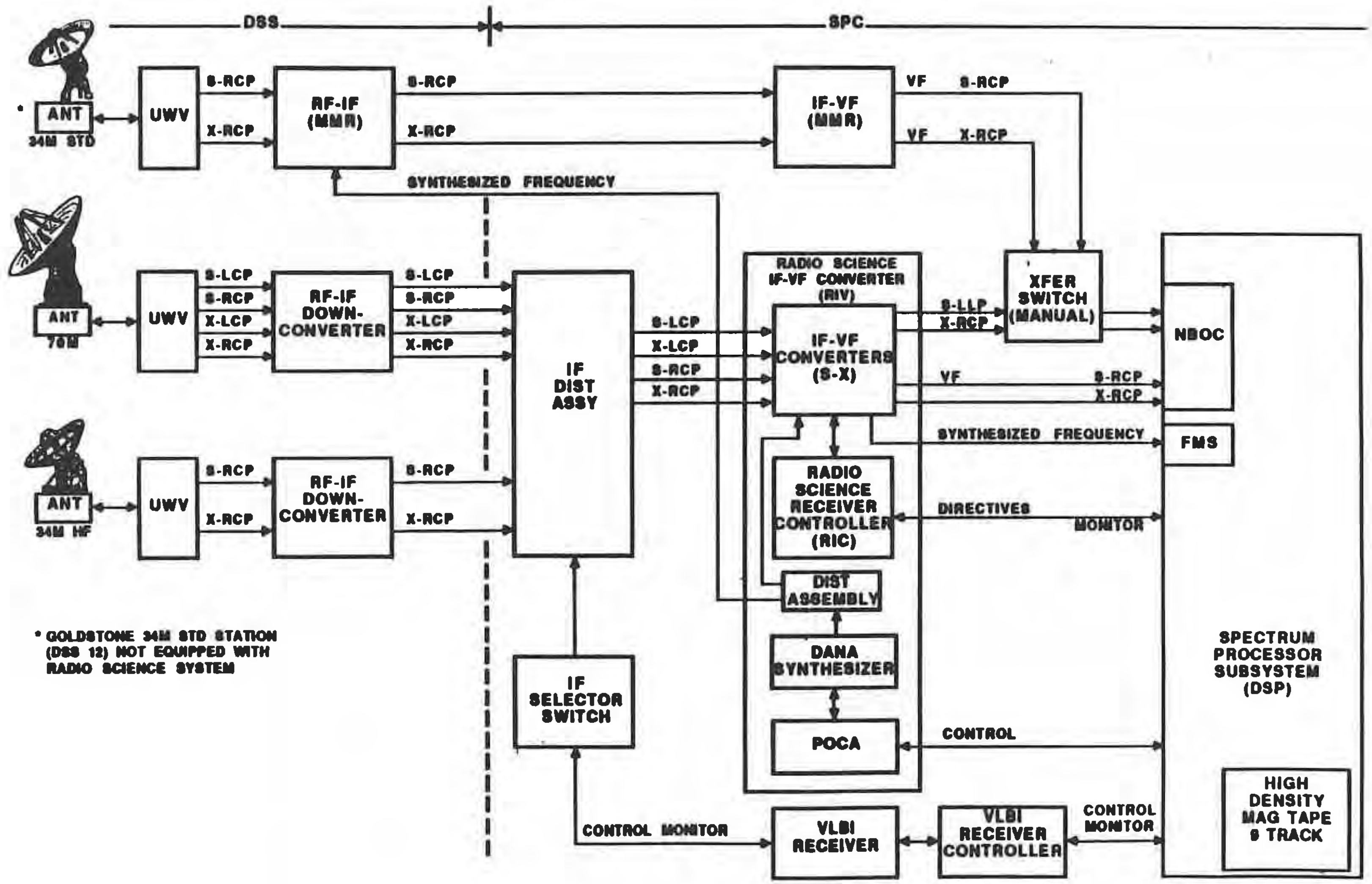
RCVR - RECEIVER
RDA - RANGE DEMODULATION ASSEMBLY
R/E - RECEIVER EXCITER
R/V - RS IF VF DOWNCONVERTER
RS - RADIO SCIENCE
SDA - SUBCARRIER DEMODULATION ASSEMBLY
SLE - SIGNAL LEVEL ESTIMATOR
SPTP - SYSTEM PERFORMANCE TEST PROCESSOR
SRA - SEQUENTIAL RANGING ASSEMBLY
SRC - SUN REFLECTOR CONTROLLER
SSA -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

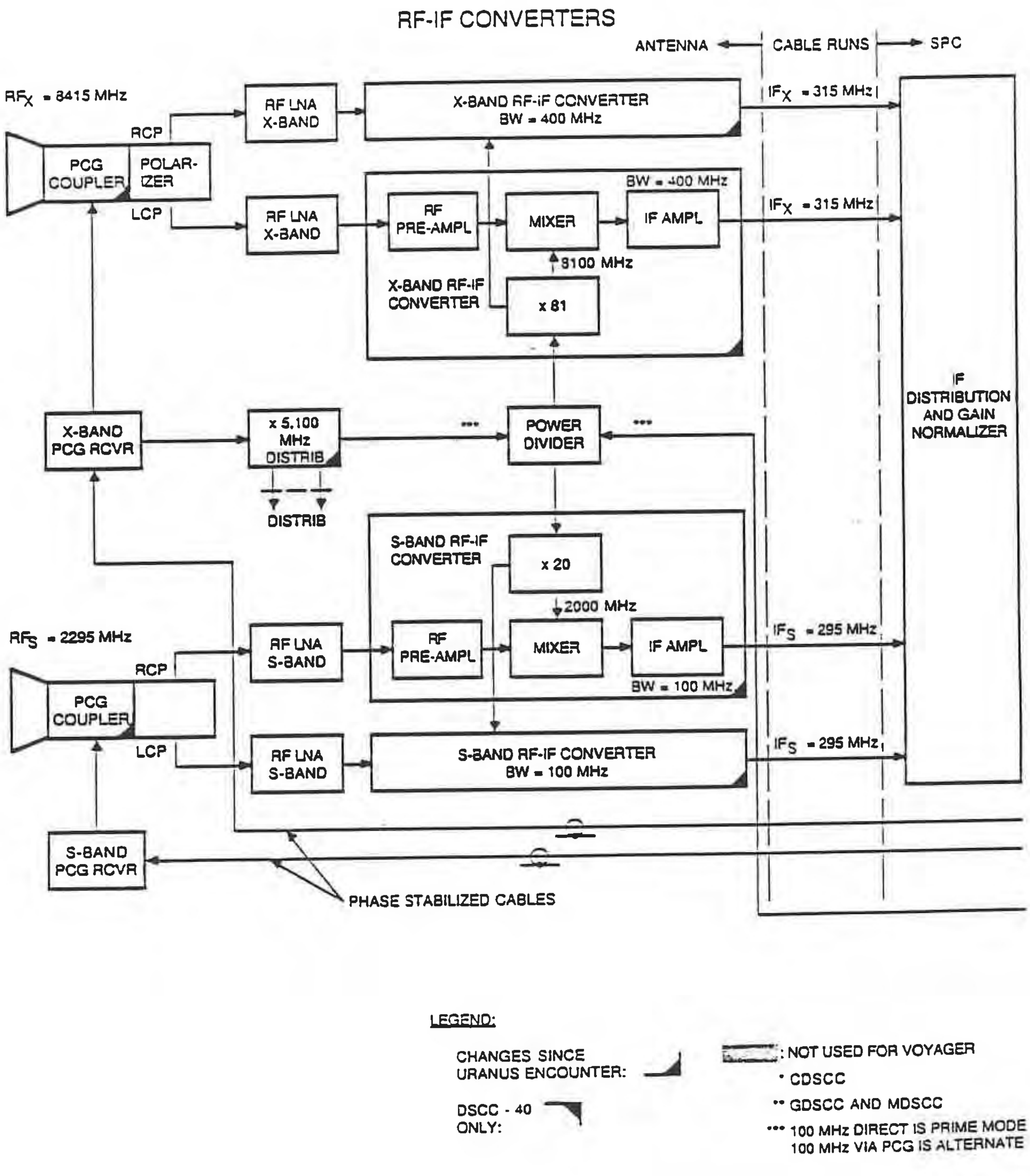
TSA - TELEMETRY SIMULATION ASSEMBLY
TWM - TRAVELING WAVE MASER
TXR - TRANSMITTER
T TX - TEST TRANSMITTER
T XLT - TEST TRANSLATOR
UWV - MICROWAVE

Figure 3-6

Figure 3-7

DSN RADIO SCIENCE SYSTEM

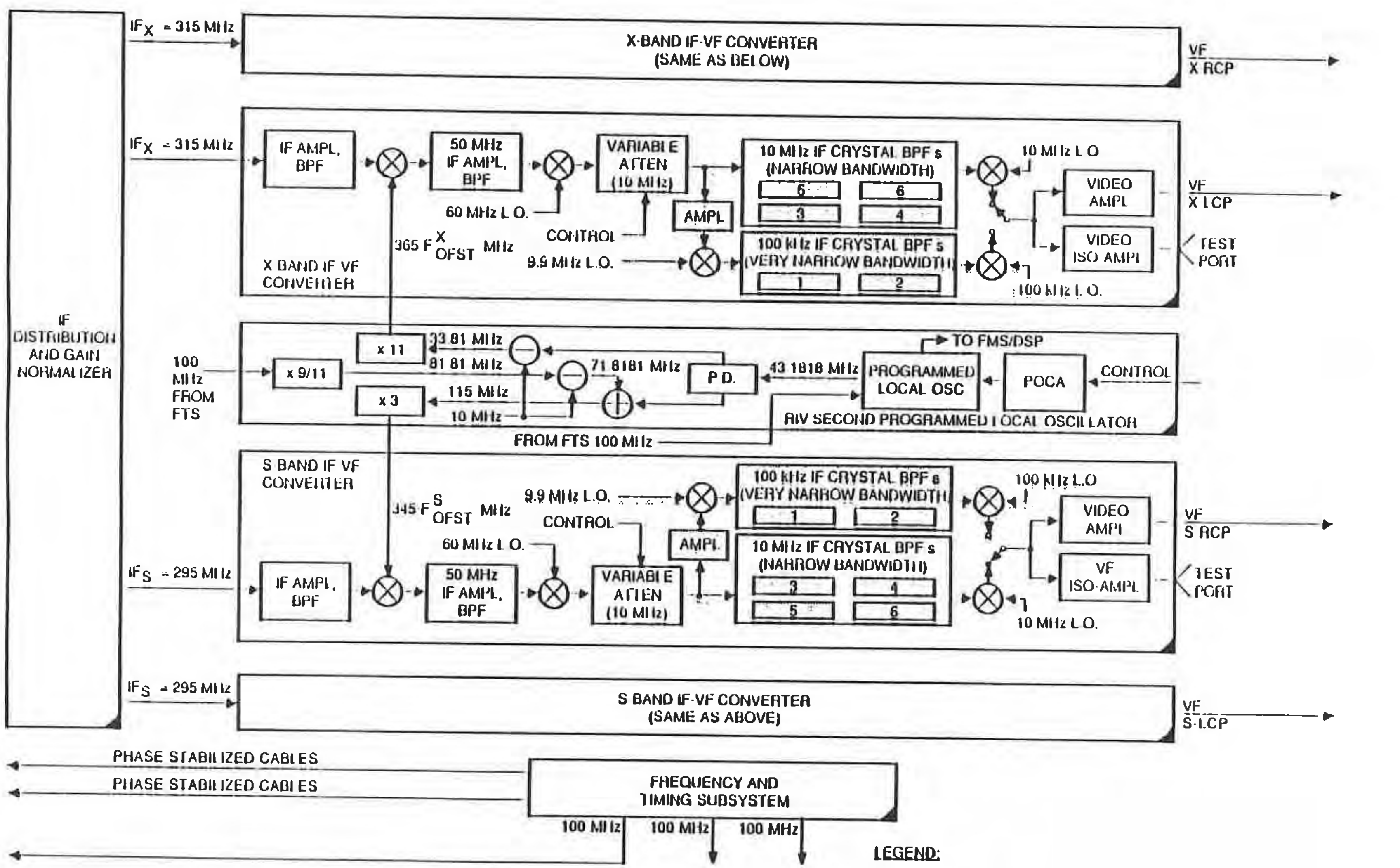




DSCC OPEN-LOOP RECEIVER (RF-IF)

Figure 3-8 (A)

IF-VF CONVERTER (RIV)



DSCC OPEN-LOOP RECEIVER (IF-VF)

Figure 3-8 (B)

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

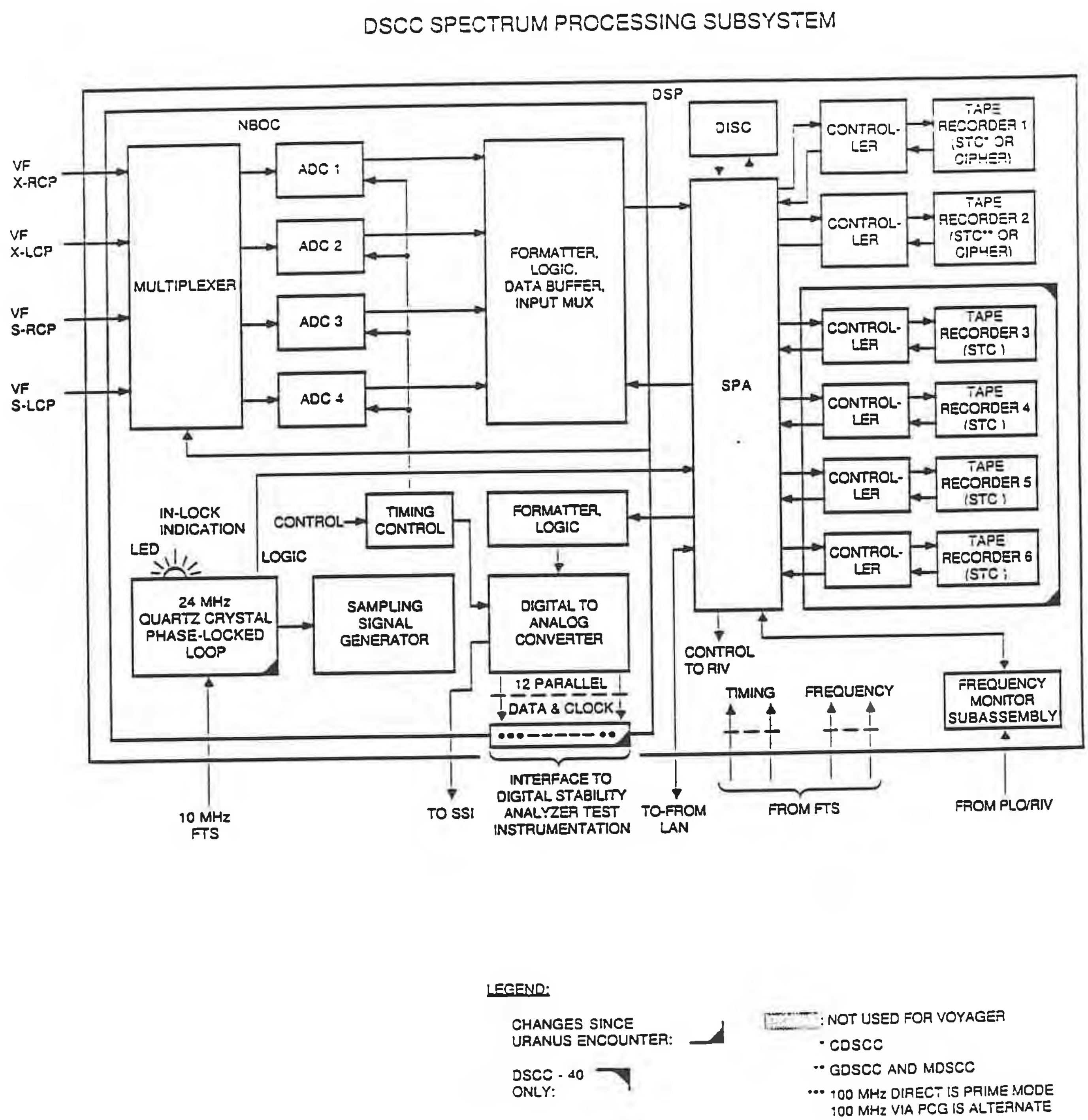

DSCC SPECTRUM PROCESSING SUBSYSTEM
DSP
NBOC
VF X-RCP
VF X-LCP
VF S-RCP
VF S-LCP
MULTIPLEXER
ADC 1
ADC 2
ADC 3
ADC 4
FORMATTER, LOGIC, DATA BUFFER, INPUT MUX
DISC
SPA
CONTROL-LER
TAPE RECORDER 1 (STC* OR CIPHER)
TAPE RECORDER 2 (STC** OR CIPHER)
TAPE RECORDER 3 (STC)
TAPE RECORDER 4 (STC)
TAPE RECORDER 5 (STC)
TAPE RECORDER 6 (STC)
IN-LOCK INDICATION
LED
CONTROL
TIMING CONTROL
LOGIC
FORMATTER, LOGIC
24 MHz QUARTZ CRYSTAL PHASE-LOCKED LOOP
SAMPLING SIGNAL GENERATOR
DIGITAL TO ANALOG CONVERTER
12 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 3-8 (C)

Figure 3-9

DSN TRACKING SYSTEM
70-METER DSS

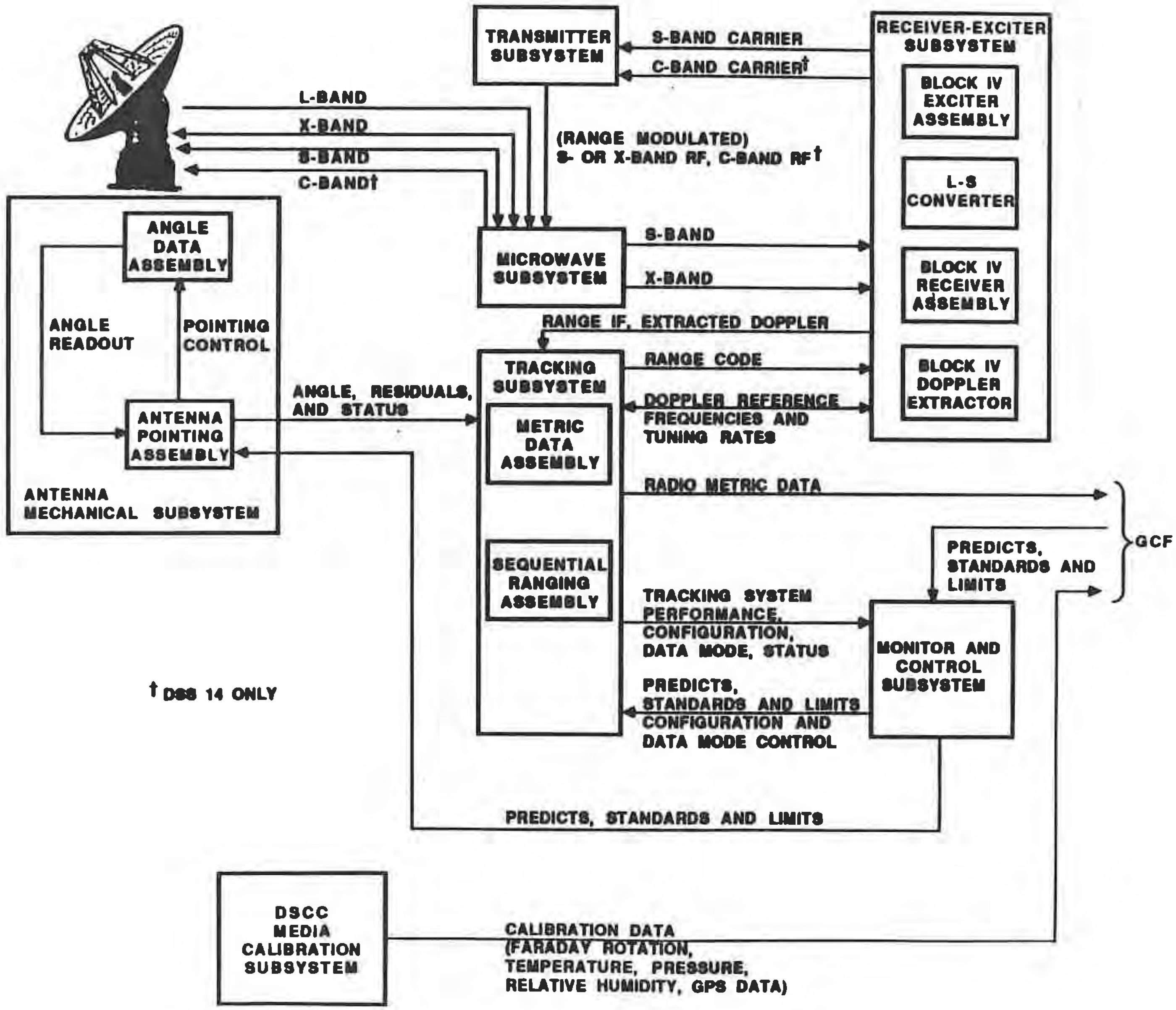
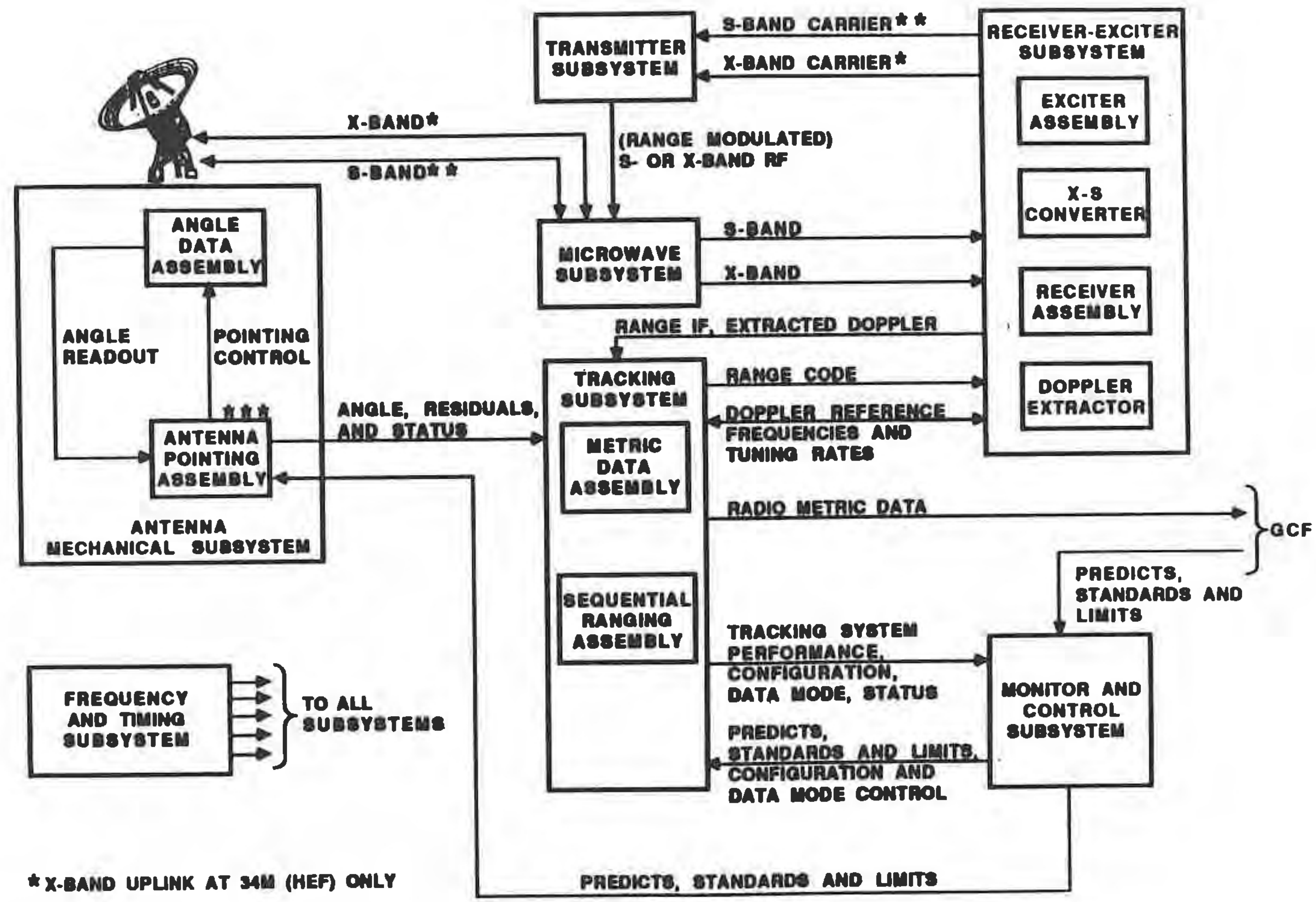


Figure 3-10

DSN TRACKING SYSTEM
34-METER DSS



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

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

***SHARED WITH 70M DSS

6483-2254

SECTION 4

PERSONNEL RESPONSIBILITIES

4.0 Introduction

The Radio Science Support Team (RSST), part of the Radio Science Systems Group, 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 multimission organizations. The RSST serves as the sole operational interface between the Investigators of the Radio Science Team and the other elements of the Flight Projects and the Deep Space Network. Figure 4.1 shows the organization of the Radio Science Systems Group.

More specifically, the RSST develops and integrates spacecraft and ground operation sequences for the acquisition of experiment data. This requires interfacing with the spacecraft team, navigation team, and other elements of the projects. The RSST provides specifications for data acquisition equipment required by scientific investigations. The RSST monitors the development and implementation of the Ground Data System to be used by Radio Science to ensure that the performance of the hardware and software are capable of meeting Radio Science specifications. The RSST coordinates the process of data acquisition by participating in the planning and allocation of resources or real-time operations and by conducting real-time operations and collecting the data observables. In order to prepare the data observables for scientific analysis, the RSST logs, archives, and validates the data products.

4.1 RSST Individual Responsibilities

4.1.1 Science Coordinator/Experiment Representative

The Science Coordinator/Experiment Representative's primary responsibility is to plan and coordinate the Radio Science experiments so as to achieve the maximum return of quality data for the various experiments. The planning involves the development of Radio Science flight and ground instrumentation and the definition of requirements for the various Radio Science experiments. Coordination involves the scheduling of development and operations to meet the Radio Science requirements. The planning and coordination activities involve the Flight Projects, Deep Space Network and other tracking stations, plus the Radio Science experimenters and support personnel.

The Science Coordinator/Experiment Representative develops the observation strategy, performs mission analysis trade-off studies, performs inter-experiment science integration, and provides sequence inputs. During real-time operations, the Coordinator monitors the progress of the experiment and provides recommendations to the operations personnel to optimize its performance.

The Science Coordinator/Experiment Representative provides overall team direction, coordinates the teams's needs and resources, and ensures that schedules and staff plans are adequate and are being met.

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 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 operations, and real-time monitoring.

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 verifies the presence and accuracy of the activity's Sequence Of Events (SOE) and predictions required by the station. 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 insures 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, overseeing development, implementation, testing, documentation, and delivery of software. He reports to the various projects on the software development status via periodical presentations.

The secondary responsibilities include using the Radio Science software for data analysis and validation, assisting in Radio Science operations, and representing Radio Science at selected Project meetings.

4.1.5 Computer Engineer

The Radio Science Computer Engineer is responsible for the proper operation of the RSST computing equipment and peripherals. His primary responsibility is the administration and upgrading of the RODAN computer facility (described in section 9) including interfaces (e.g., RODAN-GCF lines).

Secondary responsibilities include the proper operation of the Real-time Monitoring System (RMS) and, eventually, administration and upgrading of the SUN workstations. The Computer Engineer also assists in Radio Science operations and represents Radio Science at selected Project and DSN meetings.

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 also maintains data interface agreements.

Secondary responsibilities include performing system back-ups and related tasks on the RODAN computer.

4.2 RST Flight Project Interfaces

4.2.1 Galileo MDT and Ulysses SOT

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 (SOT) 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.

4.2.2 Galileo MCT and Ulysses SEGs Operators

The Galileo Mission Control Team (MCT) and Ulysses SEGs Operators 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 and Ulysses ACEs

The Galileo ACE and Ulysses 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

The Galileo and Ulysses 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 fro their respective Flight Projects including those relevant to Radio Science.

4.3.2 The Ops Chief

The Ops Chief is the DSN's lead person for all DSN operations in support of Flight Projects.

4.3.3 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.

4.3.4 TRACK CON

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

4.3.5 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 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 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 Experiment Rep.	3-0662
Gerard Benenyan	Display Software Engineer	3-1073
Carole Hamilton	Group Supervisor	4-2081
Dwayne Chong	Pioneer Venus Orbiter Support	4-8514
Mick Connally	Mars Observer Experiment Rep.	4-3826
Ann Devereaux	Ground Instrument Engineer	3-1143
Paula Eshe	Data Products Engineer	3-0663
Randy Herrera	Act'g GLL Sci.Coord.; Comp.Eng.	3-0664
Tony Horton	Operations Engineer	3-1142
David Morabito	Software System Engineer	3-0665

Deep Space Network

Sal Abbate	R.S. Sys. Cog. Ops. Eng.	584-4461
Pat Beyer	Galileo TDS Manager	4-0055
Shlomo Dolinski	Radio Science System Engineer	4-6824
Dennis Enari	Ulysses TDS Manager	4-0074
Thorl Howe	Mars Observer NOPE	584-4444
Bob O'Connor	Galileo NOPE	584-4422
Tim Pham	R.S. Sys. Development Cog. Eng.	4-4288
Roy Rose	Ulysses NOPE	584-4418
Marv Traxler	Mars Observer TDS Manager	4-0070
Bill Tucker	Ulysses Ass't NOPE	584-4470

Comm Chief 3-5800
Data Chief 3-7974
NATTRK 3-7810
Ops Chief 3-7990
Support Chief 3-0505
Track Controller 3-5858

Flight Projects

Galileo MSA (ACE) 3-5890
Ulysses MSA (ACE) 3-0559

Radio Science Operations area 3-0666

Table 4-2 Radio Science Investigators & Staff

Galileo

Radio Propagation

Taylor Howard	(Stanford U)
Von Eshelman	(Stanford U)
David Hinson	(Stanforf U)
Arv Kliore	(JPL)
Gunnar Lindal	(JPL)
Richard Woo	(JPL)
Michael Bird	(U Bonn)
Peter Edenhofer	(U Bochum)
Martin Pätzold	(DLR)
Herbert Porsche	(DFLR)
Hans Volland	(U Bonn)

Celestial Mechanics

John D. Anderson	(JPL)
Frank Estabrook	(JPL)
John W. Armstrong	(JPL)
James Campbell	(JPL)
Timothy Krisher	(JPL)
Eunice Lau	(JPL)

RSST: Sami Asmar, Paula Eshe, Randy Herrera, Tony Horton, David Morabito

---

Ulysses

Coronal Sounding

Michael Bird	(U Bonn)
Peter Edenhofer	(U Bochum)
Martin Pätzold	(DLR)
Hans Volland	(U Bonn)

Gravitational Waves

Bruno Bertotti	(U Pavia)
Sami Asmar	(JPL)
Gianni Comoretto	(Arc.)
Paolo Bonifazi	(CNR)
Luciano Iess	(CNR)
Giacomo Giampieri	(U Pavia)
Alfonso Messeri	(CNR)
Hugo Wahlquist	(JPL)
Roberto Ambrosini	(I. Rad)

RSST: Sami Asmar, Paula Eshe, Randy Herrera, Tony Horton, David Morabito

---

Mars Observer

Atmospheric Structure

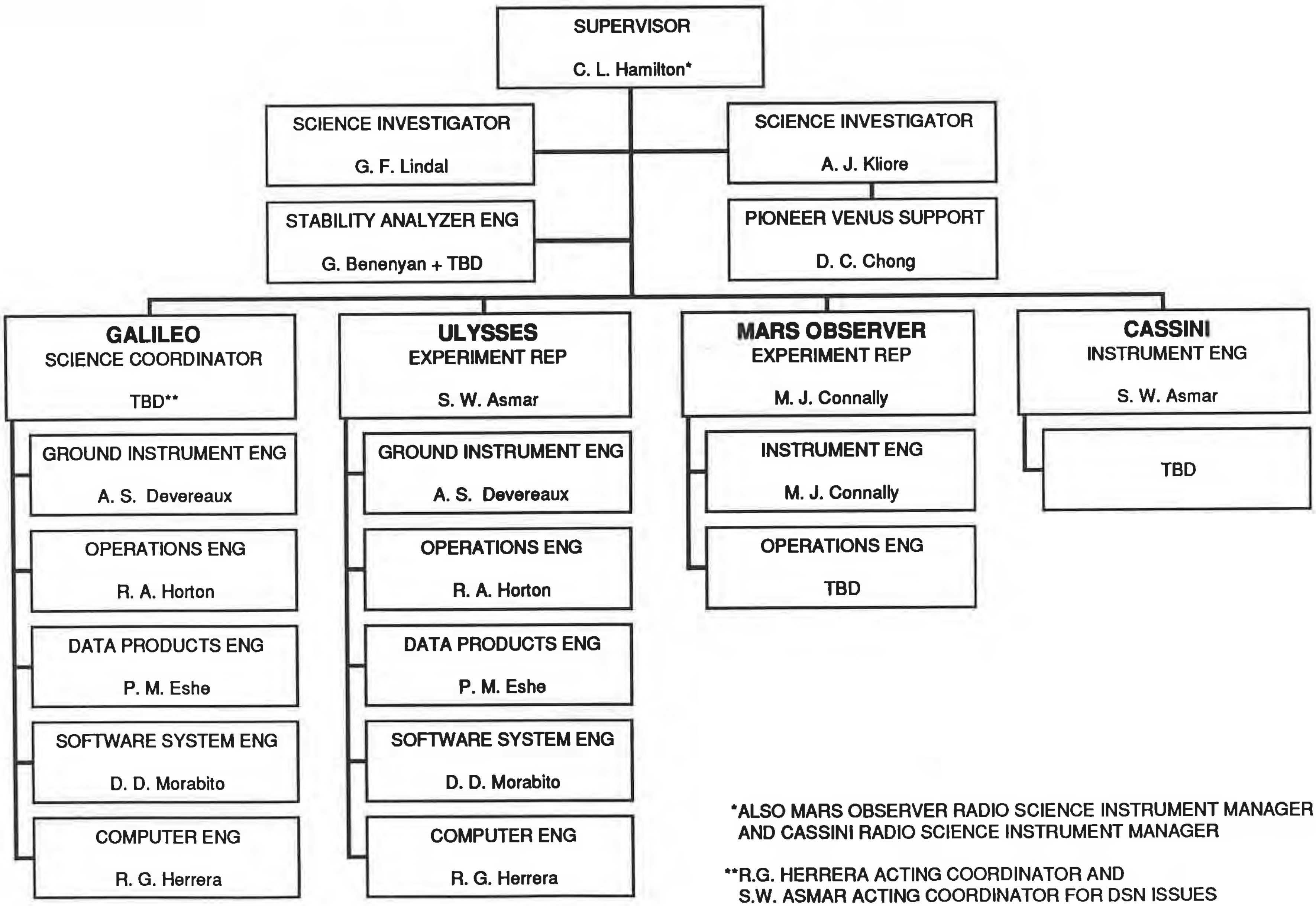
G. Leonard Tyler	(Stanford U)
David Hinson	(Stanford U)
Richard Woo	(JPL)
Richard Simpson	(Stanford U)

Gravity Field

Georges Balmino	(CNES)
William Sjogren	(JPL)
David E. Smith	(GSFC)

RSIT: Mick Connally, Carole Hamilton

RADIO SCIENCE SYSTEMS GROUP
3394



*ALSO MARS OBSERVER RADIO SCIENCE INSTRUMENT MANAGER AND CASSINI RADIO SCIENCE INSTRUMENT MANAGER

**R.G. HERRERA ACTING COORDINATOR AND S.W. ASMAR ACTING COORDINATOR FOR DSN ISSUES

SECTION 5

PRE-PASS PREPARATIONS

5.0 Introduction

This section describes the pre-pass operations for the Radio Science activities. Here, products that are essential for real-time support will be identified. All products relative to real-time support are ideally 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 predicts 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 later 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 predicts used to tune the closed-loop receivers for initial acquisition.

Radio Science (DSP) predictions will be required for those Galileo and Ulysses 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 ideally should contain all ground events necessary for station support during each pass.

When requested, a version of the ISOE will be created from the files residing on the NSS computer and will be reformatted and sent to the Medicina station in Bologna, Italy. Contents of this version of the ISOE will show scheduled events for the Madrid station tracking the Ulysses spacecraft.

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

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 3-3 contains 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 display system.

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.	Then 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 going to the Comm Chief first with the configuration information, and then to the OPCH who will then instruct the Comm Chief to carry out the directive. Asking for 56 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 in the 56 kb line 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 AB switch position is set to RODAN 3.

GCF/COMM	4.	Comm Chief proceeds to patch the appropriate CHIEF memory line(s) in 230 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, than all that he can do at his end is to seat and re-seat the patch cord or swap connections to another modem pair. At 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 normalize the line(s) for future support.

It is desired to have the lines set to the following nominal configurations between passes:

<u>RODAN</u>

1	56K Doppler DSCC 10
2	56K Duplex DSCC 40
3	224K Simplex (any DSCC)
4	56K Duplex DSCC 60
5	N/A

5.5 RASM / GPVAX File Transfer

The Remote Access Schedule Mailbox (RASM) has been provided for users that don't have normal access to the Network Support System (NSS). For Radio Science, RASM will provide a means of file transfer from the NSS computer to the General Purpose VAX (GPVAX) minicomputer. Such products that will become available to radio science are: Radio Science predictions, Sequence Of Events (SOE's) and other general information which are design to support the pass. Once these products are transferred to the GPVAX, by way of Macintosh SE/30 computer, they can in turn be sent to the Medicina VLBI station using SPAN mailing system.

File transfer is initiated using a Macintosh SE/30 computer due to extensive security system on the NSS computer. This procedure is initiated as follows:

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

RASM

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.

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 Telebit 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 , initiate an automatic script which calls RASM, and waits for the echo response from RASM which is provided below:

   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:

Continued RASM Log On and Transfer Procedure

```
************************************************************************
*      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]

55120026.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

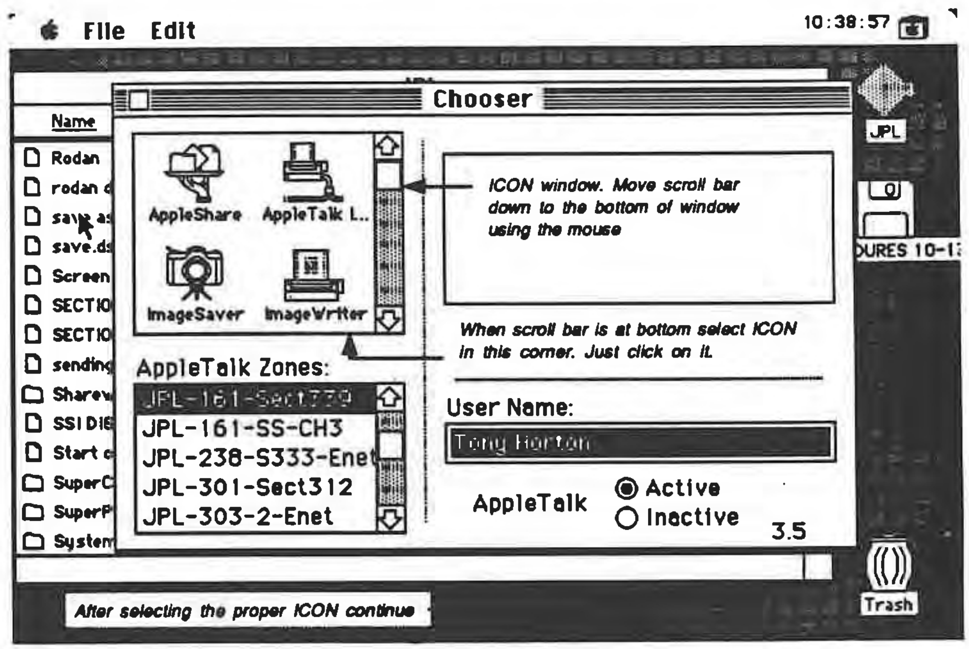
HOW TO GET THE CHOOSER WINDOW

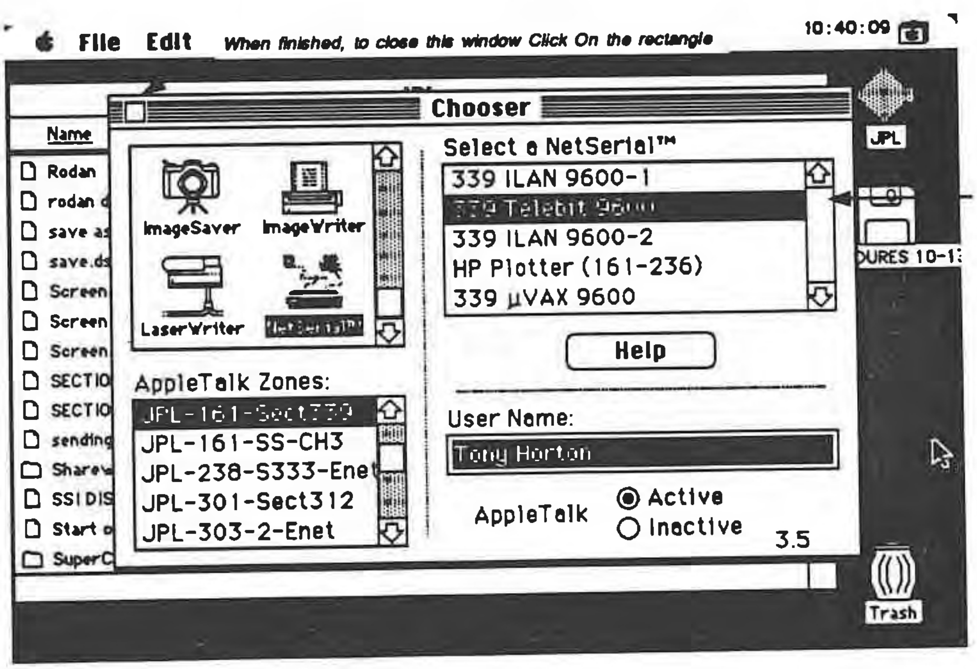
Look for the little apple icon in upper left hand corner of the hard disk display. Click on the apple, and drag down to the word Chooser and click again.The following window will open:

Example of Little Apple Window and Top line Display:

File Edit

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





Look in this window for 339 Telebit 9600 and select it by clicking on the words.

Continued Summary of the File Transfer Section

Example of the Open Capture File Window

File Edit Settings Phone Scripts File Transfer 10:43:15

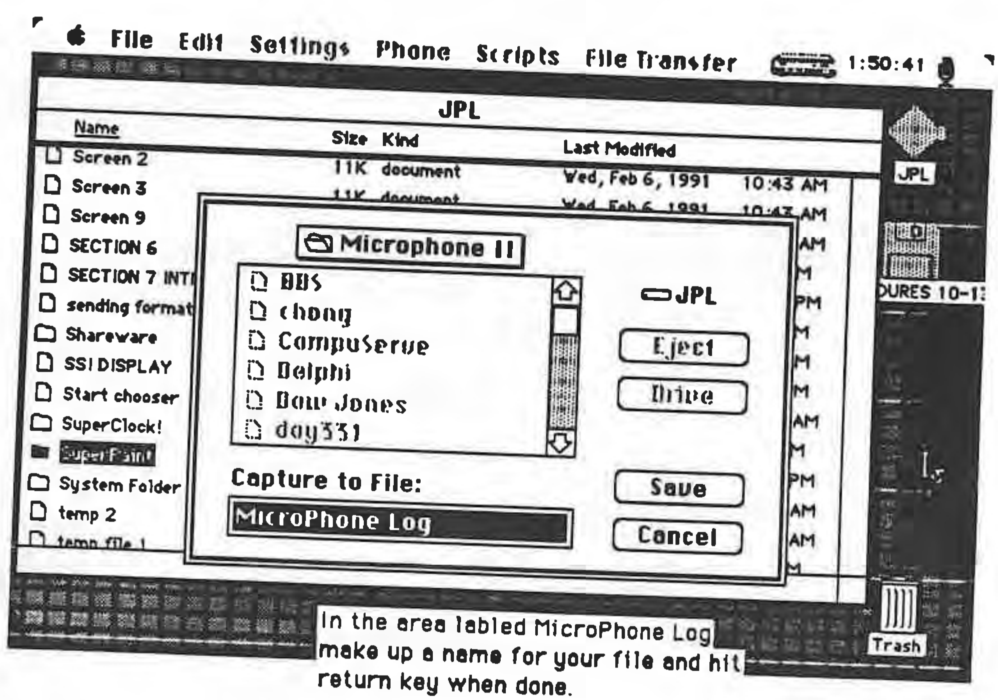
NEW SETTINGS
OPEN SETTINGS
CLOSE SETTINGS
SAVE SETTINGS
SAVE SETTINGS AS

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
QUIT



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.

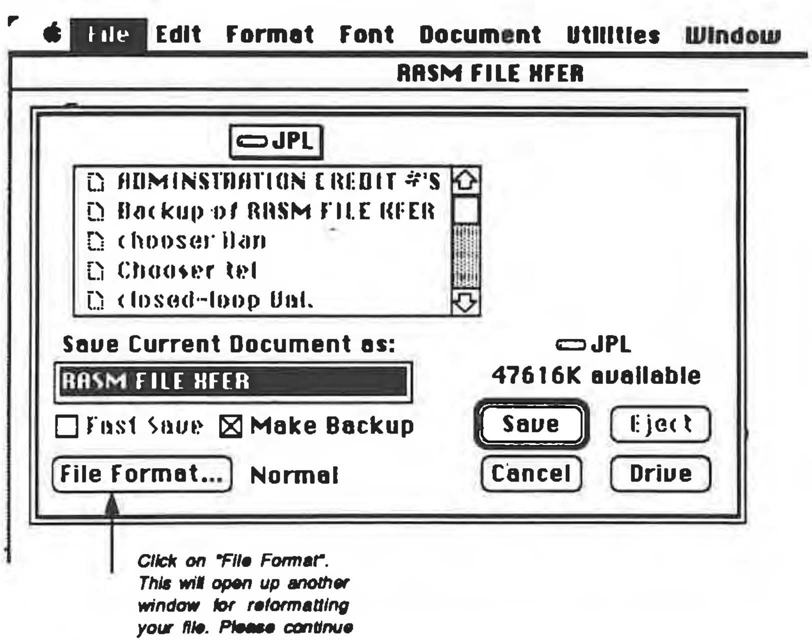
2. Then mark the beginning and end of the file using the mouse "shift key and click function together". This will mark the file so that reformatting is accomplished all at once.

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.

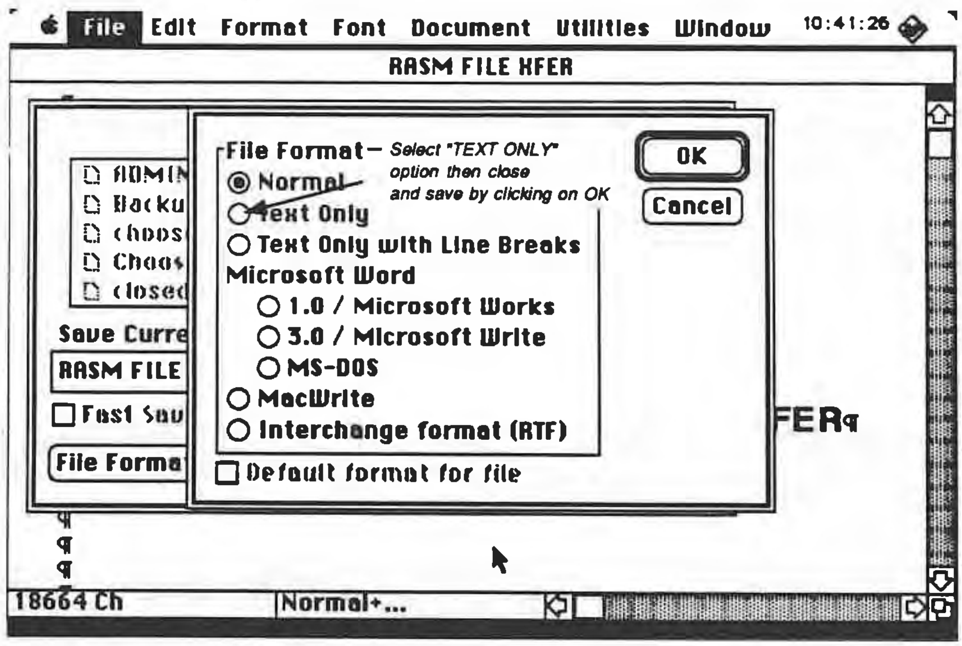
5. Select the **Text Only** by clicking on the option just in front of it. Close the window by clicking on the **"OK".** Now, click on **Save** seen on the SAVE AS.. window. This window re-open due to your previous click. Because you have marked the beginning and end of the file it will reformat before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

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



Continued Example for File Format window

File Format... Window



Summary Of Edit and Reformat Procedure

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 Telebit 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**

GPVAX

3. GPVAX will respond with:

   Connecting .. (1) 36208A3 Success

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

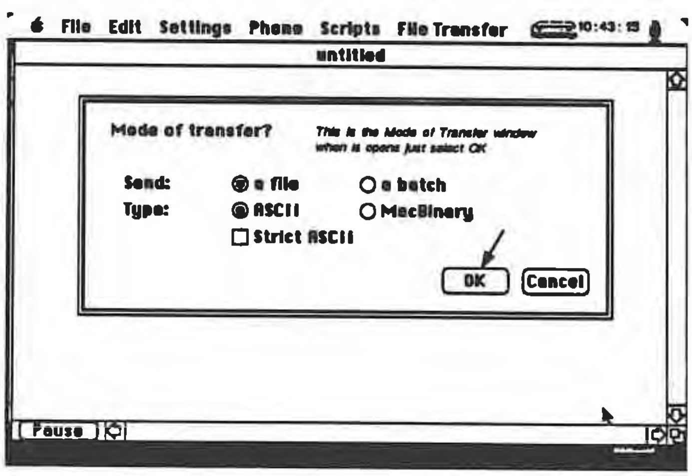
----

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

Sending File:

From Volume: **This Window Monitors File Transfers in progress.**

File Type / Creator:

Protocol: Kermit

File Mode: ASII

Bytes Transfered: Out Of

Elapsed Time: Est Remaining Time:

Status: Packet

Blocks Retried:

O abort

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

- 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

SECTION 6

REAL-TIME OPERATIONS

6.0 Introduction

This section describes those events which occur during the real-time operations period. Elements of the Radio Science Team (RST), Mission Control Team (MCT), Network Operations Control Team (NOCT), the Deep Space Station (DSS), and the Medicina VLBI station will be involved in the real-time operations. The attached tables show a summary of the schedule of real-time operations.

6.1 Radio Science Real-Time Operations

Real-time operations have been broken into three parts: events prior to acquisition, events during the recording period, and events following the recording period.

6.1.1 Events Prior To Data Acquistion

During this period, activities include checking the correct configuration of the RODAN GCF lines, availability and correctness of the SFOS, ISOE and any 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, predict hardcopy (if available), the Network Operatins 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 6-2 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 TrackCon 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 6-1. 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" or "Ulysses 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 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 (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/GC, NOPE, Ops Chief and NATTRK to coordinate the selection of displays.

TABLE 6-1

VOICE NET COMMUNICATION

INTER-8:	Standard Project operational net to NOCC for communication between Ulysses ACE and OPCH
INTER-5:	Standard Project operational net to NOCC for communication between Galileo ACE and OPCH
GDSCC-1:	Standard NOCC-to-DSN Complex control net (Goldstone)
CDSCC-1:	Standard NOCC-to-DSN Complex control net (Canberra)
MDSCC-1:	Standard NOCC-to-DSN Complex control net (Madrid)
FAC COORD:	OPS CON - Facilities coordination
CMTRY:	Commentary (and music)

Table 6 - 2

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

RADIO SCIENCE USO / GWE / SCE VALIDATION SHEET

PROJECT / ACTIVITY : ______________________

DATE / DOY / STATION (S) / PASS#: ______________________

RST PERSONNEL: ______________________

RMS STATUS: CL OR OL ONLY, BOTH circle 1.**RECORD TIME** **STOP TIME**

RODAN-L/RATE:	1	2	3	4	5
	56K	56K	224K	56-224K	224K

Note: Put U/L AND OR D/L STATION BEFORE RODAN - LINE /RATE

NOCC DISPLAYS

S-DOP F-607	X-DOP F-607

MDA FORMAT

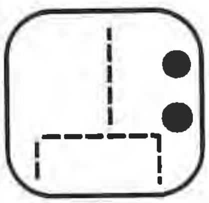
S-RNG F-617	X-RNG F-617

SRA FORMAT

STATUS F-708 & 709

DSP FORMAT

TEXT



SSI DISPLAY

MDA C-LIST — S & X- BAND

Dopp Samp Rate: ____ / ____

RESID: ____ / ____

*MDTR: ____ / ____

SEP ANGLE =

SSI C-LIST — OPEN-LOOP MONITOR

ODAN: ______

Signal Presence: YES / NO

Full B/W: ______

Trans size: ______

Average ______

SRA C-LIST — S & X - BAND

T0 , T1 , T2, T3: ______

OF COMP: ______

PR / NO: ____ / ____

P DRVID: ____ / ____

MON 5-9 C-LIST — S & X- BAND

AGC : ____ / ____

SNT: ____ / ____

AGC - BW: ____ / ____

LOOP-BW : ____ / ____

Note 1: Galileo NOP Table 12-2. Ulysses Table 12-1. SSI CFG Table 12-3. NOCC RS SOM NMO-5267-OP. NOCC TRACK SOM NMK-5216-OP-I/VER 11.0. MDA SOM DMK-5206-0P-F/VER 10.81. DSP SOM DMO 5205-OP-D.
Note 2: RMS limits 1.0 Volt p-p. Sta should use SSS=A,B,C,D OCI to verify Sig Pres on each channel.

DSP CHAN CFG AS PER NOP:

CHAN	70M	34 HEF	34 STD
A =	1 XR	1 XR	3 XR
B =	2 SR	2 SR	4 SR
C =	3 XL	1 XR	3 XR
D =	4 SL	2 SR	4 SR

DSP STATUS — *On duty fill in*

CHANNEL	A	B	C	D
Filter				
Chan Assign (J)				
Attenuation				
RMS VOLTS				

NBOC MODE =

Sample rate =

Predict Set Code =

COMMENTS / DRs :

RAH 6/91

Ulysses First Solar Conjunction, C1

Schedule of DSN Coverage

1. First Priority Interval :

Definition:	C1 - 15 days to LOS and ROS to C1 + 15 days
1991 Actual dates:	06 August to 17 August (estimated) 25 August (estimated) to 05 September
SCE Requirements:	12 hours DDR data daily, with 2 hours of these tracked simultaneously at 2 stations (70-m DSN), on the average. Doppler sample rate: 1 per second. Open-loop data at 70-m stations only.

2. Second Priority Interval :

Definition:	C1 - 30 days to C1 - 16 days and C1 + 16 days to C1 + 30 days
1991 Actual dates:	22 July to 05 August 06 Sept to 20 Sept.
SCE Requirements:	8 hours DDR (70-m DSN), on the average Doppler sample rate: 1 per 10 second

3. Third Priority Interval :

Definition:	C1 - 90 days to C1 - 31 days and C1 + 31 days to C1 + 90 days
1991 Actual dates:	23 May to 21 July 21 Sept. to 19 November
SCE Requirements:	2 hours DDR (70-m or 34-m), on the average Doppler sample rate: 1 per 10 sec

LOS: Loss of Signal
ROS: Recovery of Signal

C1 DSN Coverage Schedule as of 20 May 1991

doy	dss	start	stop	pre	post	conf	
146	61	0810	1910	130	030	400K	(26 May '91)
147	42	0040	1015	130	015	400K	
147	43	2355	1055	200	030	430K	
149	42	0030	1020	130	015	400K	
149	61	1320	2320	130	030	400K	
150	61	0800	1740	130	015	400K	
151	42	0025	1040	130	030	400K	
152	42	0025	1030	130	015	400K	
152	12	1600	0100	130	030	400K	
153	61	1105	2305	130	030	400K	
154	12	1555	0600	130	030	400K	
155	12	1555	0130	130	015	400K	
156	61	0745	2240	130	015	400K	
156	12	2030	0455	130	030	400K	
157	12	1550	0350	130	030	400K	
158	61	1050	2250	130	030	400K	
159	61	1050	2235	130	015	400K	
160	61	1045	2245	130	030	400K	
161	61	1000	2145	130	015	400K	
162	61	1100	2240	115	030	400K	
163	61	1055	2235	115	030	400K	
164	43	0320	1020	200	030	430K	
164	12	1530	0330	130	030	400K	
165	61	0725	1820	130	015	400K	
166	61	0720	1905	130	015	400K	
167	61	0720	1920	130	030	400K	
168	61	0715	1715	130	015	400K	
169	61	0715	2220	130	030	400K	
170	61	1015	2215	130	030	400K	
170	42	2330	1010	130	015	400K	
171	61	1100	2215	115	030	400K	
172	61	0705	2145	130	015	400K	
173	61	0705	2145	130	015	400K	
174	61	0705	2205	130	030	400K	
174	12	2215	0505	115	030	400K	
175	61	0700	2145	130	015	400K	
176	12	1455	0325	130	015	400K	
177	61	0705	2140	130	015	400K	
178	12	1525	0455	130	030	400K	
179	61	0700	1630	130	015	400K	
180	61	0655	2045	130	015	400K	
180	42	2300	1000	130	030	400K	

181	42	2300	0950	130	030	400K	
182	61	0650	1555	130	015	400K	
182	12	1440	0430	130	015	400K	
183	42	2250	0945	130	030	400K	
184	42	2245	0930	130	015	400K	
185	61	0730	1100	115	015	400K	
185	42	2245	0925	130	015	400K	
186	42	2240	0940	130	030	400K	
187	61	0635	2125	130	030	400K	
187	42	2240	0910	130	015	400K	
188	61	0635	1915	130	015	400K	
189	61	0630	2055	130	015	400K	
189	43	2145	0715	200	015	400K	
190	14	1715	2230	130	030	400K	
190	42	2225	0930	130	030	400K	
191	42	2225	0925	130	030	400K	
192	42	2225	0855	130	015	400K	
193	42	2225	0855	130	015	400K	
194	61	0620	2050	130	015	400K	
195	61	0615	2035	130	015	400K	
196	61	0800	2030	130	030	400K	
197	61	1130	2030	130	030	400K	
197	42	2205	0835	130	030	400K	
198	42	2200	0835	130	030	400K	
199	42	2200	0855	130	030	400K	
200	12	1550	2020	115	015	400K	
200	42	2155	0820	130	015	400K	
201	42	2155	0835	130	030	400K	
202	61	0800	2030	130	030	400K	(21 July '91)
203	61	0550	2020	130	015	400K	
203	42	2145	0855	130	030	400K	
204	42	2140	0725	130	030	400K	
205	12	1550	2020	115	015	400K	
205	43	2125	0720	130	015	400K	
206	42	2135	0845	130	030	400K	
207	63	0915	1915	200	015	430K	
207	42	2135	0845	130	030	400K	
208	43	2045	0720	200	015	430K	
209	43	2200	0825	200	030	430K	
210	63	0930	1930	200	015	430K	
211	63	1130	1825	200	015	430K	
211	14	1555	0245	200	030	430K	
212	14	1515	0330	200	030	430K	
213	43	2110	0710	200	015	430K	
214	43	2110	0800	200	015	430K	
215	63	0715	1950	200	030	430K	

216	63	0935	1955	200	030	430K	
217	63	0900	1915	200	015	430K	
218	63	0930	1855	200	015	430K	(6 Aug '91)
218	43	2130	0500	200	015	430K	
219	43	2010	0635	200	015	430K	
220	43	2110	0750	200	030	430K	
221	14	1600	2315	200	015	430K	
221	43	2005	0630	200	030	430K	
222	14	1615	0145	200	015	430K	
222	43	2130	0715	200	015	430K	
223	14	1705	0015	200	015	430K	
223	43	2000	0720	200	015	430K	
224	63	0745	1905	200	015	430K	
224	14	1450	2200	200	015	430K	
225	63	1000	1905	200	015	430K	
225	14	1450	0015	200	015	430K	
226	63	1000	1905	200	015	430K	
226	14	1500	0015	200	015	430K	
227	63	1045	1915	145	030	430K	
227	43	1945	0725	200	015	430K	
228	63	1120	1915	200	030	430K	
228	14	1445	0135	200	015	430K	
229	14	1700	0130	200	015	430K	(17 Aug '91)
229	43	2115	0730	200	030	430K	
230	63	0630	1850	200	015	430K	
230	14	1450	2015	145	015	430K	
231	63	0900	1900	145	030	430K	
231	14	1430	2300	200	015	430K	
232	63	1130	1900	200	030	430K	
232	14	1430	0145	200	015	430K	
233	63	1000	1855	145	030	430K	
233	14	1440	2345	145	015	430K	
234	14	1545	0210	145	015	430K	
234	43	1920	0545	200	015	430K	
235	63	1000	1855	145	030	430K	
235	43	1920	0545	200	015	430K	
236	14	1515	2330	200	015	430K	
236	43	1915	0545	200	030	430K	
237	63	0600	1850	200	030	430K	
237	14	1435	0045	145	015	430K	
238	14	1600	0145	145	015	430K	
238	43	2145	0600	145	015	430K	
239	63	1000	1825	145	015	430K	
239	14	1410	0000	200	015	430K	(25 Aug '91)
239	43	1905	0000	200	030	430K	
240	63	1000	1825	145	015	430K	
240	14	1410	0100	200	030	430K	

241	63	1100	1825	145	015	430K	
241	12	1405	2320	130	015	400K	
241	43	1905	0535	200	030	430K	
242	14	1405	0000	200	015	430K	
242	43	1905	0535	200	030	430K	
243	63	1000	1815	145	015	430K	
243	14	1415	0000	145	015	430K	
244	63	1000	1810	145	015	430K	
244	14	1405	0000	145	015	430K	
245	63	1130	1825	145	030	430K	
245	14	1410	0130	145	015	430K	
246	14	1530	0035	145	015	430K	
246	43	1945	0645	145	030	430K	
247	14	1505	0030	145	015	430K	
247	43	2100	0530	145	015	430K	
248	63	1000	1800	145	030	430K	(5 Sept '91)
248	14	1105	2300	200	015	430K	
249	14	1340	2250	200	015	430K	
249	43	1835	0640	200	030	430K	
250	63	1025	1750	145	015	430K	
250	14	1335	1910	200	015	430K	
250	43	1845	0630	145	030	430K	
251	14	1500	0100	145	015	430K	
252	63	0900	1330	115	015	400K	
252	14	1300	0110	200	015	430K	
253	14	1655	2110	200	015	430K	
253	43	1825	0430	200	030	430K	
254	14	1545	0000	200	030	430K	
254	43	1900	0500	200	015	430K	
255	43	1815	0430	200	015	430K	
256	43	1810	0440	200	030	430K	
257	43	1810	0440	200	030	430K	
258	14	1225	0045	200	015	430K	
259	63	0705	1735	200	030	430K	
260	63	0600	1600	145	015	430K	
260	43	1810	0440	200	030	430K	
261	14	1500	0000	200	015	430K	
261	43	1810	0425	200	030	430K	
262	43	1810	0440	200	030	430K	
263	43	1810	0440	200	030	430K	(20 Sept '91)
264	43	1810	0440	200	030	430K	
265	14	1425	0025	145	015	430K	
266	12	1045	2230	130	015	400K	
267	61	0750	1445	130	030	400K	
267	12	1130	1955	130	015	400K	
268	12	1040	2225	130	015	400K	
269	61	0250	1230	130	015	400K	

269	43	1730	0345	200	015	430K
270	12	1055	2225	115	015	400K
271	12	1030	2215	130	015	400K
272	12	1025	2210	130	015	400K
273	12	1025	2210	130	015	400K
274	12	1020	2205	130	015	400K
275	61	0235	1245	130	015	400K
275	42	1745	0515	130	015	400K
276	12	1015	2200	130	015	400K
277	61	0245	1245	130	015	400K
277	12	1025	2025	130	030	400K
278	12	1005	2150	130	015	400K
279	61	0225	1410	130	015	400K
280	61	0225	1225	130	030	400K
280	12	1000	2000	130	030	400K
281	12	0955	2305	130	030	400K
282	12	0955	2305	130	030	400K
283	12	0955	2305	130	030	400K
284	61	0725	1225	130	030	400K
284	12	0955	2305	130	030	400K
285	12	0945	2325	130	030	400K
286	61	0200	1220	130	015	400K
286	42	1710	0410	130	015	400K
287	12	0945	2300	130	030	400K
288	12	0940	2300	130	030	400K
289	12	1300	2300	130	015	400K
290	12	0935	2300	130	030	400K
291	61	0750	1545	130	030	400K
291	12	1300	2300	130	030	400K
291	43	1610	0430	200	030	430K
292	61	0750	1515	130	030	400K
292	12	1245	2300	130	030	400K
293	61	0300	1530	130	030	400K
294	61	0745	1520	115	030	400K
294	12	1240	2240	130	030	400K
295	12	1110	2240	115	015	400K
296	12	1040	2240	130	030	400K
297	12	1040	2240	130	030	400K
298	12	1040	2240	130	030	400K
299	12	1040	2240	130	030	400K
300	61	0115	1255	130	015	400K
300	43	1625	2045	115	015	400K
301	12	0915	2045	115	015	400K
302	12	1030	2230	130	030	400K
303	61	0125	1505	115	030	400K
303	43	1600	2045	130	015	400K
304	61	0120	1240	115	015	400K

304	12	1040	2015	115	015	400K	
305	12	1055	2220	115	030	400K	
306	12	1115	2215	130	030	400K	
307	12	1015	2215	130	030	400K	
308	12	0835	2145	130	030	400K	
309	12	0830	2205	130	030	400K	
310	12	0830	2055	130	030	400K	
311	61	0040	1005	130	015	400K	
311	12	0825	2055	130	030	400K	
312	12	0820	1930	130	030	400K	
313	61	0045	0945	130	015	400K	
313	12	0820	1830	130	030	400K	
313	43	1540	2010	115	015	400K	
314	61	0400	1425	115	015	400K	
314	43	1715	0040	045	015	400K	
315	12	0810	2130	130	030	400K	
316	61	0025	0930	130	015	400K	
316	12	0825	1600	115	030	400K	
317	61	0025	1005	115	030	400K	
317	12	0855	2125	130	030	400K	
318	12	0800	2125	130	030	400K	
318	43	1520	2000	115	015	400K	
319	61	0015	1015	130	015	400K	
319	12	0755	2130	130	030	400K	
320	12	0755	2130	130	030	400K	
321	61	0025	1350	130	030	400K	
322	61	0005	0910	130	015	400K	
322	12	0745	2100	130	030	400K	
323	61	0000	0910	130	030	400K	(19 Nov '91)
323	12	0745	2100	130	030	400K	
323	61	2355	0845	130	015	400K	
324	12	0745	2100	130	030	400K	
325	12	0745	2045	130	030	400K	
326	61	0010	0955	130	015	400K	
326	12	0740	1945	130	030	400K	
326	43	1450	2030	115	015	400K	
326	61	2345	0800	130	030	400K	

config. code: 4/2: Ranging/no ranging
3/0: DSP/no DSP
8/0: PPM/no PPM (2 if PPM at DSS 12)
F, G, K: S, X, or dual band

ULYSSES SOLAR CORONA EXPERIMENT 1991

DOY	DSS	PST DOW	UTC START	PASS#	RNG MOD ON	RNG MOD OFF	S&X RNG ACQ	STRT SCE	CL-DATA	OL-DATA	ATDF	0L-ODR	P-FLD	CL VALID	OL VALID	COMMENTS: PAGE 1 LUD 6/05/91
146	61	Tue	8:10	233	9:54	11:54	9:55	9:40								
147	42	Mon	0:40	234	2:20	4:20	2:25	3:19								
147	43	Mon/Tue	23:55	235	2:04	4:04	2:05	3:03								DR G3901 Bad PDX FOR X-B AT 158/0519
149	42	Wed	0:30	236	2:09	4:09	2:10	3:10								DR G3911 Scheduling Late AOS.
149	61	Wed	13:20	236	14:59	16:59	15:00	16:00								
150	61	Thur	8:00	237	9:39	11:39	9:40	10:40								DR G3927 Late BOT due to PDX. S-B RIL @0943 & X-B
																RIL @ 1006.
151	42	Fri	0:25	238	2:40	4:04	2:05	3:05								DR G3938 Sched BOT conflict/w rise time & Dloading PDX.
152	42	Sat	0:25	239	2:04	4:04	2:09	3:05								
152	12	Sat	16:00	239	17:39	19:39	17:40	18:40								
153	61	Sun	15:55	240	12:44	22:24	12:45	13:45								
154	12	Mon	15:55	241	17:43	5:19	17:44	18:46								
155	12	Tue	7:45	242	17:43	1:04	17:44	18:46								
156	61	Wed	20:30	243	9:33	16:21	9:34	10:36								DR G3964 Bad predicts late RIL. STA used FRO to lock up.
156	12	Wed	15:50	243	22:18	4:14	22:19	23:21								
157	12	Thur	15:50	244	17:38	3:09	17:38	18:41								
158	61	Fri	10:50	245	12:28	16:16	13:41	13:41								
159	61	Sat	10:50	246	12:38	22:09	12:39	13:42								
160	61	Sun	10:45	247	12:32	16:30	12:33	13:37								
161	61	Mon	10:00	248	11:44	15:57	11:45	12:49								
162	61	Tue	11:00	249	12:29	21:59	12:29	13:34								
163	61	Wed	10:55	250	12:34	16:27	12:25	13:29								
164	43	Thur	3:20	251	5:34	9:39	5:35	6:39								
164	12	Thur	15:30	251	17:14	2:49	17:15	18:19								
165	61	Fri	7:25	252	9:10	12:26	9:11	10:16								
166	61	Sat	7:20	253	9:04	18:39	9:05	10:11								
167	61	Sun	7:20	254	9:04	18:39	9:05	10:11								
168	61	Mon	7:15	255												
169	61	Tue	7:15	256												
170	61	Wed	10:15	257												

170	42	Wed/Thur	23:30
171	61	Thur	11:00
172	61	Fri	7:05
173	61	Sat	7:05
174	61	Sun	7:05
174	12	Sun	22:15
175	61	Mon	7:00
176	12	Mon	14:55
177	61	Tue	7:05
178	12	Tue	15:25
179	61	Wed	7:00
180	61	Thur	6:55
180	42	Thur/Fri	23:00
181	42	Fri	23:00
182	61	Fri	6:50
182	12	Fri	14:40
183	42	Fri	22:50
184	42	Sat	22:45

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, the 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

For the three types of activities discussed in this handbook, there are different sets of data products required. The Galileo USO test data product delivery strategy and schedules are given in Table 7-1. The Ulysses Solar Corona Experiment data product delivery strategy and schedules are given in Table 7-2. These tables along with the following subsections describe each of the products as they relate to the specific activities. The format and operational interface numbers for these currently applicable (as well as other) data products are specified in Table 7-3 for Galileo and in Table 7-4 for Ulysses.

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 NBODR. The tape contains up to four channels of digitized receiver data from the OLR as well as POCA tuning, timing, configuration and status information. When applicable, the DSP NBODR tape(s) will be logged and delivered to the RSST via the appropriate means.

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. It is recommended that station operators be informed to write the tape recording density onto the tape labels.

The tape(s) is to be shipped to JPL in the next available consolidated shipment. Once at JPL, the tape is to be delivered to the RSST (230/103) (Attn: P. Eshe) where it will be logged and 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 open-loop data after a pass. The NBIDRs will be manufactured by the NDP and delivered to the RSST after completion of playback.

7.1.2 Closed-loop Tracking Data

Closed-loop tracking data in the form of an ATDF will be requested from Multi-Mission NAV (MMNAV) via a request memo which specifies the spacecraft ID, and the start and stop UTC times of the desired data. If only a portion of the data are required between the start and stop times, then the request memo will specify a list of the desired passes, each specified by station ID and start and stop UTC times. For the case of USO tests, the request memo will be issued periodically (e.g., once per month) and will specify that only one-way data are desired. MMNAV will then produce the ATDF which then can be picked up by or delivered to the RSST.

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, a CRSPOSTA file manufactured from the best available navigation solution will be required.

The RSST will communicate the appropriate request 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 is the output CRS product to be delivered to the Orbiter Engineering Team (OET) and Radio Science. However in practice, Radio Science receives the file with an ASCII format (CRSPOSTA), and OET receives it with 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 to where you want the CRSPOSTA file(s) to be copied.

2) Type "FTP" then "OPEN HOSTB".

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 RS-89-349/CRS-D1 RS-89-349/CRS-D1

5) When the FTP prompt appears after successful transfer, 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 navfilename,filename
```

The @EMBED command will take the delivered NAV file named "navfilename" and recover the ASCII into the assigned file named "filename" which can then be transferred.

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) 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 you choose on your VAX.

3) Then FTP the file from your VAX to the desired partition in RODAN. Note that you may have to perform the FTP while logged onto RODAN if it doesn't work from your VAX.

7.1.4 NOCC Passfolder

The NOCC hardcopy data which may be requested by the RSST consists of the complete passfolder which includes 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 the various media measurements.

7.1.6 Small Forces History File

A Small Forces History File (Attitude History File) will be required for the Ulysses Solar Corona Experiment 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 executed by the Ulysses spacecraft 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 by UNAV.

7.1.7 DPTRAJ Listing

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

7.2 Other Post-pass Activities

Currently, there are no requirements for post-pass calibrations for the Radio Science passes. It is important however 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. NBIDRs of these playback data will be generated on the DRG in NDPA and will be ready for pickup 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)	Request memo to Margie Medina, MMNAV. When notified, tape can be picked up by an RSST rep.	Within seven days.
NBODR(s)	Only if open-loop data were acquired. The station will ship the NBODR(s) to JPL Attn. P. Eshe, Mail stop 230/103.	Within a month after test.
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 Rolanda Dean (507-215). Passfolder then mailed to P. Eshe.	Within seven working days following the pass.

TABLE 7-2

DATA PRODUCT DELIVERY STRATEGY AND SCHEDULE

ULYSSES SOLAR CORONA EXPERIMENT

PRODUCT	DELIVERY STRATEGY	DELIVERY SCHEDULE
NBODR(s)	The station will ship the NBODR(s) to JPL Attn. P. Eshe, Mail stop 230/103.	Within one month of end of a pass.
Playback IDRs	To be generated only if specially requested. Request to R. Rose. IDR(s) to be delivered to P. Eshe from DSN NOCC NDPA.	Within one week (normally two days) of end of a pass.
ATDF	A request memo is sent to L. Campanelli, MMNAV. When notified, tape can be picked up by an RSST rep.	No more than seven days of latest data on tape.
NOCC Passfolder	Phone request made to Rolanda Dean (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 on NAV VAX GROUCHO 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 7-3

GALILEO

DATA PRODUCT INTERFACE AGREEMENTS

DATA PRODUCT	SOURCE	USER	FORMAT #	IFA #
Archival Tracking Data File (ATDF)	DSN	RSS	SIS 1001-14	NAV-1
Narrowband Open-Loop Data (NBODR)	DSN	RSS	DSN 820-13 RSC 11-10A SIS 233-03	DSN-22
Narrowband Play-back Intermediate Data Record (NBIDR)	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 7-4

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
Narrowband Open-Loop Data (NBODR)	DSN/TRK	RSS	DSN 820-13 RSC 11-10A	1taa
Narrowband Play-back Intermediate Data Record (NBIDR)	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

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, and the PAS is primarily concerned with experiment planning and analysis of data.

There are five program sets which have been or are planned to be formally delivered to the Galileo Project (and some will also be used by Ulysses). They are RCLVAL and ROLVAL in the DRS, and STBLTY, FARACHK and LMSPEC in the PAS. RCLVAL has been delivered to the Galileo project in 1990 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) has been delivered to the Galileo project in 1984, but is not applicable for this edition of the handbook. The remaining three programs (ROLVAL, STBLTY and FARACHK) are planned for delivery in the 1992-1994 time frame and are discussed in Sections 8.1.6, 8.2.1, and 8.2.2 respectively (see Table 8-1). Listed next to each program in Table 8-1 is the name of the Cognizant Programmer (the person responsible for development and modification), and a "rough" estimate of the number of routines and number of lines of code. The number of routines and lines of code refer only to the contents of the main source directory of the program and does not take into account insert elements or routines used by the program residing in outside directories (utility or otherwise).

The existing Voyager software code for the program sets listed in Table 8-1 will serve as a base for the Galileo/Ulysses software development. The original Voyager versions will remain intact in their original directories, while the new versions will be developed in the appropriate Programmer's UFD. It appears that almost all of the required code exists for the planned 1992-1994 delivered versions. It is expected that some modification of specific routines will be required, and that some routines will require extensive restructuring (e.g., breaking them down into smaller subroutines) in order to comply with Project guidelines. The major time consuming tasks appear to be source code documentation (flowcharts and program descriptions, etc.), and possible rewrite of those routines for which source code is missing.

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. As the final link in the Radio Science Ground Data System, this section on the DRS will describe the data processing, validation strategies, and validation software required to support Radio Science investigations.

8.1.1 Data Sources

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

8.1.2 Data Logging Scheme

TBD

8.1.3 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) PRIME computer Facility in Building 230.

8.1.4 Data Destinations

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

8.1.5 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 set has been formally delivered to the Galileo Project in 1990 and is routinely being used to perform the validation of Galileo USO closed-loop data. RCLVAL will also be used to validate ATDFs of selected passes from the Ulysses Solar Corona Experiment.

The data validated include Doppler pseudoresiduals and signal strengths (AGCs). RCLVAL is also used to flag times the data fell within or outside of prespecified tolerance limits, to flag times of data gaps, and to flag times and values of doppler sample rate and "flagged" signal mode changes. Plots of doppler pseudoresiduals and AGCs can also be generated by the program and archived.

8.1.6 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 as a test bed. It is planned that ROLVAL will be delivered to the Galileo Project sometime in the 1992/1994 time period.

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

ROLHDR - performs header dumps of POCA frequencies, time tags, rms voltages, and min max rms voltage dump (formally NBHDR).

ROLFFT - performs signal presence verification by producing plots of power spectral density according to specifications provided by user (formally NBFFT).

ROLSMP - produces plots of sample rms voltages versus time and will be modified to produce histograms (formally NBSMPLS).

These programs share several routines which have the same names but reside in different directories. As redundant routines are identified, it is expected that a unified shared routine directory will emerge, and the numbers given in Table 8-1 may be significantly revised. Each of these main programs consist of a large number of lines of code, and it is expected that restructuring these programs into many smaller subroutines will be a major task.

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 NBODRs/NBIDRs 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 will be used by the program set to estimate the "predicted" or "model" frequency which will be differenced from the observed frequency extracted from the open-loop or closed-loop data.

STBLTY is currently being used to perform the stability analysis of Radio Science data involving the Galileo USO as the signal source.

The STBLTY program is currently being modified to estimate 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. Listed below are descriptions of what each program does.

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 an output 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 most 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 (doesn't require FILTER file). It is more appropriate to run 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 tracking data from ATDFs (C/L file), or open-loop data output from digital filtering and detection programs (NBDECIM-DETPHS or PLLDEC). OCEP reconstructs the observed sky frequencies from the input doppler frequencies (from an input ATDF) or from the input recorded and POCA frequencies (from an input file generated by the open-loop detection software which used open-loop tapes as input).

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

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

8.2.2 Faraday Rotation Signal Processing (FARACHK)

FARACHK will be used to perform stability analysis processing on the S-band RCP and LCP signals acquired from Faraday rotation observations, either of the solar corona during cruise or the Jupiter magnetic field environment during Galileo orbital operations. FARACHK is expected to be used on Galileo data acquired within plus or minus 14 days of first conjunction on January 21, 1992. It is expected that FARACHK will be tested on Ulysses First Opposition Test data acquired between December 1990 and January 1991, where the polarization of the Ulysses transmitted signal will be checked for degree of ellipticity. If the Ulysses transmitted signal does indeed have a significant degree of ellipticity, FARACHK will be used to process Ulysses Solar Corona data.

It is intended that the first available version of FARACHK, if delivered before 1993, will only perform the stability analysis function. The real-time transmission of NRV blocks is not expected to occur until around 1993. A future version of FARACHK may perform real-time processing. Additional processing functions for a future version may be desired such as preliminary magnetic field parameter estimation, depending upon Investigator requirements.

The programs expected to be contained in the FARACHK program set include;

PLLDEC - this program will be used to read the ODR tape or playback IDR and perform the signal detection. Both the SRCP and SLCP signal channels will be processed, each in a separate run, with each run producing an output file of the signal frequencies for that channel.

LOCCOR - this (possible) program will perform local model correlation signal detection on Radio Science open-loop data. This program will be used in place of PLLDEC when the data contain gaps.

FARACHK - reads the frequencies from the output files produced by PLLDEC (or LOCCOR) and computes the SRCP - SLCP frequency differences. Also performs stability analysis processing, and plotting and summarization of results. A future version may perform additional functions such as computing preliminary magnetic field parameter estimates.

TABLE 8-1

RADIO SCIENCE SUBSYSTEM

PRELIMINARY
PROGRAM SET SUMMARY
(for 1992-1994 deliveries)

PROGRAM SET	PROGRAM	COGNIZANT PROGRAMMER	NUMBER OF ROUTINES	NUMBER OF LINES OF CODE
STBLTY	FILTER	MORABITO	10	661
	NBDECIM	ASMAR	5	440
	DETPHS	ASMAR	8	640
	PLLDEC	ASMAR	1	299
	GETTRAJ	MORABITO	12	836
	OCEP	MORABITO	17	1632
	RESID	MORABITO	3	402
	STBLTY	ASMAR	15	1535
	USOSUMRY	ASMAR	1	315
ROLVAL	ROLHDR	ASMAR	8	1914
	ROLFFT	ASMAR	11	2999
	ROLSMP	ASMAR	7	1834
FARACHK	PLLDEC	ASMAR	1	299
	LOCCOR	MORABITO	TBD	TBD
	FARACHK	ASMAR	1	380

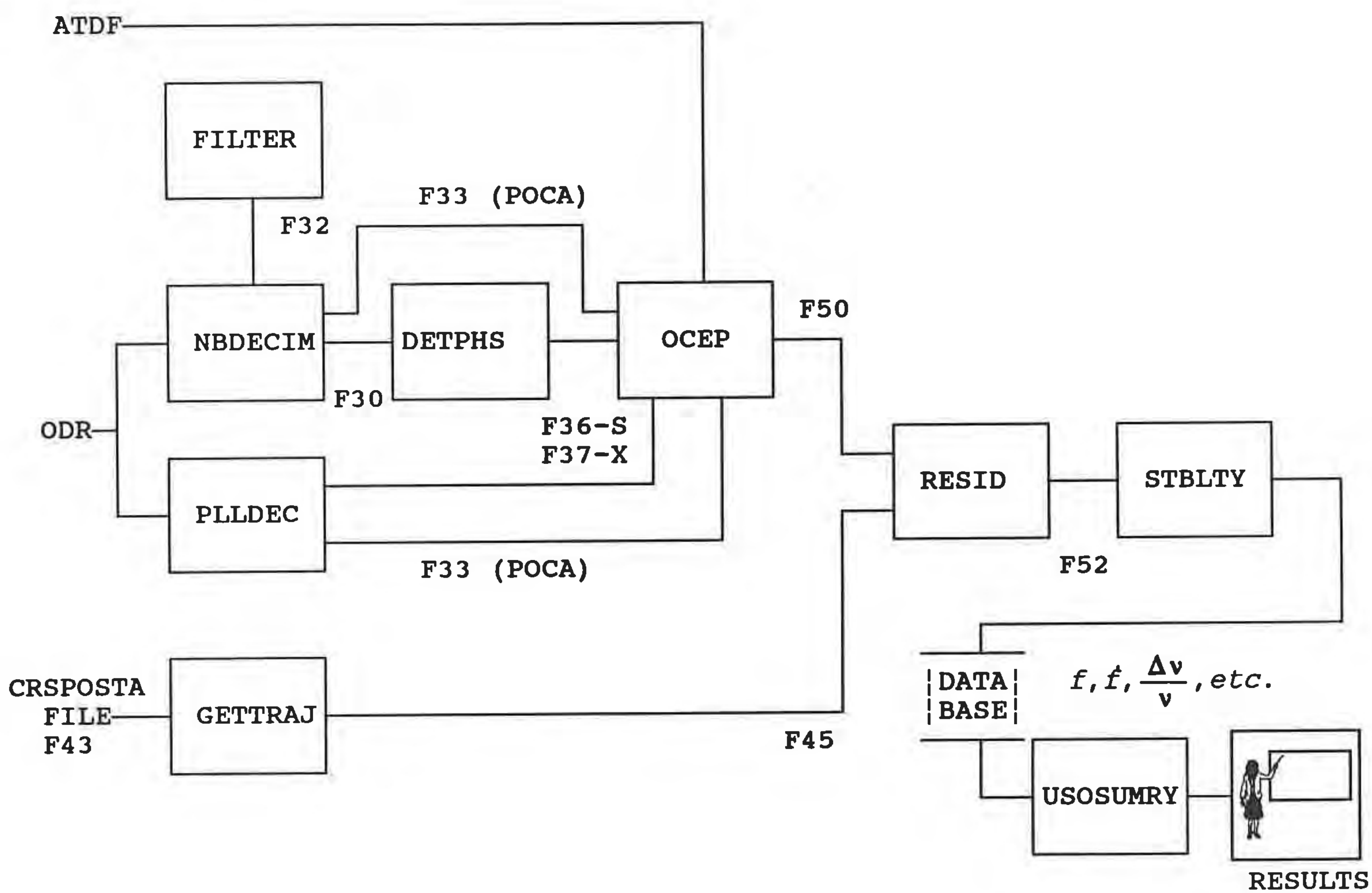


FIGURE 8-1 - STBLTY PROGRAM SET

SECTION 9

COMPUTER SUPPORT

9.0 Introduction

The Radio Science computer support activities include data collection, data archiving, and real-time displays on the PRIME 4050 Computer and/or a SUN workstation. The Radio Science Real-time Monitoring System (RMS) is a real-time display system that displays real-time information necessary for monitoring the instrument and experiment.

The displays provided by Radio Science are different from the displays provided by the NOCC, although there is some overlap. Both systems may be used during Radio Science activities.

An overview of the RODAN computer system is presented in Section 9.1. Start-up and takedown procedures are discussed in Section 9.2. The display system on the PRIME 4050 computer is discussed in Section 9.3. The SUN workstation displays are discussed in Section 9.4. Finally, computer security is discussed in Section 9.5.

9.1 Overview

The 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, 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, and an HP 9000 workstation located in building 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, it is sent to the first floor Radio Science area where RODAN is located. The data is sent to RODAN on four receive-only lines at either 56 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 the various user terminals hooked up to the PRIME and can be sent over the Radio Science subnet where they can be picked up by the Radio Science workstations, a SUN 4/60 and SUN 4/330 both sharing 654 Mb of memory, or by a SUN 4/110 workstation to be used by the Galileo TELECOM group (once they can connect to the Ethernet).

9.1.1 GCF Lines to RODAN

The digital lines which carry real-time data into the RODAN from the DSN's GCF are "receive only" and are tapped off of lines thru splitters located between Data Sets and the Digital Matrix Switch.

The output of these splitters go directly to modems in the Building 230 basement which are hard-wired via twisted pair lines to modems located in the RODAN computer room. The output of these modems conform to EIA RS-449/422A standards; these are connected to the input ports of RODAN's front-end data acquisition/filter computer. These standards are expected to be replaced by the T1 standard some time around 1992.

9.1.2 Data Flow

Within RODAN, data proceed sequentially through successive processes until they are logged onto disk by the FARMER process (refer to Figure 9-1). These disk files constitute a data base that is accessed as needed by the display programs. The data are also forked within RODAN and a copy is sent out via TCP packets in a broadcast to the Radio Science subnet, which acts as a multiple feed/link to each Radio Science workstation connected to the subnet. The data flow is described in the following subsystems and processes.

9.1.2.1 HP Serial Interface

Five Programmable Serial Interfaces (Hewlett-Packard 98691As) have been modified 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.

9.1.2.2 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 transmitted to RODAN via a IEEE-488 parallel interface.

9.1.2.3 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.

9.1.2.4 FARMER and ROUTERTCP

FARMER identifies selected data streams, and unpacks and archives each data stream to a data base disk file. ROUTERTCP, likewise, identifies selected data for the workstations and sends these data out to the Radio Science subnet in a broadcast format to the workstations.

9.1.2.5 PRIME Displays

There are several CPL files which display the RMS data graphically and in tabular form on the PRIME; each of these "programs" is an executable file written in PRIMOS Command Procedure Language (CPL). These particular CPL files contain input data for the DISPLAY program residing in the TSS UFD. Each CPL file provides a set of displays chosen from among 49 available choices offered by DISPLAY.RUN (see Table 9-1).

9.1.2.6 Radio Science Workstations

Two SUN workstations, the 4/330 (GODZILLA) and the 4/60 (GAMURA), are connected to the Radio Science subnet, each executing an independent copy of the RMS display software for workstations. A user may have up to ten graphics windows open at any one time. The number and types of displays available on the workstations are described in 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 you need not read this section. (Note that emergency startup and shutdown procedures are provided in a white notebook labeled "RODAN Handbook" which resides next to the console in the RODAN computer room.)

9.2.1 Startup Sequence

The RMS system startup involves the execution of a series of processes on the PRIME and a dedicated process on the HP front-end. Though either the HP front-end or PRIME can be started first, it is recommended that the PRIME be activated first, followed by the HP front-end.

If the PRIME is started first (i.e., the IEEE-488 controller is initialized followed by the execution of HPIN, FARMER, and various display programs), the HPIN will generate DMA timeout warning messages until it sees data coming from the HP front-end (NOTE: HPIN generated DMA timeout messages are also generated if data are coming in slowly). FARMER is an infinite-loop polling routine which checks the circular buffer for the next available data; hence, FARMER waits on HPIN, and various display routines wait on FARMER.

If the HP front-end is started first, then finding the PRIME not receptive, it will hang as soon as it tries to send packets to the PRIME via the IEEE-488 interface. This will initially cause buffer overflow errors when data blocks start transferring to the PRIME. Once the PRIME is started, normal operations will commence.

On the PRIME computer, HPIN, FARMER, and any display programs must be started in that order. HPIN is normally always running as a system phantom, so there is no need to either start or stop it. Each process shares a system resource with the preceding process; moreover, the former initializes the shared interface, and the latter does not. Hence, the order in which these routines are started is essential for successful RMS startup.

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.

9.2.1.1 HP Setup

The Hewlett-Packard 9220 computer, used as the front-end of the RMS, is located in the bottom of the FPS Array Processor rack.

9.2.1.1.1 G.C.F. Lines

Figure 9-2 is a block diagram description of the interconnection of the RODAN lines between the GCF in building 230/B3 and the Radio Science RODAN computer system located in building 230/103A. 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	CURRENTLY NOT FUNCTIONAL	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 control depending on the toggle setting of an AB switch located behind a steel plate in a rack located in the basement of building 230. Currently only RODAN 3 can carry valid data to the Radio Science computer, as RODAN 5 is "nonfunctional".

The configuration of each line may be confirmed or modified for any of the three DSN complexes by calls to the OPS Chief (X37990) and COMM Chief (X35800). Refer to Section 6 for specific details of the procedure for setting up RODAN lines. Once the procedure is initiated, you can verify that the proper lines are connected by observing the reception of the particular data type on the FARMER display screen on the PRIME or the MONITOR display screen on the HP.

9.2.1.1.2 Power Switches

Turn on the power switches for the main box, the floppy disk drives, the printer and the monitor.

9.2.1.1.3 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 slot of the disk drive (HP 9122) with the label on top. 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's activity light will go out).

If the H.P. is already on, and the system needs rebooting for any reason, then you may press "SHIFT RST", while the disk is in the slot. If the H.P. does not boot properly, then try cycling power.

This disk should stay in the drive or next to it at all times, although 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).

9.2.1.1.4 Program Startup

Execute the filter program by pressing "X" (execute), then type "FILTER [CR]". Type the three select codes of the interfaces which are to be used (e.g., "20 [CR]", then "21 [CR]", and then "22 [CR]") when prompted. See Section 9.2.1.1.1 for the correspondence between the lines and the codes.

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

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

Check that data are coming over the line, and that you have typed the correct select codes.

You can determine whether data and clock are present on the GCF line by looking at the LED lights on the front panels of the Data Sets. Both Carrier and Traffic LEDs must be lit. For RODAN-4, set the clock speed to either 224 Kbps or 56 Kbps depending on the incoming clock speed.

You can verify the proper interface select code by looking at the back of the HP to check which interface the cable is plugged into. The relevant interfaces are numbered 20 through 24 and are in the left half of the backplane. These codes should correspond to the RODAN lines as listed in Section 9.2.1.1.1.

Only if the problem cannot be located locally should you call the OPS Chief and report that the line is not working properly. The most likely problem, if the HP is set up properly, is that a cable may not have been completely plugged in when the line was connected by the COMM Chief.

If you wish, you may execute the MONITOR program on the HP to get some indication of the kind of data blocks present on the line. 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 for data to be logged by FARMER, the program FILTER must be executing on the HP 9220).

9.2.1.2 HPIN

If the HPIN process, usually called "SYSTEM (HPIN.CPL)", is not currently running on the PRIME, then you can start the HPIN phantom process by typing "PH TSS>HPIN". (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).

The status of the phantom can be checked to some extent with "STAT USER", and "STAT SEM". The former should show a phantom named HPIN with device GP0 assigned. The latter should show the semaphore number 1 with a value between 177634 and 0. (The number is a negative, 16 bit integer displayed in octal. The value is the number of data blocks in shared memory waiting for the FARMER process to read them.)

9.2.1.3 FARMER

Login at a Tektronix 4107 terminal as username "FARMER". After you are logged in, type "FARMER" to execute this process.

The program will then ask you for a configuration file. The configuration file is a listing of parameters in a specific order that FARMER uses to determine which data it should accept. These files which reside in the TSS UFD 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, named accordingly. The latter file will accept data for any 70-m station which happens to be tracking Galileo. All of these files will only accept data related to specific Galileo passes. Other files will be set up to accept data for Ulysses Radio Science activities and other type Galileo passes. Enter the filename.

FARMER will then prompt for the name of the subdirectory to which the data will be logged. Type in an appropriate subdirectory name (e.g., GLL_USO_DOY233).

9.2.1.4 Display Startup

See Section 9.3 for a detailed description of the setting up and running of the DISPLAY software using a terminal connected to the PRIME computer.

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

9.2.2 Take-down Procedures

Display programs can be stopped by entering the appropriate response given in the menus. At the end of a pass, the FARMER process should be stopped by typing control-P, followed by "LO" to logout of that 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 OPS Chief or COM Chief.

9.3 PRIME Display Generators

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.

It is planned that the PRIME DISPLAY software will be modified to function on the IBM PCs using PCPLOT with Tek 4105 terminal emulation at some time in the future.

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 displaying data, 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 you want to look at. These questions are self-explanatory and will not be described in detail. Table 10-1 provides a list of all available data types along with each data type's corresponding data number. The data number is one of the inputs which DISPLAY will request while setting up each plot.

After entering all the required data specifications, DISPLAY will set up the text and/or graph 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 it is not desired to wait for this initial backfilling, then enter a control-P (to cancel the backfilling), and enter the real-time command (R) and all graphs will start displaying immediately at real-time. The control-P break always resets any

backfilling in progress.

Instead of running DISPLAY directly, the User may desire to have often-used display configurations stored in a CPL file. Examples of CPL files for specific display configurations follow (e.g., to display open-loop data, type "CPL RTOL" then "CR"):

```
FILE:  RTOL.CPL     (for open-loop data)
PAGE 1: GRID 1: SSI Spectrum stacked right
        GRID 2: SSI Spectrum
PAGE 2: GRID 1: DSP RMS Voltages (S-band)
        GRID 2: DSP RMS Voltages (X-band)
PAGE 3: GRID 1: SSI Peak Frequency History (All inputs)
        GRID 2: SSI Peak Power History (All inputs)
TEXT PAGE:  NRV STATUS

FILE:  RTTRK.CPL  (for closed-loop TRK data)
PAGE 1: GRID 1: S-band AGC
        GRID 2: X-band AGC
PAGE 2: GRID 1: S-band Pseudoresiduals
        GRID 2: X-band Pseudoresiduals
PAGE 3: GRID 1: Number of S-band cycle slips
        GRID 2: Number of X-band cycle slips

FILE:  RTSS.CPL  (for SSI only)
PAGE 1: GRID 1: SSI (All inputs)
        GRID 2: SSI Peak Power History (All inputs)

FILE:  RTSNT.CPL  (for system noise temperature from MON
                   data)
PAGE 1: GRID 1: SNT (RCVR A)
        GRID 2: SNT (RCVR B)

FILE:  RTTXT.CPL  (for text NRV display)

TEXT PAGE:  NRV STATUS
```

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 should 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 here; 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. 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 - interactive specification of desired 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 (in UTC) of the first time limit chosen 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 - interactive specification of the desired 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 x=t, that is, use the command "P t". For a copy of a graph, set "x" equal 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 equal 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 Displays

This section discusses how set up and to run the display software on the Sun workstations. This automated procedure will initialize the SUN display environment with three terminal emulation windows, two graphics pages, and one page consisting of a combination of a graphics page and a text page.

9.4.1 Things to do Before Running the Displays

1) In RODAN, attach to the "router" subdirectory. Edit your configuration file (e.g., "ws_40") to specify exactly the data you desire to receive. The contents of this configuration file must match a subset of the contents of the configuration file residing in the "TSS" subdirectory in RODAN (except for the first two lines of the file residing in the router subdirectory which specifies the start and stop times of the data reception). 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 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 available 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) In Sun "GODZILLA" - in "/home/tss", edit the configuration file to reflect start, stop times and all of the data types that are desired to be received and archived.

3) The data base area on the computer disk needs to be initialized prior to reception of data. This process allocates all or part of 50 MB "virtual memory" as a time dependent linear storage space. This ensures that sufficient space is available as well as opens up data space for any pre-dated data. Initialize "virtual memory" - by either running "get_live_data", or "load from tape/disk" utilities. These can be invoked through "DATA BASE UTILITIES" (see Section 9.4.3).

9.4.2 Invoking and Running the "DISPLAY" Software

1) Make sure that you have configured your system for the 50 MB virtual space (see Section 9.4.1). (Please note: GODZILLA is already configured for this, upon LOGIN. No user action is required if using GODZILLA.)

2) Login as user "tss".

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

4) Upon entering the password, the computer shall place the user in the directory containing all of the executable code, configuration files, and utilities necessary for running the full "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 of the data base is empty or is uninitialized. The "display" software will automatically invoke "Data Base Utilities" to allow the user to proceed with data base initialization. See Section 9.4.3 below on how to use the "Data Base Utilities".)

5) A window titled "STARTUP MENU" will be displayed which contains choices (See Figure 9-3, Item A). Select "new display" by pointing the mouse on this item and clicking the LEFT mouse button. This shall invoke the "display" program.

6) Upon selecting "new display", a menu will appear in the upper right hand corner of the display titled: "Main Selection Menu" (see Figure 9-4, Item A). Depending on user desires, you can proceed to the first selection "CREATE A NEW PLOT", which will process information that is already in the data base. To choose another data base, or initialize a new "live" data monitoring session, first invoke the "DATA BASE UTILITIES", and then select the source of data desired. This selected data will be filled into the data base and the user will be ready to select "CREATE A NEW PLOT" in the "Main Selection Menu", to view these data in a plot form. The most common action taken by the user, will be to select "Data Base Utilities". Upon invoking this selection, the user will be presented with the following choices (see Figure 9-5, Item A):

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

7) Select the appropriate choice listed above in item 6. Each of these items are described in detail in Section 9.4.3.

8) If "get live data" (see Section 9.4.3.1) was selected, then the user must set up "routertcp" (see Section 9.4.4).

9) When "get live data" (see Section 9.4.3.1) or "load from tape/disk" (see Section 9.4.3.2) above is chosen, and the appropriate data set is loaded in, the user can then select the option "CREATE A NEW PLOT" from the main selection menu (see Figure 9-4, Item A).

10) Next, when the "Data Type Selection Menu" appears, the user can select from among the various data types. Selections from this menu automatically detect what data types are available in the "virtual memory" and display them (see Figure 9-7,

Item A).

11) After selecting a data type, the user can then select from among the various "Plot Types" or data to be displayed in a plot, which is the next menu (see Figure 9-10).

12) 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 8-10. The various plots created can be moved around or manipulated by using the various mouse commands described in Section 9.4.5.

13) When done with any RMS activities, the user can then quit or close out each window. If the user wants to terminate display software and log out, then this can be done by placing the mouse on the background and clicking the RIGHT mouse button. Another menu will appear. Move the mouse to the EXIT SUNVIEW item and click the mouse (see Figure 9-11). 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 Data Base Utilities

Each of the data base utility items will be discussed in detail in this section.

9.4.3.1 "get live data"

This selection is used for acquiring and displaying "real-time" live data. When this choice is invoked (by pointing to this selection with a mouse, and pressing the LEFT mouse button), a program is accessed which initiates a socket communication link that will enable reception of data from the PRIME computer. At this point, the program will execute an infinite loop, waiting for data to commence transmitting. The user needs to login to "PRIME" and initiate the "routertcp" program (see Section 9.4.4).

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

If the database 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 shall not be cleared and new data shall be appended to the existing data base. Please note, that the data base is configured to accept data for the specified time range. If your new data requires a storage location which falls beyond the specified time limits of the data base area, then you may lose data.

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

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

This is a safety step and lets the user save data before destroying or clearing the data base. If "n" is selected, then the program displays:

"Save the data base and try again".

After which, the "get live data" program will terminate. The user, now can make a new selection from the top panel.

If the user types in "y", then the database shall be cleared and the following message shall appear:

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

The user is being prompted for a configuration file (e.g. "ws_40"). This file can have any name. An example of this file 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

The software shall make a calculation of space allocation based on the specified data types and requested time span. If the "virtual memory" limits are exceeded, the user shall be presented with the proper error message:

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

The user then, 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 shall proceed with creating, initializing and partitioning the "virtual memory" to accommodate the data monitoring run. The software is then invoked to start an infinite loop to receive data. At this point, the user needs to open a new window, or from another terminal, the user must login to "RODAN" and initiate the data dissemination program. (See Section 9.4.4).

When the "RODAN" ROUTERTCP process starts sending data, its reception at "GODZILLA" shall become evident, as data packet messages are displayed in the utilities panel. These packet received messages will appear as follows:

SOURCE INET ADDRESS 80952B39
SETUP_SOCKET 1
SOCKET 0
BIND 0
ADDRES -2137707759
" " "
(see Figure 9-6, Item B for rest of received messages)

These messages indicates that the system is functioning normally. The user may then close the window in order to reduce cluttering the display. (Note: do not "quit" the window, just "close" it.) This can be done by pointing the mouse pointer at the top bar of the window, and clicking the RIGHT button on the mouse. A menu shall appear with one of the choices being "close". This will reduce the window to an icon.

The "Display" software will go into full action. The first menu shall appear labeled: "MAIN MENU". This will allow you to continue on to create plots. A stand-alone utility "gauge" shall be automatically invoked and will appear as an icon. Point the mouse on the "gauge" icon and press the LEFT button. The icon shall open up into a window, displaying the available data and the data types. The "gauge" acts the same way as a "fuel gauge" as it shows how much of the allocated data space in the "virtual space" is filled. This can also serve as a warning device, in case the data space is filling up for a particular data type. (See the "MAIN MENU" for a list of the available choices.)

9.4.3.2 "load from tape/disk"

The next selection on the "DATA BASE UTILITIES" is "load from tape/disk". This option allows the user to access old or previously saved data base for perusal or examination. Select this option by pointing the mouse pointer on this choice and pressing the LEFT button. The existing data base that is in the "virtual memory" shall be displayed and the user will be prompted:

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

The user, again, is confronted with the same choices as in the "get live data" selection. A "n" response shall give the user a further prompting:

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

A "y" answer shall bypass initialization or deletion of the "virtual memory" space and a "n" response shall void this process and terminate loading any new data from any file or tape. A message "Try again" shall appear and the whole process will be aborted. The User may invoke new action by selecting from among the available choices on the panel. 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.

If a "y" answer is given to the first question, a program that removes all shared memory segment or data base segment from the "virtual memory" is invoked and then the user is prompted:

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

If "f" is selected, the user is next prompted for directory name. This should be a subdirectory name where the desired data base is archived (e.g. gll). 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/gll 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 specifying the directory name the data base is automatically loaded into the "virtual memory" and the program displays:

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

The "DATA BASE UTILITIES" window can be deleted, by pointing the mouse pointer to the top frame of the "DATA BASE UTILITIES" and pressing the RIGHT mouse button. A menu shall appear and one of the choices is "quit". Select this option to destroy this window. Alternatively, this window can be deleted by pointing the mouse on the "quit" item in the "data base utilities" menu and clicking the RIGHT button.

In response to the prompt;

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

if "t" is selected, software is invoked which will allow the user to load a previous data base from the tape cartridge. The program shall prompt the user as follows:

"Install tape and press RETURN when ready "

When the user presses the return key, the files shall automatically be extracted from the tape and placed into the "virtual memory" and onto the disk under a created directory name having the same name as the directory it was archived under.

9.4.3.3 "save to tape/disk",

If the user selects "save to tape/disk" choice, this means that the user is requesting an archiving utility. The data may be archived to either a hard disk sub-directory or onto a tape. When this choice is selected, the user is prompted as follows:

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

All "virtual memory" collected data shall be archived into the subdirectory specified by the user. Next, the user has a choice to backup the files on to the tape. The user shall be prompted as follows:

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

A "n" response shall terminate this utility and the user can proceed to make another selection on the "DATA BASE UTILITIES" panel.

A "y" response shall initiate a program prompt as follows:

"install tape and press RETURN when ready "

The tape drive for "GODZILLA" is located in the RODAN computer room, on top of the SUN workstation. As you enter and face the far wall, it is located in the far right hand corner of the room. The database files shall automatically 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 shall 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.

After tape writing completes, or if it is desired to examine the contents of a tape, the following command will list the contents of the tape:

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

9.4.3.4 "list sub-directories"

This option lists 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.

9.4.3.5 "Report about present data base"

This option displays the status of the current "virtual memory" database.

9.4.3.6 "Quit".

This option shall terminate the "Data Base Utilities" menu and close the window.

9.4.4 Making RODAN Run

1) Login to RODAN through a NEC terminal OR you can use a shell window in SUNVIEW to access RODAN.

2) Accessing RODAN through a shell window in "sunview".

Point mouse pointer to the background (grey) location on the screen and press down the RIGHT mouse button. A menu will appear and one of the choices will be "Shells". Move the mouse to the right of the submenu, and select "Shell Tool". A window will appear in the middle of the screen (see Figure 9-12). Type in

"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 in: login router

Computer responds: Password?

Type in: 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 in: a router(CR) (attach to directory "router")

In case there are error messages or the program aborts, do the following:

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

If there were several attempts to create an archiving directory named "doyxxx" for the incoming data for a particular day, there may be a left-over directory file of the same name. The above delete command will remove these files so that the RODAN software will be allowed to automatically 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)
```

We are now ready to initiate data dissemination. Return to the SUN software (by moving the mouse to a "SUN" window, and initiate "get_live_data" option). After answering all the questions (see "get_live_data" description), the "SUN" software shall initiate a socket program to start receiving data. Now return to RODAN (move the mouse pointer into the "RODAN" window), and type:

```
routertcp (CR)
```

Computer responds:

```
Enter name of file containing stream parameters
```

Type in:

```
ws_40 (CR)
```

The name of this configuration file (e.g., ws_40) need not be identical to the name of the "farmer" configuration file. However its contents must match a subset of the contents of the "farmer" configuration file.

Note: You can interrupt or cancel execution of any program on the PRIME by typing:

```
(cntl)p
```

RODAN should start sending data packets, and "SUN" window shall display reception of those data packets. You are now on your way to receiving Great Science Data (GSD)!

The RODAN computer shall respond with something similar to the following:

```
SOURCE INET ADDRESS 80952B39
SETUP_SOCKET 1
SOCKET 0
BIND 0
ADDRES  -2137707759
"  "  "        "
(See Figure 9-6 item A for remainder of message)
```

If the telnet connection is broken between a window and the PRIME, then, by pressing the "pause" button on the workstation keyboard, the user is placed back to the point where the user may login.

For further details on setting up and running RODAN software, see the RODAN System Administrator.

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 various display windows (see the "Display Test Software Operations Manual" by G. Benenyan for a description of the full set of WS commands):

To make a graph larger or smaller; Position mouse to corner or edge of plot, hold down "Control" key and press CENTER mouse button simultaneously. Move mouse to desired location. Release CENTER mouse button.

To move a graph; Position mouse to corner or side of plot, and press CENTER mouse button and continue to hold it down. Move mouse to desired location. Release CENTER mouse button.

To change start time; move mouse to top bar of window, press LEFT mouse button, move to desired location on top bar, and release left mouse button. To take effect, position mouse to 'jump' and click LEFT mouse button.

To change time span; move mouse to second bar, press LEFT mouse button, move to desired location on second bar, and release LEFT mouse button. To take effect, position mouse to 'jump' and click LEFT mouse button.

To change the vertical scale of a graph; position mouse to top bar of graph, press and release the RIGHT mouse button, go to "modify graph" and press and release the RIGHT mouse button. Position mouse on number for which a change is desired and press and release the LEFT mouse button. To change the number, click

the delete key appropriately, then enter in desired value and hit return key. Do the same thing with the next number. To allow the modifications to take effect, position the mouse pointer to "accept parameters" and then click the LEFT button.

To display values of a particular data point (X,Y), position mouse to top of plot, hold down right mouse button, go to "Compute XY", and release right mouse button. Move mouse to point on plot and click the RIGHT mouse button.

To place a plot in front of another plot, position mouse at edge of plot and click the LEFT mouse button.

To obtain a hardcopy of the plot, point the mouse onto the top bar of the graphics window, and press the RIGHT botton. One of the choices displayed will be "Print". Upon selection of this item, the plot window will automatically be resized to full screen, temporarily making the plot monochrome. A snapshot of the screen will then be taken by invoking a "screendump". 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.

To plot discrete points instead of a continuous line, or vice versa, position mouse to top bar of plot and click the RIGHT mouse button. When the menu appears, select "modify plot" (position and click the RIGHT mouse button). The graph parameters window will then appear. Position mouse to value displayed next to "Plot-mode" and click LEFT mouse button. Hit delete key appropriately then enter desired value ("-1" for continuous line, "43" for "+" sign, or any other ASCII decimal equivalent for desired plotting symbol). Position mouse to "Accept parameters" and click LEFT mouse botton to accept.

9.4.6 Sample Runs

9.4.6.1 Sample Run One

The user desires to create a "doppler residuals" plot featuring spacecraft 55 SDOP data from DSS 42. A previous data base already exists in memory and is ready for use. The following example illustrates each step of this sample run:

1) Login: tss(CR)

2) Password: (Enter password)

3) Point mouse and press LEFT button on "new display" selection (menu located at the upper left hand area of screen) .

4) Another menu shall appear - "Main Selection Menu". Point mouse and press and release LEFT button on "CREATE A NEW PLOT" selection (menu located at the upper right hand area of the screen).

5) Another menu shall appear - "Data Type Selection Menu". Point mouse and press and release LEFT button on "SDOP 42-55" selection (menu located at the upper right hand area of the screen).

6) Another menu shall appear - "SDOP Selection Menu". Point mouse and press and release LEFT button on "DOP_RESID" selection (menu located at the upper right hand area of the screen).

   A plot shall appear with the desired data type, reflecting the most recent data present in the database. Also, the "Main Selection Menu" shall appear.

   To select other data from the data base for display, use the two "sliding bars" on top of the display plot. This is used to manipilate the "X-axis" or the time scale. The first sliding bar indicates the START time of the data you desire plotted. The second "sliding bar" indicates the time span of the data you desire plotted in "hours:minutes". Point the mouse inside the "sliding bar" and press the LEFT button. You may hold down the LEFT button and "drag" the sliding bar to the desired location. The Day/time indicator located to the left of the sliding bar, provides proper feedback as to the "START" time selection. The "Span" sliding bar operates in the same way. To implement the new settings, point the mouse on the "Jump" selection located to the left of the sliding bars, and press the LEFT button.

7) Backing out or terminating the session; Point the mouse and press LEFT button on the "ERASE DESKTOP" in the "Main Selection Menu" located at the upper right hand corner of the screen. This shall erase all of the plots that are still on the screen. Next, point the mouse on the "Exit Program" selection and press the LEFT button. The computer shall ask you for confirmation. Confirm by clicking the LEFT mouse button without moving the pointer, and the "display" software shall terminate. Next, point mouse in the "background" area of the screen (non-window area), press LEFT mouse button. A menu shall appear, where one of the choices, is - "Exit Sunview". Select this option. The computer, again, shall ask you for confirmation. Confirm. You will be out of the "sunview" windowing enviorment. All that remains to do, is to logout. Type in "exit(CR)" and you are finished.

9.4.6.2 Sample Run 2

The user desires to start a new data base and start receiving "live" data. Ensure that the correct configuration file resides in the "/home/tss" directory (e.g "ws_40"). Ensure that the proper configuration file resides in the RODAN "router" directory (e.g. "wss_40").

The user desires to create a "doppler residuals" plot, featuring spacecraft 55 SDOP data from DSS 42. Each step of this sample run is described as follows:

1) Login: tss(CR)

2) Password: (Enter password)

3) Point mouse and press LEFT button on "new display" selection (menu located at the upper left hand area of screen) .

4) Another menu shall appear - "Main Selection Menu". Point mouse and press LEFT button on "DATA BASE UTILITIES" selection (menu located at the upper right hand area of the screen).

5) Another menu shall appear in the middle of the screen - "DATA BASE UTILITIES". Point mouse and press the LEFT button on "get live data". Configuration of the present data base shall be listed, and the user shall be prompted:

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

   Enter: n(CR)

   Is it ok to delete the existing data base? (y or n only)

   Enter: y(CR)

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

   Enter: ws_40(CR)

Something similar to the following shall appear:

```
start time =  90/267/16: 0: 0
start time =  90/267/23:30: 0
SSI 40 77 shm segment size (Kbyte): 5912
NRV 40 77 shm segment size (Kbyte): 1104
XDOP 43 77 shm segment size (Kbyte): 3168
```

SDOP 43 77 shm segment size (Kbyte): 3168
ANG 43 77 shm segment size (Kbyte): 72
M59 43 77 shm segment size (Kbyte): 296
Total shared memory used: 13736 Kbyte
initiating tcp socket"

Now, go to your RODAN terminal, and start up "routertcp". Information should start flowing to your computer, and you can "close" your "DATA BASE UTILITIES" window, by pointing mouse to the top black bar of the window and pressing the RIGHT button. A menu shall appear, where one of the choices is - "close". Select this option. This will reduce the window to a small icon. The "Main Selection Menu" shall appear at the upper right hand corner of the screen. Point the mouse to the "CREATE A NEW PLOT" selection then press and release the LEFT button.

6) Another menu shall appear - "Data Type Selection Menu". Point mouse then press and release LEFT button on "SDOP 42-55" selection (menu located at the upper right hand area of the screen).

7) Another menu shall appear - "SDOP Selection Menu". Point mouse and press on "DOP_RESID" selection (menu located at the upper right hand area of the screen). A plot shall appear with the desired data type, reflecting the most recent data in the database.

To select other data from the database for display, use the two "sliding bars" on top of the display plot. This is used to manipilate the "X-axis" or the "time scale". The first sliding bar indicates the START time of the data you desire to be plotted. The second "sliding bar" indicates the time span of the data you desire to be plotted in "hours:minutes". Point the mouse inside of the "sliding bar", then press the LEFT button. You may hold down the LEFT button and "drag" the sliding bar to the desired location. Day/time indicator, to the left of the sliding bar, provides proper feedback as to your "START" time selection. "Span" sliding bar operates in the same way. To implement the new settings, point mouse and press LEFT button on the "Jump" selection, located to the left of the sliding bars.

To modify "Y-scale", point mouse to the top black bar of the window frame that you desire to change. Press RIGHT mouse button. A menu shall appear, with one of the choices being "Modify graph". Select this option by pointing mouse to it, and pressing the Right mouse button. A menu shall appear that contains all kinds of parameters that can be changed.

About the third row down, there are two parameters labeled: "Y_Data_Min", and "Y_Data_Max". These are the lower and upper limits of the Y-scale of your plot. To change them, point mouse on to the data portion of the field that you desire to change, and press the LEFT mouse button. The field shall invert in color, to indicated that it was selected. Now, press "Delete" key on the keyboard, to first erase the previous value, then enter the new value as desired. Next, point mouse to "Accept parameters" menu choice on the top of the "Graph Parameter Window", and press the LEFT mouse button. The menu shall disappear and the graph shall redraw with the new parameter changes taking effect.

9.5 Computer Security

The following computer security practices must be adherred to:

A. Passwords

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

2. Passwords should be at least six characters long.

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

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

4. 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.

5. Passwords should be changed at least every 90 days.

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

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

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

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

F. 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.

G. 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 FRENNQUENCY
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

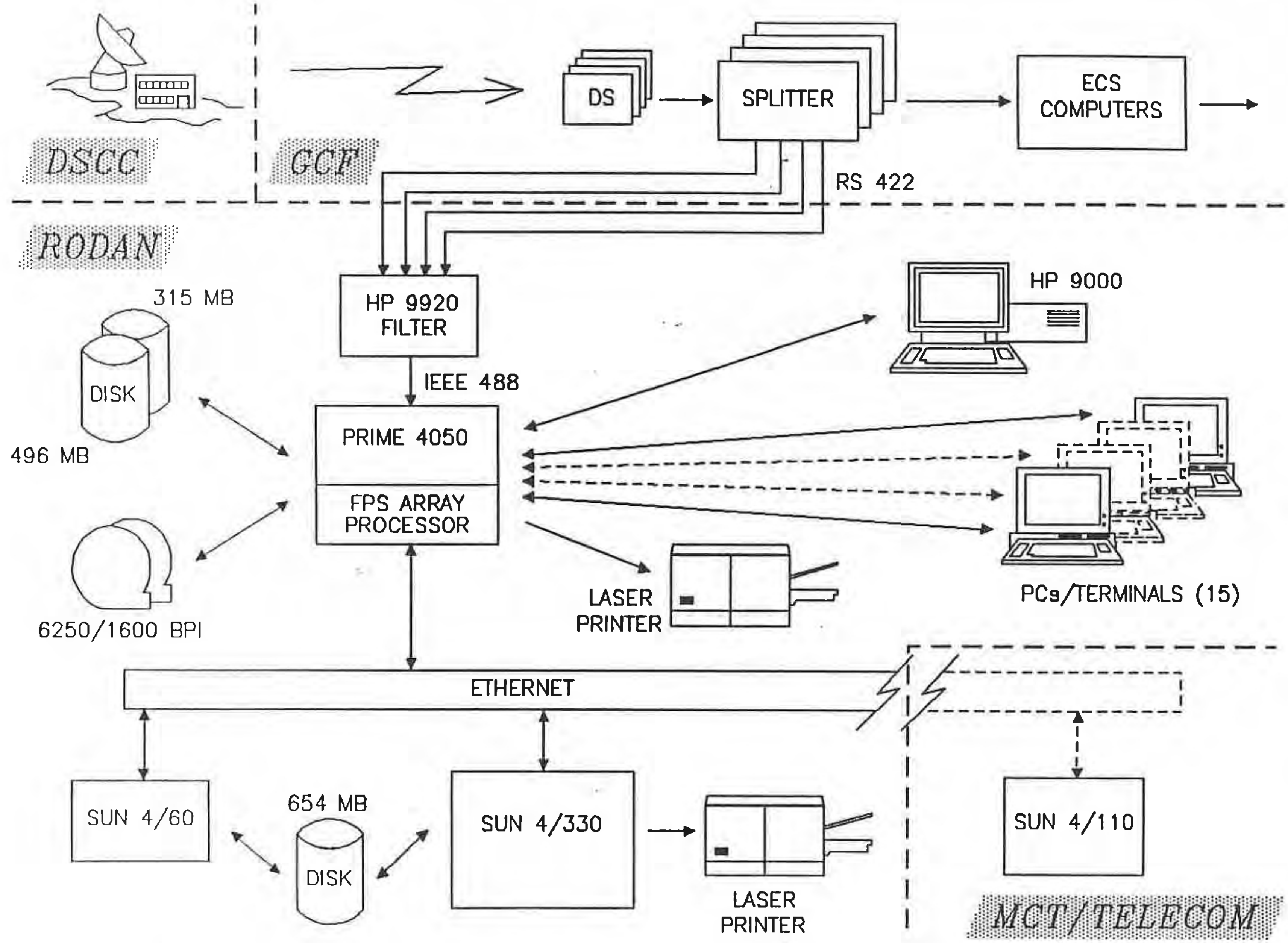
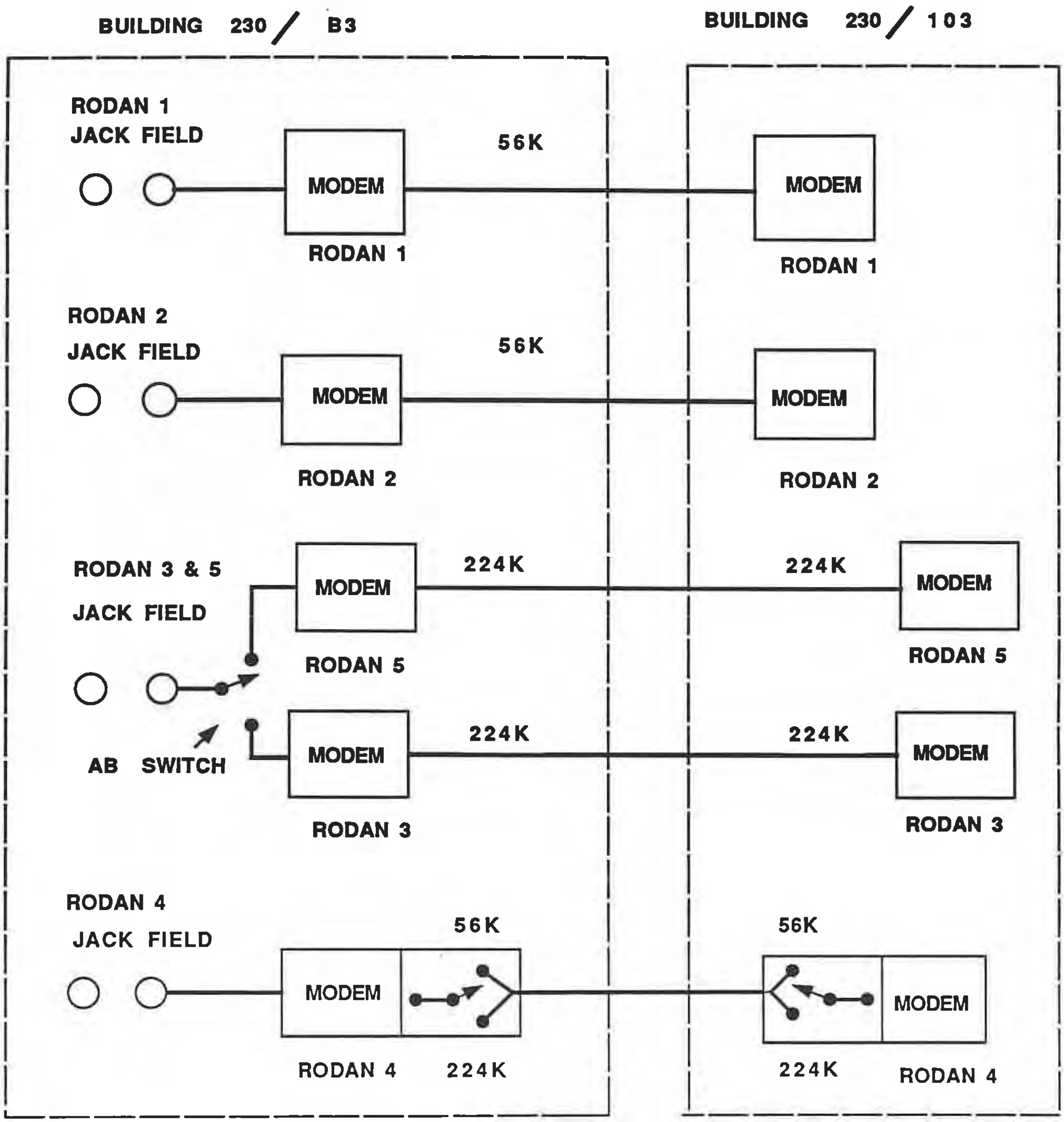

DSCC
GCF
DS
SPLITTER
ECS
COMPUTERS
RS 422
RODAN
315 MB
DISK
496 MB
HP 9920
FILTER
IEEE 488
PRIME 4050
FPS ARRAY
PROCESSOR
HP 9000
PCs/TERMINALS (15)
6250/1600 BPI
LASER
PRINTER
ETHERNET
SUN 4/60
654 MB
DISK
SUN 4/330
LASER
PRINTER
SUN 4/110
MCT/TELECOM

Figure 9-1

RODAN GCF MULTI-MISSION CONFIGURATION



RODAN GCF lines configuration are as follows: RODANS 1, 2, and 4 for High Speed closed-loop data. RODAN 3 and 5 for Goldstone , Canberra, and Spain open-loop data. As a backup for Canberra and Spain RODAN 4 can be configured for closed-loop and open-loop data. [RODAN 5 is connected but non-operational at this time.]

Effective:06/10/91

RAH

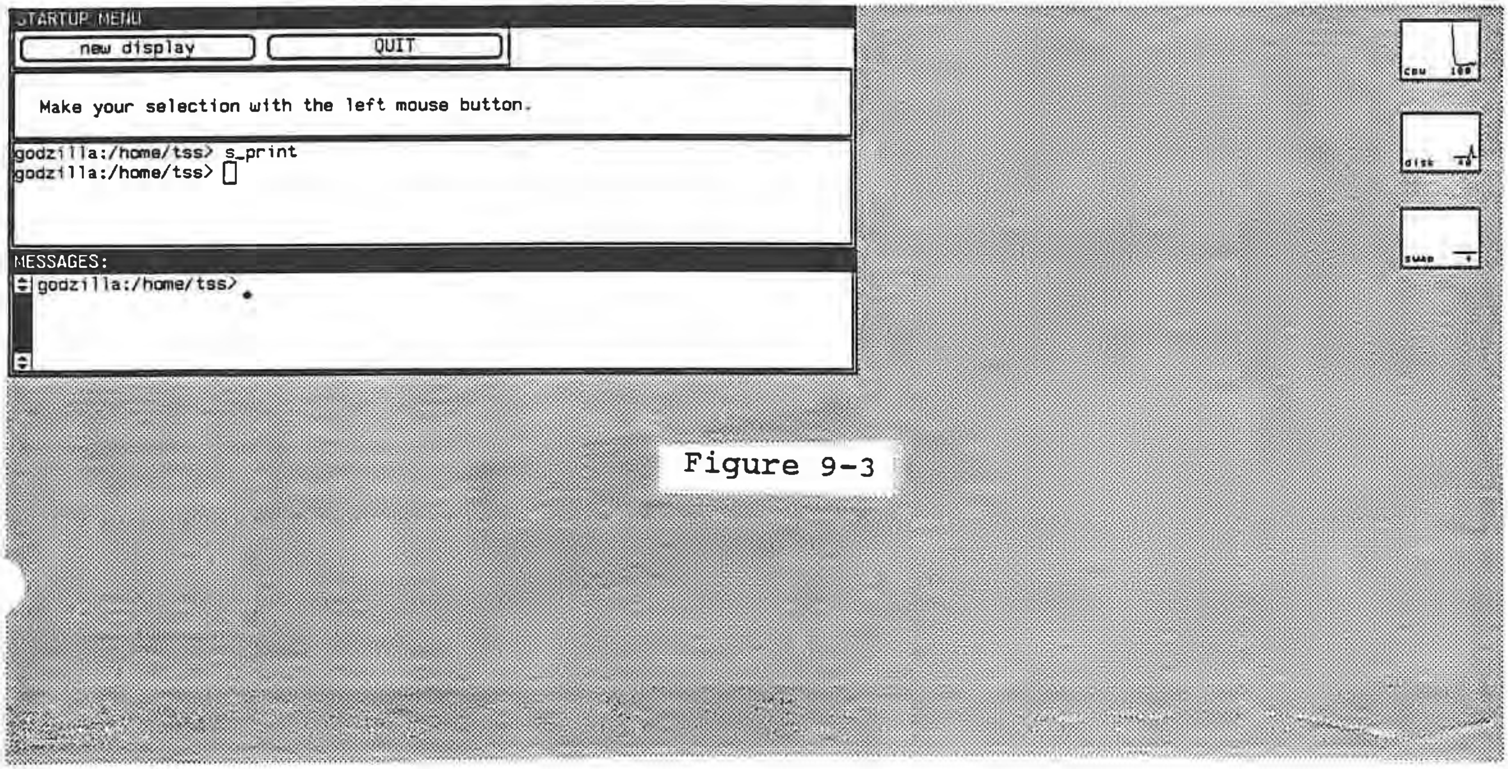


Figure 9-3

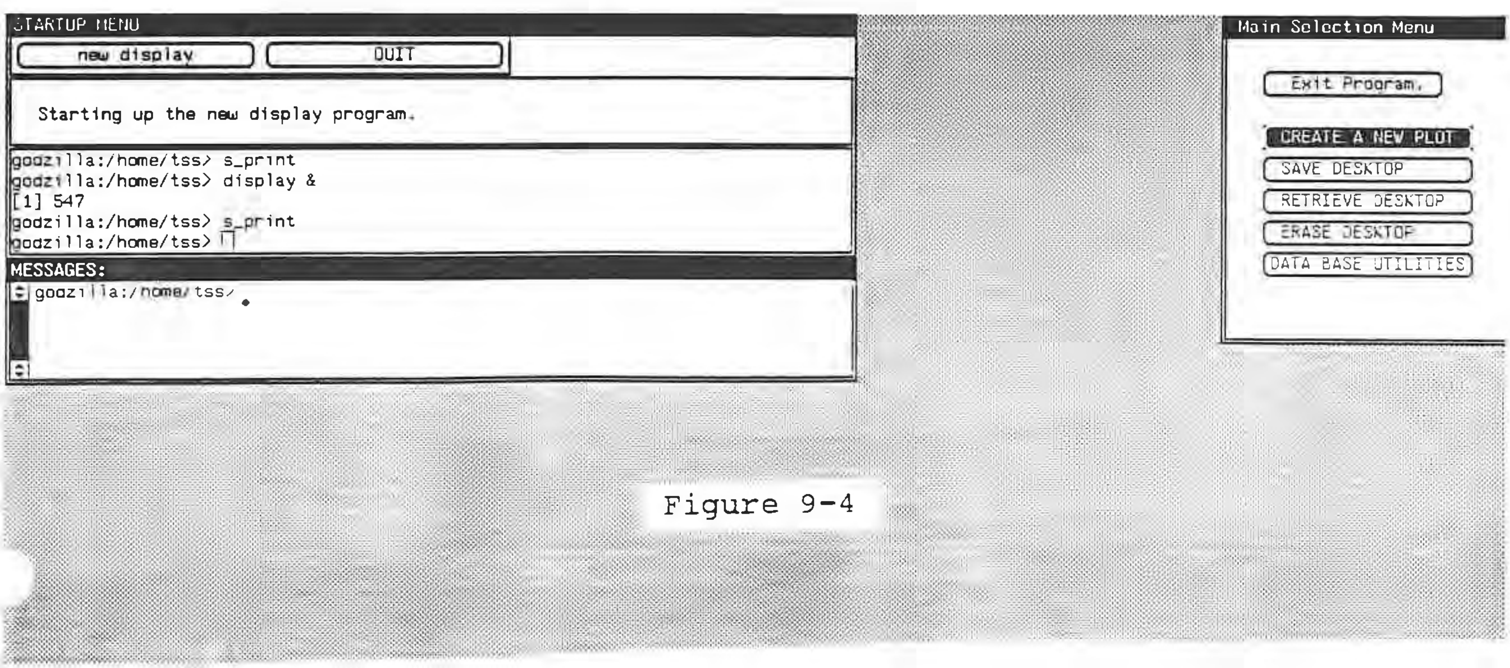


Figure 9-4

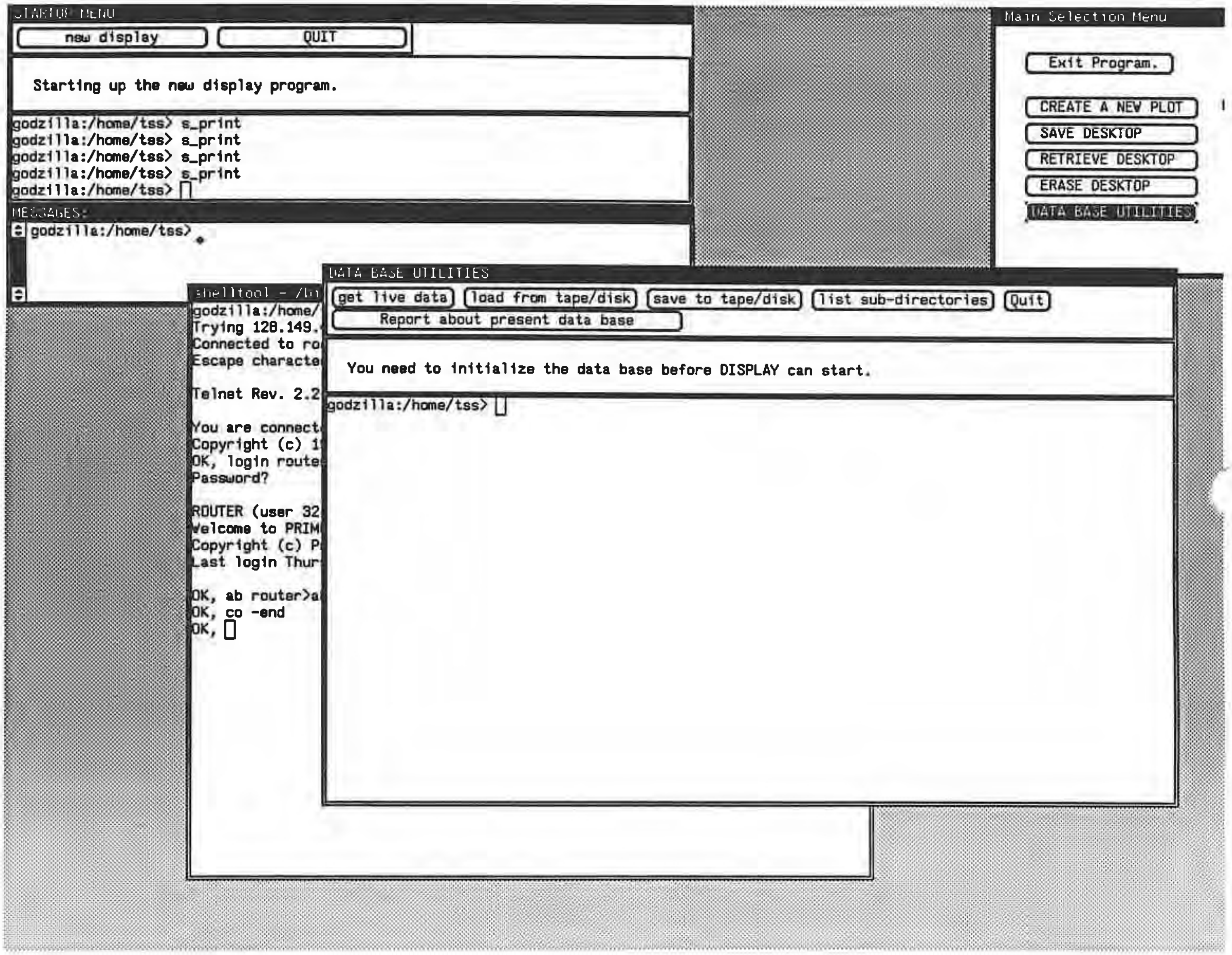

STARTUP MENU
new display
QUIT
Starting up the new display program.
godzilla:/home/tss> s_print
godzilla:/home/tss> s_print
godzilla:/home/tss> s_print
godzilla:/home/tss> s_print
godzilla:/home/tss>
MESSAGES:
godzilla:/home/tss>
Main Selection Menu
Exit Program.
CREATE A NEW PLOT
SAVE DESKTOP
RETRIEVE DESKTOP
ERASE DESKTOP
DATA BASE UTILITIES
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>
OK, co -end
OK,

Figure 9-5

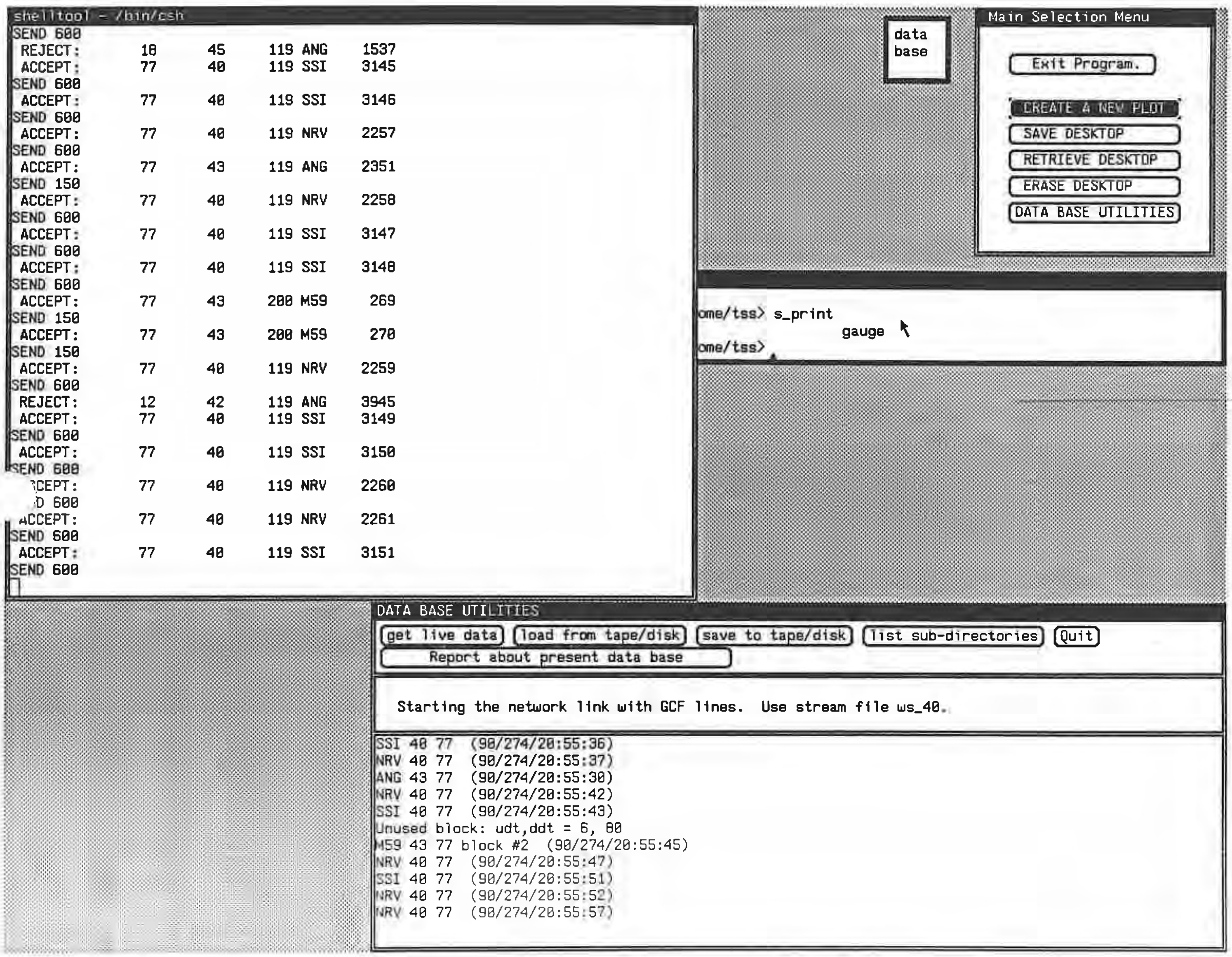

shelltool - /bin/csh
SEND 600
REJECT: 18 45 119 ANG 1537
ACCEPT: 77 40 119 SSI 3145
SEND 600
ACCEPT: 77 40 119 SSI 3146
SEND 600
ACCEPT: 77 40 119 NRV 2257
SEND 600
ACCEPT: 77 43 119 ANG 2351
SEND 150
ACCEPT: 77 40 119 NRV 2258
SEND 600
ACCEPT: 77 40 119 SSI 3147
SEND 600
ACCEPT: 77 40 119 SSI 3148
SEND 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 9-6

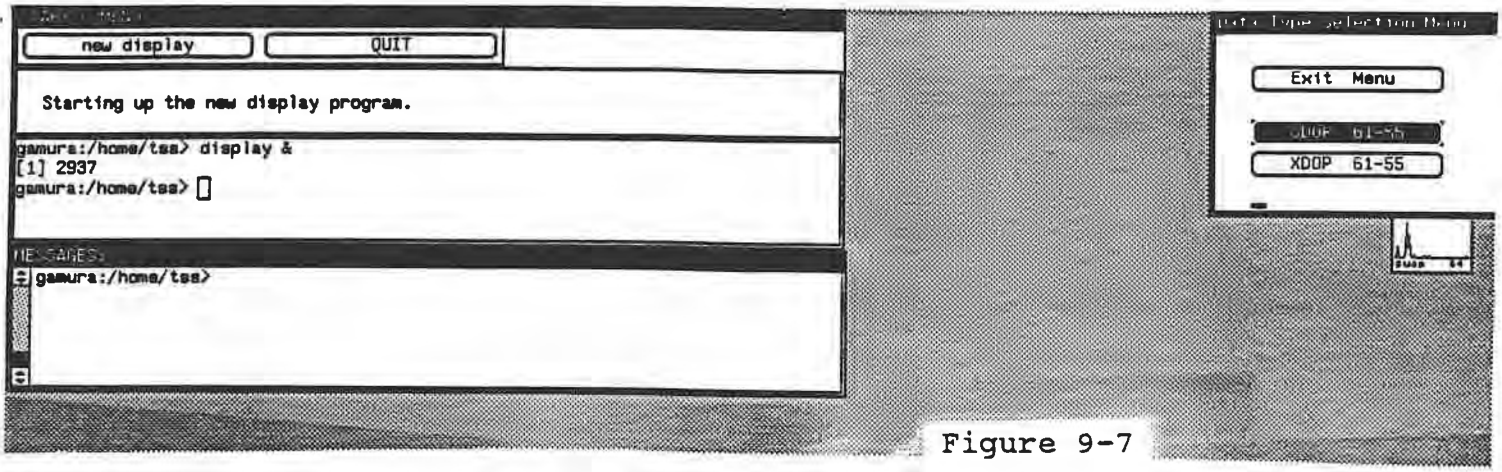


Figure 9-7

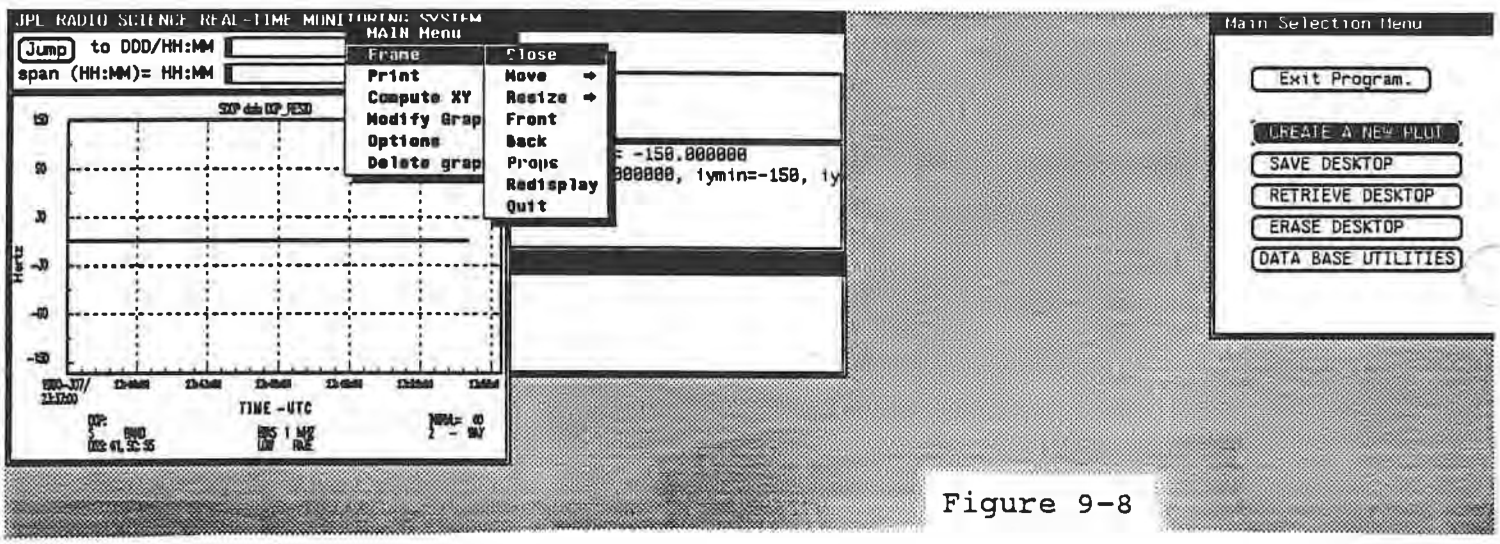


Figure 9-8

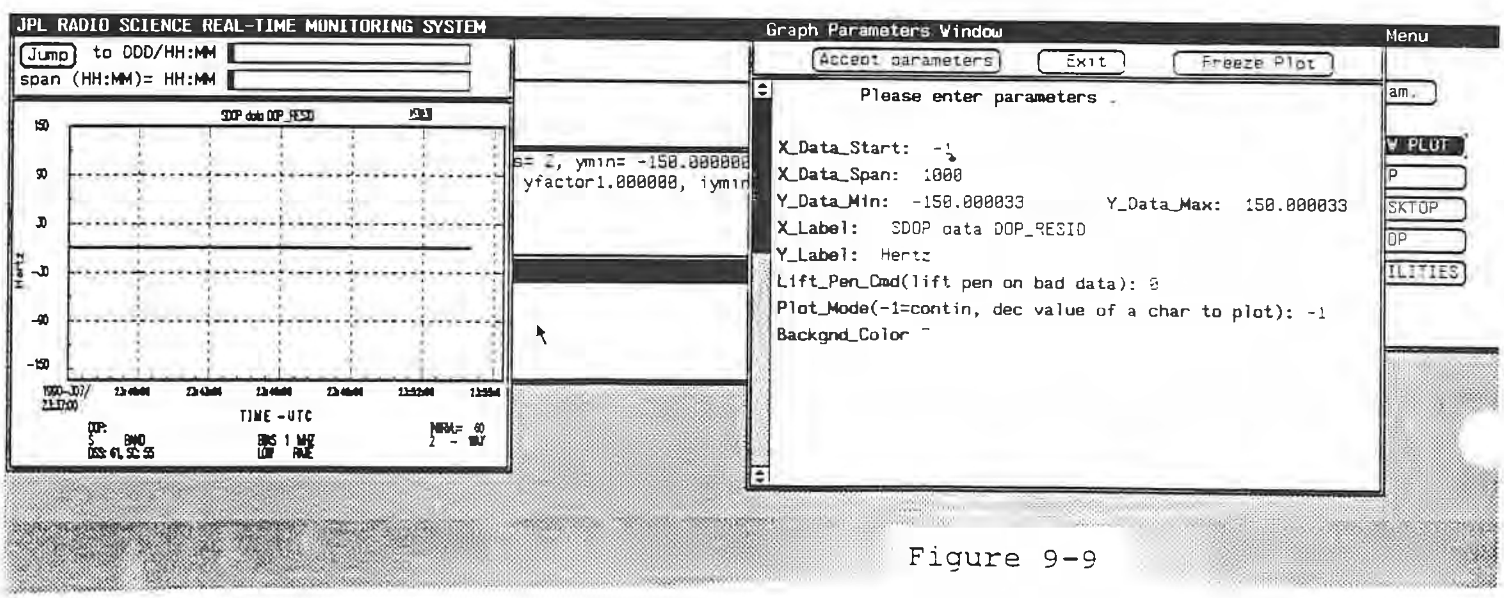


Figure 9-9

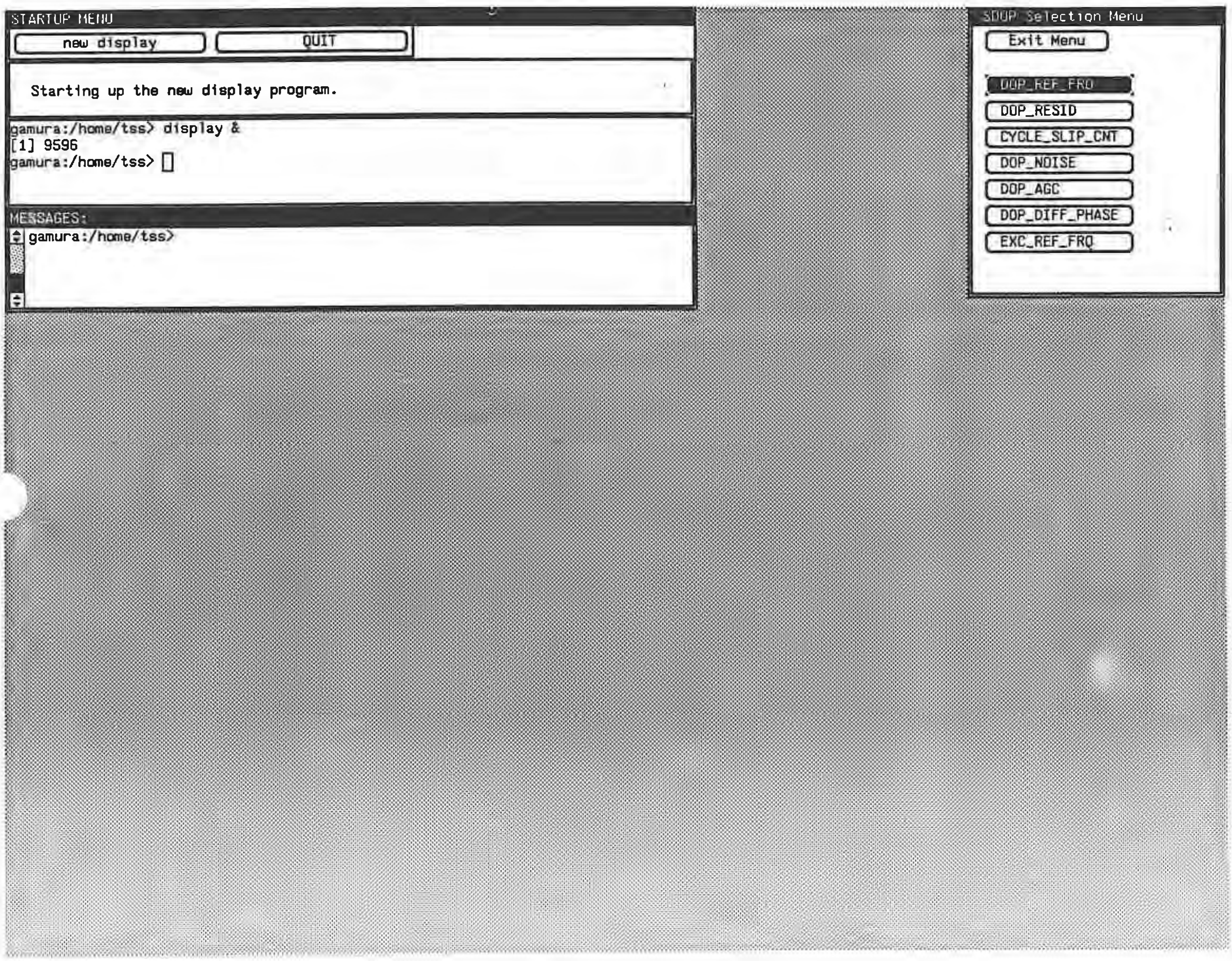

STARTUP MENU
new display
QUIT
Starting up the new display program.
gamura:/home/tss> display &
[1] 9596
gamura:/home/tss>
MESSAGES:
gamura:/home/tss>
SDOP Selection Menu
Exit Menu
DOP_REF_FRQ
DOP_RESID
CYCLE_SLIP_CNT
DOP_NOISE
DOP_AGC
DOP_DIFF_PHASE
EXC_REF_FRQ

Figure 9-10

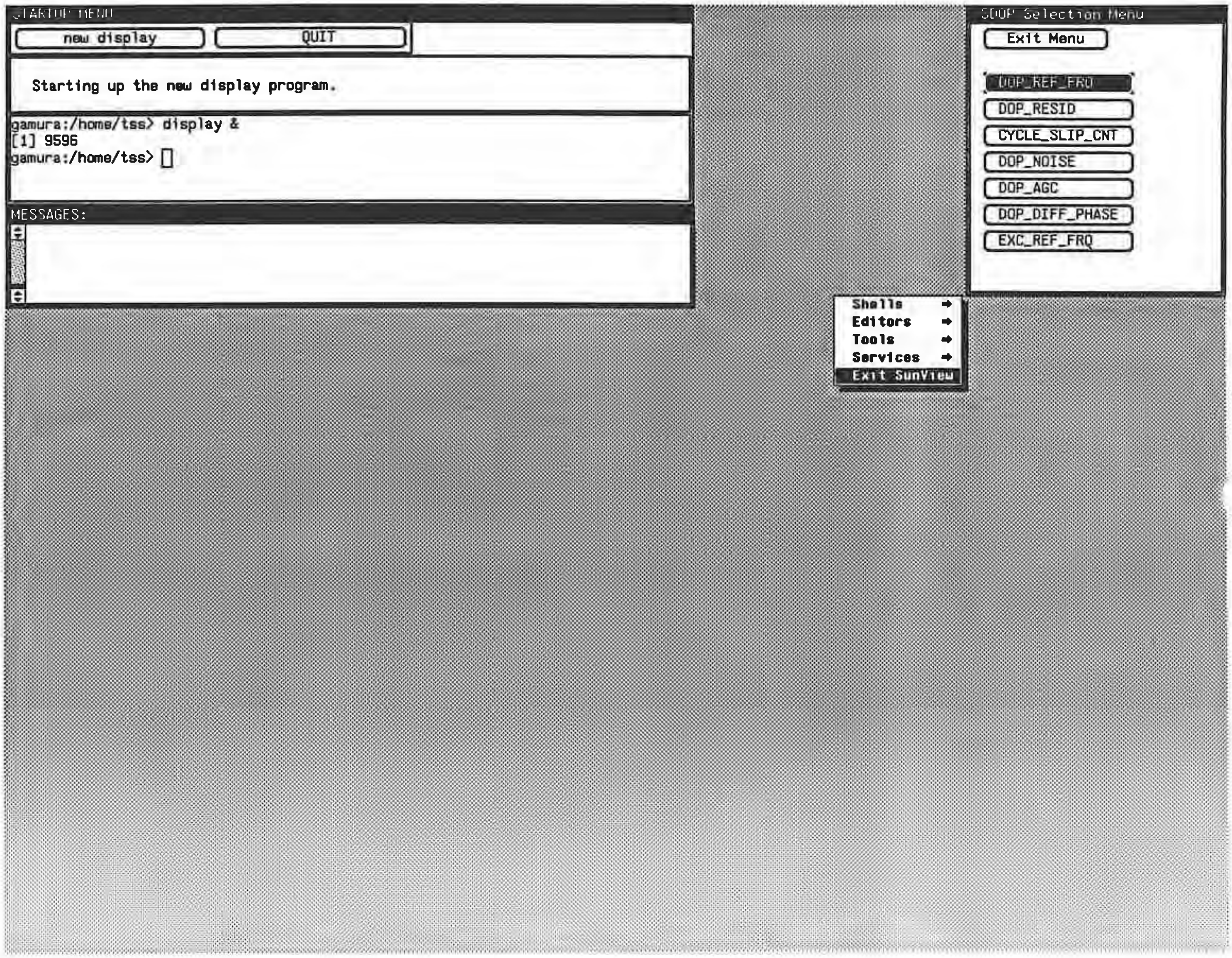

STARTUP MENU
new display
QUIT
Starting up the new display program.
gamura:/home/tss> display &
[1] 9596
gamura:/home/tss>
MESSAGES:
SDOP Selection Menu
Exit Menu
DOP_REF_FRQ
DOP_RESID
CYCLE_SLIP_CNT
DOP_NOISE
DOP_AGC
DOP_DIFF_PHASE
EXC_REF_FRQ
Shells
Editors
Tools
Services
Exit SunView

Figure 9-11

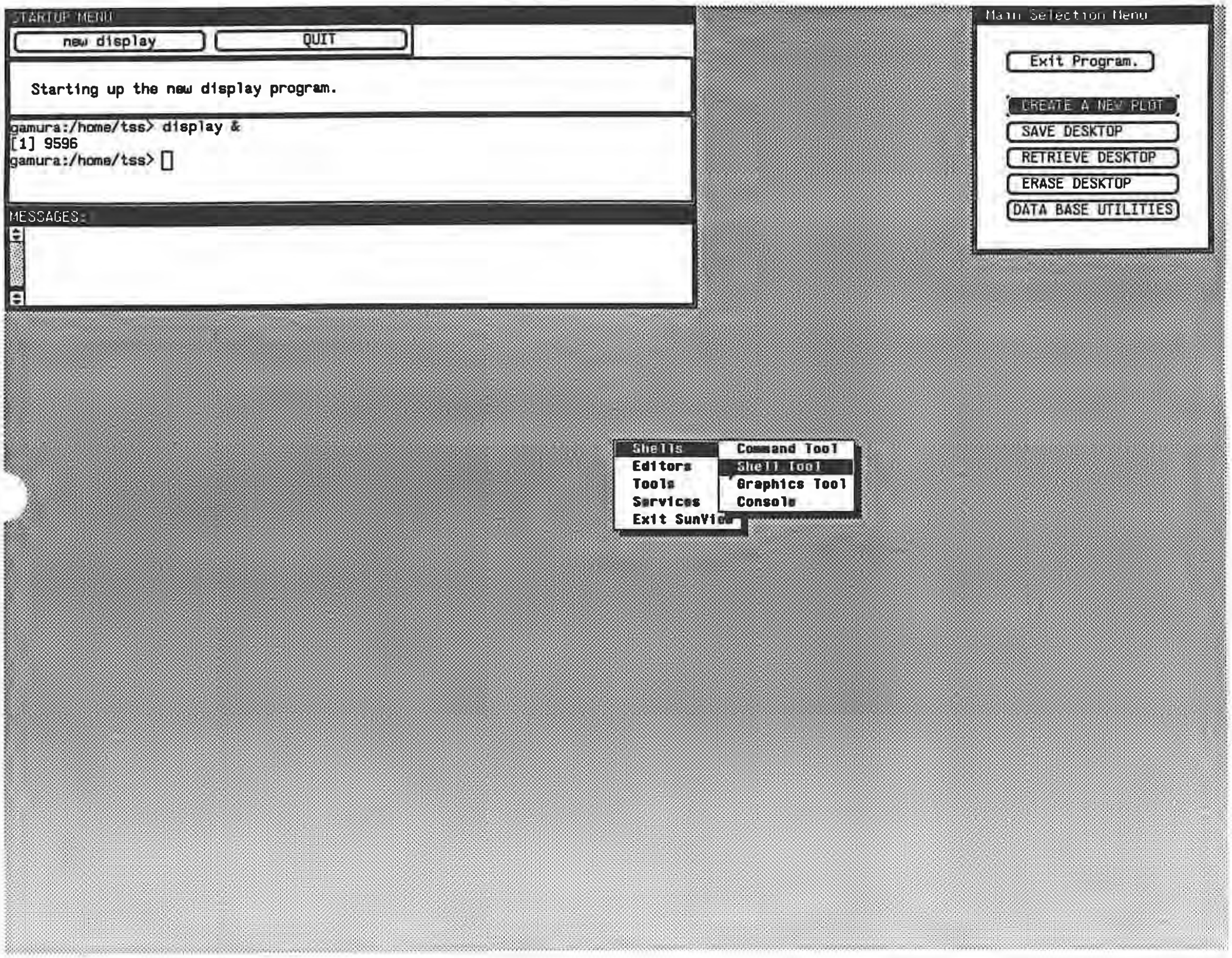
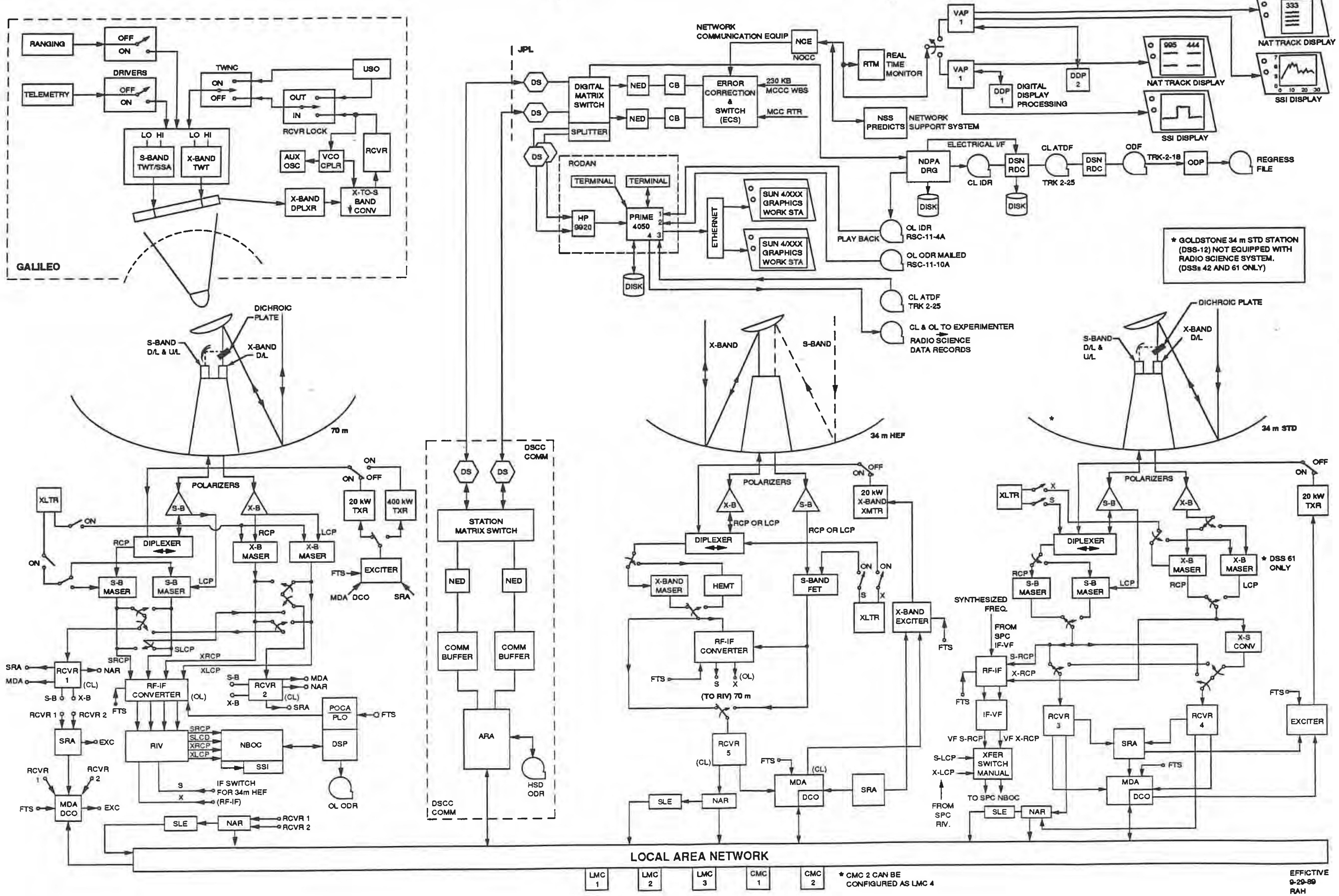

STARTUP MENU
new display
QUIT
Starting up the new display program.
gamura:/home/tss> display &
[1] 9596
gamura:/home/tss>
MESSAGES:
Main Selection Menu
Exit Program.
CREATE A NEW PLOT
SAVE DESKTOP
RETRIEVE DESKTOP
ERASE DESKTOP
DATA BASE UTILITIES
Shells
Editors
Tools
Services
Command Tool
Shell Tool
Graphics Tool
Console

Figure 9-12

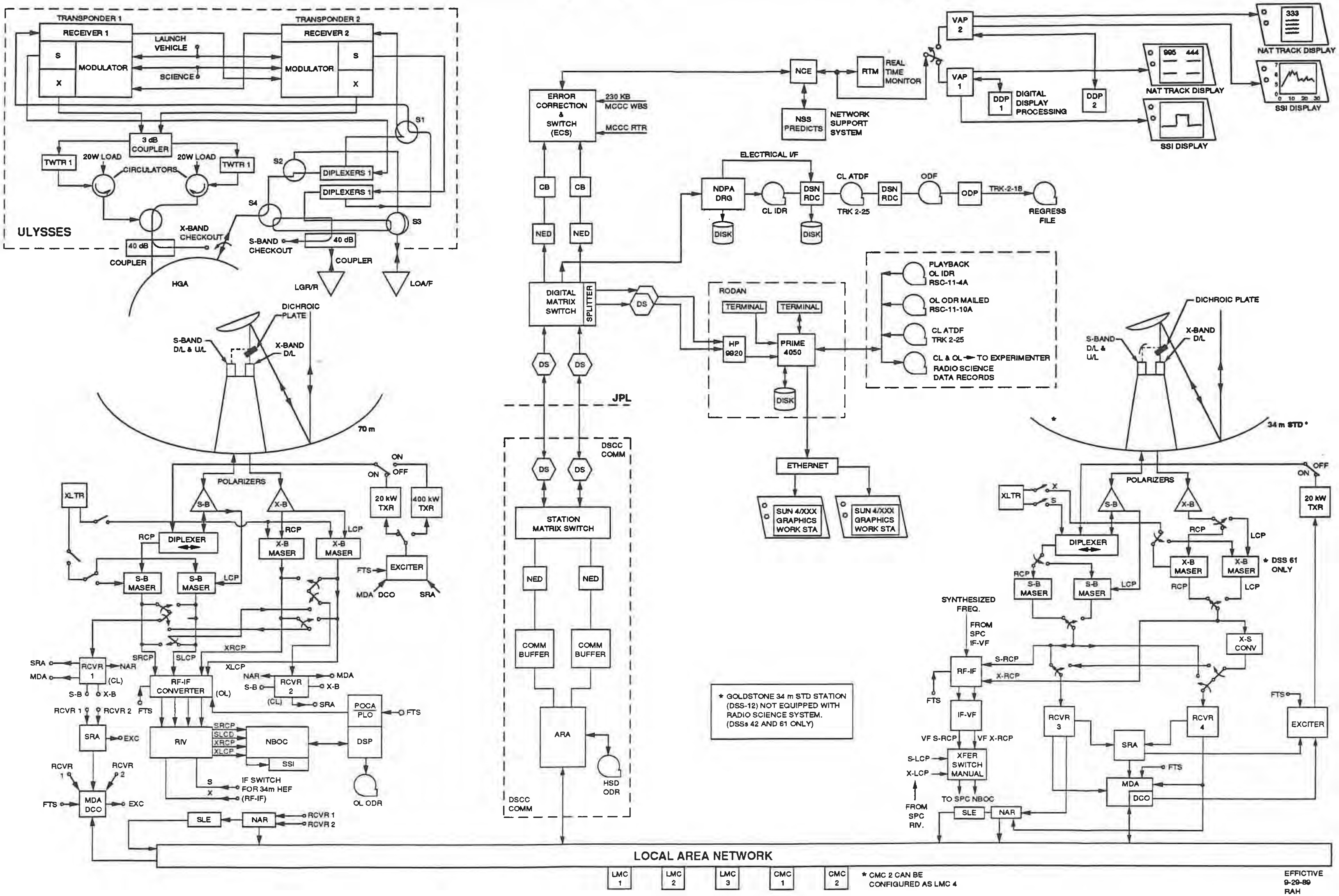
APPENDIX A

END-TO-END SYSTEM DIAGRAMS

GALILEO RADIO SCIENCE END-TO-END DIAGRAM



ULYSSES RADIO SCIENCE END-TO-END DIAGRAM



APPENDIX B

USEFUL FORMULAE

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

$$F_{antenna}^{S-band} = 3(F_{poca} + \frac{790}{11} \times 10^6) + 1950 \times 10^6 + F_{recorded}^{S-band} + TBD$$

-fsamp

$$F_{antenna}^{X-band} = 11(F_{poca} - 10 \times 10^6) + 8050 \times 10^6 + F_{recorded}^{X-band} + TBD$$

-3*fsamp

fsamp = sample rate

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

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

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

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

RIV OUTPUT

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

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

ODAN OUTPUT

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

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

B-4: SSI update interval:

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

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 in km/sec

F_{USO} is the predicted USO frequency.

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

$\Delta F_{NCOH \rightarrow COH}$ = 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 Mission Controller
ADC	Analog-to-Digital Converter
AGC	Automatic Gain Control signal level
AMS	Antenna Mechanical Subsystem
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)
CR	Carriage Return
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
DMT	Data Management Team
DOY	Day Of Year
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
GLL	Galileo Project
GNAV	Galileo Navigation Team
GPS	Global Positioning System
GSD	Great Science Data!
GWE	Gravitational Wave Experiment
HB	Radio Science HandBook
HGA	High-Gain Antenna (spacecraft)
IA	Interface Agreement
ICD	Interface Control Document
IDR	Intermediate Data Records 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
MB	Megabyte
MCA	Master Clock Assembly
MCCC	Mission Control Computer Center
MCT	Mission Control Team
MDA	Metric Data Assembly
MGC	Manual Gain Control
MI	Modulation Index
MISD	Mission Director's Voice Net
MMNAV	Multi-Mission Navigation Team
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
MOU	Memorandum of Understanding
MSA	Mission Support Area
MTS	MCCC Telemetry Subsystem
NAR	Noise Adding Radiometer
NATTRK	Network Analysis Team Tracking Analyst
NAV	Project Navigation Team
NB	Narrow-Band
NBIDR	Narrow-Band Intermediate Data Record
NBOC	Narrow-Band Occultation Converter
NBODR	Narrow-Band Original Data Record
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
ODR	Original Data Record
OEA	Operations Engineering Analysis
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
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
QOP	Quod Occultum Patefaciet (That which is hidden shall reveal) with apologies to Paul Rosen
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
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
TLC	Tracking Loop Capacitor
TMO	Time Offset (OCI)
TMU	Telemetry Modulation Unit
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
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

The Medicina Station

This appendix is not applicable for volume 2 of the Radio Science Handbook. It has appeared in volume 1 and will appear in volume 3.

APPENDIX E

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