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GOLDSTONE SOLAR SYSTEM RADAR (GSSR)

JJ574450

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Projected DSN Support: Continuous

Project Responsibility: Jet Propulsion Laboratory (JPL)

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Sponsor: OSO
Program Manager: S. Ostro

A. MISSION DESCRIPTION

The primary objective of the Goldstone Solar System Radar is the investigation of solar system bodies by means of Earth-based radar. Targets of primary interest include the Galilean moons, Saturn's rings and moons, and Earth-approaching asteroids and comets. Planets are also of interest, particularly Mercury and the planets to which NASA has not yet planned spacecraft visits.

B. PROGRAM PROFILE

Based on a history of solid achievement, includng the definition of the Astronomical Unit, imaging and topography of Mars, Venus, and Mercury, and contributions to the general theory of relativity, the program will continue to support Flight Project requirements and its primary objectives. The individual target objectives are as follows:

Galilean Moons: X-band observations will be used to put some limits on the small-scale structure of the regolith.

Mercury: Construct radar maps of portions of the unimaged hemisphere at ~10-km resolution. Make a series of closure-point ranging measurements to be used for testing gravitation theories, including general relativity. Some of this work is coordinated with Arecibo observations, as part of a cooperative effort to minimize systematic sources of error. Refine estimates of Mercury's pole direction, to evaluate available theoretical explanations for the planet's spin/orbit resonance.

Venus: Refine the rotation period and pole direction as much as possible prior to Magellan's orbital insertion. Obtain high-resolution (to ~1 km) radar images of surface regions that cannot be mapped from Arecibo, at very small incidence angles (θ near 0°), i.e., with a viewing geometry very different from that (θ~30°) in Magellan images. Locate geologically interesting regions as candidates for Magellan high-resolution investigation. Refine existing estimates of Fresnel reflection coefficients for surface units with anomalously high radar albedoes, and determine those regions' angular backscattering law.

Moon: Construct 100-to-200-meter-resolution images of selected regions in each component of the Stokes vector, to elucidate the scattering mechanism and the nature of near-surface structure, and to constrain the electrical properties of the regolith. Measure topography in selected areas, to refine geologic interpretations of lunar landforms.

Mars: Maintain the accuracy of the Mars orbital ephemeris. Measure surface topography at tropical latitudes (±20°). Determine the surface reflectivity and effective slope for multiple ground tracks within the tropics. Use dual-polarization, cw measurements and joint Goldstone-VLA bistatic observations to elucidate the global variations in the surface's small-scale structural complexity. Constrain the surface's gross geometry at scales (~1 cm to ~10 m) relevant to the safe landing and maneuverability of a spacecraft. Test hypotheses about temporal variations in radar reflectivity that might result from seasonal melting of subsurface ice.

Phobos and Deimos: Detect 3.5-cm radar echoes and estimate each satellite's radar albedo, polarization signature, and angular scattering law. Constrain the satellites' surface bulk density and small-scale roughness.

Near-Earth Asteroids: Secure recovery of newly discovered objects. Refine orbits of previously observed objects. Use delay/Doppler imaging to obtain information about dimensions, shapes, and spin vector. Constrain surface's dual-polarization scattering properties and elucidate near-surface characteristics at cm-to-km structural scales. Measure the asteroid's radar cross section; estimate the radar albedo and use it to bound the regolith bulk density, porosity, and metal concentration.

Mainbelt Asteroids: Using time-delay measurements, shrink the line-of-sight component of positional error ellipsoid. Use power spectra to constrain pole direction and diameter. Estimate surface slope at topographic scales, and near-surface roughness at small scales. Measure the asteroid's radar cross section; estimate the radar albedo and use it to bound the regolith bulk density, porosity, and metal concentration.

Comets: Search for clouds of large ($\geq$ cm) particles near the nucleus, such as those discovered around Halley and IRAS-Araki-Alcock. Image the nucleus and determine its size, shape, spin properties, and surface characteristics. Refine estimates of orbital elements, to clarify the dynamical history of long-period comets and to assist spacecraft navigation during missions to short-period comets.

Europa, Ganymede, and Callisto: Determine the 3.5-cm radar albedo and circular polarization ratio of each of these icy satellites, whose 13-cm properties are extraordinary. Use the results to constrain existing theoretical explanations for the bizarre radar signatures. Search for radar features, localize them, and seek correlations with features in Voyager (and eventually Galileo) images. Refine the prediction ephemerides for each satellite, especially Callisto, to assist targeting of the Galileo spacecraft, by measuring echo Doppler frequencies. The precision of Doppler estimates depends on echo strength, and radar measurements with the minimum precision required for ephemeris improvement cannot be obtained during 1993-98 unless Goldstone has a 1.0-megawatt transmitter.

Io:	Obtain the first 3.5-cm radar detection of this volcanically active satellite, and use estimates of radar properties to provide information about the surface bulk density and small-scale roughness.
Saturn's Rings:	Use delay-Doppler images in each Stokes vector component to constrain the manner in which radar waves are backscattered from the classical ring sections, and to infer the physical properties of ring particles. Use bistatic observations, with Goldstone transmitting and the VLA receiving, to image the ring system at 1200-km resolution.
Saturn's Icy Satellites:	Detect the first radar echoes from Iapetus and possibly Rhea, to ascertain whether these objects, whose surfaces contain nonwater ices, share the unusual radar properties of Jupiter's icy moons.
Titan:	Detect the first radar echoes from Titan, and measure this object's radar albedo and angular scattering law. These measurements would constitute mankind's first direct measurements of Titan's surface. They would permit evaluation of the diverse models proposed for the configuration of Titan's surface, which might be at least partially covered by a deep, ethane-rich ocean.

C. COVERAGE

1. Coverage Goals

For this program, the coverage goals vary significantly with the target of opportunity. All of these goals (listed Table 1) require the support of DSS 14, which is the only facility with the necessary high-power transmit capability, and occasional support from DSS 12 and DSS 13. DSS 18 will replace DSS 12 in mid-1993. A replacement 34-m antenna (also designated DSS 13) will replace the current DSS 13 in 1992 for X-band reception and at a later date for S-band reception.

Table 1 lists the estimated GSSR usage for 1990-2000.

Table 1. Estimated Program Support for 1990-2000

Targets	Opportunities Per year	Tracks Per Opportunity	Tracks Per year
Mars	1 per 2 to 6 years	40	20
Venus	1 per 1 to 6 years	20	12
Jupiter	1	20	20
Saturn	1	30	30
Objects	6	7	42
Asteroids	4	5	20
Mercury	3	7	21
Moon	15	1	15
Total Tracks per year			180
Average Tracks per Month			15

NOTE: One radar "track" consists of 8 hours of observing time, preceded by 1.5 hours of pre-cal and followed by 0.5 hours of post-cal. Each track requires DSS 14. Interferometric observations (most Venus and selected Mercury tracks) also use DSS 13 and one other 34-m station.

The 10-year period covered by these estimates will include planetary encounters and prolonged planetary operations by several major flight projects. For this reason, it is considered unlikely that the DSN could sustain the average level of radar support requested while meeting its commitments to in-flight projects. It is estimated that 50 percent of the requested support is a more realistic expectation on which the program should base its science planning.

2. Network Support

Specific requirements for antenna time on DSS 14 are prepared on a yearly basis and submitted to the scheduling office for negotiation at least 6 months ahead of the earliest need date. The facility support to be provided by the DSN is indicated in the following table:

System	Goldstone Only 12 14	
S-band RAD	P	Antenna support requirements for 6 months ahead are published in the JEMS GSSR bulletin board which is updated on a weekly basis.
X-band RAD	P	

NOTE: P=Prime

3. Compatibility Tests

Compatibility testing with DSN systems will be supported by the DSN Radio Astronomy Unit. This data type is not required to be supported by the DSN ground data system.

D. FREQUENCY ASSIGNMENTS

Frequencies are allocated according to the following table:

System	Uplink (MHz)	Downlink (MHz)	Polarization
S-band	2320.00	2320.00	RCP
X-band	8495.00	8495.00	RCP

E. SUPPORT PARAMETERS

The support parameters for the Telemetry, Command and Support Systems are listed below:

(1) Telemetry

No support required

(2) Command

No support required

(3) Support

Uplink Power	400 kW
Antenna Rate	Sidereal
Antenna Angle Data	Required
Antenna Autotrack	Required
Doppler Rates	Moderate
Range Format	None
Recording	
. Analog	Not Required
. Digital	Not Required
. VLBI	Not Required

F. TRACKING SUPPORT RESPONSIBILITY

The allocation of responsibilities for tracking support is listed in the following table:

Program Phase	Support Responsibility
Implementation	DSN (331)
Planetary Operations	DSN (440)

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