Jet Propulsion Laboratory
California Institute of Technology

DSN OVERVIEW

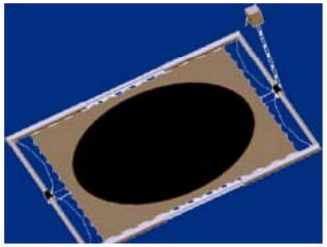
July 31, 2012

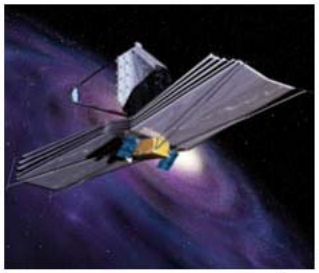
Jim Erickson

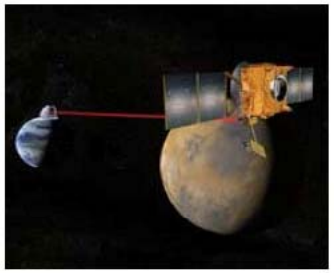
Joe Statman

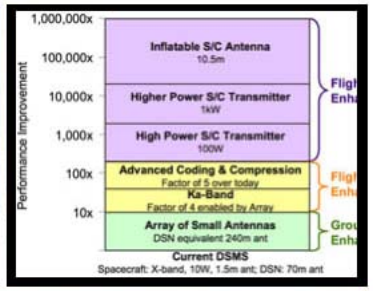
Wallace Tai

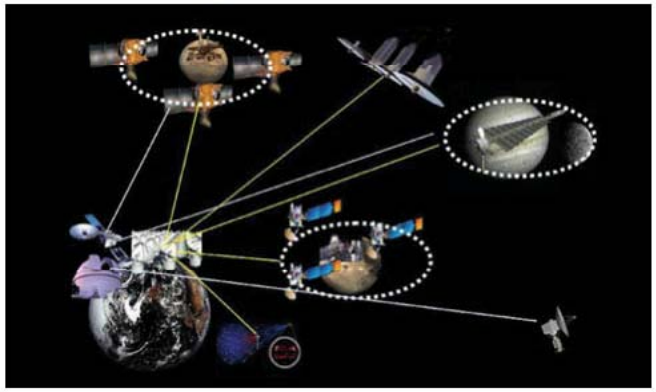
InterPlanetary Network Directorate (IND)

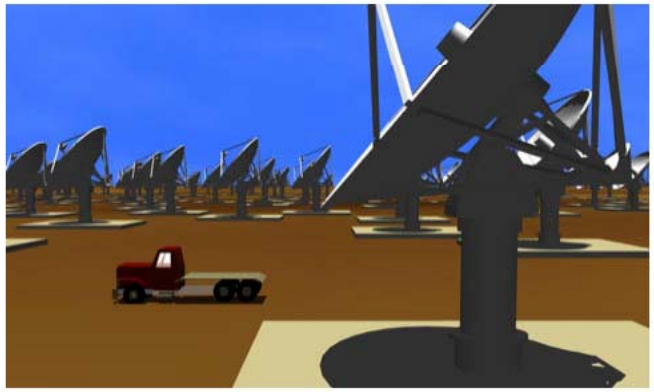












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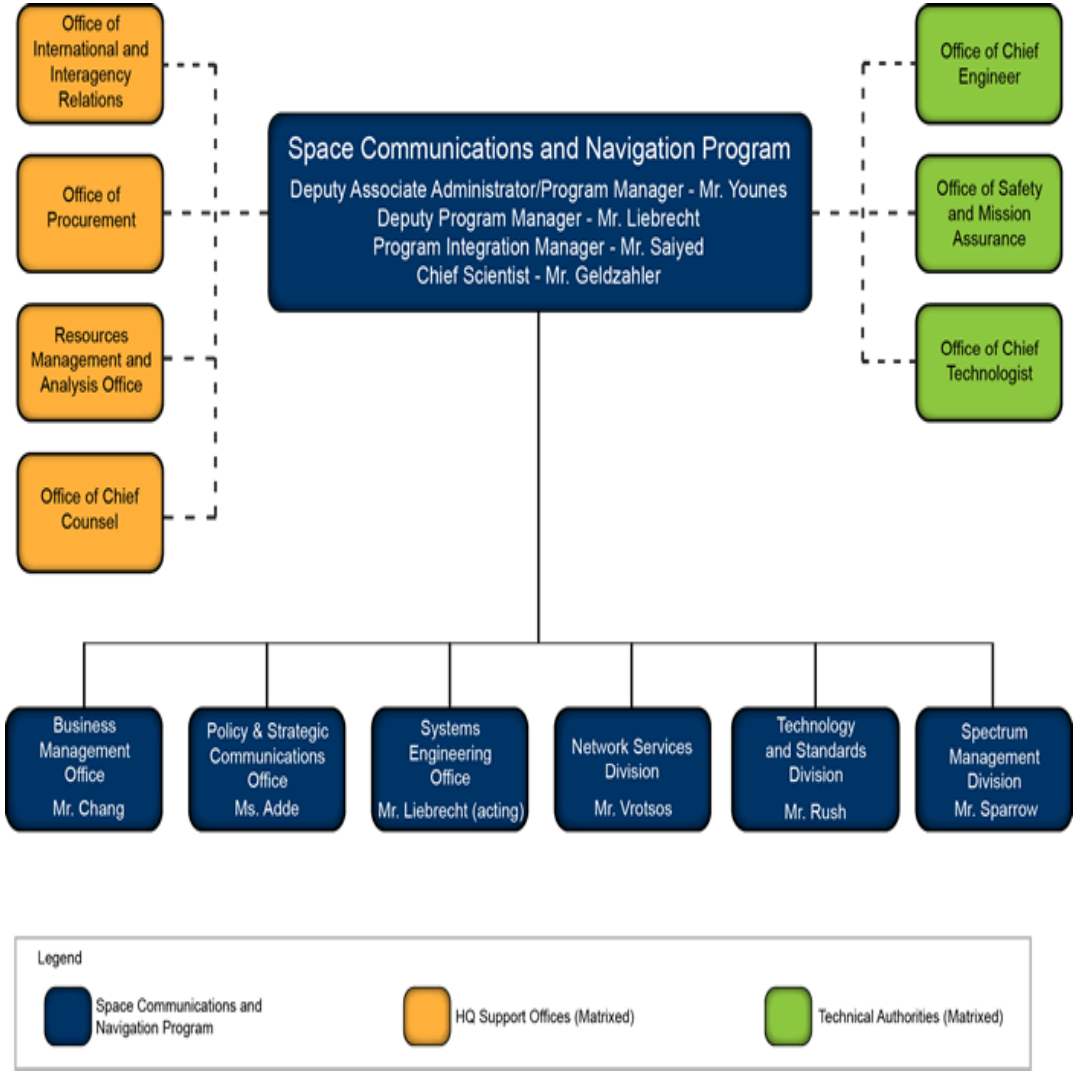
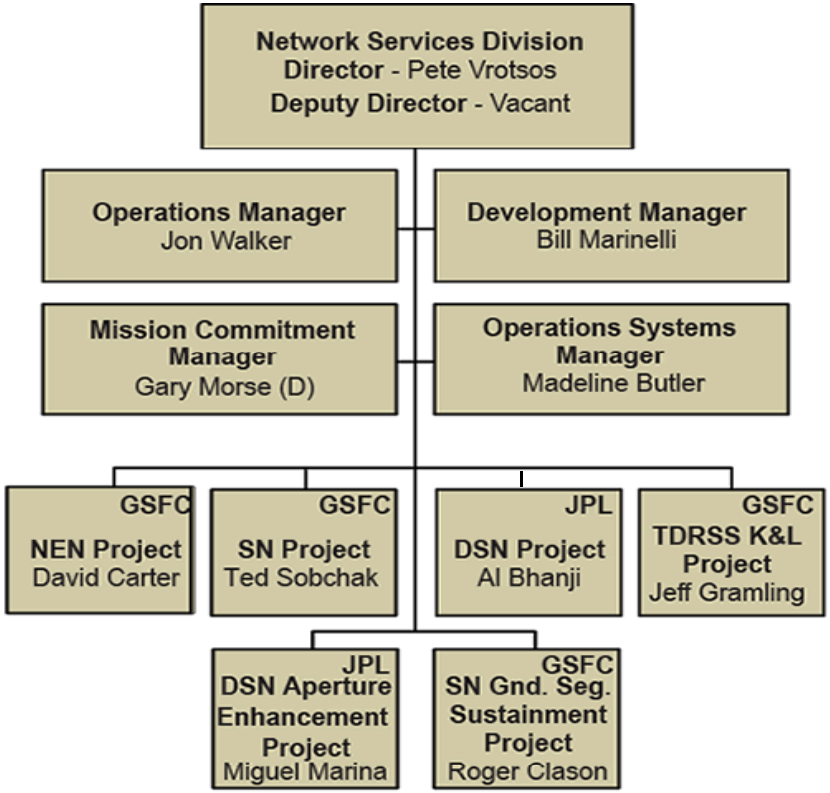
SCaN Organization Chart Summary



Network Services



Legend:
Network Services

Revised: 11/2011

IND ORGANIZATION CHART

Effective: May 7, 2012

900
INTERPLANETARY NETWORK DIRECTORATE (IND)
John McNamee, Director
William Rafferty, Deputy Director

900 Staff
Adrian Hooke, Space Networking Architecture, Technology and Standards Mgr.
Michael Rodrigues, SCaN Special Assistant
Les Deutsch, IND Chief Technologist
Bob Preston, IND Chief Scientist
Jose Macias, IND Assurance Mgr. (51)
Page Garcia, Administrator (60)
Lorna Deady, Executive Staff Coordinator

903 – ARCHITECTURE, STRATEGIC PLANNING & SYSTEM ENGINEERING
Les Deutsch, Mgr. (AD)
Wallace Tai, IND Chief System Engineer
Farzin Manshadi, Spectrum Manager

904 – BUSINESS OPERATIONS
Deborah Padilla, Mgr. (25)
Yolanda Cuevas, Proj. Controls Mgr. (25)

902 – DSN / MISSION SERVICES PLANNING & MANAGEMENT PROGRAM
Jim Erickson, Mgr.

- 9021 - Mission Support Definition & Commitments
  Jim Erickson, Mgr. (AD)
- 9022 - DSN Planning & Scheduling
  Belinda Arroyo, Mgr.

920 – DEEP SPACE NETWORK (DSN) PROJECT
Al Bhanji, Mgr.
Wayne Sible, Dep. Mgr

- 921 - Service Management
  Pat Beyer, Mgr.
- 922 - TT&C End-to-End Data Services
  Ana Maria Guerrero, Mgr.
  Robert Navarro, Dep. Mgr.
- 925 - Antenna Front End, Facilities & Infrastructure
  Peter Hames, Mgr.
  Wendy Hodgin, Dep. Mgr.
- 926 - DSN Aperture Enhancement
  Miguel Marina, Mgr.
  Hal Ahlstrom, Dep. Mgr
- 927 - Operational Efficiencies Task
  Michael Levesque, Mgr.

930 – MULTIMISSION GROUND SYSTEMS & SERVICES PROGRAM
Dave Linick, Mgr.
Andy Dowen, Dep. Mgr.

970 – COMMUNICATION TECHNOLOGIES & STANDARDS PROGRAM
Steve Townes, Mgr.

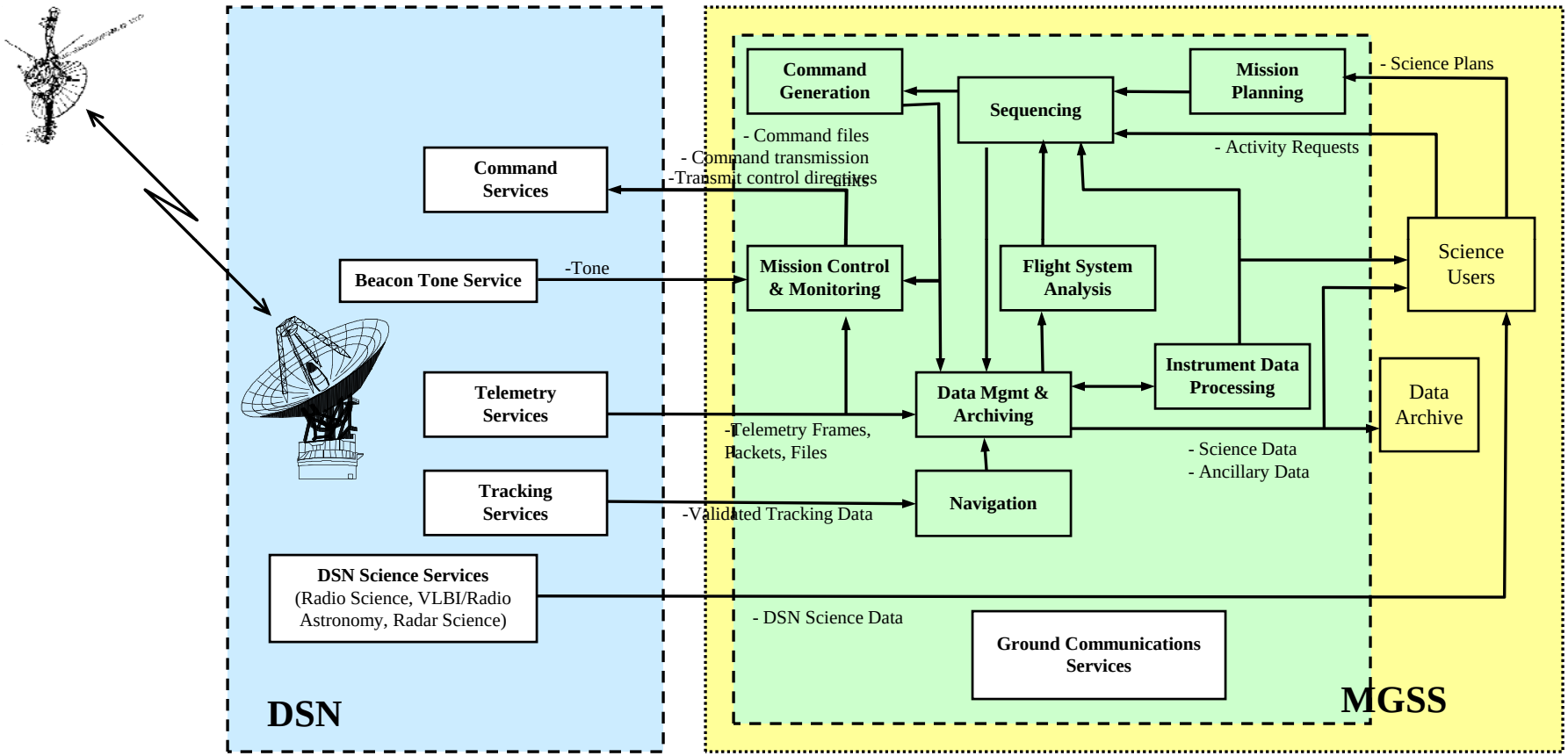
- 971 - DSN Advanced Engineering Program
  Faramaz Davarian, Mgr.
- 972 - SCaN Technology Program
  Dimitrios Antsos, Mgr.

Legend:
AD = Additional Duty
SCaN = Space Communications and Navigation
TT&C = Tracking, Telemetry, and Command

The Multi-Mission Systems

- **There are two multi-mission systems under the management of the InterPlanetary Network Directorate (IND):**
  - Deep Space Network (DSN)
  - Multi-Missions Ground Systems and Services (MGSS)
- **The product lines:**
  - DSN - Data Services
  - MGSS - Mission Services and MOS/GDS tools

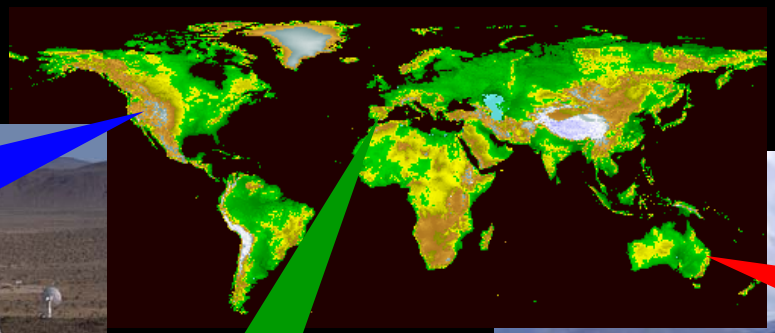
DSN and MGSS
In the Context of Mission Operations



Multi-Mission Operations
Deep Space Network (DSN)

The Deep Space Network

Comprises three major tracking sites around the globe to provide continuous communication and navigation support for the world's deep space missions



Goldstone
Operated by ITT for NASA/JPL

Madrid
Operated by INSA for INTA

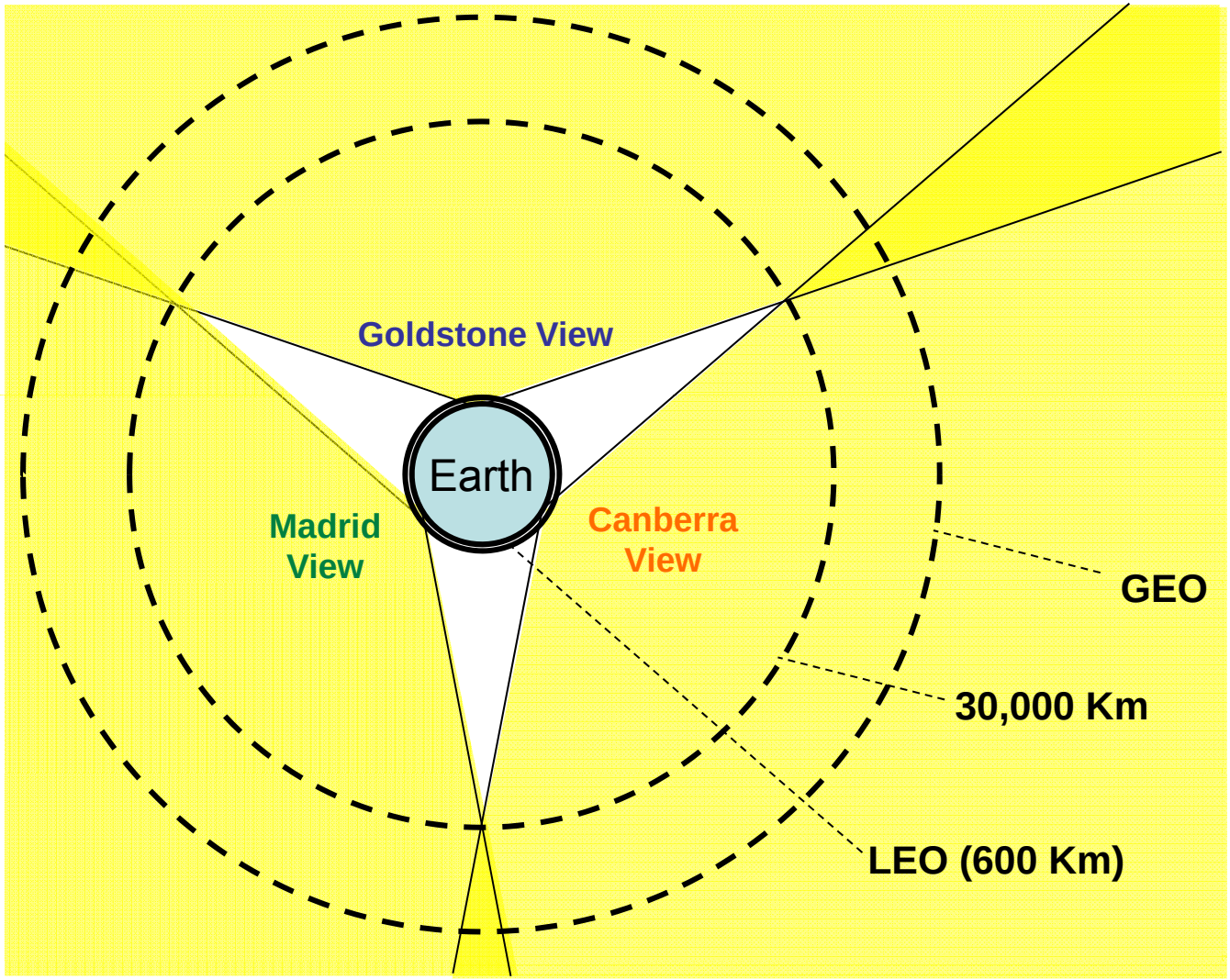
Canberra
Operated by Raytheon for CSIRO

DSN Geometry

DSN can provide continual tracking to spacecraft above 30,000 km altitude

SN can provide continual tracking to spacecraft below GEO

Creates opportunities for NASA network overlap



View looking down on the Earth's North Pole

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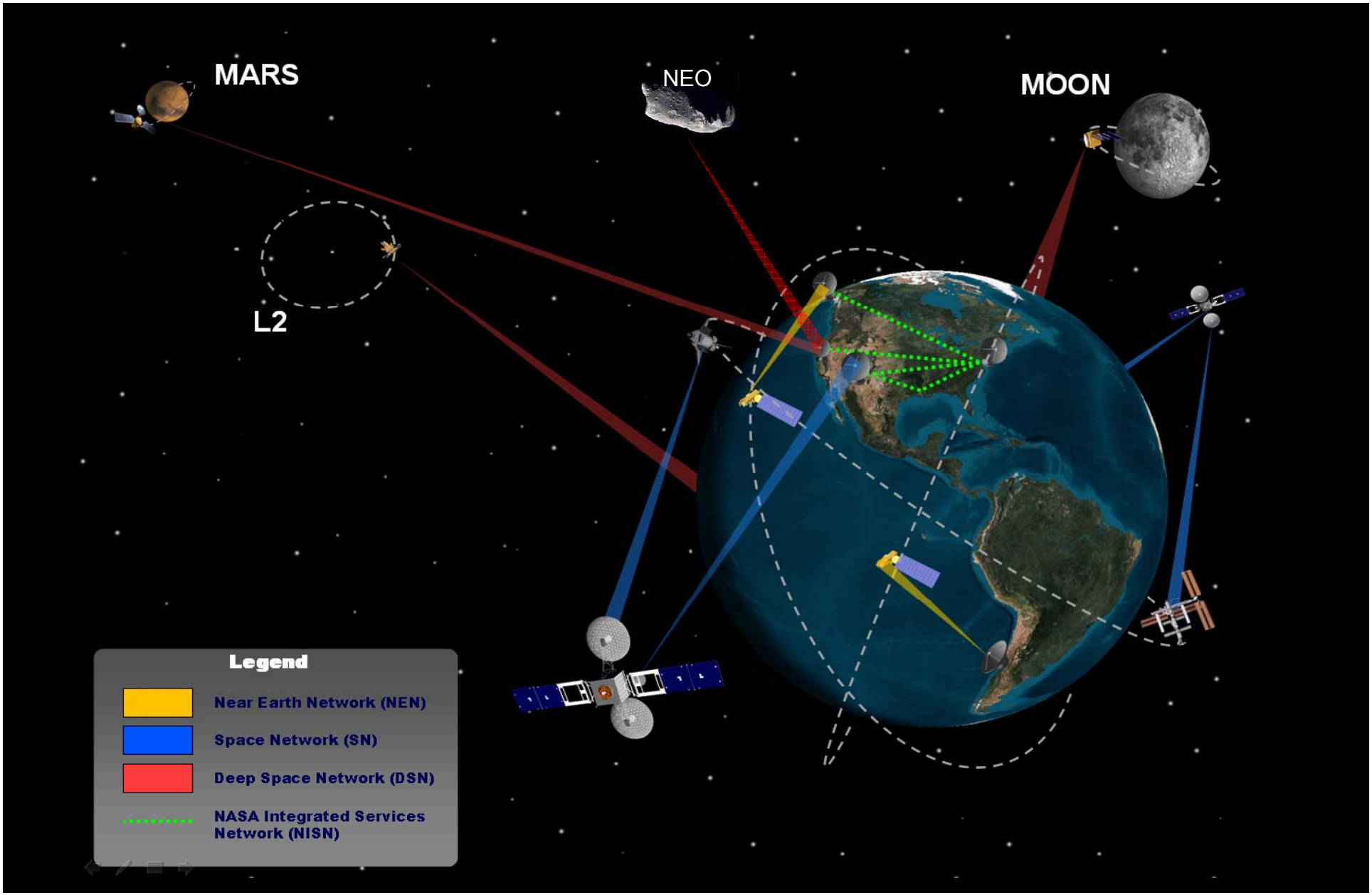
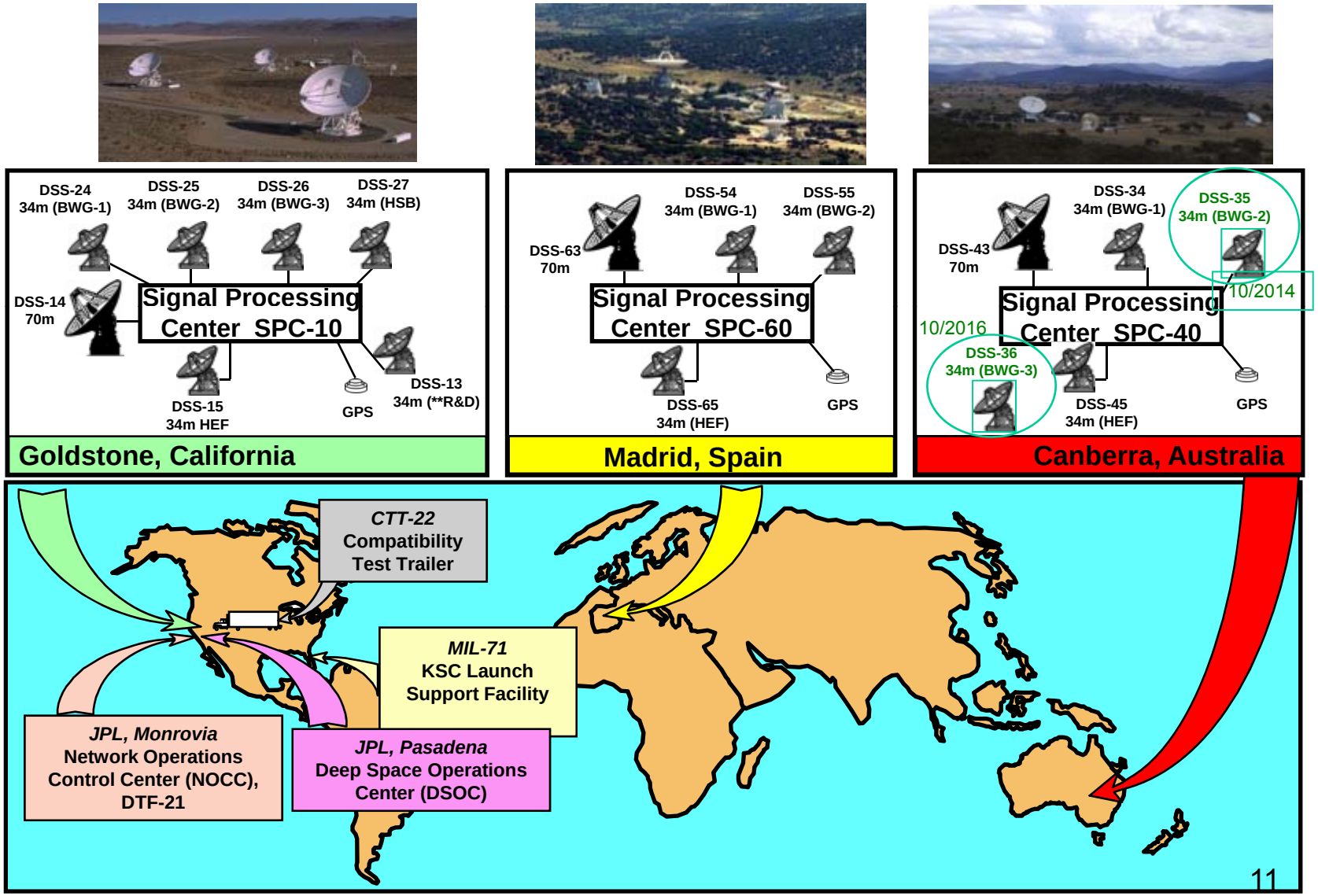
DSN in the Space Communications Architecture



DSN Facilities



Key Characteristics of DSN Operations

- DSN operates under a service provision paradigm.
  - Standard services
  - Standard interfaces
- Multi-mission operational capabilities in DSN are highly diversified.
  - Mission domains: deep space, HEO L1/L2, Lunar, and LEO
  - Robotics as well as human-rated missions (in the recent past)
  - Assets are capable of S-, X, and Ka-bands for both near Earth and deep space
- Continuous 24x7 operations is conducted at all 3 DSN sites and NOCC.
- Guaranteed high service reliability/availability for supporting mission critical events is achieved through inherently redundant assets/operational capabilities of the network.
- The use of central signal processing facilities in the DSN, with equipment shared among the antennas, facilitates adding new capabilities: e.g. LDPC coding,

Key Characteristics of DSN Operations (Cont)

- Persistently provided TT&C services with high performance to an aggregate of missions (usually 30 to 40 at a given period) for decades.
- Mission support activities are structured into a set of repeatable, standard operational activities.
- Resource allocation and scheduling are conducted by flight missions via a collegial process
  - Guided by an overarching set of priorities, which places Human Spaceflight at the top
  - DSN facilitates such process by providing logistics management and tools.
- Mode of operations is largely tool-assisted, human controlled operations.

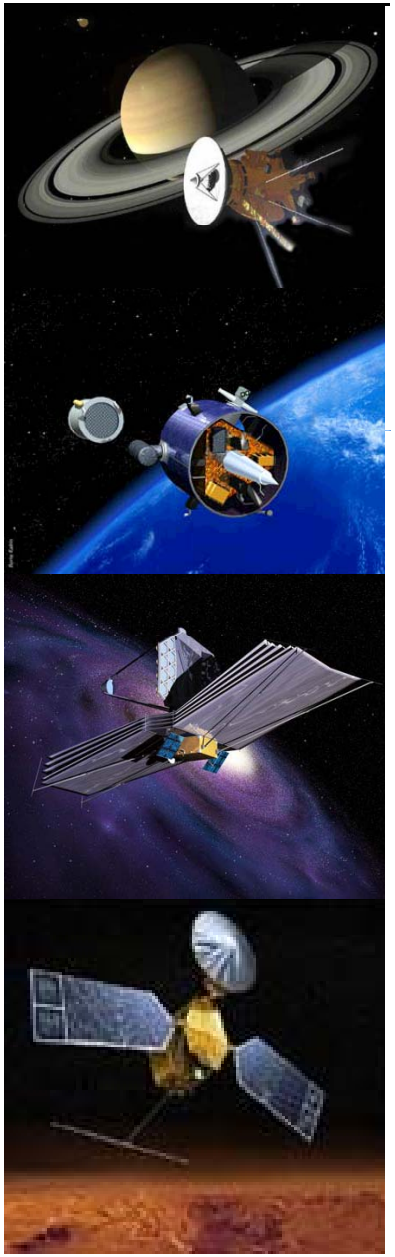
DSN Services

- **Command Services**
  - Command Radiation Service
  - Command Delivery Service
- **Telemetry Services**
  - Frame Service
  - Packet Service
  - Telemetry File Service
  - Beacon Tone Service
- **Tracking Services**
  - Validated Radio Metric Data Service
  - Delta-DOR Service
- **Calibration and Modeling Services**
  - Platform Calibration Service
  - Media Calibration Service
- **Radio Science Services**
  - Experiment Access Service
  - Data Acquisition Service
- **Radio Astronomy / VLBI Services**
  - Signal Capturing Service
  - VLBI Data Acquisition Service
  - VLBI Data Correlation Service
- **Radar Science Services**
  - Experiment Access Service
  - Data Acquisition Service

DSN Engineering Support

- System Engineering Support
- Advanced Mission Planning Support
- Emergency Mission Operations Center Support
- RF Compatibility Test Support
- Mission System Test Support
- Spectrum and Frequency Management Support
- Spacecraft Search Support

DSN Customer Base – Space Missions



Deep space missions

- Typically require extreme sensitivity of the DSN
- The DSN is the only NASA tracking network that fully supports the deep space spectrum
- The DSN is interoperable with foreign partner assets
  - These include the ESTRACK network of 35m stations, as well as JAXA's 34 and 64 m assets
  - This provides an extra set of resources for redundancy and coverage

Lunar missions

- The DSN has supported all lunar missions
- The DSN is the only NASA entity to do so since Apollo

Other Category-A missions

- HEOs and Libration Point missions typically require high performance from the ground
- The DSN is the only NASA entity that supports missions beyond Lunar Distances

Relay operations

- The DSN routinely supports relay operations at Mars, providing service to a secondary set of customers on the Martian surface

Current DSN Customer Base

Legacy LEO

- RADARSAT (O)

LEOP**

- GOES O, P, R, S (C)
- NOAA N' (C)
- LRO (C)

HEO, Lunar, L1 & L2

- CHANDRA (O)
- WMAP (O)
- INTEGRAL (O)
- JWST (C)
- ISTP-GEOTAIL (O)
- ISTP-WIND (O)
- ISTP-SOHO (O)
- ISTP-POLAR (O)
- ACE (O)
- ISTP-CLUSTER II (O)
- SELENE (C)
- LCROSS (C)
- Chandrayaan-1

DEEP SPACE***

- MARS GLOBAL SURVEYOR (O)
- CASSINI (O)
- 2001 MARS ODYSSEY (O)
- GSSR (O)****
- HAYABUSA (A.K.A., MUSES-C) (O)
- MARS EXPRESS (O)
- MER -- SPIRIT & OPPORTUNITY (O)
- ROSETTA (O)
- MESSENGER (O)
- MARS RECONNAISSANCE ORBITER (O)
- VENUS EXPRESS (O)
- NEW HORIZONS (O)
- DAWN (C)
- PHOENIX (C)
- JUNO (C)
- MARS SCIENCE LABORATORY (F)
- MARS SCOUT (F) (X)
- NEW FRONTIERS (F) (X)
- DISCOVERY (F) (X)
- EGS (O)****
- GBRA (O)****
- SPITZER SPACE TELESCOPE (O)
- KEPLER (C)
- SIM (F)
- DISCOVERY (F) (X)
- VOYAGERS 1 & 2 (O)
- ULYSSES (O)
- STEREO A & B (O)
- ATOT (O)****
- SPACE GEODESY (O)****
- GODR (O)****
- REFERENCE FRAME CALIBRATIONS (O)
- MIDEX (F) (X)
- NMP (F) (X)

NOTES

*~17 additional spacecraft fall under "Emergency Support Only" and are not shown.

**LEOP = Launch & Early Orbit Phase; almost all DSN missions receive such support, but those listed as "LEOP" receive no routine DSN support.

***Deep Space includes missions utilizing Earth leading and trailing orbits, since spacecraft in such orbits drift out well beyond Lagrange point distances.

****Support assumes the form of ground-based observations for mission reference ties (e.g., GP-B), VLBI co-observations, radio astronomy, solar system radar, orbital debris, etc.

KEY

- Astrophysics
- Heliophysics
- Theme Independent
- Planetary Science
- Earth Sciences & Non-NASA

(O) = Operating or utilizing ground-based observations in support of flight preparations (as of 11/06)
(C) = Commitment to support, but not yet operating (as of 11/06)
(F) = Future commitment to support anticipated (as of 11/06)
(X) = An as yet to be determined mission associated with an established Science Mission Directorate program line in which missions are competitively bid.

DSN's Role in Lunar Missions Support

- **In the past, DSN supported many Lunar missions:**
  - Ranger missions
  - Surveyor - Lunar landers (in mid-60's)
  - Mapping Lunar orbiters (in late 60's)
  - Apollo
  - MUSES-A
  - Clementine
  - Lunar Prospector
  - LCROSS (NASA)
  - SELENE (JAXA)
  - Chandrayaan-1 (ISRO)
- **Present and near-term future Lunar missions supported by the DSN:**
  - LRO (NASA)
  - GRAIL (NASA),

  and potentially,
  - Chandrayaan-2 (ISRO), if …..

ROUTINE AND EMERGENCY SERVICE TRACKING/NAVIGATION EXPERTISE

DSN Support to Lunar Missions: Benefits to Missions

- DSN 34-m antennas offer greater than 6 dB of additional gain over other NASA assets (18m or smaller), and already exist around the Earth
- The ≥ 6 dB gain can be translated into ≥ 6 dB EIRP reduction on the spacecraft side. NASA can take advantage of this higher gain in several ways:
  - Spectrum compatibility
  - User burden
  - Availability/Performance gain
  - Mission scenario flexibility
  - Asset utilization efficiency
- In addition, there are other reasons strongly pointing to the benefits of relying on DSN for support:
  - Spectral diversity/versatility
  - Existing infrastructure
  - Global coverage
  - Cost effectiveness
  - Programmatic/technical risks
  - Track records

DSN Support To HSF MPCV
Lunar Missions Coverage Analysis Conclusions (1 of 2)

- Requested by JSC MPCV project, a coverage analysis was performed on SCaN network support to MPCV lunar missions: EM1, EM2, L2Flyby, and L2 Waypoint.
- Two sets of most feasibly ground station sites are considered:
  - DSN3: DSN Goldstone, Canberra, and Madrid
  - DSN6: DSN3 plus Usuda, Santiago, and Hartebeesthoek (HBK) stations
- Given the various mission trajectories, the coverage gap is less than 5%:
  - EM-1: DSN3 = 2%, DSN6 = 1.1%
  - EM-2: DSN3 = 4.39%, DSN6 = 3.92%
  - L2Flyby: DSN3 = 0.9%, DSN6 = 0.1%
  - L2Waypoint: DSN3 = 0.4%, DSN+HBK = 100%

DSN Support To HSF MPCV

Lunar Missions Coverage Analysis Conclusions (2 of 2)

- The difference in coverage gap between DSN3 and DSN6 is less than 1%. The added benefit by additional stations is relatively minor.
- Only one critical event,TCM-4 in EM-2, would fall into the DSN gap. This gap can be eliminated by augmenting the DSN3 with HBK.
- The optimal choice of ground stations to support lunar missions is the 3 DSN sites augmented by HBK. The existing CSIR 13.2m station at HBK seems to be a good candidate.

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DSN Assets for Category-A Mission Support
- Present -

Antenna Dia (m)	Type	Location	DSS No.	Date On-Line	S-Band Uplink	S-Band Downlink	S GAIN / C/T @ 45 deg (dE	X-Band Uplink	X-Band Downlink	X GAIN / C/T @ 45 deg (dE
34	BWG-1[1,3]	Goldstone, CA USA	24	Exist.	2025 - 2120 [11]	2200 - 2300	56.7 / 41.2	7145 - 7190 [9] 7190 - 7235 [9]	8400 - 8500	68.1 / 53.2
34	BWG-1[1,3]	Canberra, Australia	34	Exist.	2025 - 2120 [11]	2200 - 2300	56.7 / 40.8	7145 - 7190 [9] 7190 - 7235 [9]	8400 - 8500	68.3 / 52.8
34	BWG-1[1,3]	Madrid, Spain	54	Exist.	2025 - 2120 [11]	2200 - 2300	56.7 / 41.0	7145 - 7190 [13] 7190 - 7235 [13, 17]	8400 - 8500	68.3 / 53.7
34	BWG-2[1,3]	Goldstone, CA USA	25	Exist.	-	-	-	7145 - 7190	8400 - 8500	68.4 / 53.6
34	BWG-2[1,3]	Madrid, Spain	55	Exist.	-	-	-	7145 - 7190 [9] 7190 - 7235 [9, 17]	8400 - 8500	68.3/55.3
34	BWG-3[1,3]	Goldstone, CA USA	26	Exist.	-	-	-	7145 - 7190 [9] 7190 - 7235 [13, 17]	8400 - 8500	68.3 / 55.4
34	HEF[1,3]	Goldstone, CA USA	15	Exist.	-	2200 - 2300	56.0 / 40.2	7145 - 7190 [9]	8400 - 8500 [15]	68.3 / 54.0
34	HEF[1,3]	Canberra, Australia	45	Exist.	-	2200 - 2300	56.0 / 40.2	7145 - 7190 [9]	8400 - 8500 [15]	68.3 / 54.0
34	HEF[1,3]	Madrid, Spain	65	Exist.	-	2200 - 2300	56.0 / 39.6	7145 - 7190 [9]	8400 - 8500 [15]	68.3 / 54.0
34	HSB[1]	Goldstone, CA USA	27	Exist.	2025 - 2120 [10]	2200 - 2300	55.1 / 34.5	-	-	-
70	D.S.[3]	Goldstone, CA USA	14	Exist.	2110 - 2120 [11,12]	2270 - 2300	63.5 / 51.0	7145 - 7190 [9]	8400 - 8500	74.5 / 62.9
70	D.S.[3]	Canberra, Australia	43	Exist.	2110 - 2120 [11,12]	2270 - 2300	63.5 / 50.9	7145 - 7190 [9]	8400 - 8500	74.6 / 62.8
70	D.S.[3]	Madrid, Spain	63	Exist.	2110 - 2120 [11,12]	2270 - 2300	63.5 / 50.9	7145 - 7190 [9]	8400 - 8500	74.6 / 62.7

NOTES:

1. These stations can be used for Earth Orbiting (Category A) missions.
2. Performance values based on 45 deg. elevation, vacuum conditions and Diplexed (if possible) single band mode.
3. These stations are used for Deep Space (Category B)

11. Transmit power range: 200 W to 20 KW
12. Transmit power range: 20 KW to 400 K
13. Transmit power range: 200 W to 4 KW (
14. Transmit power range: 50 W to 800 W (
15. 8200 - 8600 MHz for

Forward Link Data Service – Key Attributes		**Remark**
Frequency Bands	Near-Earth S-band	Present capability
Antenna Types	34m BWG, 34m HEF	Present capability
Polarizations	RCP or LCP; No RCP/LCP simultaneity	Present capability
Modulation Types	BPSK directly on carrier (no ranging);	Present capability
	SS-UQPSK (with ranging)	New capability (not funded)
Forward link Data Rate	Maximum 256 kbps Minimum 7.8 bps	Present capability, with minor update can increase to 1Mbps
Forward Error Correction Code	LDPC rate 1/2 CCSDS Synchronization and Channel Coding (ref. CCSDS 131.0-B-2)	New capability, in the DSN plan, but yet to be funded
Data from MOC to DSN	<u>Alternative 1:</u> MPCV-specific Space Internetworking • Stream of AOS frames over a TCP/IP interface; • CCSDS Space Link Extension (SLE) Enhanced Forward CLTU Service (ref. CCSDS 912.11-O-1);	New capability - minor extension from the current SLE CLTU capability; in the DSN plan, but yet to be funded
	<u>Alternative 2:</u> DSN as Space Internetworking service provider • TCP/IP interface with forward data in IP datagrams	New capability, in the DSN plan, but yet to be funded
Data from DSN to Spacecraft	<u>Alternative 1:</u> MPCV-specific Space Internetworking • Encoded AOS frame per CCSDS AOS Space Data Link Protocol (ref. CCSDS 732.0-B-2)	New capability - minor extension from the current TC capability; in the DSN plan, but yet to be funded
	<u>Alternative 2:</u> DSN as Space Internetworking service provider • IP datagrams encapsulated in AOS frames; • CCSDS Encapsulation Service (ref. CCSDS 133.1-B-2); • CCSDS IP over CCSDS Space Links (ref. CCSDS 702.1-B-1);	New capability, in the DSN plan, but yet to be funded

Return Link Data Service - Key Attributes		**Remark**
Frequency Bands	Near-Earth S-band	Present capability
Antenna Types	34m BWG, 34m HEF	Present capability
Polarizations	RCP or LCP; RCP/LCP simultaneity at some stations	Present capability
Modulation Types	OQPSK/SQPSK (no ranging)	Present capability
	SS-UQPSK, SQPN (with ranging)	New capability (not funded)
Return link Data Rate	Maximum: 6 Mbps Minimum: 10 bps (> 40 bps recommended for timely acquisition)	Present capability. We understand the EM-1 &-2 maximum rate is 3 Mbps
Forward Error Correction Code	LDPC rate 1/2 CCSDS Synchronization and Channel Coding (ref. CCSDS 131.0-B-2)	New capability, in the DSN plan, but yet to be funded
Data from DSN to MOC	<u>Alternative 1:</u> MPCV-specific Space Internetworking • Stream of AOS frames over a TCP/IP interface; • CCSDS Space Link Extension (SLE) RAF/RCF (ref. CCSDS 911.1-R-1.7 and 911.2-R-1.7); On-line timely/On-line complete/Off-line	Present capability
	<u>Alternative 2:</u> DSN as Space Internetworking service provider • TCP/IP interface with forward data in IP datagrams	New capability, in the DSN plan, but yet to be funded
Data from Spacecraft to DSN	<u>Alternative 1:</u> MPCV-specific Space Internetworking • Encoded AOS frame per CCSDS AOS Space Data Link Protocol (ref. CCSDS 732.0-B-2)	Present capability
	<u>Alternative 2:</u> DSN as Space Internetworking service provider • IP datagrams encapsulated in AOS frames; • CCSDS Encapsulation Service (ref. CCSDS 133.1-B-2); • CCSDS IP over CCSDS Space Links (ref. CCSDS 702.1-B-1)	New capability, in the DSN plan, but yet to be funded

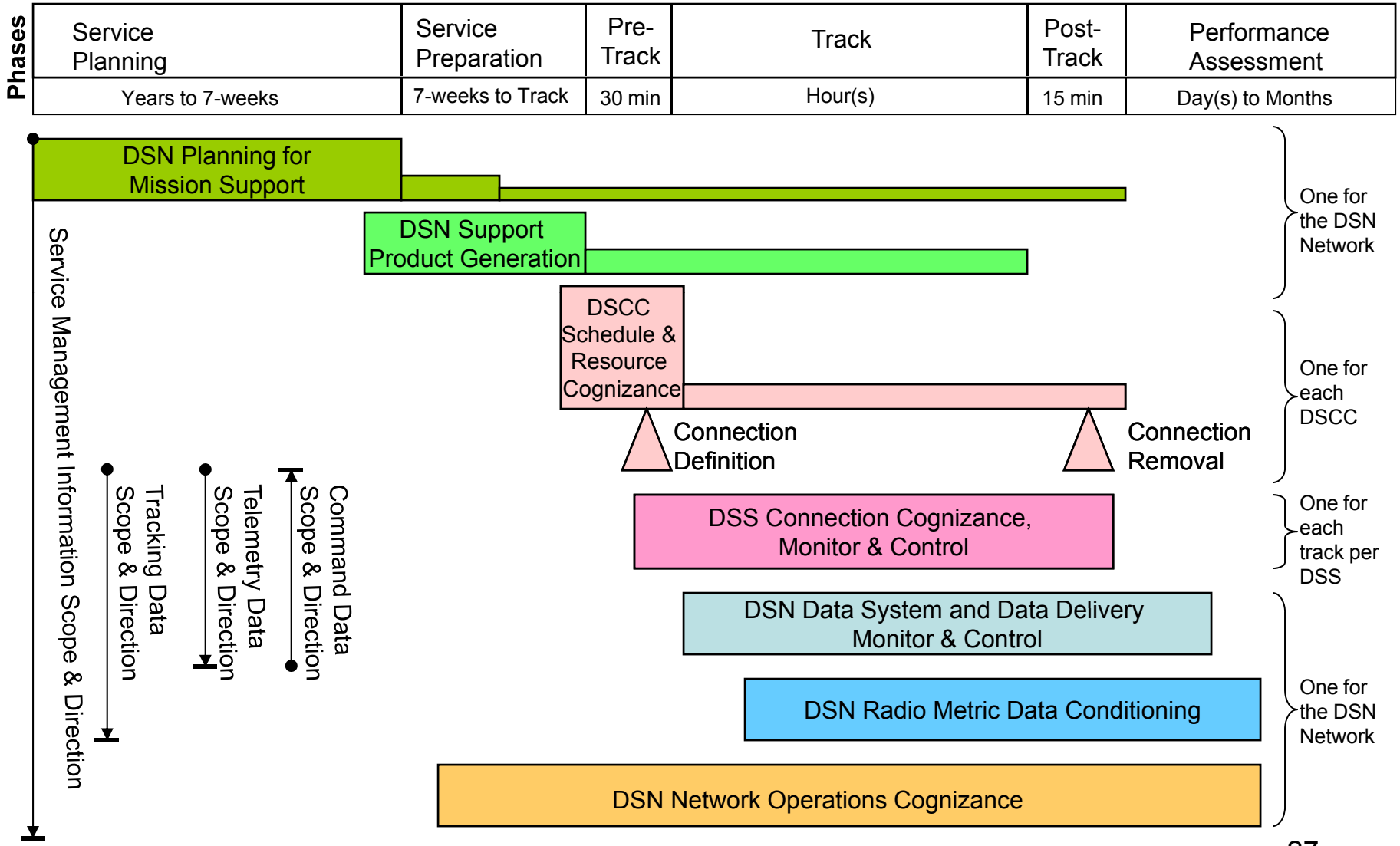
Radiometric Data Service - Key Attributes		Remark
Frequency Bands	Near-Earth S-band	Present capability
Antenna Types	34m BWG, 34m HEF	Present capability
Tracking Data Types	Range, Doppler, Angle (mainly for initial acquisition during LEOP)	Ranging in TDRSS DG1 is assumed - New capability (not funded).
Modulation Types	SS-UQPSK, SQPN	Ranging in TDRSS DG1 is assumed - New capability (not funded)
Ranging Type	Pseudo-noise	
Range Accuracy (1σ Error)	1 meter	
Doppler Accuracy (1σ Error)	0.2 mm/s, 60s Compression	
Doppler Measurement Rate	0.1 second	
Data Latency	Doppler/Range: 5 minutes (95%)	
Data Modes (DSN to MOC)	Stream data mode File data mode	
Delivery Modes (DSN to MOC)	On-line; Off-line	
Interface standards	CCSDS Tracking Data Messages (TDM) for data contents/format; CCSDS Cross Support Transfer Service (CSTS) for Radiometric Data for interface protocol	

DSN Support to Category-A Missions
Key DSN Assets

- Relevant assets:
  - 34m HSB: DSS-27, S-band uplink and downlink
  - 34m BWG-1 subnet: S-band uplink and downlink; X-band uplink and downlink
  - Other 34m BWG: X-band uplink and downlink
  - 34m HEF subnet: S-band downlink; X-band downlink only
  - 34m BWG, one at each site: Near-Earth Ka-band downlink
- Frequencies / transmitters for near-Earth missions
  - S-band uplink: 2025 – 2110 MHz
    - 200 W - 20 KW transmitter at 34m antenna
  - S-band downlink: 2200 – 2290 MHz
  - X-band uplink: 7190 – 7235 MHz
    - 200 W - 4 KW* transmitter at 34m BWG antenna
  - X-band downlink: 8450 - 8500 MHz
  - Ka-band downlink: 25.5-27 GHz

* Requirement for maximum transmitting power is 4 KW, but showed that the implementation actually achieved 20 KW.

DSN Operational Activities



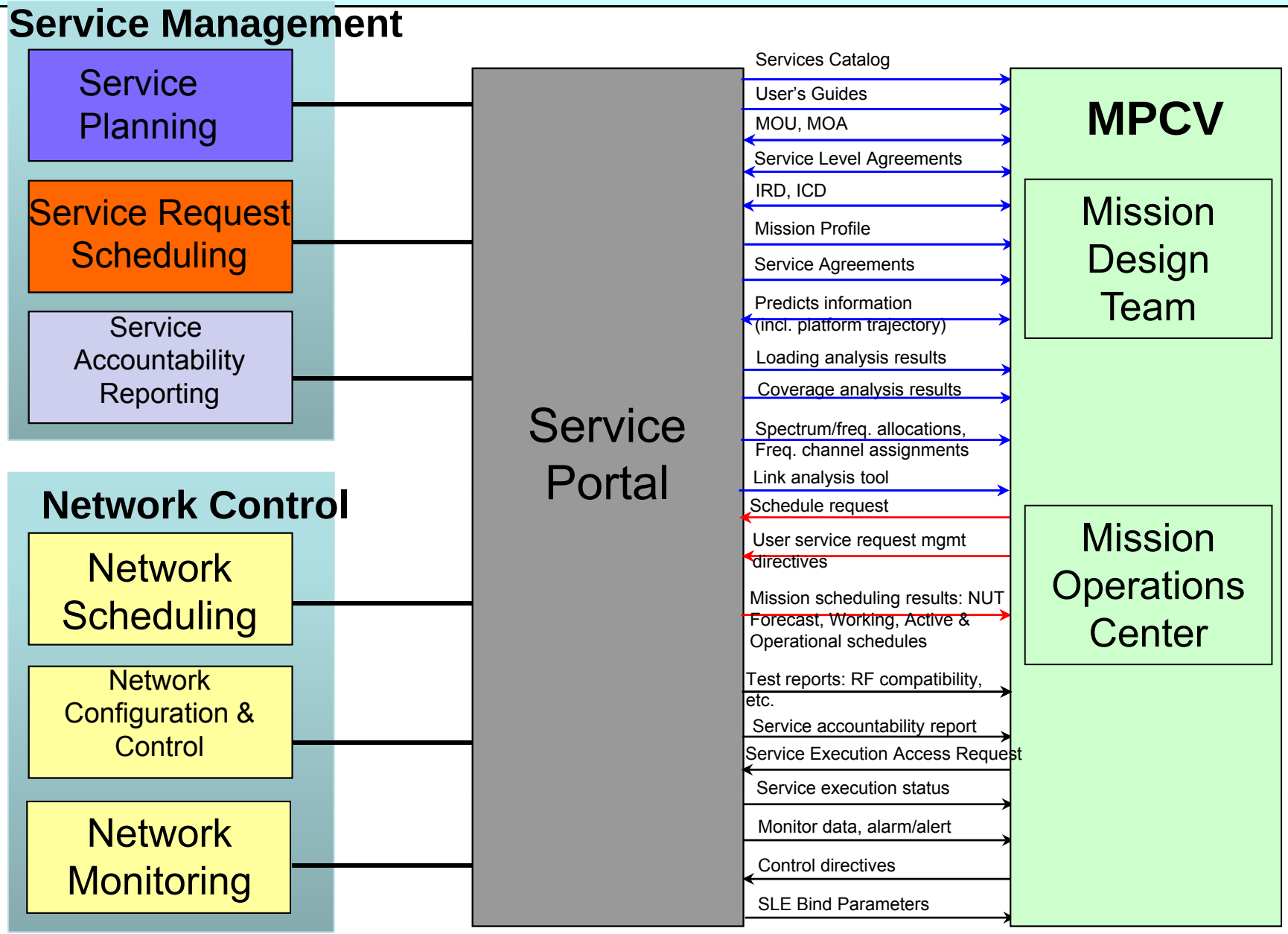
Importance of the DSN

- Currently, enables three dozen science missions valued at roughly $15B, from geostationary Earth orbit and beyond, and invaluable ground-based science observations
- NASA's primary asset for lunar communications
- Prepared to save all space missions
  - At least four missions have been saved, in part, by the DSN
- Is an essential enabler for the Exploration Vision
- Reaches out to next generation of space scientists and engineers
- Is one of NASA's most important assets

Goldstone 70m and 34m antennas viewed from Earth orbit

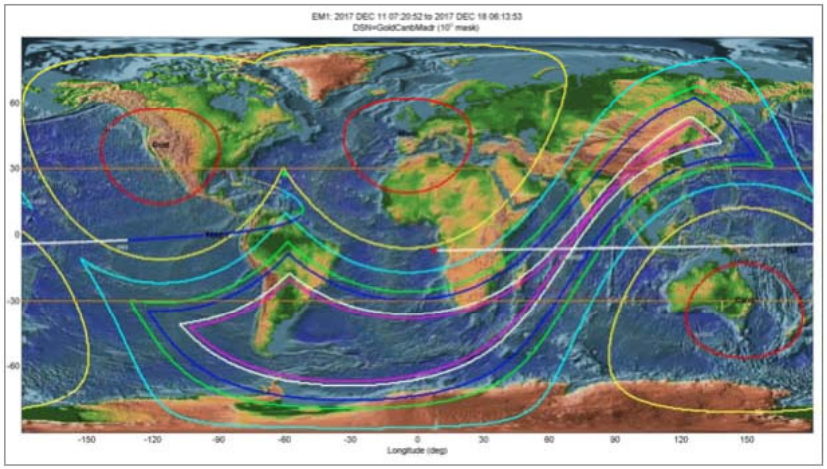
Backup

Service Management & Network Control Functions
MPCV – DSN Interfaces

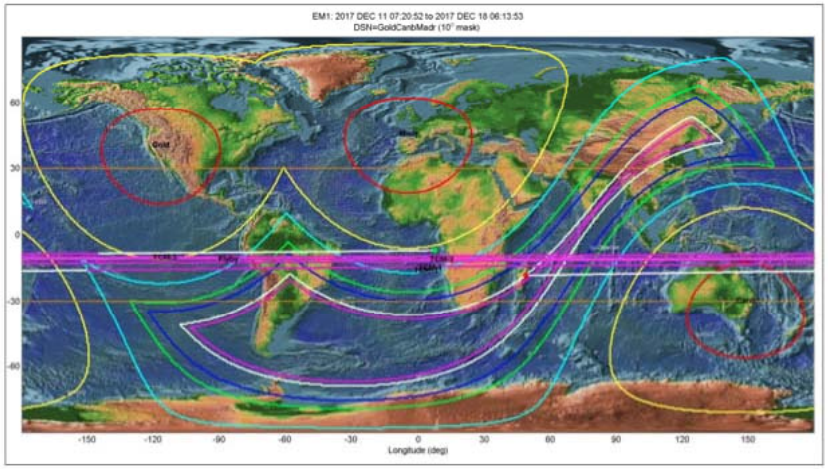


EM1 Trajectory (200,000 km cut-off) – DSN3

To Moon

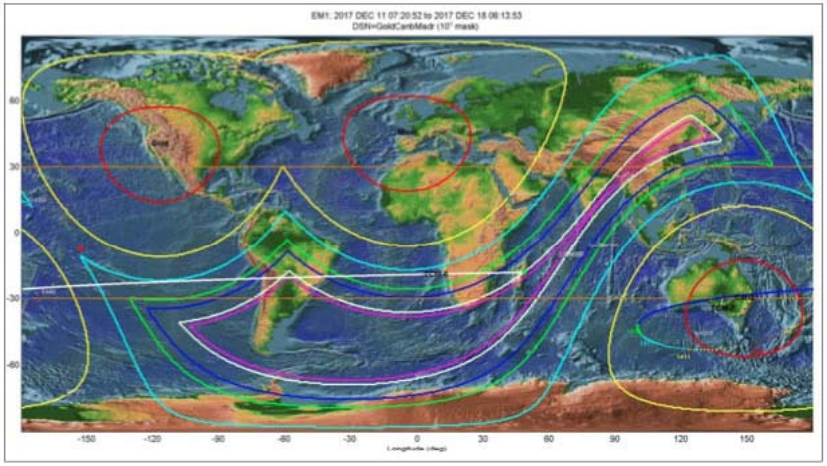


Near Moon



Remarks:

- Time between dots is a minute
- Starting position is in green
- Ending position is in red
- Horizon mask is 10 degrees

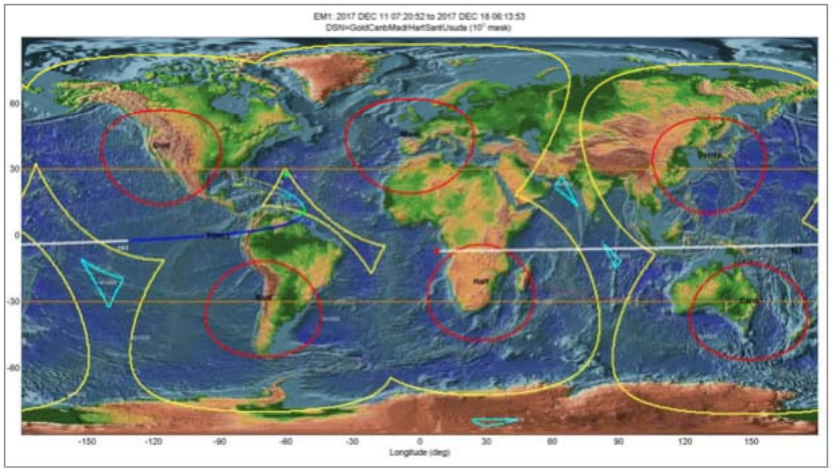


Earth Return

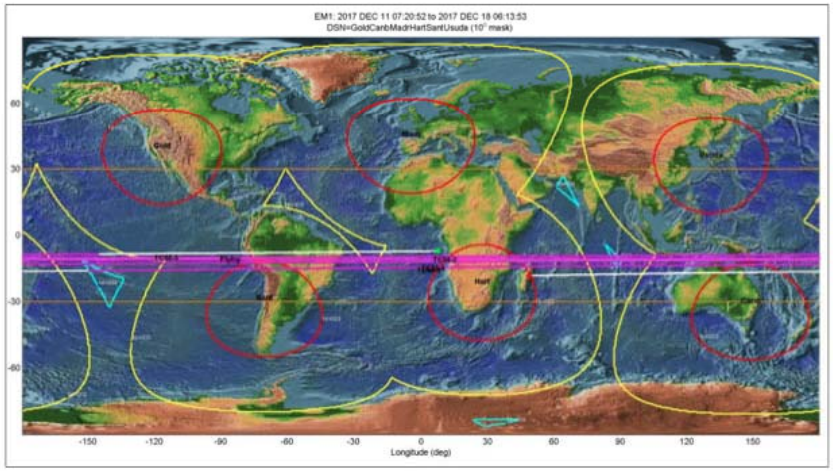
Contours:
1,000 km (red)
5,000 km (yellow)
10,000 km (cyan)
20,000 km (green)
30,000 km (blue)
100,000 km (white)
250,000 km or more (magenta)

EM1 Trajectory (200,000 km cut-off) – DSN6

To Moon

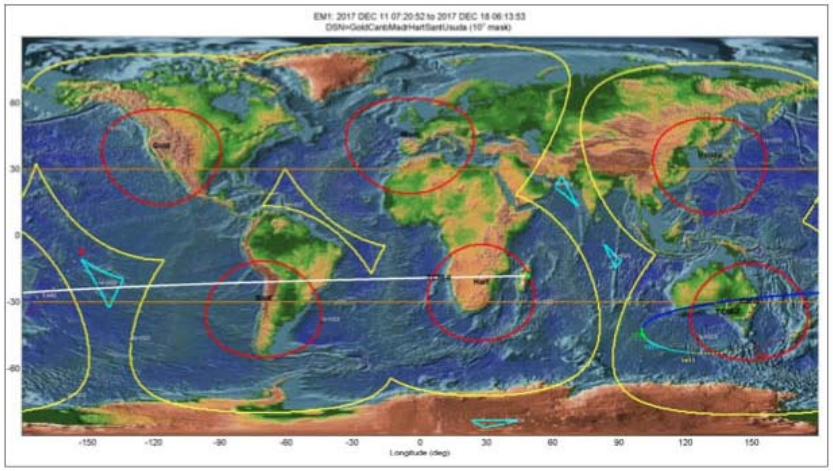


Near Moon



Remarks:

- Time between dots is a minute
- Starting position is in green
- Ending position is in red
- Horizon mask is 10 degrees

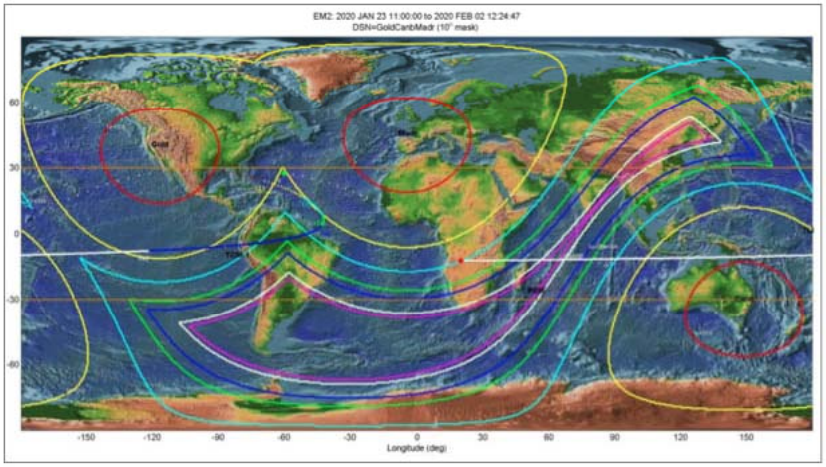


Earth Return

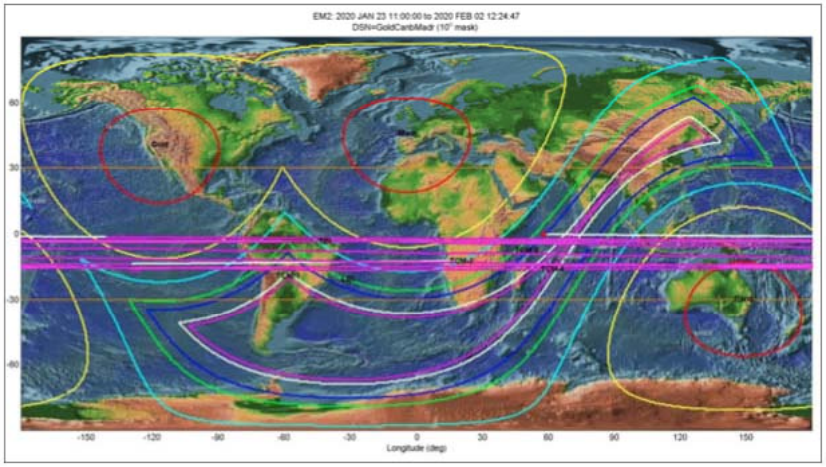
Contours:
- 1,000 km (red)
- 5,000 km (yellow)
- 10,000 km (cyan)
- 20,000 km (green)
- 30,000 km (blue)
- 100,000 km (white)
- 250,000 km or more (magenta)

EM2 Trajectory (200,000 km cut-off) – DSN3

To Moon

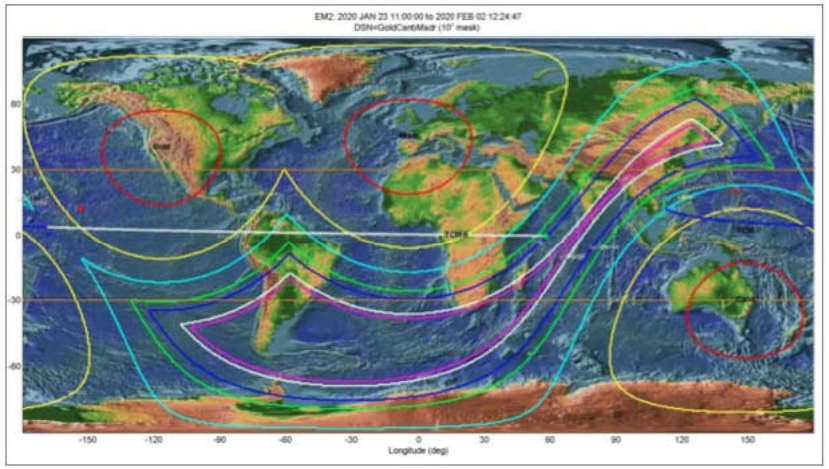


Near Moon



Remarks:

- Time between dots is a minute
- Starting position is in green
- Ending position is in red
- Horizon mask is 10 degrees

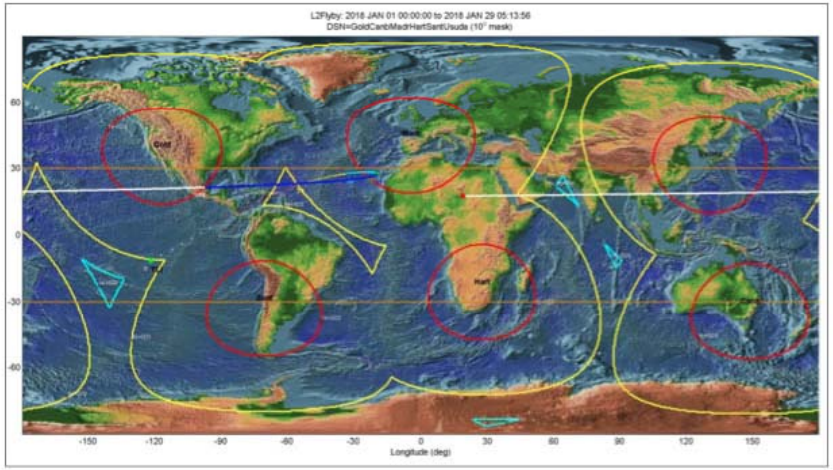


Earth Return

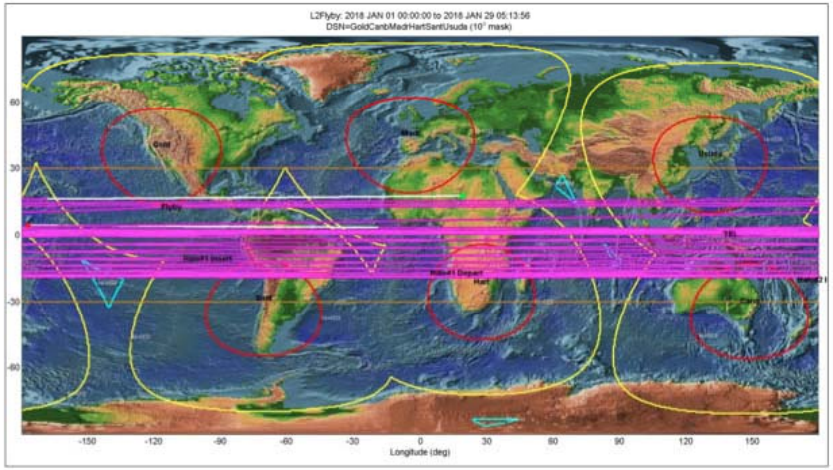
Contours:
1,000 km (red)
5,000 km (yellow)
10,000 km (cyan)
20,000 km (green)
30,000 km (blue)
100,000 km (white)
250,000 km or more (magenta)

EM2 Trajectory (200,000 km cut-off) – DSN6

To Moon

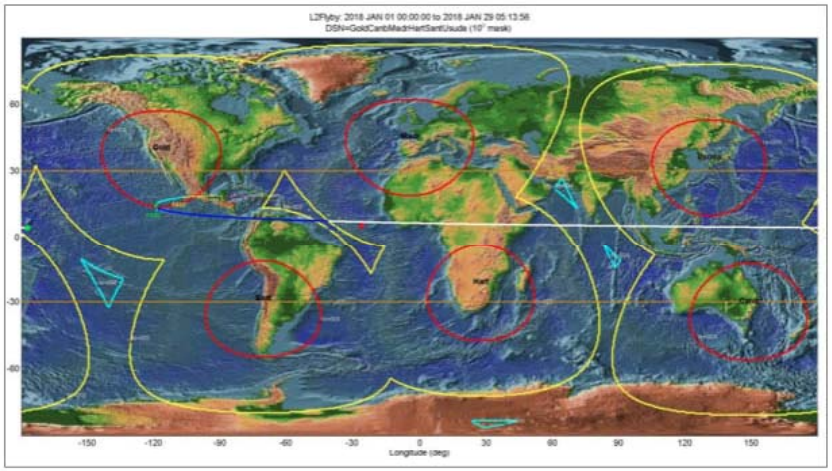


Near Moon



Remarks:

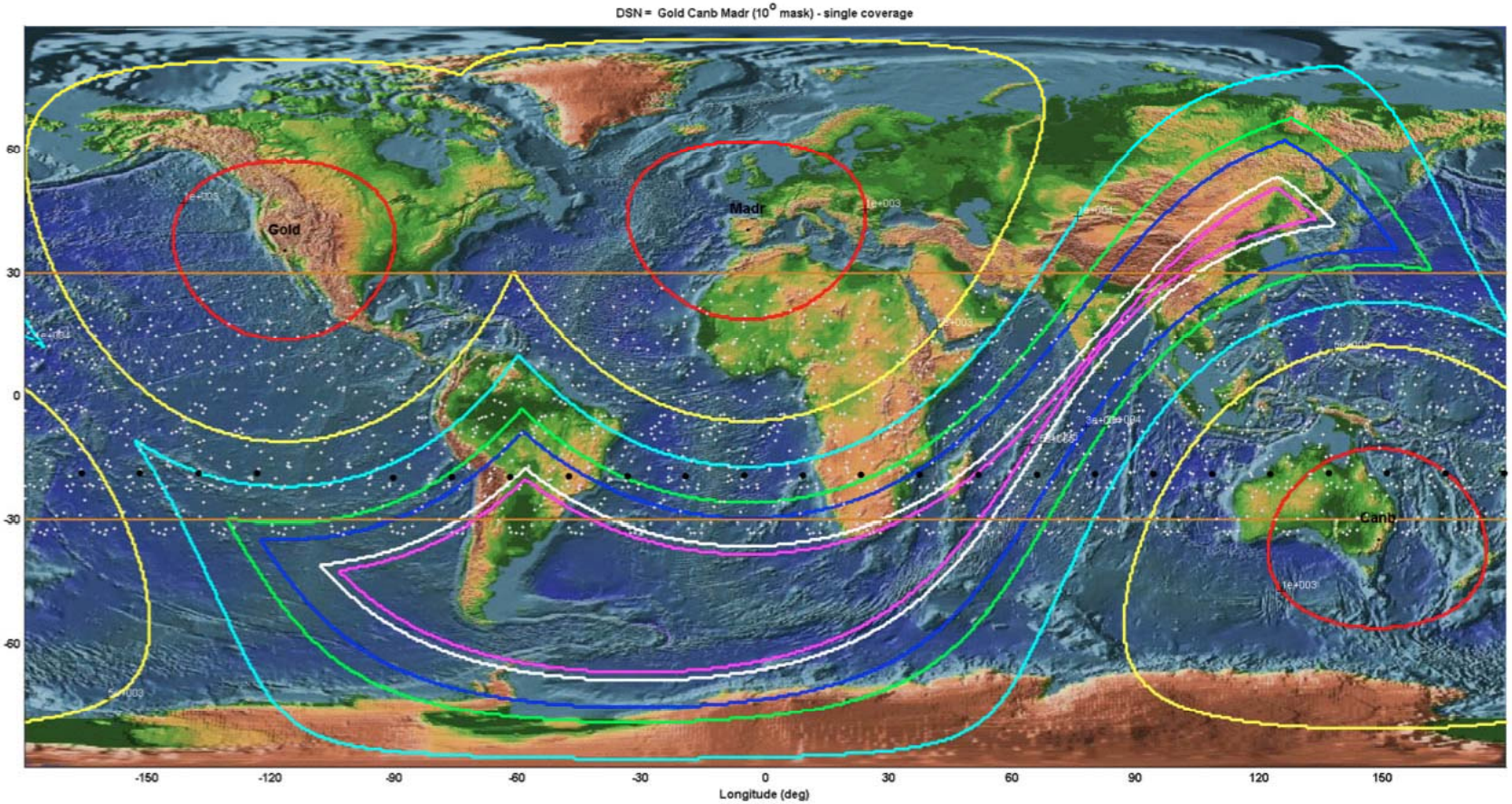
- Time between dots is a minute
- Starting position is in green
- Ending position is in red
- Horizon mask is 10 degrees



Earth Return

Contours:
- 1,000 km (red)
- 5,000 km (yellow)
- 10,000 km (cyan)
- 20,000 km (green)
- 30,000 km (blue)
- 100,000 km (white)
- 250,000 km or more (magenta)

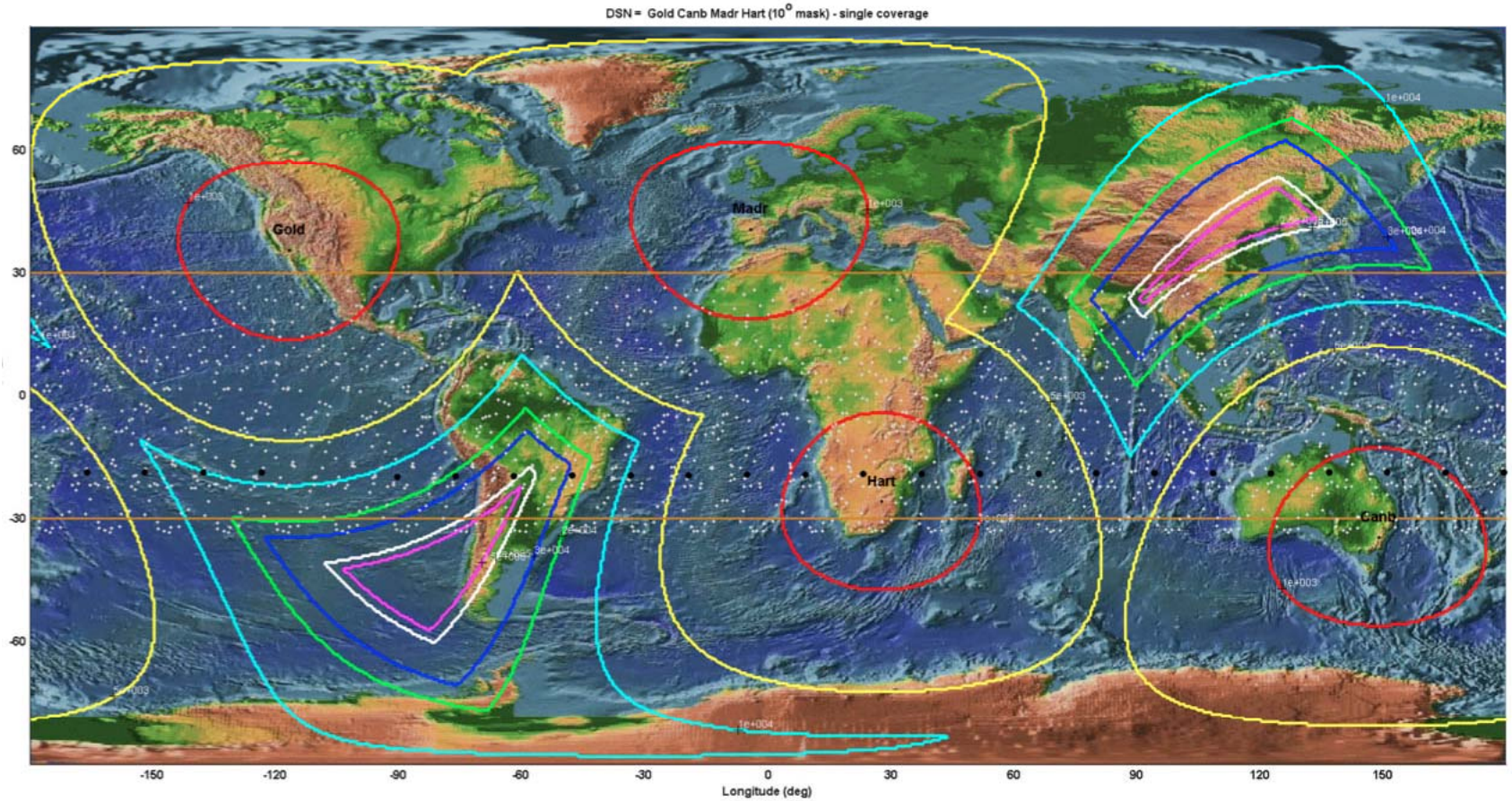
Waypoint DSN Coverage (10-deg mask)



Contours: black dots are one-hour footprints of spacecraft moving right to left totaling 24 hrs
1,000 km (red) 5,000 km (yellow) 10,000 km (cyan) 20,000 km (green) 30,000 km (blue) 100,000 km (white) 250,000 km or more (magenta)

SC - Altitude > 350,000 km; Latitude > -34 deg

Waypoint DSN + HBK Coverage (10-deg mask)

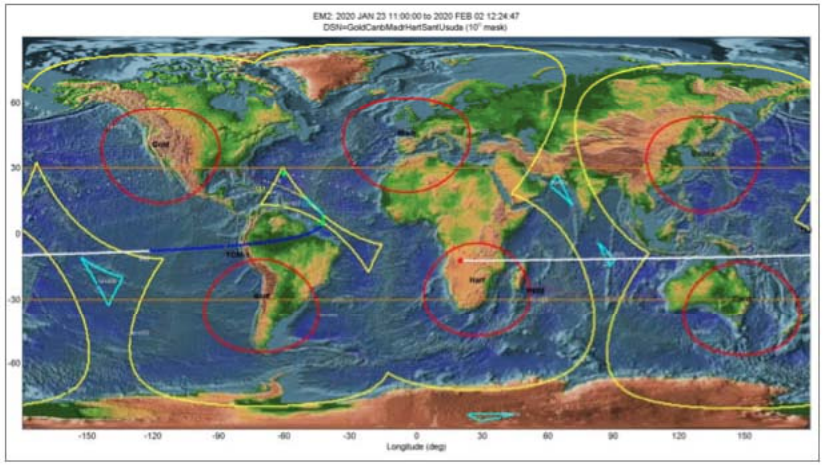


Contours: black dots are one-hour footprints of spacecraft moving right to left totaling 24 hrs
1,000 km (red) 5,000 km (yellow) 10,000 km (cyan) 20,000 km (green) 30,000 km (blue) 100,000 km (white) 250,000 km or more (magenta)

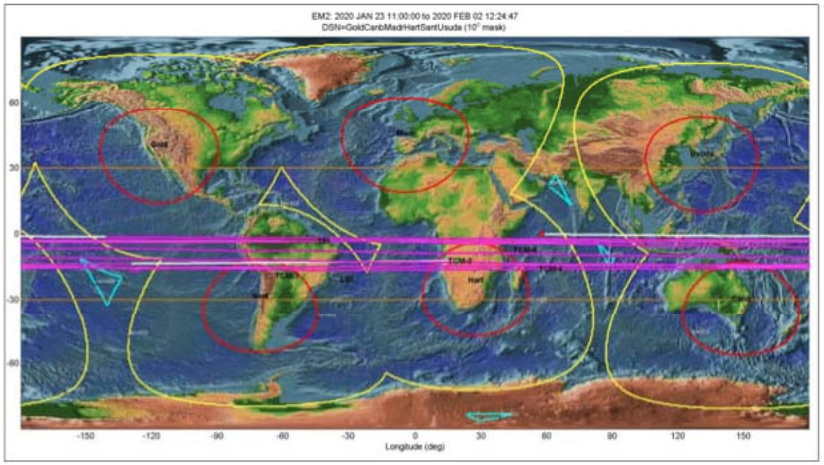
SC - Altitude > 350,000 km; Latitude > -34 deg

EM2 Trajectory (200,000 km cut-off) – DSN6

To Moon

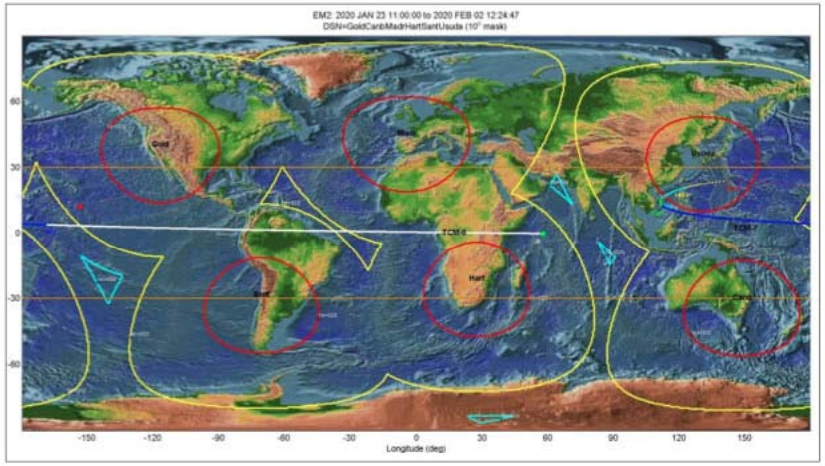


Near Moon



Remarks:

- Time between dots is a minute
- Starting position is in green
- Ending position is in red
- Horizon mask is 10 degrees

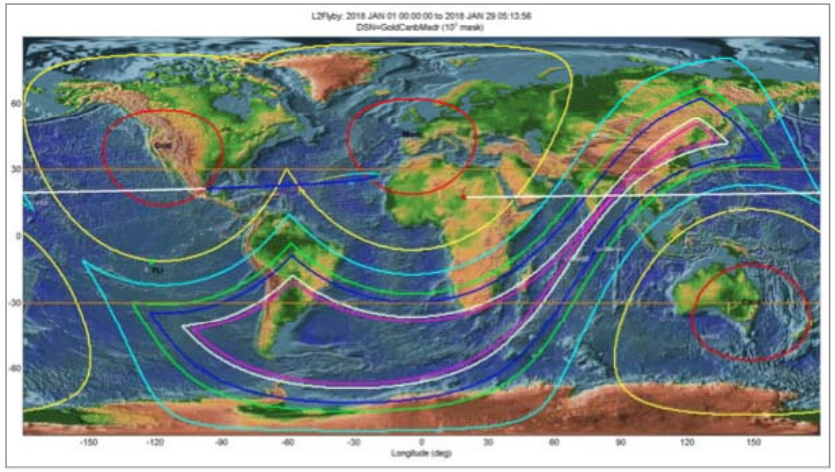


Earth Return

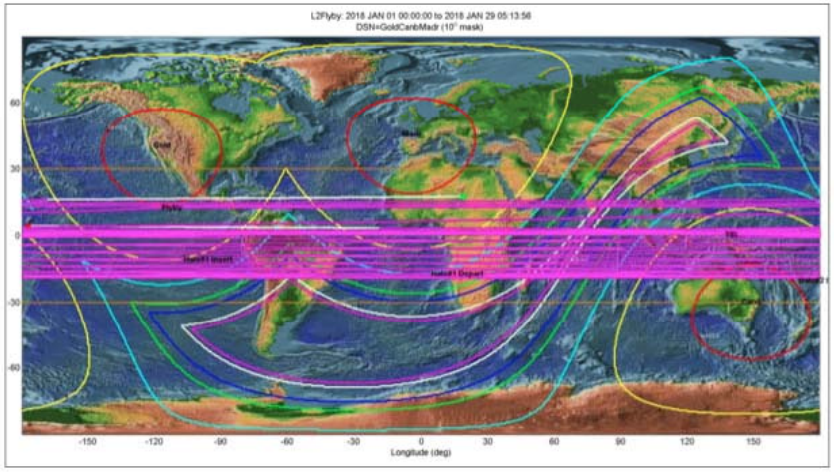
Contours:
1,000 km (red)
5,000 km (yellow)
10,000 km (cyan)
20,000 km (green)
30,000 km (blue)
100,000 km (white)
250,000 km or more (magenta)

Flyby Trajectory (200,000 km cut-off) – DSN3

To Moon

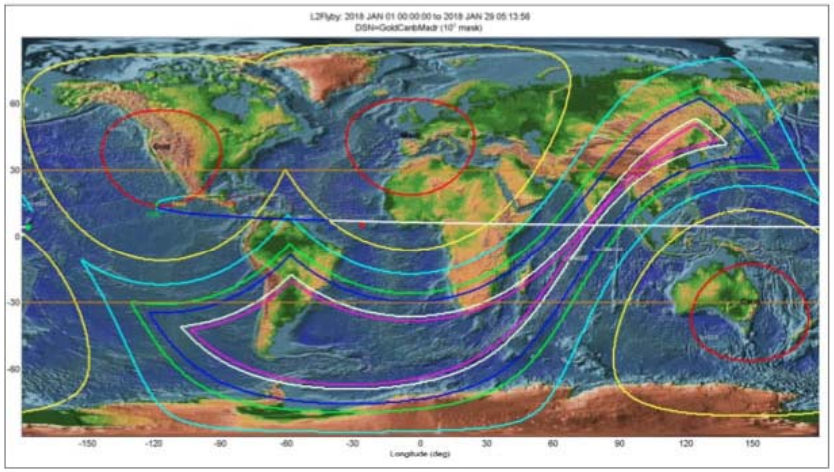


Near Moon



Remarks:

- Time between dots is a minute
- Starting position is in green
- Ending position is in red
- Horizon mask is 10 degrees



Earth Return

Contours:

- 1,000 km (red)
- 5,000 km (yellow)
- 10,000 km (cyan)
- 20,000 km (green)
- 30,000 km (blue)
- 100,000 km (white)
- 250,000 km or more (magenta)

DSN Support to Lunar Missions - SELENE

Programmatic Overview / Center Support

SELenological and Engineering Explorer (SELENE) goal is to obtain scientific data of the lunar origin and evolution, and to develop the technology for future lunar exploration. SELENE consists of a Main Orbiter and two small satellites, Relay satellite. The instruments and the relay satellite are used to carry out global mapping of the lunar surface. Launch Vehicle is an H-IIA launching from Tanegashima Launch site of the Tanegashima Space Center Launch is currently scheduled no earlier than 18 July 2007. The spacecraft is managed and operated by JAXA. The DSN will be augmenting the JAXA stations for launch plus 40 days.

Key Mission Events

Event	Date
Launch Period	18 July 2007
Prime DSN support	L to L +40 days

DSN Tracking Summary

TLM, CMD, & TRK, RNG
Telemetry Rates Max 4kbps -2kbps
26/34 meter support S-Band U/L & D/L
8-16 hours per day for 40 days

Telecommunications Summary

S-Band
Uplink 2084 MHz
Downlink 2263MHz
TLM Rates: 2kbps and 4kbps
TLM Code: MCD 2

DSN Support to Lunar Missions
LRO

Key Mission Events

Event	Date
Launch Period	Oct. 2008
Prime DSN support	L to L +5 days

DSN Tracking Summary

TLM, CMD, & TRK, RNG
Telemetry Rates Max 256kbps -125bps
34 meter support S-Band U/L & D/L
8-16 hours per day for 40 days

Programmatic Overview / Center Support

Lunar Reconnaissance Orbiter (LRO) objective is specifically targeted to prepare for and support future human exploration of the moon. LRO specific objectives are to: characterize the lunar radiation environment, biological impacts, and potential mitigation, to determine a high-resolution global, geodetic grid of the Moon in 3 dimensions, assess in detail the resources and environments of the Moon's polar cap regions, and to perform high spatial resolution of the Moon's surface. The co-payload with LRO is the LCROSS spacecraft. The mission is operated and managed by Goddard with the use of the DSN during the launch and early orbit.

Telecommunications Summary

Near Earth S-Band
Uplink 2091 MHz
Downlink 2271MHz
TLM Rates: 0.125, 2, 16, 32, 64, 128, and 256 kbps
TLM Code MCD 2 and Reed-Solomon

DSN Support to Lunar Missions
LCROSS

Programmatic Overview / Center Support

Lunar CRater Observation and Sensing Satellite (LCROSS) is a lunar impact mission. Its objective is to look for water ice at one of the lunar poles.
LCROSS mission consists of two main parts, the Shepherding Spacecraft (S-S/C) and the attached Centaur Upper Stage. As the spacecraft approaches the Moon's south pole, the Centaur will separate, and will then impact a lunar crater in the polar region of the Moon. A plume from the Centaur crash will develop as the S-S/C heads in towards the Moon. The S-S/C will fly through the plume collecting science data. Nominal Mission length is 100 days. LCROSS is a co payload with LRO, launching in October 2008 on an Atlas V.

Key Mission Events

Event	Date
Launch Period	Oct. 2008
Prime DSN support	L to L +90 days

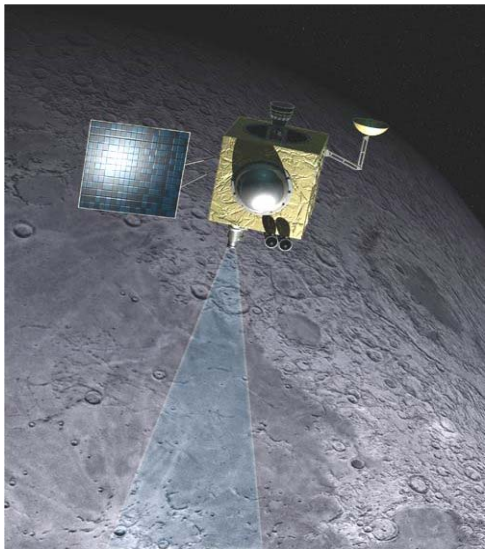
DSN Tracking Summary

TLM, CMD, & TRK, RNG
Telemetry Rates Max 1.1 Mbps -125bps
34 meter support S-Band U/L & D/L
70 meter S-band D/L only during impact
2-4 hours every 3 days for 100 days

Telecommunications Summary

Near Earth S-Band
Uplink 2070 MHz **Tentative**
Downlink 2248MHz **Tentative**
TLM Rates: 1.1 Mbps through 125bps
TLM Code MCD 2 and Reed-Solomon

DSN Support to Lunar Missions
Chandrayaan-1



Programmatic Overview / Center Support

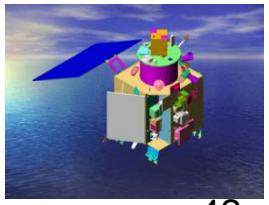
Chandrayaan -1 is a two year lunar orbiter mission managed by the Indian Scientific and Research Organization (ISRO) with a final operational 100 km by 100 km circular orbit optimized for full surface observation. The objective of the mission is to complete a full photo selenological and chemical mapping of the moon. The spacecraft utilizes a flight proven spacecraft bus inherited from a geosynchronous METSAT mission along with India's Polar satellite Launch Vehicle (PSLV-XL). The spacecraft includes a complement of 11 instruments, five from within ISRO, and six international instruments including two from the U.S; the Mini SAR from Johns Hopkins Applied Physics Lab, and the Moon Mineralogy Mapper from JPL. ISRO is establishing two new Deep Space facilities near Bangalore to be used in support of the mission, an 18m and a 32m S/X antenna. The project plans on augmenting its ground support with an 18m antenna at APL and at least one NASA DSN station.

DSN Tracking Summary

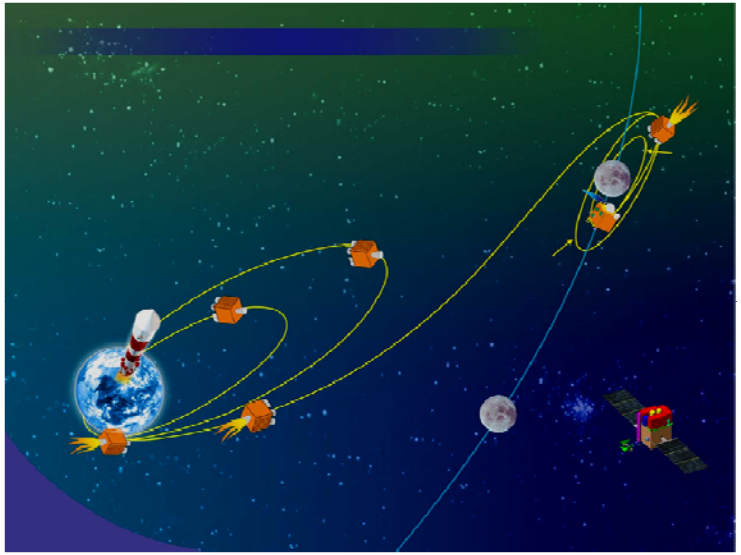
Launch, Cruise, Lunar Orbit Insertion, On orbit Ops
TLM, CMD, & TRK (RNG)
S-band TLM Rates: 2000, 1000, & 500 sps
Rate 1/2 Turbo coding
34m U/L & D/L
X-band Sci TLM 2 X 4.2 Msps QPSK
RS + concatenated coding
34m D/L only

Key Mission Events

Event	Date
Launch	June 30, 2008
Cruise Phase	June 30- July 6, 2008
On Orbit	to July 7 2010



DSN Support to Lunar Missions
Chandrayaan-1



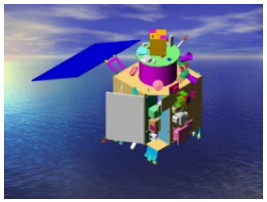
Launch Services / Navigation

The Chandrayaan-1 mission has a planned launch date of April 9, 2008 from the Satish Dhawan Space Center, Sriharikota. The spacecraft will be launched using a five and a half day 240 x 36000 km geosynchronous transfer orbit to get to the moon. The initial lunar orbit of 1000 km will be used for spacecraft checkout with a final 100 km circular mapping orbit. Principal navigation responsibility belongs to ISRO. Navigation consultancy is being negotiated within the limits of ITAR to provide orbit and lunar injection verification.

Mission Requirements Summary

Chandrayyan-1 support includes launch and early orbit during gaps in coverage with ISRO and APL assets. DSN to provide S-band TT&C only during LEOP. On orbit operations includes the high rate science telemetry on the X-band channel, (no TT&C or virtual channels) at 8.4 Mb/s uncoded. ISRO is requesting the DSN backup the APL facility for high rate data capture, as well as fill in the APL/Bangalore gap during specific observational sampling periods.

Telecommunications Summary

S-Band Prime TT&C only. DSN for LEOP through on orbit health and safety.
X-Band backup for high data rate telemetry, down link only. Request is to fill the gap between APL set and Bangalore rise.

Uplinks: 2041.598 MHz MHz & 2054.195 MHz
Downlinks: 8483.968 MHz, 2217.120 MHz & 2230.800 MHz
Subcarriers: 32.0 KHz & 128 KHz (Sine wave)
TLM Rates: Engineering: 250, 500, & 1000 b/s uncoded
Science: 4.2 Mb/s uncoded
TLM Code: S-band R=1/2 Turbo, X-band RS concatenated
Command: PCM/PSK/PM with 8 kHz sine wave subcarrier
CMD Rate: 125 b/s