



# An Introduction to the DSMS Strategic Mission Model V5.0

**NASA**

Interplanetary Network Directorate  
Jet Propulsion Laboratory  
California Institute of Technology

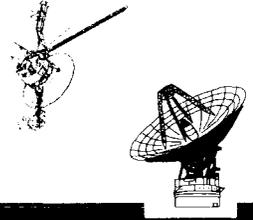
D. S. Abraham  
August 5, 2003



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# Topics



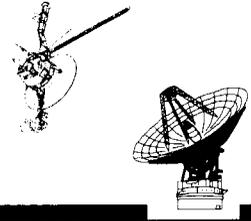
- I. What is the DSMS Strategic Mission Model?**
- II. What Is In the Mission Model?**
- III. How is the Model Used?  
(Some Example Aggregate Findings)**
- IV. How is the Model Maintained?**
- V. What Are the Open Issues?**
- VI. Key Questions for You**



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# What is the DSMS Strategic Mission Model?



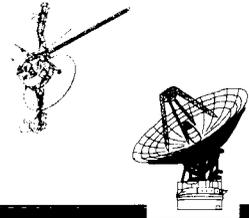
- DSMS -- The Deep Space Mission System (DSMS) is a consolidated system of the two JPL multi-mission systems, i.e. the Advanced Multi-Mission Operations System (AMMOS) and Deep Space Network (DSN), providing support to flight projects and science investigations. In general, the DSMS support to its customers can be categorized into 3 types:
  - (1) mission operations *services*,
  - (2) *tools* used by customers to operate their missions and to develop their mission operations system (MOS), and
  - (3) other *engineering support* such as those activities performed to support project mission design, telecommunication link analysis, end-to-end integration and test, etc.
- DSMS Strategic Mission Model -- a large EXCEL workbook containing detailed information on current and future Space Science Enterprise missions that are relying, or potentially will rely, on the Deep Space Network for their telecommunications and navigation support.



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## What is the DSMS Strategic Mission Model? (Continued)



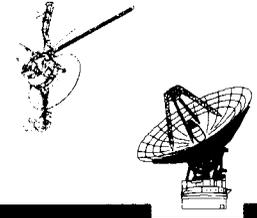
- Purpose – to enable identification and analysis of mission demographic trends pertinent to DSMS long-range planning.
- Applicable Time Horizon – data fields reasonably populated for missions out to about the 10-year time horizon; rudimentary mission information available out to about the 20-year time horizon.
- History – originated in 2000 to support the DSN’s “70m-equivalent Capability Study.” Since then, updated on roughly an annual basis to support the annual Program Operating Plan submission as well as other DSN-related long-range planning activities.
- Included Missions – only currently operating missions and those future missions which appear in NASA budgets, strategic plans, roadmaps, or NASA-solicited National Academy of Science studies are included in the Mission Model.
  - The next three pages summarize mission sets contained in the model.
    - All of the missions on the first page are treated in the model.
    - All of the missions in red or blue text on the second two pages are treated, to at least some degree, in the model (since they are possible DSN supports).



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# Approved Mission Set: DSN Supports\*



## Legacy LEO

- RADARSAT (O)

## LEOP\*\*

- GOES N-P (C)
- NOAA N, N' (C)
- PROSEDS (C)

## HEO, Lunar, L1 & L2

- CHANDRA (O)
- WMAP (O)
- INTEGRAL (O)

- LUNAR-A (F)
- ST-5 (C)

## DEEP SPACE\*\*\*

- GALILEO (O)
- MARS GLOBAL SURVEYOR (O)
- CASSINI (O)
- NOZOMI (O)
- STARDUST (O)
- 2001 MARS ODYSSEY (O)
- GSSR (O)\*\*\*\*
- HAYABUSA (A K A MUSES-C) (O)
- MARS EXPRESS (O)
- MER -- SPIRIT & OPPORTUNITY (O)
- ROSETTA (C)
- DEEP IMPACT (C)
- MESSENGER (C)
- MARS RECONNAISSANCE ORBITER (C)
- DAWN (C)
- MARS SCOUT (F)
- MARS TELECOMMUNICATIONS ORBITER (F)
- MARS SCIENCE LABORATORY (F)
- NEW HORIZONS (C)
- NEW FRONTIERS (F) (X)
- JUPITER ICY MOONS ORBITER (F) (X)
- GRAVITY PROBE B (O)\*\*\*\*
- EVN (O)\*\*\*\*
- GBRA (O)\*\*\*\*
- MEGA (O)\*\*\*\*
- SIRTIF (C)
- KEPLER (C)
- SIM (F)
- ORBITAL DEBRIS (O)
- SPACE GEODESY (O)
- DISCOVERY (F) (X)
- MIDEX (F) (X)
- NMP (F) (X)

### NOTES

\*~20 additional spacecraft fall under "Emergency Support Only" and are not shown.

\*\*LEOP = Launch & Early Operations Phase; almost all DSN missions receive such support, but those listed as "LEOP" receive no other significant 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, or orbital debris.

### KEY

- Structure & Evolution of Universe Theme
- Astronomical Search for Origins Theme
- Solar System Exploration Theme
- Cross-Theme Affiliation
- Unaffiliated with Space Science Enterprise

(O) = Operating or utilizing ground-based observations in support of flight preparations (as of 8/03)  
 (C) = Commitment to support, but not yet operating (as of 8/03)  
 (F) = Future commitment to support anticipated (as of 8/03)  
 (X) = Not specifically called out in Code S approved "Mission Set Database" or "Mission Set Change Log"

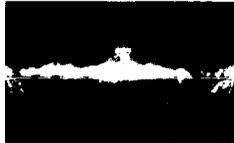
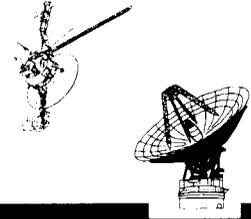




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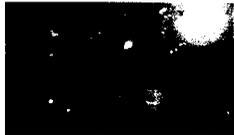
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# Possible Technology-Driven and Foreign-Led Missions



SEU

- HERSCHEL
- PLANCK
- RADIOASTRON
- ASTRO-F



ASO

- GAIA



SSE\*\*

- LUNAR A
- SELENE
- ROSETTA
- VENUS EXPRESS

- MARS TELECOMMUNICATIONS ORBITER
- ESA MARS SAMPLE RETURN
- BEPI COLOMBO
- PLANET-C VENUS SURVEYOR



SEC\*\*\*

- SOLAR-B

- SOLAR ORBITER



CROSS-CUTTING

- SPACE TECHNOLOGY 5
- SPACE TECHNOLOGY 6
- SMART-2 / SPACE TECHNOLOGY 7
- SPACE TECHNOLOGY 8

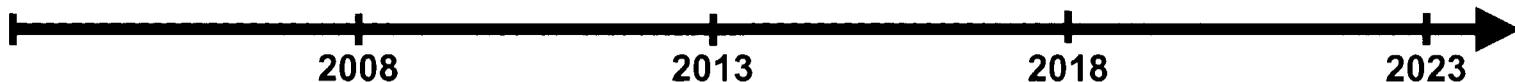
- SPACE TECHNOLOGY 9

## -- Work In Progress --

NOTE: ONLY RED ITEMS ON THIS PAGE USED IN LATEST DSMS MISSION DEMOGRAPHICS ANALYSIS - WITH THE EXCEPTION OF RADIOASTRON (WHICH WAS ONLY USED IN THE FREQUENCY BAND & SPACECRAFT LOCATION ANALYSES). NO INTERNATIONAL AGREEMENTS FOR DSN SUPPORT EXIST FOR THE FOREIGN BLUE AND BLACK MISSIONS ON THIS PAGE (EXCEPT FOR RADIOASTRON). SUCH SUPPORT AGREEMENTS ARE THE RESPONSIBILITY OF CODE S, AND CODE S MAY CHOOSE NOT TO PARTICIPATE IN ANY PARTICULAR MISSION.

### Key

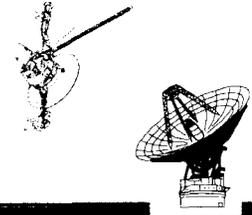
- DSN Support Likely
- DSN Support Possible
- DSN Support Unlikely



Very Approximate Launch Epoch



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# What Is In the Mission Model?

## EXCEL Worksheet Title

## Worksheet Fields

Mission Identification & Description

Mission Name; Mission Aliases; Mission Description

Mission Set Correlations

Mission Name; In GSFC/CSOC-maintained mission set?; In DSMS Plans & Commitments Mission Set?; In RAPWEB DSN User / Mission Set?; In RAPWEB DSN User / Future Mission Set?

Programmatic Context

Mission Name; Space Science Enterprise Theme Area; Lead Agency; Cooperating Agencies; NASA HQ Lead Organization; U.S. Lead Center; Program Affiliation; WAG at U.S. Mission Cost through Launch + 30 Days (M\$)

General Support Requirements

Mission Name; LEOP Support Requested?; TT&C Support Requested? Co-Observation Support Requested? AMMOS Support Requested?

Mission Characterization (Part A)

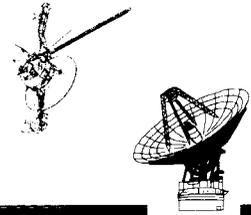
Mission Name; Current Project Phase; Launch Year; Last Year of Prime Mission; Last Year of Extended Mission; Mission Destination Description; Mission Destination Classification; Maximum Distance from Earth (AU); Number of Exploration Elements; Number of Exploration Elements Communicating Directly with Earth.



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# What Is In the Mission Model? (Continued)



## EXCEL Worksheet Title

## Worksheet Fields

Mission Characterization (Part B)

Mission Name; Exploration Element Descriptions;  
Trajectory Description; Low-Thrust Propulsion?  
Passive Formation Flight?; Active Formation Flight?  
Entry, Descent, and Landing?; Sample Return?

Downlink & Uplink Frequencies

Mission Name; Near-Earth, Deep Space, or HEDS  
Downlink Frequencies?; Number of S-Band  
Downlinks?; Number of X-Band Downlinks?; Number  
of Ku-Band Downlinks?; Number of Ka-Band  
Downlinks?; Number of Optical Downlinks?; Near-  
Earth, Deep Space, or HEDS Uplink Frequencies?;  
Number of S-Band Uplinks?; Number of X-Band  
Uplinks?; Number of Ka-Band Uplinks?; Number of  
Optical Uplinks?

D & U Parameters (A)

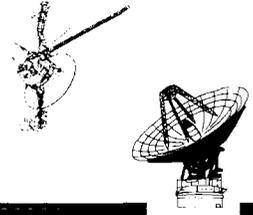
Mission Name; Link Distance for Maximum Data Rate  
at Destination? (AU); Maximum EIRP for Prime  
Downlink (W); Spacecraft Transmit Power for Prime  
Downlink (W); Spacecraft HGA or Optical Aperture  
Diameter (m); Spacecraft Communications  
Subsystem Description



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# What Is In the Mission Model? (Continued)



## EXCEL Worksheet Title

## Worksheet Fields

### D & U Parameters (B)

Mission Name; Maximum Downlink Data Rate for Prime Link (kbps); Spacecraft Health & Safety Data Downlink Rate (kbps); Forward Error Correction Coding Scheme; Maximum Downlink Symbol Rate for Prime Link (kbps); Project-Estimated Total Data Volume Per Day (Mb); Daily Data Volume Devoted to Spacecraft Health & Safety (Mb); Onboard Data Storage Capacity Per Spacecraft (Mb); Maximum Onboard Data Rate Into Storage (kbps); Desired Prime Mission Tracking Time Per Day (hrs); Maximum Uplink Data Rate (kbps)

### Tracking & Nav. Reqmnts. (A)

Mission Name; 11m Tracking Need?; 26m Tracking Need?; 34m Tracking Need?; 70m Tracking Need?; Prototype Array Tracking Need? 1m Optical Tracking Need? 10m Optical Tracking Need? Other Tracking Stations Needed? Other Types of Tracking Needs?

### Tracking & Nav. Reqmnts. (B)

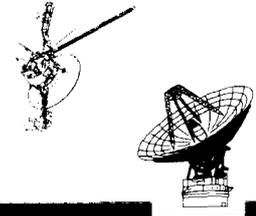
Mission Name; Cruise Duration (Days); 11m Tracking Hours During Cruise; 26m Tracking Hours During Cruise; 34m Tracking Hours During Cruise; 70m Tracking Hours During Cruise; Other Tracking Hours During Cruise; Encounter Duration (Days); 11m Tracking Hours During Encounter; 26m Tracking Hours During Encounter; 34m Tracking Hours During Encounter; 70m Tracking Hours During Encounter; Other Tracking Hours During Encounter



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# What Is In the Mission Model? (Continued)



## EXCEL Worksheet Title

## Worksheet Fields

Tracking & Nav. Reqmnts. (C)

Mission Name; Post-Encounter Relay Asset or Sample Return Duration (Days); 11m Tracking Hours During Post-Encounter; 26m Tracking Hours During Post-Encounter; 34m Tracking Hours During Post-Encounter; 70m Tracking Hours During Post-Encounter; Other Tracking Hours During Post-Encounter; Navigation Strategy Description; Navigation Requirements

Proximity Communications

Mission Name; Type of Proximity Link(s) Associated with Relay?; Total Number of Proximity Comm. Nodes (Excluding Relay)?; Number of UHF Nodes (Excluding Relay)?; Number of L-Band Nodes (Excluding Relay)?; Number of S-Band Nodes (Excluding Relay)?; Number of X-Band Nodes (Excluding Relay)?; Number of Ka-Band Nodes (Excluding Relay)?; Number of Optical Nodes (Excluding Relay)?; Maximum Data Rate From Relay to Node? (kbps); Maximum Data Rate To Relay From Node? (kbps); Maximum Separation Distance Between Node and Relay? (km)

Notes & References

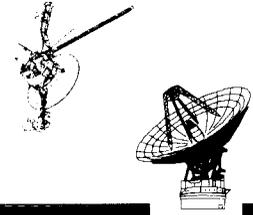
Mission Name; Additional Notes; Mission Web Site URL; Source References; Name of Data Input Source; Date of Last Data Update

**Note:** Field completion depends on data availability. Not all of the fields mentioned can be completed for every mission, particularly the far-future missions.

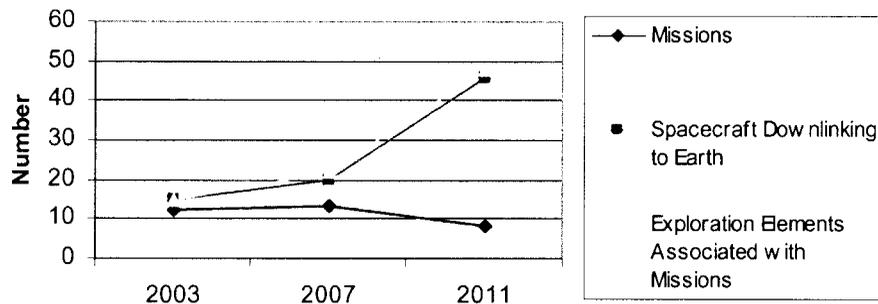


# How is the Model Used?

## (Some Example Aggregate Findings)

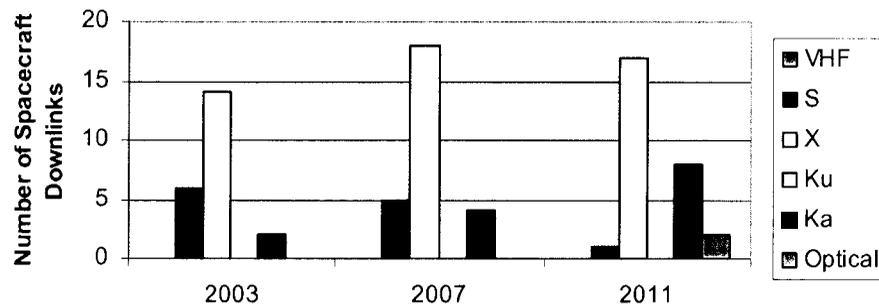


**Number of Near-Earth (HEO, Lunar, and L Pt.) Mission Supports as a Function of Time**

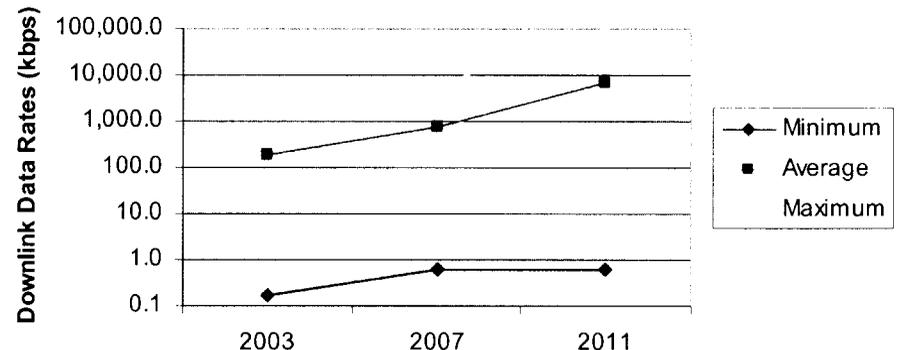


- Constellations drive increase in future near-Earth spacecraft supports.
- Bandwidth constraints & enhanced link performance drive migration to higher frequencies.
- 1-to-2 order of magnitude increase in downlink data rates over next 8 years.

**Number of Deep Space Downlinks as a Function of Frequency Band and Time**



**Deep Space Downlink Rates as a Function of Time**



For a detailed description of how the Model is used, please see the accompanying paper:

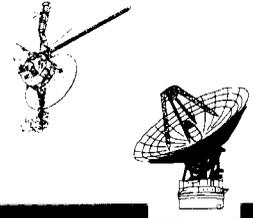
Abraham, D. S., "Identifying Future Mission Drivers on the Deep Space Network," paper 02-T3-64, Space Ops 2002 Conference, Houston, Texas, October 9-12, 2002.



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# How is the Model Maintained?



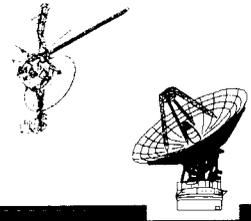
- The Mission Model requires continuous maintenance.
  - As missions mature through their development cycle, so do their parameters.
  - Many missions get deferred, cancelled, or experience changes in scope.
  - New missions frequently emerge as new strategic plans and “roadmaps” are produced and as competitively bid missions are selected.
  - Because Code S is increasingly relying on competitively bid missions in the future, the model will have to be evolved to provide for a more probabilistic treatment of mission options for competitively bid mission lines.
- With the above in mind, DSMS long-range planning staff routinely update the mission model on a “best efforts” basis throughout the course of the year via an access-controlled Docushare site.
  - Provides for configuration control and change history.
- The Model mission set and associated dates are periodically compared with other JPL and GSFC mission sets, with participation by the personnel maintaining those other mission sets, to ensure consistency between models.
- Currently studying relational database systems for possible Model migration.



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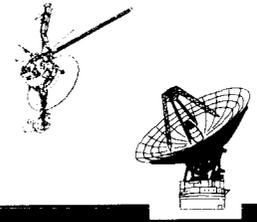
# What Are the Open Issues?



- Security -- while many different entities have expressed interest in obtaining access to the Mission Model, security concerns may impede any JPL-external release of the information.
  - Mission Model contains information that might be subject to International Traffic in Arms Regulations (ITAR); for instance, specific spacecraft uplink and downlink frequencies, coding schemes, and radio frequency subsystem descriptions. We are currently investigating whether this is a valid concern or not.
- Proprietary Data -- because the majority of future Space Science Enterprise missions are in some way competitively bid, many of the concept designs from which the Model parameters have been derived are considered proprietary. Only aggregate Mission Model findings are generally approved for JPL-external release.
- Approved Mission Set – NASA Headquarters has been historically reluctant to officially “bless” a future mission planning set. Because of this, we have adopted the practice of only including those missions which appear in recent “official” NASA budgets, strategic plans, roadmaps, and NASA-solicited National Academy of Science studies. This approach has not raised any objections during presentations to NASA Headquarters-convened review boards.



# Key Questions for You



- Specifically, what data do you really need?
  - Depending on the specific data being requested, some of the concerns on the prior page may or may not apply.
  - Aggregate, statistical summary data for just about any of the fields renders the first two issues on the prior page moot.
- How much data do you really want?
  - This Mission Model deals with only the telecommunication needs for Code S missions that currently rely, or in the future may rely, on the DSN. Yet, there are almost 100 missions and 100 corresponding fields worth of data.
  - Imagine dealing with the totality of NASA missions and associated fields for the areas of power, transportation, human capabilities, and communications.
    - Analysis challenge
    - Maintenance challenge
  - Perhaps some level of aggregate, statistical summary data might be appropriate as inputs to your database; even so, the database will be huge.