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Mission Introduction to the DSN

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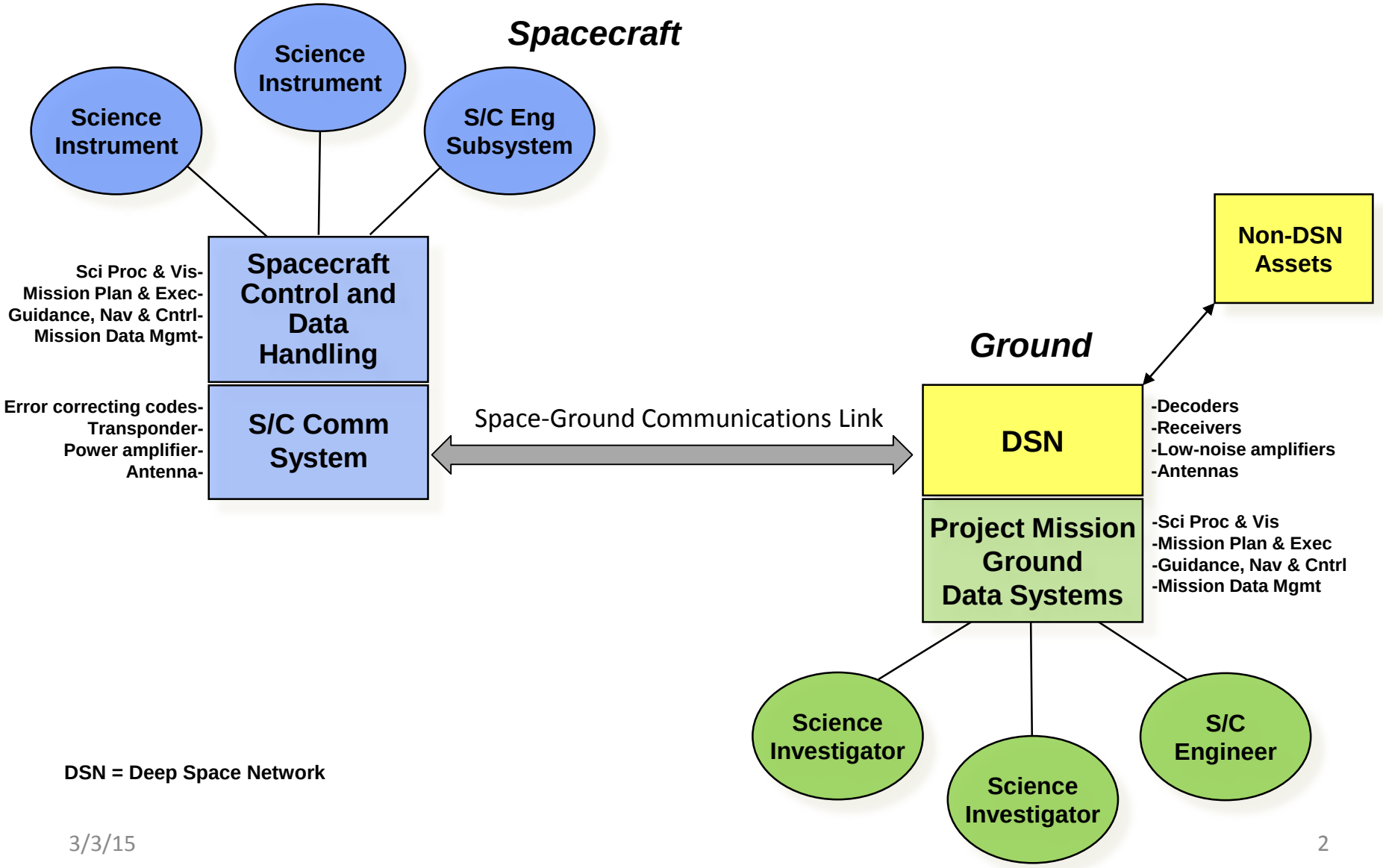
The DSN's Role in Space-Ground Communications



DSN = Deep Space Network

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DSN Overview

- The DSN is optimized to conduct telecommunication and tracking operations with multiple deep space scientific missions (category B missions)
  - The DSN also has the ability to support some near-Earth missions, including those at lunar distances, the Sun-Earth LaGrange points, and in highly elliptical Earth orbits (category A missions)

- The DSN offers services to a wide variety of mission customers, at multiple frequency bands, through all phases of a mission's lifetime

Customers	**Mission Phases**
• NASA • Other Government Agencies • International Partners	• Launch and Early Orbit Phase (LEOP) • Cruise • Orbital • In-situ
Mission Orbits	**Frequency Bands**
• Geostationary or Geosynchronous Earth Orbit (GEO) • Highly Elliptical • Lunar • La Grange • Earth Drift-Away • Planetary	• S-Band (2 GHz) • X-Band (7, 8 GHz) • Ka-Band (26, 32 GHz)

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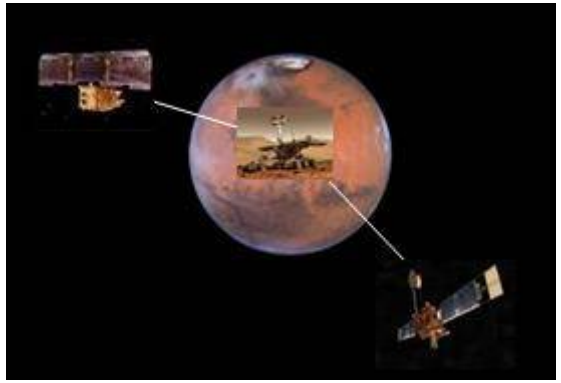
DSN: The Big Picture

DSN Antenna

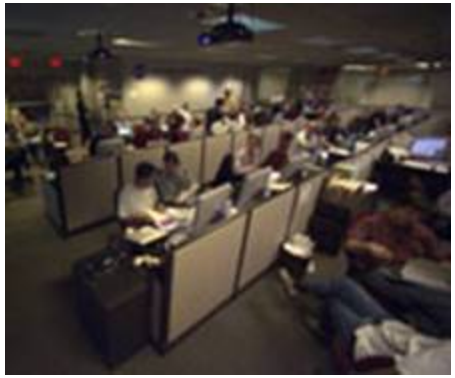


Spacecraft Operations

DSCC Signal Processing Center (SPC) located at the DSN complex

WAN

JPL Deep Space Operations Center (DSOC)



Mission Operations Center (MOC)

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DSN Resources

- The DSN consists of Deep Space Communications Complexes with ground stations located near
  - Madrid, Spain
  - Canberra, Australia
  - Goldstone, California
- At each complex there are a variety of antennas, including 34-meter Beam Wave Guide (BWG), 34-meter High Efficiency (HEF), and 70-meter antennas
- In addition, the DSN supports RF testing using the following facilities
  - Development and Test Facility (DTF-21), located near JPL
  - Compatibility Test Trailer (CTT-22), able to come to the spacecraft site
  - DSN test facility (MIL-71), located at the Kennedy Space Center, Florida

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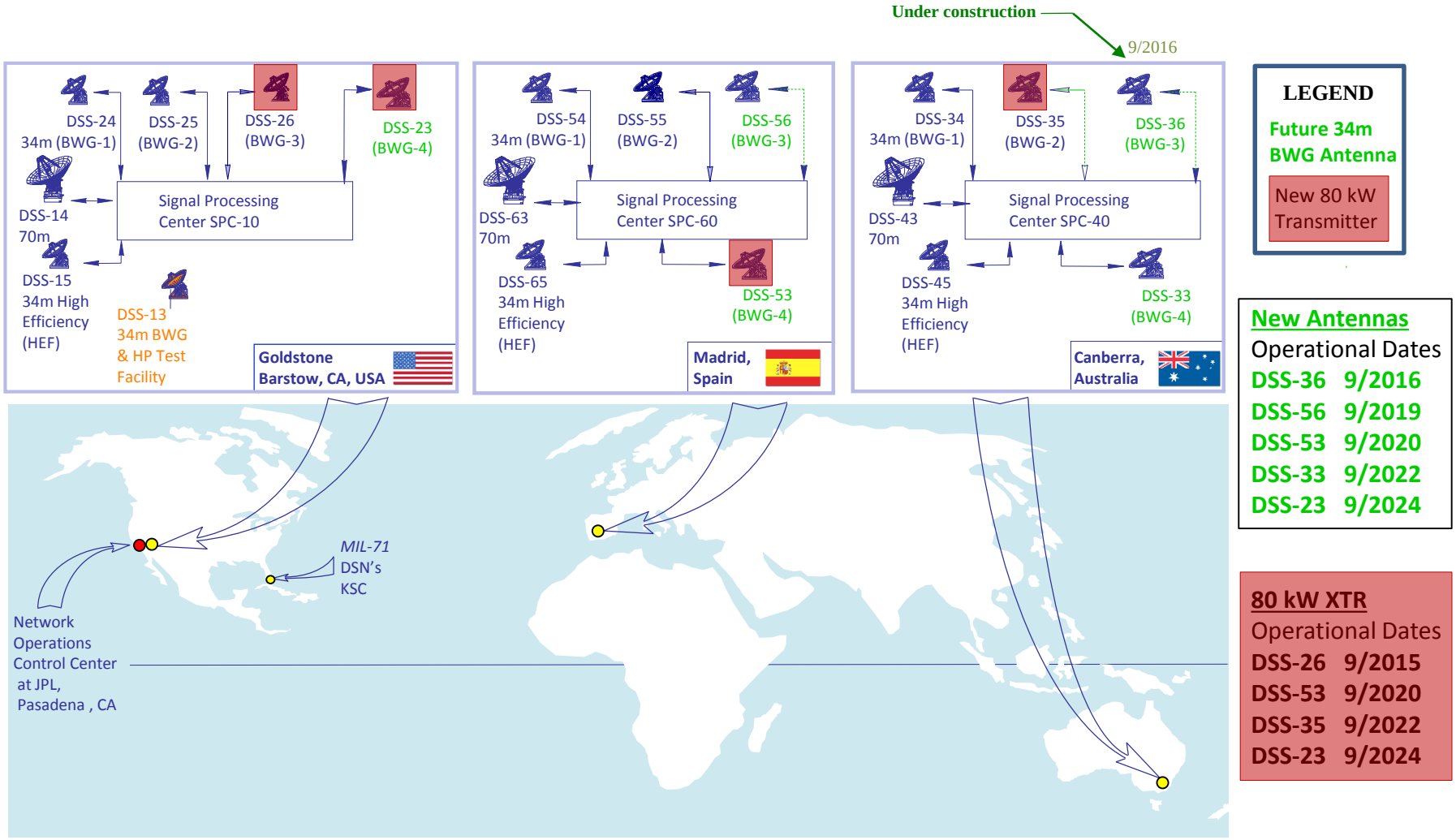
DSN Resources



LEGEND

Future 34m BWG Antenna

New 80 kW Transmitter

New Antennas

Operational Dates

DSS-36 9/2016
DSS-56 9/2019
DSS-53 9/2020
DSS-33 9/2022
DSS-23 9/2024

80 kW XTR

Operational Dates

DSS-26 9/2015
DSS-53 9/2020
DSS-35 9/2022
DSS-23 9/2024

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What the DSN Provides

As described in the DSN Services Catalog (820-100), the DSN provides:

- Engineering Support
  - System Engineering
  - Advanced Mission Planning
  - Emergency Mission Operations Center
  - RF Compatibility Test
  - Mission System Test
  - Spectrum and Frequency Management
  - Spacecraft Search
- Data services for Space Communication and Navigation
  - Standard
  - Custom

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Characteristics of DSN Standard Data Services

- "Pick & Choose”
  - DSN standard data services are independent of each other
- "Plug & Play”
  - DSN standard data services are multi-mission in nature and generally require table adaptations
  - No development is required on the part of the DSN beyond configuration, parameter updates, mission service validations and interface testing
  - Development on the customer’s side is limited to using the standard service and meeting its interfaces
- Standard Interfaces
  - DSN-provided data services are accessed via well-defined, standard data and control interfaces
    - the Consultative Committee for Space Data Systems (CCSDS),
    - the Space Frequency Coordination Group (SFCG),
    - the International Telecommunication Union (ITU),
    - the International Organization for Standardization (ISO),
    - de facto standards widely applied within industry,
    - and common interfaces specified by the DSN
  - Data service interface standards enable interoperability with similar services from other providers
  - Mitigates the need for additional development effort on the part of both the DSN and the customer
  - Maximizes the customer's opportunities to reuse

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Standard Data Services

- **Command Services**
  - Radiation
  - Delivery
- **Telemetry Services**
  - Frame
  - Packet
  - Telemetry File
  - Relay Service
  - Beacon Tone
- **Tracking Services**
  - Validated Radio Metric Data
  - Delta-DOR (Differential 1-way ranging)
- **Calibration and Modeling Services**
  - Platform Calibration
  - Media Calibration
- **Radio Science Services**
  - Experiment Access
  - Data Acquisition
- **Radio Astronomy / Very Long Baseline Interferometry (VLBI) Services**
  - Signal Capturing
  - VLBI Data Acquisition
  - VLBI Data Correlation
- **Radar Science Services**
  - Experiment Access
  - Data Acquisition
- **Service Management**
  - Allocation and scheduling of assets
  - Configuring, monitoring, and controlling the DSN asset
  - Reporting service execution results

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Custom Data and Support Services

- While the DSN encourages use of standard services, some customers require better performance than that provided by the standard data services

- “Tailored" services can be provided when the standard services must be heavily customized in order to meet the customer's operations needs, or when the nature of the customer’s endeavor requires functions that are not supported by the standard services

- Missions pay for the additional cost for custom/tailored services. All non-standard service requests and costs are negotiated with the DSN on a case-by-case basis and documented in the Service Agreement.

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Scheduling DSN Resources

- The user community schedules the DSN tracking assets
- Tracking hours are limited by practical limits of total user demand and internal engineering and maintenance
- The DSN and the deep space user community work to produce conflict-free schedules several weeks out
  - Advance DSN conflict-free schedules are important because deep space missions operate primarily under sequence control (i.e., in response to a highly accurate model of predicted events)
  - Late changes to the schedule are disruptive (and costly) to the user community in part because the schedule is typically packed very tightly
  - Demand scheduling of the DSN, in response to probabilistic or ad hoc mission events, is not within the DSN operational concept
- In addition to supporting the tracking of spacecraft, the DSN also serves the Radio Astronomy, Radio Science, and Space Radar communities with special products unique to those disciplines
  - These activities are also in competition with the limited DSN resources being requested for spacecraft tracking supports

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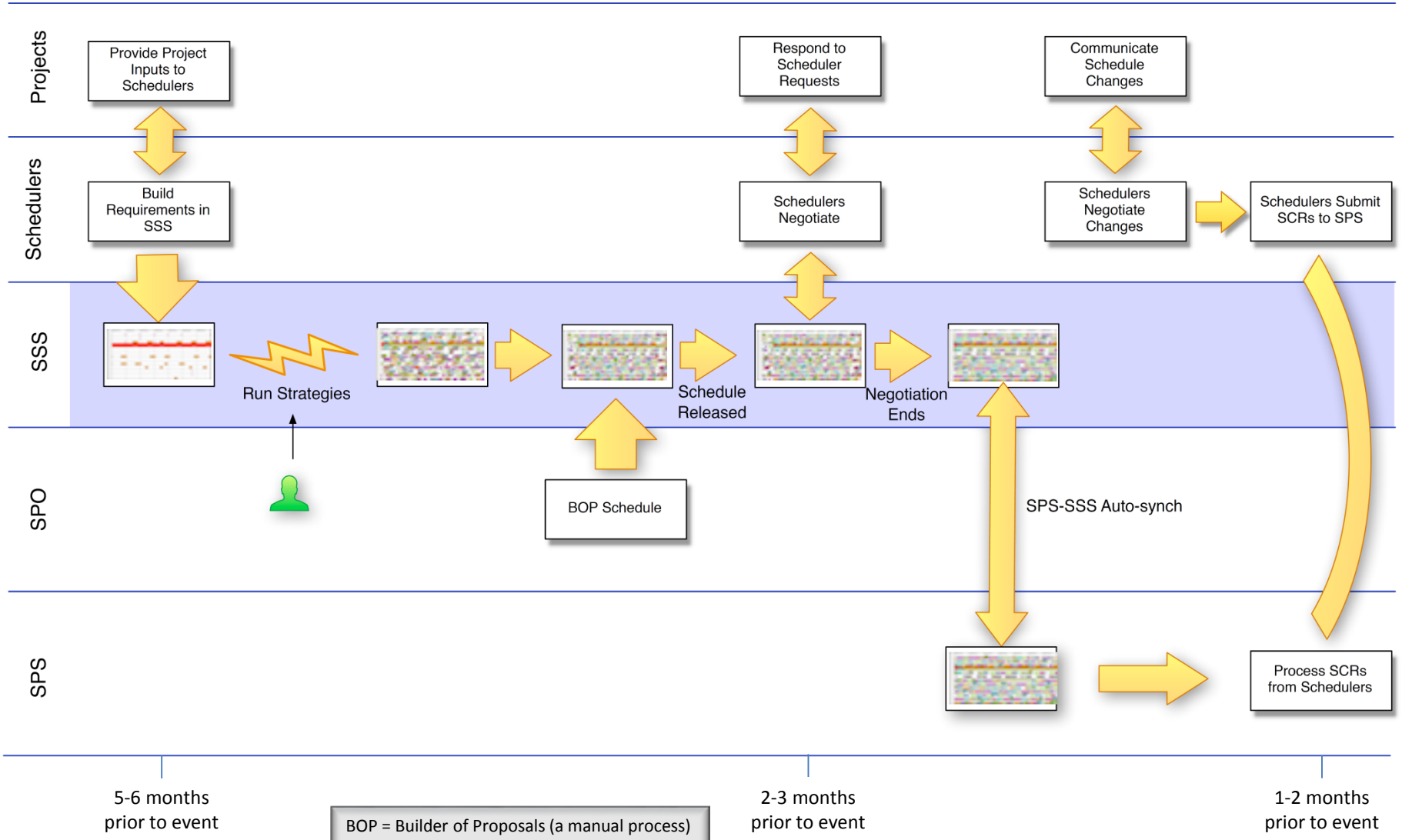
High-Level DSN Schedule Process



BOP = Builder of Proposals (a manual process)
SPO = Scheduling Process Office
SPS = Service Preparation Subsystem (portal)
SSS = Service Scheduling Software

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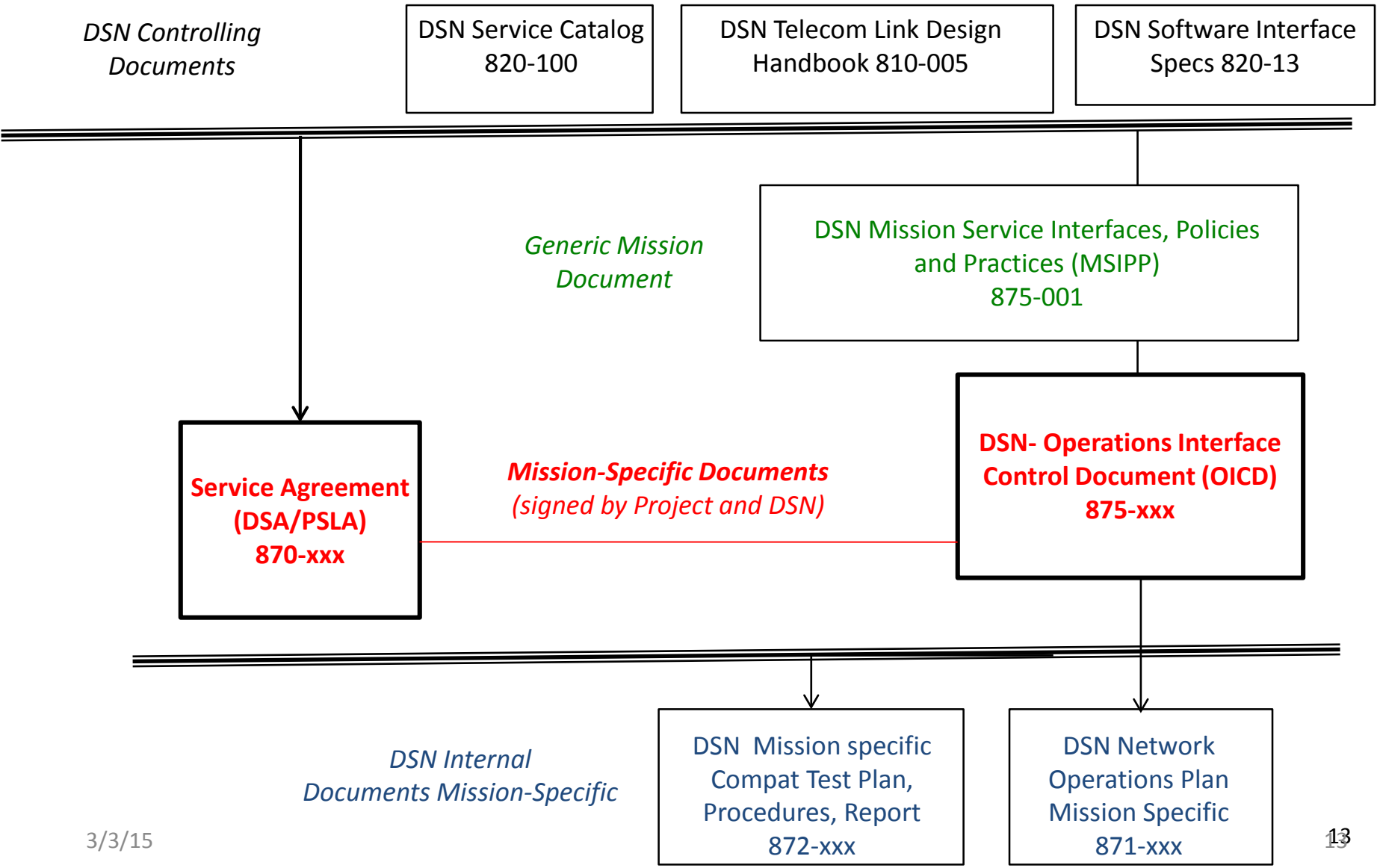
DSN Mission Interface Document Tree



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DSN-Mission Commitment Documentation

The MIM and the Mission work together to create the following:

- **DSN Service Agreement** (870 series)
  - High-level statement of standard services, cost, support duration
  - Defines custom services and cost (if any)
  - Final for MOS CDR
- **Operational Interface Control Document** (875 series)
  - Parameter values to instantiate and operate
  - Uses info typically found in Mission documents:
    - Mission Plan
    - Navigation Plan
    - Mission Ops Scenario
    - Radio Frequency Interface Control Document (RFICD)
      - Including telecommunication parameters and link budget information
  - Preliminary ready for Mission Critical Design Review (CDR)
  - Final ready for Operational Readiness Review (ORR)

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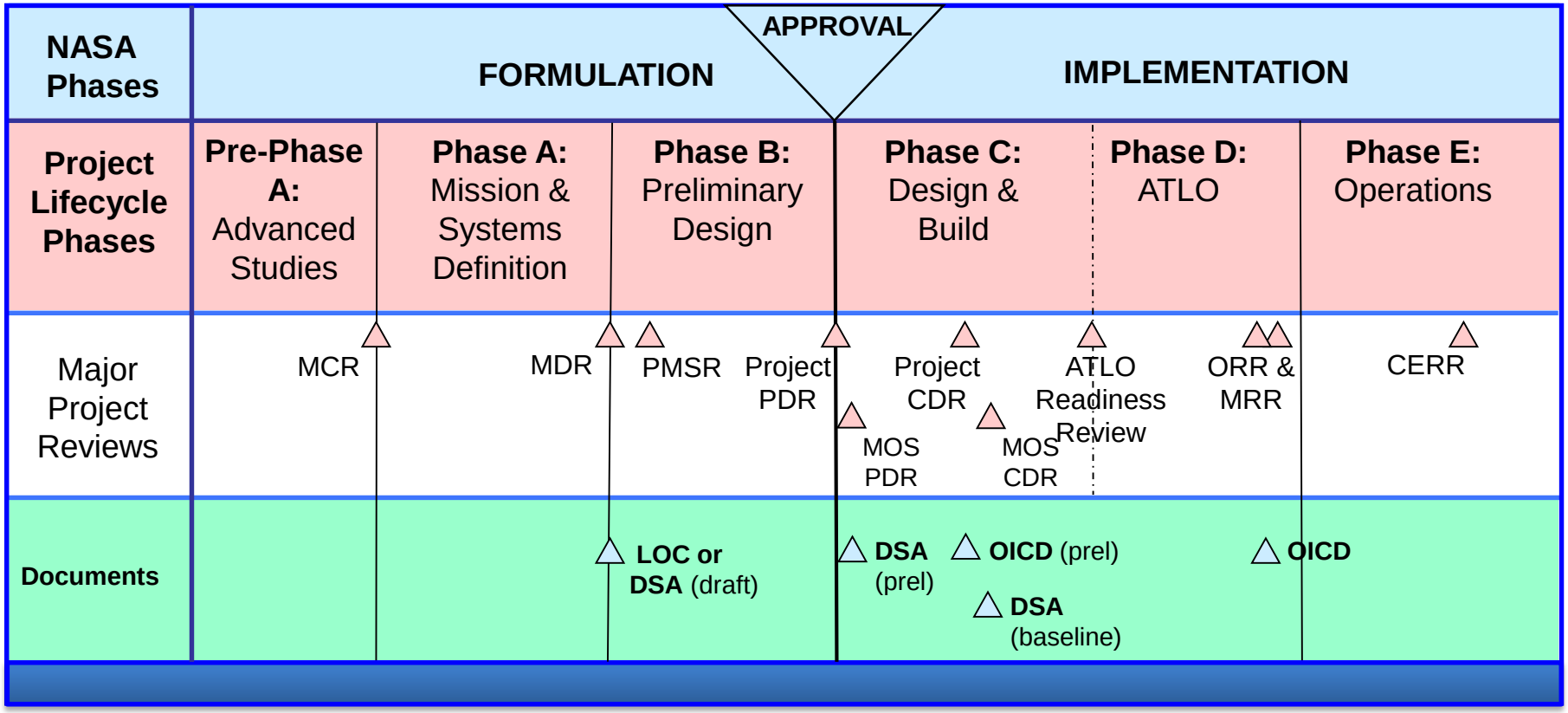
Project Lifecycle



Legend

ATLO: Assembly, Test, Launch, and Operations
CERR: Critical Events Readiness Review
CDR: Critical Design Review
DSA: DSN Service Agreement
LOC: Letter of Commitment (competed missions only)
MCR: Mission Concept Review (assigned missions only)
MDR: Mission Definition Review (assigned missions only)
MRR: Mission Readiness Review
OICD: DSN Mission Operations Interface Control Document
ORR: Operations Readiness Review
PDR: Preliminary Design Review
PMSR: Project Mission System Review (competed missions only)

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Radio Frequency Compatibility Testing

- The DSN requires pre-launch RF compatibility testing as a means to eliminate post-launch anomalies and expensive troubleshooting
  - Testing validates the spacecraft radio frequency subsystem and its telecommunications capabilities as they interact with DSN RF and data systems
  - Missions may opt to conduct end-to-end telemetry and command data flow tests following the successful completion of RF Compat tests

- RF Compatibility Testing Schedule
  - RF compatibility testing should be planned for ~1 year prior to launch, but may take place no later than 6 months prior to launch

- Additional Validation Info
  - See **DSN Mission Service Interfaces, Polices, and Practices (MSIPP)** (875-0001) for additional detail on RF Compatibility tests, as well as other validation tests to be performed with the DSN

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DSN Costs

DSN Aperture Fee: The Aperture Fee is used for full cost accounting purposes and is not an expense to a NASA mission. It is based on the specific antenna(s) used, and the number and duration of tracking passes. The aperture fee accounts for the following standard data services and engineering support:

Data Services

- Command Services
- Telemetry Services
- Tracking Services
- Calibration and Modeling Services
- Radio Science Services
- Radio Astronomy & VLBI Services
- Radar Science Services
- Initial Acquisition Provision

Engineering Support

- Systems engineering
- Advance mission planning
- Emergency mission operations center
- Mission system test
- Spectrum and frequency management
- Spacecraft search

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DSN Costs (cont.)

Additional Fees - The following services are charged to all NASA missions according to usage:

- **First Use**: The costs for development of enhancements and new capabilities that extend beyond the DSN Project baseline budget and scope are charged to the requiring mission.
- **Telemetry Tracking & Command (TTC) Mission-Specific Services**: Engineering costs for adapting and validating TTC data delivery systems for an individual mission are charged to that mission. All missions will require some TTC adaptation.
- **DSN Operations**: Costs for the operations of DSN capabilities not included in the aperture fee are funded by the using mission.
- **Special/ Unique Requirements**: Unique requirements requiring "one of a kind" capabilities are funded by the requiring mission.
- **Ground Communications**: Ground communication installation and sustaining costs (circuits, routers, voice) for mission extensions to off-site (non-JPL) locations are charged to the mission.
- **Radio Frequency (RF) Compatibility Testing:** Costs for RF compatibility testing using Development Test Facility (DTF-21), Compatibility Test Trailer (CTT-22) and MIL-71 test facility at Kennedy Space Center are not currently charged to the using mission. This is under review by NASA and may change.

Non-NASA Missions - In the case of collaborative international missions, NASA funds all mission costs for multimission services. In the case of reimbursable missions, the requesting mission funds all costs for multimission services, including properly costed DSN custom services.

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First Steps Towards DSN Support

- Task Plan
  - Funds must be transferred to the DSN to complete mission-specific work in preparation for support. This is accomplished using a task plan that is signed by NASA, the DSN, and the mission's agency (if not NASA).
  - For non-NASA missions, the task plan cannot be completed until there is a valid Space Act Agreement (SAA) in place.
  - The DSN is responsible for creating the task plan. The MIM works with the Mission to define the scope of work, and then works with the DSN to estimate costs. With this information, the task plan is then written.
  - Due to the contractual nature of the document, it takes an average of 6-8 weeks to write the task plan, get it signed, and have the funds transferred.

- Spectrum Management
  - For non-federal agency missions, the FCC regulates the use of radio frequencies using a spectrum management process called frequency allocation. It is the mission's responsibility to obtain the frequency allocation from the FCC.
  - For federal agencies, JPL's Spectrum Management office will secure the frequency authorization.
  - In addition, each DSN station supporting a mission must have an uplink transmission license. The DSN is responsible for obtaining station transmission licenses.

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Key Personnel

- **Mission Interface Manager (MIM)**
  - the mission's agent to optimize DSN technical support
- **Project Data System Engineer (PDSE)**
  - DSN processing lead for data delivery
- **Network Operations Project Engineer (NOPE)**
  - operational lead for DSN support
  - supported by team of operators, analysts (NOA), engineers (CDE, OE)
- **Mission Manager**
  - interacts with DSN to prepare and execute telecomm
- **Scheduler**
  - the mission's agent to plan and negotiate DSN tracking schedule

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DSN Mission Interface Management

- DSN Mission Support Definition and Commitments Office (9021) functions as the service provider gateway for all projects
  - DSN Mission Interface Manager (MIM) is responsible for interfacing with the customers from pre-project planning through design, development, testing, flight operations, and closeout

Mission Interface Manager Contact Info:

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Important References

- **DSN Commitments Office Website**
  - http://deepspace.jpl.nasa.gov/advmiss/index.html
- **DSN Mission Service Interfaces, Polices, and Practices (MSIPP)** (875-0001)
  - http://deepspace.jpl.nasa.gov/advmiss/proposal preparation/#
- **DSN Services Catalog** (820-100)
  - http://deepspace.jpl.nasa.gov/advmiss/proposalpreparation/#
- **DSN Telecommunications Link Design Handbook** (810-005)
  - http://deepspace.jpl.nasa.gov/dsndocs/810-005/index.cfm
- **DSN External Interface Specification** (820-013)
  - https://jaguar.jpl.nasa.gov/

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BACKUP

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DSN Station Capabilities

DSS No.	Antenna Type	Location	Agency / Ops Org	S-Band Uplink Frequency (MHz)	S-Band Downlink Frequency (MHz)	X-Band Uplink Frequency (MHz)	X-Band Downlink Frequency (MHz)	Ka-Band Downlink Frequency (MHz)
14	70m	Goldstone, California	NASA/DSN	2110 - 2118	2270 - 2300	7145 - 7190	8400 - 8500	-
15	34HEF	Goldstone, California	NASA/DSN	2025 – 2120	2200 - 2300	7145 - 7190	8400 - 8500	-
24	34B1	Goldstone, California	NASA/DSN	2025-2120	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000
25	34B2	Goldstone, California	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
26	34B3	Goldstone, California	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
34	34B1	Canberra, Australia	NASA/DSN	2025-2120	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000, 31800 - 32300
35 (Oct 2014)	34B2	Canberra, Australia	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
36 (Oct 2016)	34B3	Canberra, Australia	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
43	70M	Canberra, Australia	NASA/DSN	2110 - 2120	2270 - 2300	7145 - 7190	8400 - 8500	-
45	34HEF	Canberra, Australia	NASA/DSN	2025-2110	2200 - 2300	7145 - 7190	8400 - 8500	-
54	34B1	Madrid, Spain	NASA/DSN	2025 - 2110 2110 - 2120*	2200 - 2300	7145 - 7190, 7190 - 7235	8400 - 8500	25500 - 27000, 31800 - 32300
55	34B2	Madrid, Spain	NASA/DSN	-	-	7145 - 7190, 7190 - 7235	8400 - 8500	31800 - 32300
63	70m	Madrid, Spain	NASA/DSN	2110-2118*	2270 - 2300	7145 - 7190	8400 - 8500	-
65	34HEF	Madrid, Spain	NASA/DSN	2025 - 2110	2200 - 2300	7145 - 7190	8400 - 8500	-