National Aeronautics and Space Administration

Keeping the universe connected.

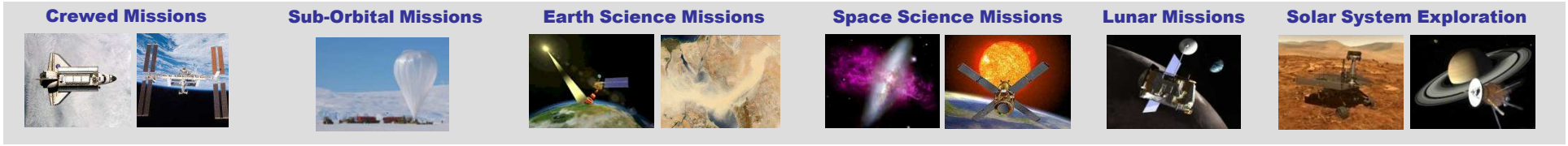
Space Communications and Navigation Overview for Discovery Announcement of Opportunity

Jon Z. Walker, SCaN
Network Services Operations Manager

July 1, 2010

www.nasa.gov

SCaN Networks



- ***DSN***
- ***NEN/NASA***
- ***NEN/Commercial***
- ***NEN/Partner***
- ***SN***

Alaska Satellite Facility
Fairbanks, Alaska

Partner Station:
Gilmore Creek, Alaska

USN Alaska
Poker Flat & North Pole, Alaska

Madrid Complex
Madrid, Spain

Kongsberg Satellite Services (KSAT)
Svalbard, Norway

Swedish Space Corp. (SSC)
Kiruna, Sweden

German Space Agency (DLR)
Weilheim, Germany

Goldstone Complex
Fort Irwin, California

waii
Hawaii

Guam Remote Ground Terminal
Guam, Marianna Islands

USN Australia
Dongara, Australia

Canberra Complex
Canberra, Australia

White Sands Ground Station
White Sands, New Mexico

White Sands Ground Terminals
White Sands, New Mexico

Merritt Island Launch Annex
Merritt Island, Florida

USN Chile
Santiago, Chile

Wallops Ground Station
Wallops, Virginia

McMurdo Ground Station
McMurdo Base, Antarctica

Satellite Applications Center
Hartebeesthoek, Africa

NASA Telecommunications Policy

- NASA is planning on transitioning to Ka-band in the future due to congestion in other bands
- SMD decision to do so starting with missions launching in 2015
- Thus the AO specifies the use of Ka-band for science telemetry, unless the bandwidth used for science data downlink conforms to SFCG Recommendation 23-1 (<12 MHz bandwidth in deep space, <8 MHz at Mars)
- In preparation for the retirement of the 70m dishes, SMD has decided on a single 34m policy (see AO for details)
- NASA Policy Directive 8074.1, Management and Utilization of NASA's Space Communication and Navigation Infrastructure, states NASA Mission Directorates shall:
  - Use SCaN networks to meet their communication and navigation requirements for human and robotic space missions
  - Where appropriate and cost-effective for the Agency, MDs, in coordination with the SCaN Program Office, may use pre-existing infrastructure external to NASA for this purpose, as long as no new facilities are constructed using NASA funds
  - Not design or develop space C&N infrastructures independent of SCaN

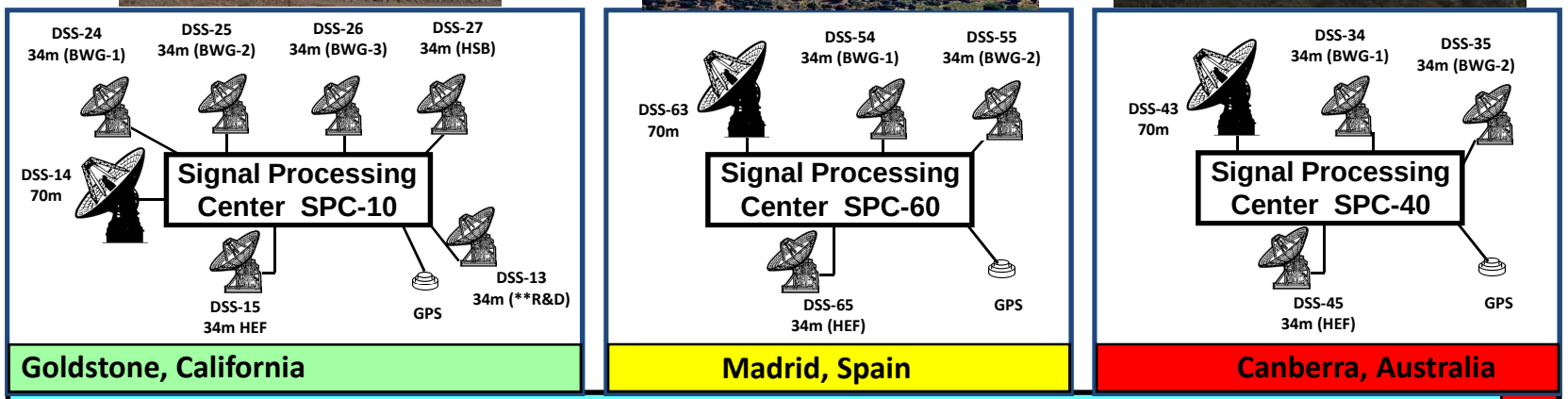
Deep Space Network (DSN)

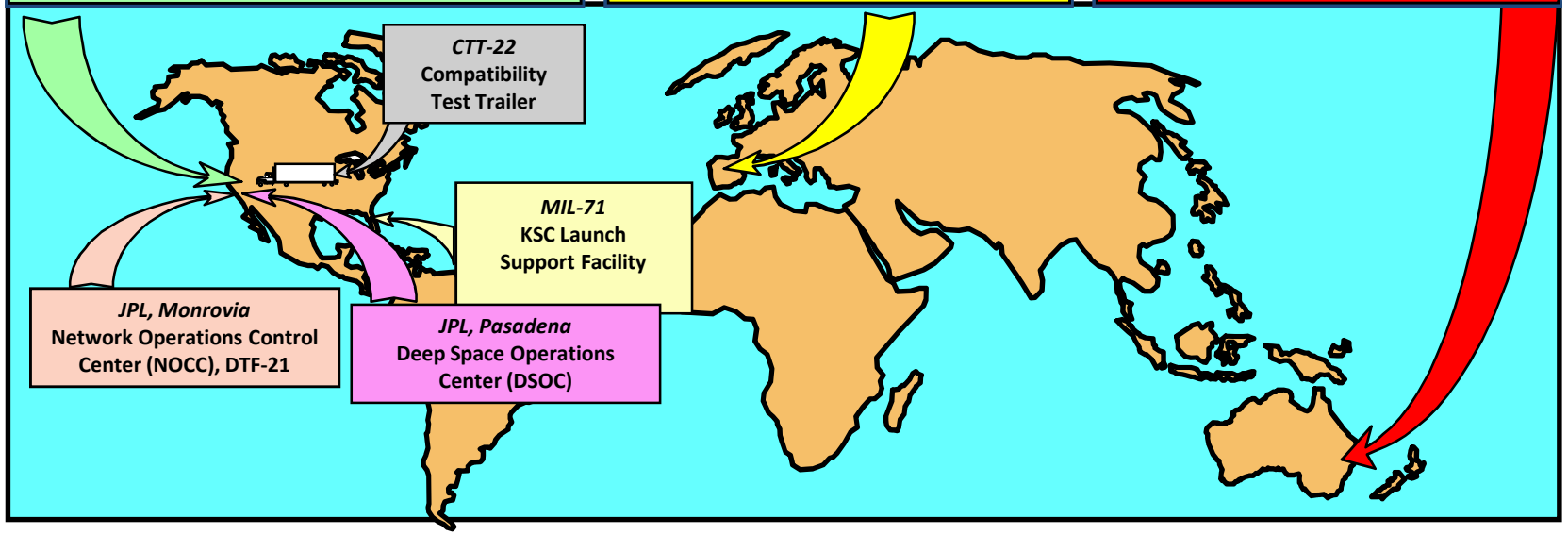
Madrid Deep Space Communications Complex
Operated by INSA

Canberra Deep Space Communications Complex
Operated by CSIRO

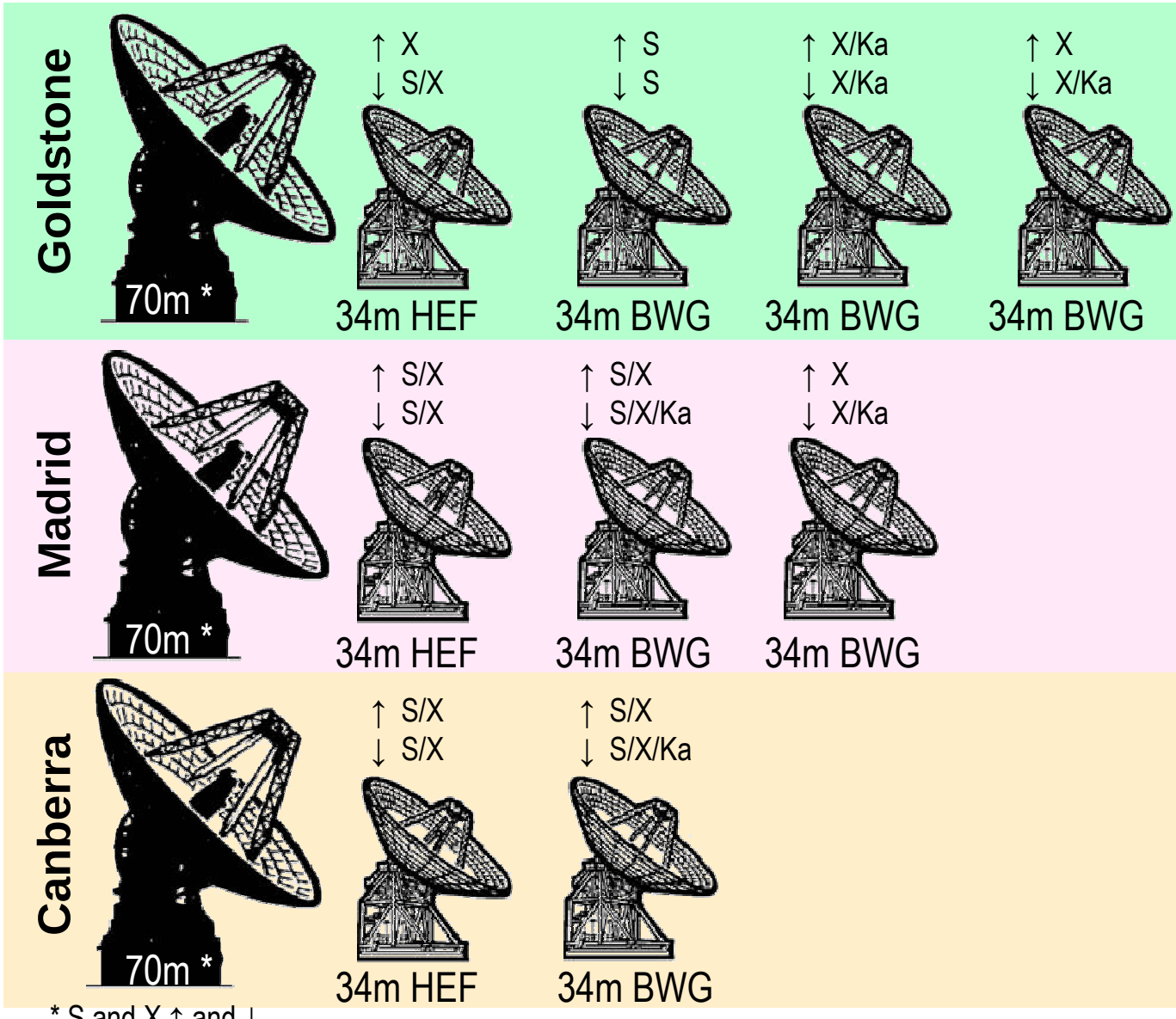
Goldstone Deep Space Communications Complex
Operated by ITT

Deep Space Network Facilities





DSN Configuration: Today



* S and X ↑ and ↓

Functions Performed By The DSN

- Spacecraft Telemetry (Downlink)
  - Collecting the data transmitted by a spacecraft
    - Images
    - Other science data
    - Spacecraft health information
  - Supports Near Earth and Deep Space S-, X-, and Ka-bands
  - Data rates from 10 bps to 6 Mbps (deep space) or 125 Mbps (near Earth)
- Spacecraft Commanding (Uplink)
  - Sending sequences of instructions from mission controllers to spacecraft
  - Supports Near Earth and Deep Space S- and X-bands
  - Data rates up to 8 kbps (256 kbps in limited cases)
- Spacecraft Tracking
  - Determining the position and movement of a spacecraft based on Doppler and range measurements
- Using the DSN as a Science Instrument
  - Radio astronomy and Radio Science
  - Radar astronomy

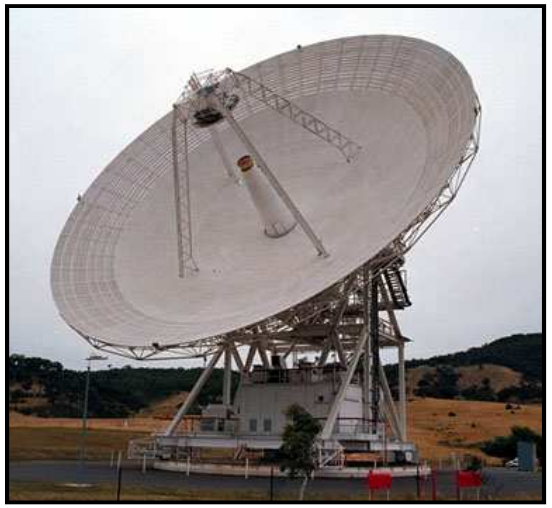
Deep Space Communications Complex (DSCC)

- Each DSCC is made up of:
  - Antenna structural and mechanical systems
    - 1 70-meter antenna
    - Multiple 34-meter antennas
  - Front end area electronics
    - Equipment hard-wired to a particular antenna
    - Microwave components, Receiver, Exciter, Transmitters, etc.
  - A Signal Processing Center (SPC)
    - Equipment switchable to any antenna or globally shared
    - Data processing equipment for Telemetry, Tracking, Command, and Radio Science
    - Central monitor and control for the DSCC
      - Operator consoles
      - Voice communications
      - Video surveillance
    - Communications equipment

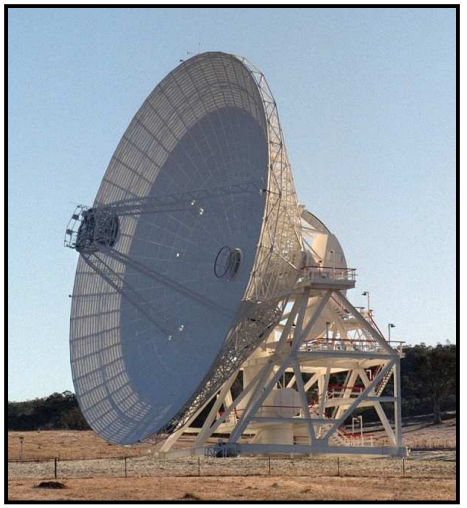
Key Subsystems of the DSN

- Antennas
  - 70-meter Antennas
    - Built in the mid-1960's to early 1970's as 64-meter antennas
    - Expanded to 70-meters in 1980's
  - 34-meter High Efficiency (HEF)
    - Built in mid 1980's
    - First DSN antennas supporting X-band uplink
  - 34-meter Beam Waveguide (BWG)
    - Built in the mid-1990's
    - Utilizes beam waveguide to remove sensitive electronics from the tipping structure

70-meter Antenna



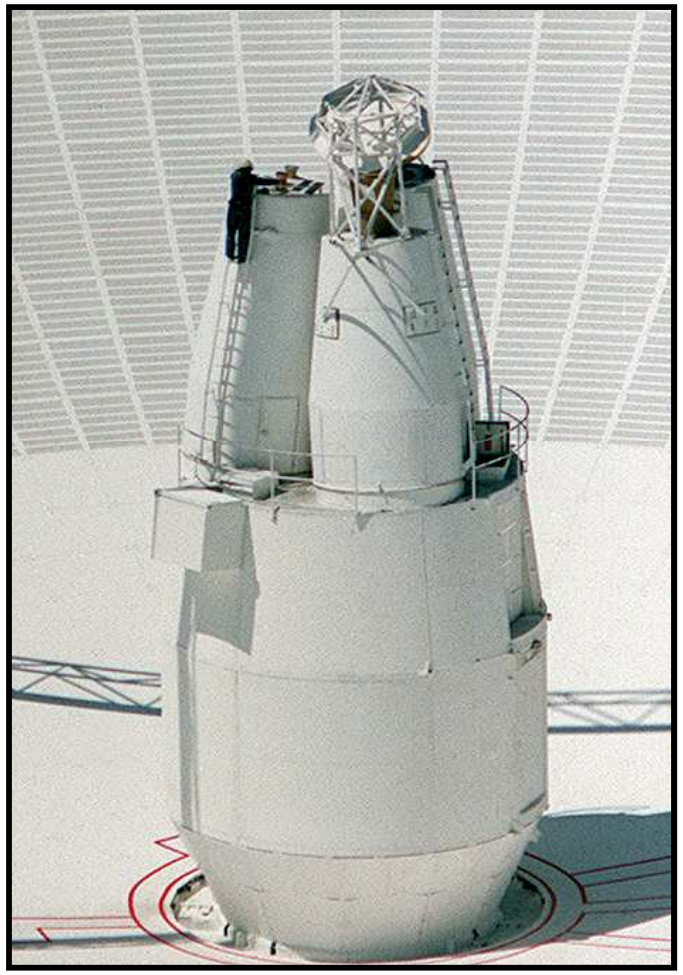
34-meter HEF Antenna



34-meter BWG Antenna

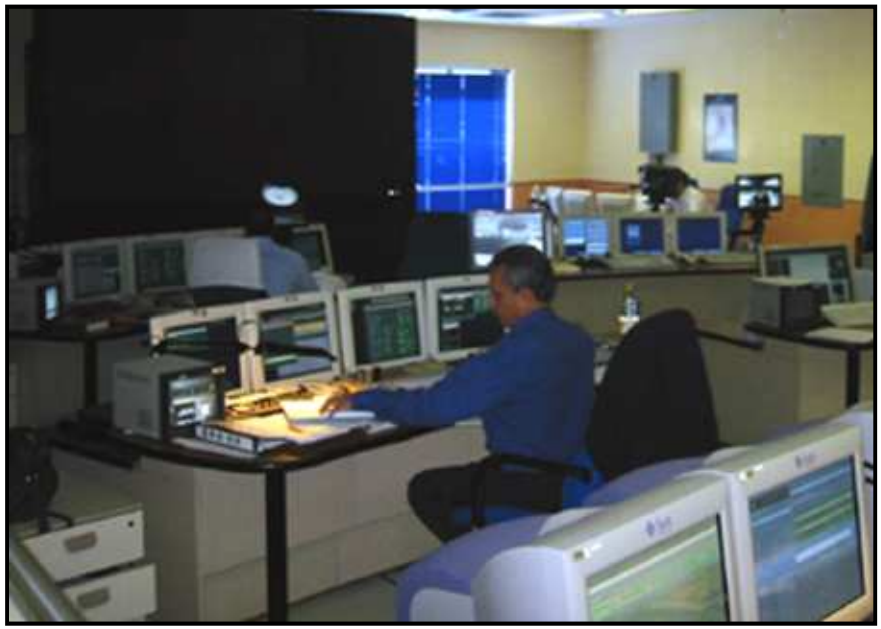
Key Subsystems of the DSN

- Front-end Electronics
  - Microwave systems
    - Specially design feed horns and wave guides
    - Support multiple frequencies
      - S-band (~2GHz)
      - X-Band (~8GHz)
      - Ka-band (~32/26GHz)
  - Low Noise Amplifiers
    - Cryogenically cooled devices operating around 6-12 K
  - Transmitters
    - High Power Transmitters for both S- and X-bands
    - Radar Transmitters for radar astronomy



Key Subsystems of the DSN

- Data Processing Subsystems
  - Receivers
    - Downconversion
    - Carrier and sub-carrier detection
  - Telemetry Processing
    - Decoding
    - Formatting
  - Radiometric Processing
    - Doppler measurement
    - Ranging
  - Command Processing
    - Formatting
    - Modulation
  - Monitor and Control
    - Operator interfaces
    - Monitoring system performance
  - Communications
    - Voice and Data
      - Between JPL and DSCC
      - Between JPL and Mission Operation Control Centers



Network Operations

- Network operations in the Pasadena area provides centralized control and coordination of DSN activities around the world
  - Network Operations Control Center at JPL
    - Real-time monitoring of DSN activities 24/7
    - Coordination of activities between the DSCC's
  - DSN Operations & Maintenance at contractor facility in Monrovia, CA
    - Operations planning and scheduling
    - Support product generation
    - Engineering support functions
      - Configuration management
      - Documentation
      - Logistics
    - Remote Operations Center

Operations Phases & Functions

Phases	Service Planning	Service Preparation	Pre-Track	Track	Post-Track	Performance Assessment
	Years to 7-weeks	7-weeks to Track	30 min	Hour(s)	15 min	Day(s) to Months

- Service Planning
  - Developing the support level agreements with missions, technical issues of using the DSN, initial mission resource utilization plans, asset allocations, and development of schedules from 8-weeks in the future and out
- Service Preparation
  - Developing near-term (7-weeks out) mission view periods, DSN service schedules, DSN sequence of events, and generating support data products
- Pre-Track
  - Assigning & configuring the subsystem equipment for the services scheduled in a link
- Tracking
  - Executing the services for telemetry, tracking, command or radio science & delivering the service data to the mission customer
- Post-Track
  - Removing a link or service that is no longer needed for support
- Performance Assessment
  - Post track data analysis to determine the quality of the services provided

DSN 70m Antenna Replacement Approach

New Antennas - 70M Replacement

- Deploy two 34m Beam Waveguide (BWG) antennas (DSS-35 & DSS-36) at the Canberra Deep Space Communications Complex
  - The antennas to be operational:
    - DSS-35 10/2014
    - DSS-36 10/2016
  - The design of the antenna and RF electronics are as close as possible to a “build to print” version of the BWG antennas currently in the DSN. (e.g. DSS-55)
  - The initially installed RF package will be the X/X/Ka system currently installed in the DSN BWG antennas
    - This includes X band uplink and downlink and Ka (32 GHZ) downlink
  - Implementation of an 80 kW feed capability at DSS-35
- Develop and Deploy an 80 kW X-band Uplink capability at one of the BWG antennas at each DSN complex to match the EIRP of the 70m antenna
  - 80 kW Transmitters to be operational at:
    - GDSCC, DSS-25 10/2015
    - CDSCC, DSS-35 10/2016
    - MDSCC, DSS-55 10/2017

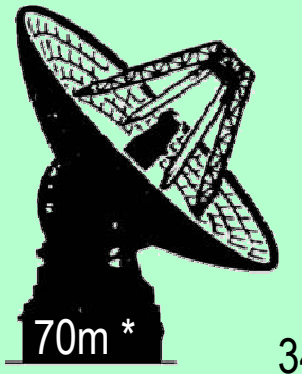
70m Antenna Replacement Plan

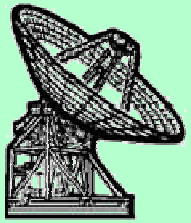
- Plan to add six 34m BWG antennas to the DSN
  - 3 in Canberra, 2 in Madrid, 1 in Goldstone
  - All new BWG antennas will have Ka-band downlink capability

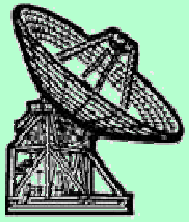
Location/DSS	Operational Date
Canberra	
– DSS-35	CY-14
– DSS-36	CY-16
– DSS-33	CY-18
Madrid	
– DSS-56	CY-20
– DSS-53	CY-22
Goldstone	
– DSS-23	CY-24

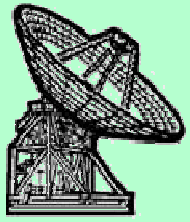
DSN Configuration: Today

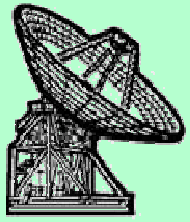
Goldstone



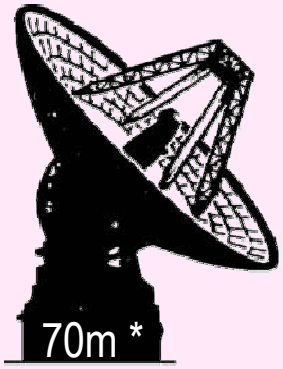

↑ X
↓ S/X
34m HEF

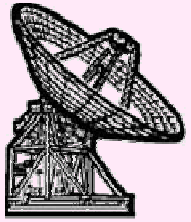

↑ S
↓ S
34m BWG

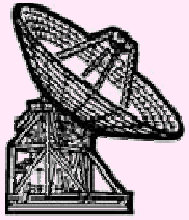

↑ X/Ka
↓ X/Ka
34m BWG

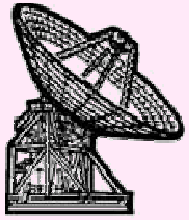

↑ X
↓ X/Ka
34m BWG

Madrid

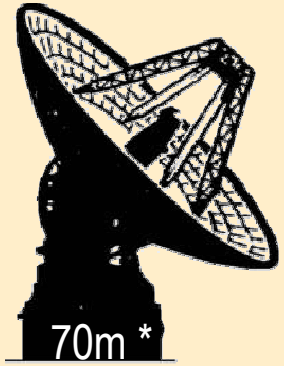


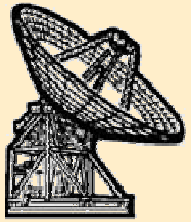

↑ S/X
↓ S/X
34m HEF

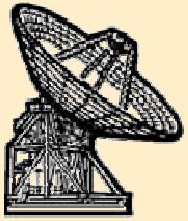

↑ S/X
↓ S/X/Ka
34m BWG


↑ X
↓ X/Ka
34m BWG

Canberra



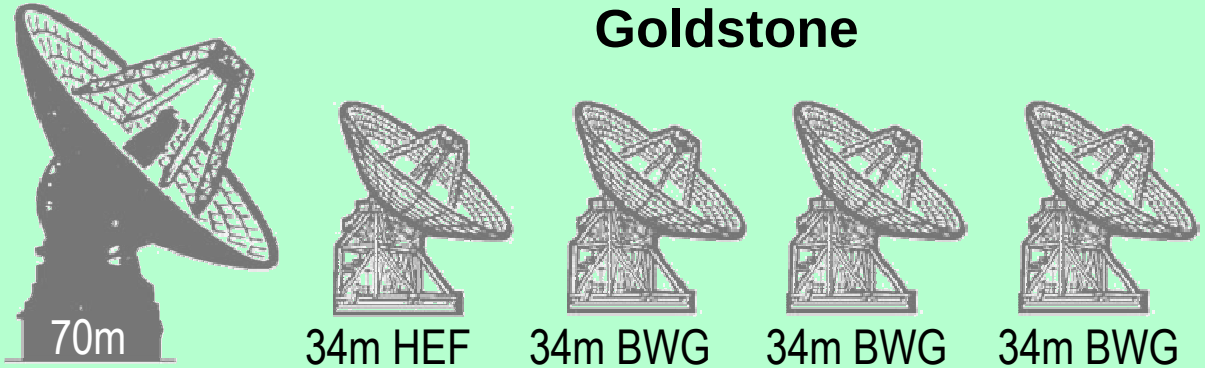

↑ S/X
↓ S/X
34m HEF


↑ S/X
↓ S/X/Ka
34m BWG

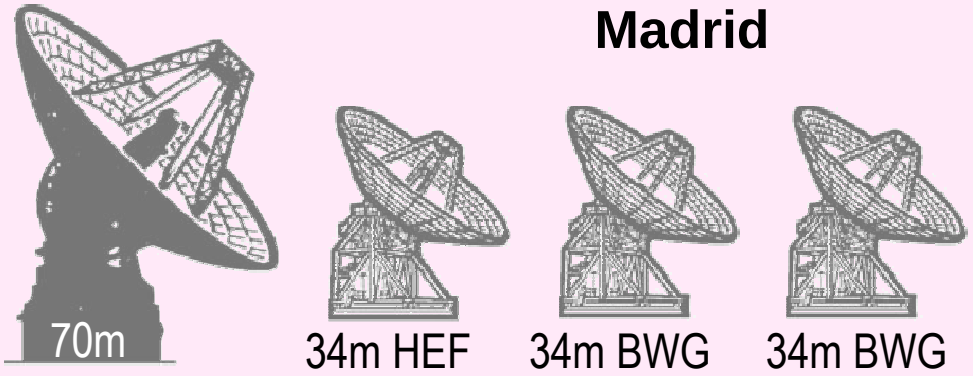
* S and X ↑ and ↓

DSN Configuration: 2016

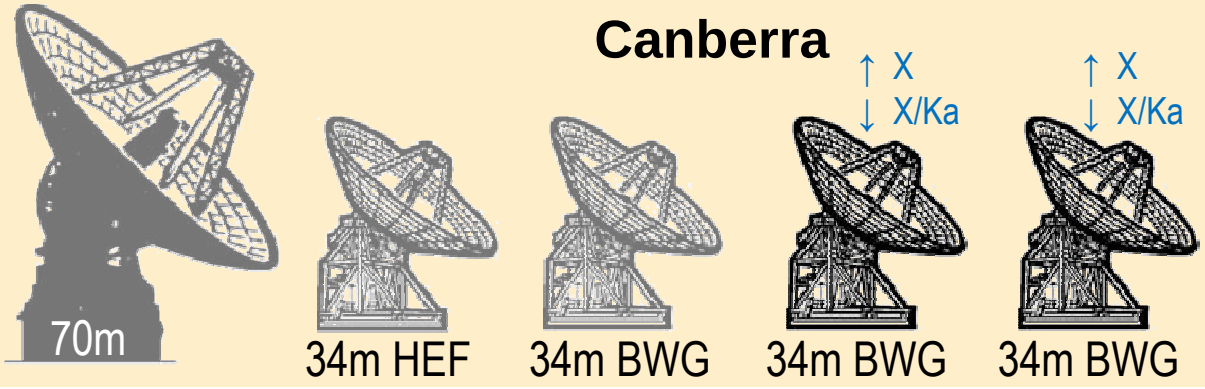
Goldstone



Madrid

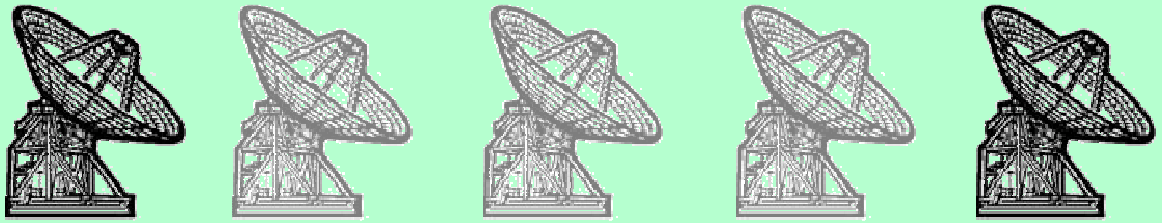


Canberra

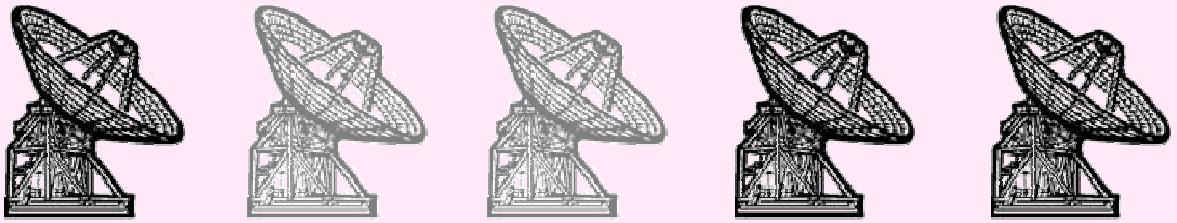


DSN Configuration: 2025

Goldstone



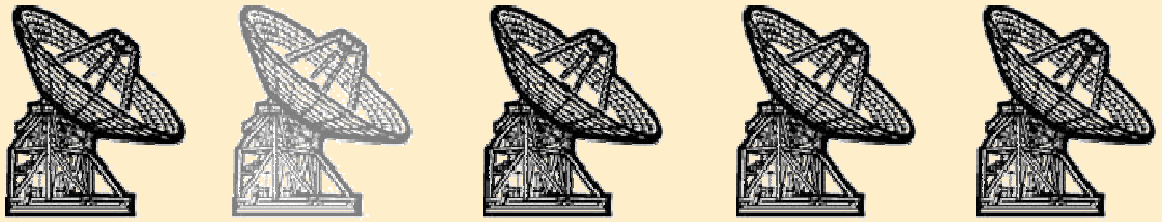
Madrid



All systems to be upgraded to have:
↑ X
↓ X/Ka

S-band will be retained for legacy missions

Canberra



Contacts

- Contacts for questions
  - Margaret Caulfield (NASA HQ, SCaN Program Office)
    - SCaN Mission Commitment Manager
    - 202-358-3971
    - margaret.i.caulfield@nasa.gov
  - Stefan Waldherr (DSN)
    - DSN Commitments Engineer
    - 818-354-3416
    - stefan.waldherr@jpl.nasa.gov
  - Scott A. Greatorex (NEN, SN)
    - Chief, Networks Integration Management Office
    - 301-286-8422
    - scott.a.greatorex@nasa.gov