Deep Space Network Spectrum Management Issues

Presentation to the NRC Committee on Radio Frequencies [CORF]

May 14, 2003

by

Dr. Barry Geldzahler

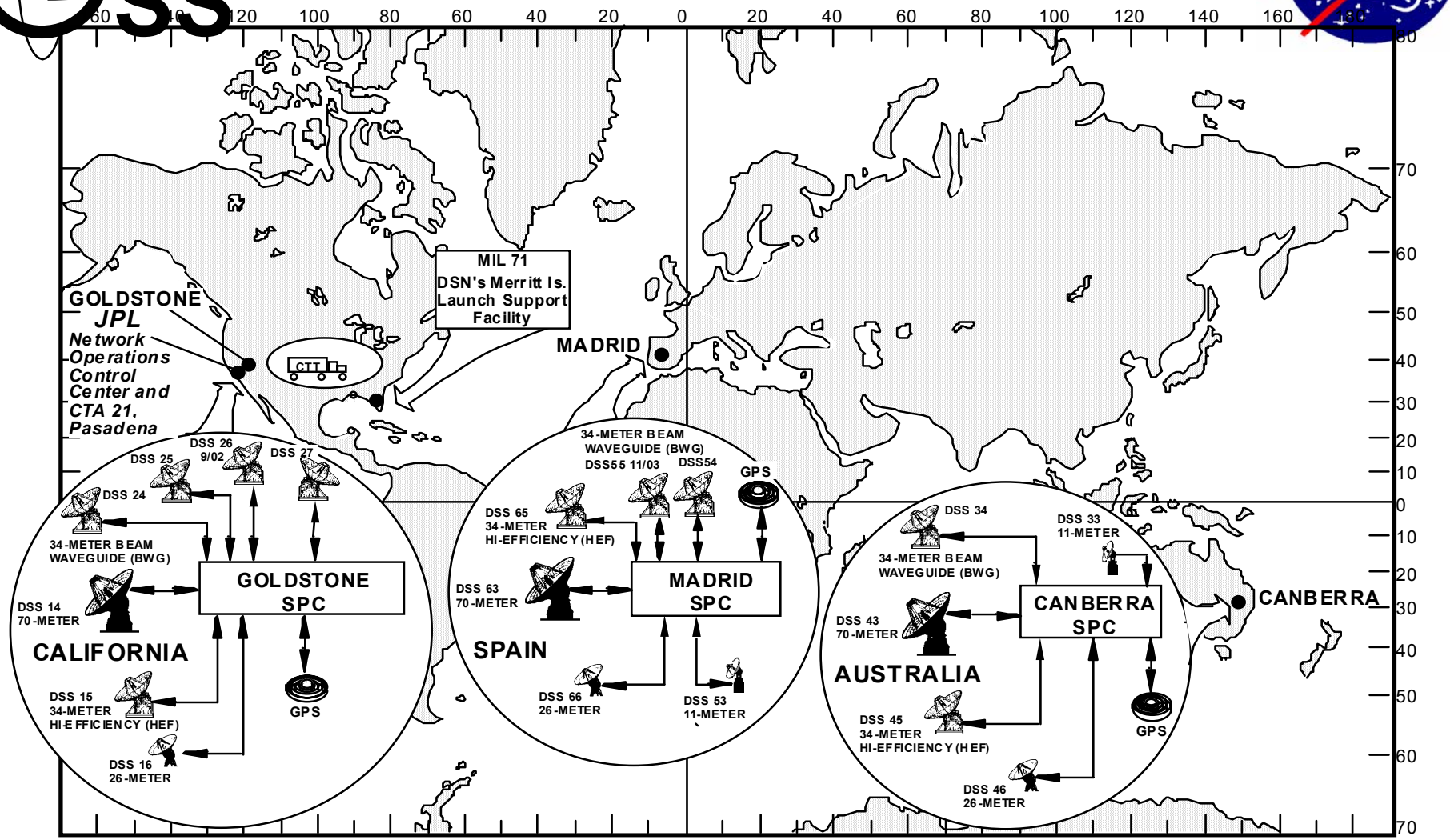
NASA HQ

Program Executive for Space Operations

202-358-0512

barry.geldzahler@nasa.gov

DSN Facilities



High Level Spectrum Concerns

- The Army National Training Center expansion at Fort Irwin for large-scale desert training.
  - The Army has purchased more than 100,000 acres south/South West of Goldstone.
  - This area is directly in the direction where our antennas track spacecraft.
  - Army is planning to use several thousand troops, several hundred vehicle and many airplanes and helicopters in that area all with state of the art communication gears.
  - With thousands of emitters, there is a significant potential for interference to Goldstone antennas.
- The interference of X-band EESS missions with X-band deep space missions. EESS missions use the 8025-8400 MHz band and usually are very wide band (several hundred MHz). The out of band emissions of EESS missions can fall within the 8400-8450 MHz band of deep space missions.
  - We need to have a NASA policy directing all NASA EESS missions to filter their out of band emissions.
- The third issue is JWST and its options and trade-offs in using X- or Ka-band.
  - This is an example of a bigger issue: what is the proper band for high data rate near-Earth missions operating at L2.

Other Spectrum Issues

- S-Band TDRSS return link (2287.5 MHz center, 6 MHz bandwidth) - Users of this link should implement filter on their satellites to reduce coordination load to project and DSN.
- X-Band uplink (7145-7190 MHz) - Approval of primary status (relative to the Fixed Service) is expected at WRC2003.
- S-Band uplink (2110-2120 MHz) - Restricted by IMT2000 at Madrid.
- X-Band downlink (8400-8450) - Growing congestion. A provisional SFCG guideline advocated moving high rate telemetry of deep space missions to the 32 GHz band. MRO will be the first mission to do so. More stringent guidelines may be needed in the future.
- S-Band downlink (2290-2300 MHz) - Reduced mission requirement.
- 32 GHz downlink - Sharing with HDFS is being studied under ITU-R.
- Mars relay links - SFCG established provisional frequency assignment guidelines (SFCG 22-1).
- Frequency assignment to new deep space missions - SFCG assigned study responsibility to NASA/JPL - SFCG RES 21-1. More bandwidth requirement expected in the future.

Future of the DSN at Radio Frequencies

- Loss of low frequencies [S-band]
- Move to higher frequencies [Ka- band]

Outlook for the DSN- Preparing for an Exciting Future

DRIVERS

- Growth of proximity links and consequent bandwidth demand on "trunk-lines"
- Migration of Space Science Enterprise mission set into deep space
- Mission plan reliance on large aperture ground stations [but this may change]
- Evolution toward more data-intensive instruments and media

NASA missions are getting more ambitious and can return more data than ever before.

Data Rates of Today's Instrumentation Are A Small Fraction of Tomorrow's Deluge

Electromagnetic radiation carries only four kinds of information:

Amplitude

Phase

Frequency

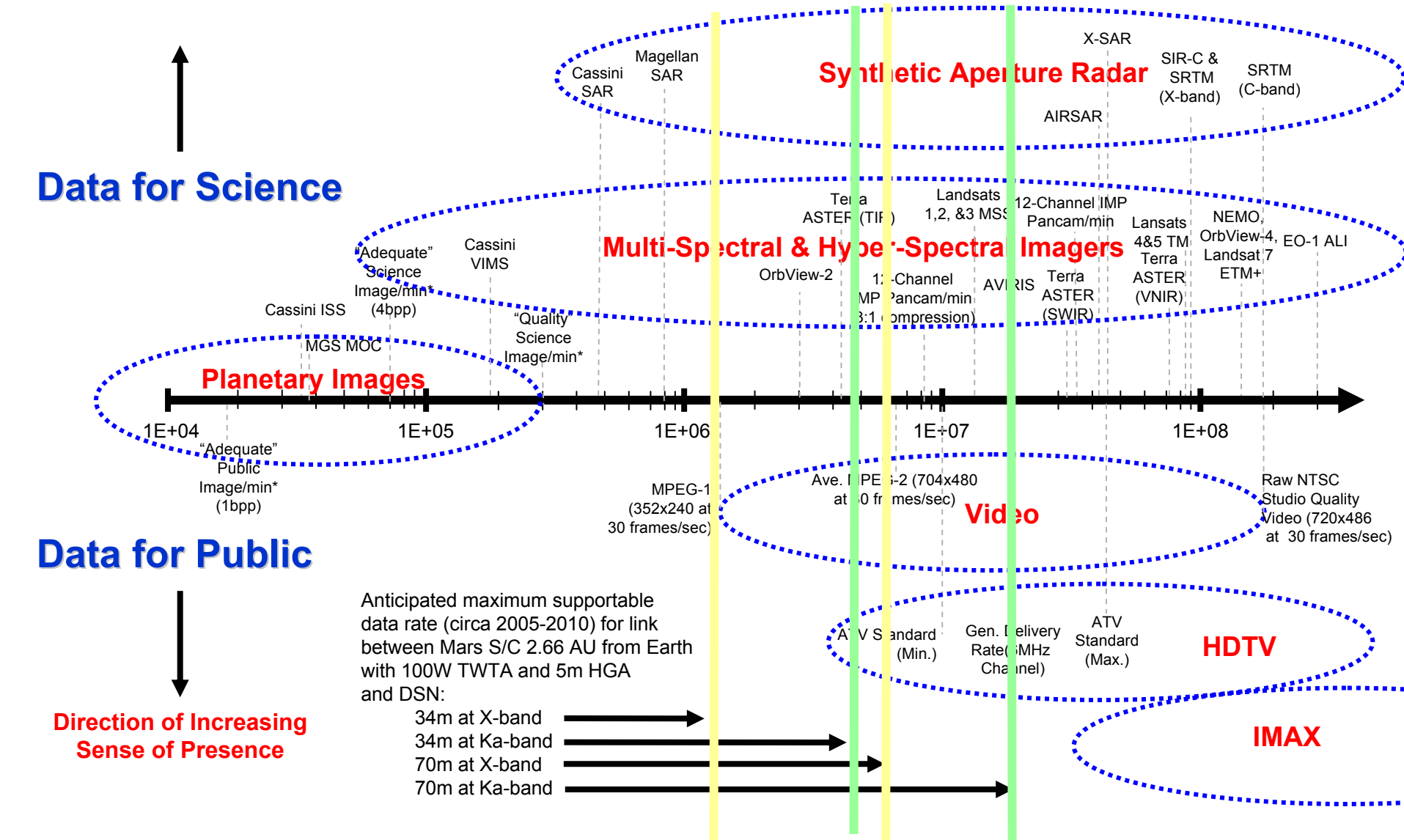
Polarization

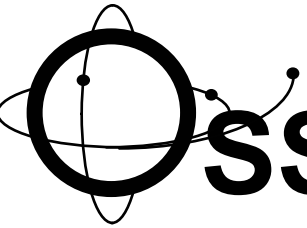
- ***Today's*** planetary studies to data generally tap only amplitude and frequency.
- ***Tomorrow's*** planetary studies will include synthetic aperture radar, interferometry, narrower channel hyperspectral imagers, polarimeters, and ???

Data rates will reach unprecedented heights, and we must begin preparations now to capture that data

Outlook for the current DSN-Requirements

e.g. Maximum Supportable Rates for a Mars Orbiter/Relay Circa 2005-2010





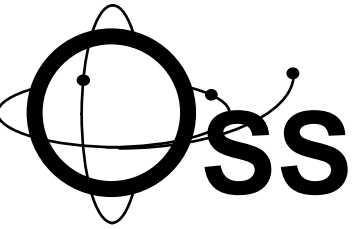
Bringing Home the Bacon

Two Approaches:

- Radio Frequencies
- Optical Communications

Radio Frequencies

- **Three Pronged Approach:**
  - More Efficient Encoding of the Data on the Spacecraft
    - We are pushing the theoretical limits of what can be accomplished in coding technologies
  - More powerful Transmitters and/or More Bandwidth on the Downlink
    - We are deploying more powerful, larger bandwidth transmitters
  - Larger Ground-based Collecting Area
    - The Next Generation Deep Space Network



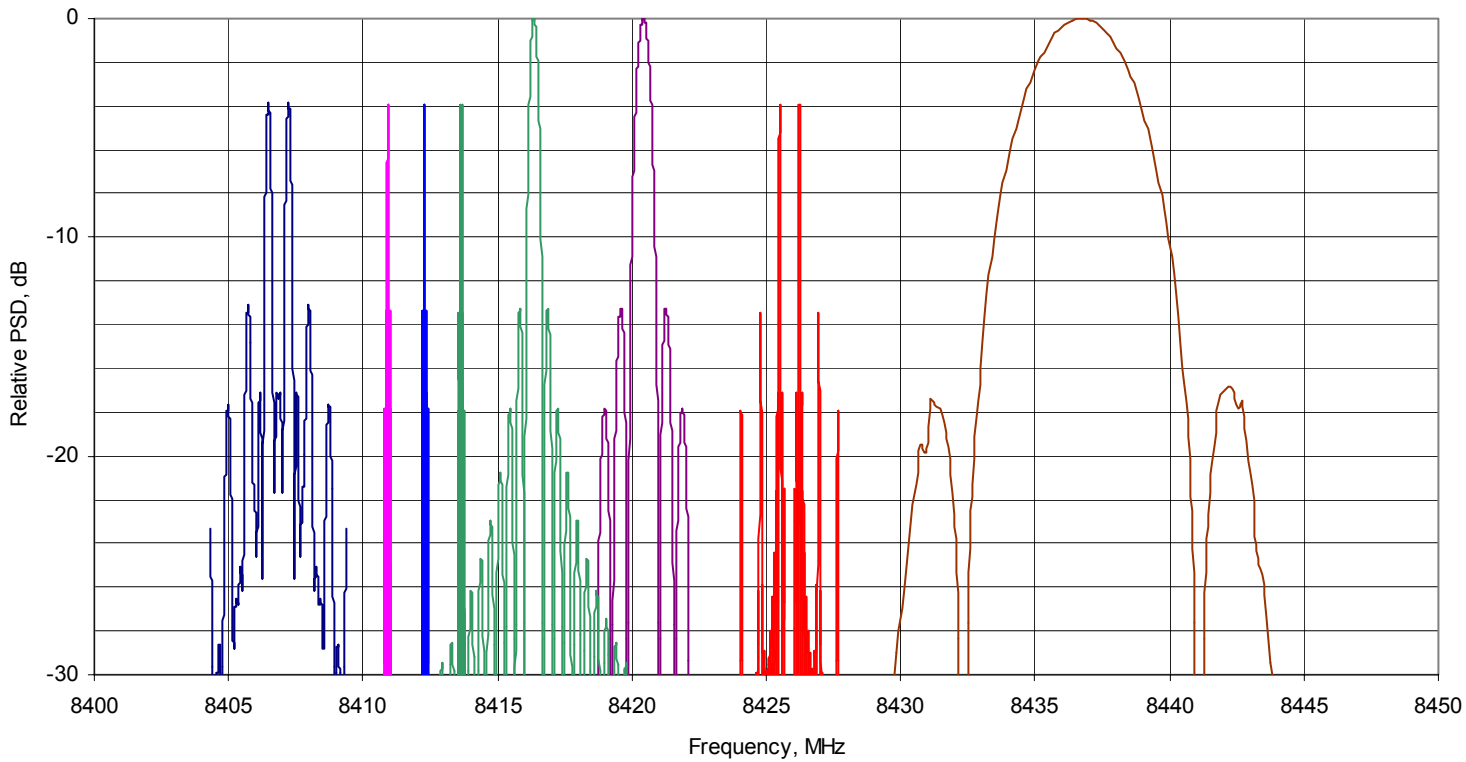
Enabling NASA Science for the Next 50 Years

The Next Generation DSN

- Increase DSN telemetry capability by a factor of 10^6
- Provide radiometric observables for precise spacecraft navigation
- Enhance DSN Science capabilities

Need to go to Ka Band

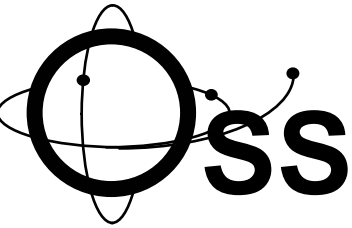
Figure 1. Spectral Occupancy of Mars Missions in 2007 Time Frame (Data rates are as currently conceived by missions)



-Only Mars Express and Odyssey have been assigned a frequency channel

-The center frequency (downlink) of the *n th* channel is given by

*8400.06 + (n-3)*1.36 MHz*



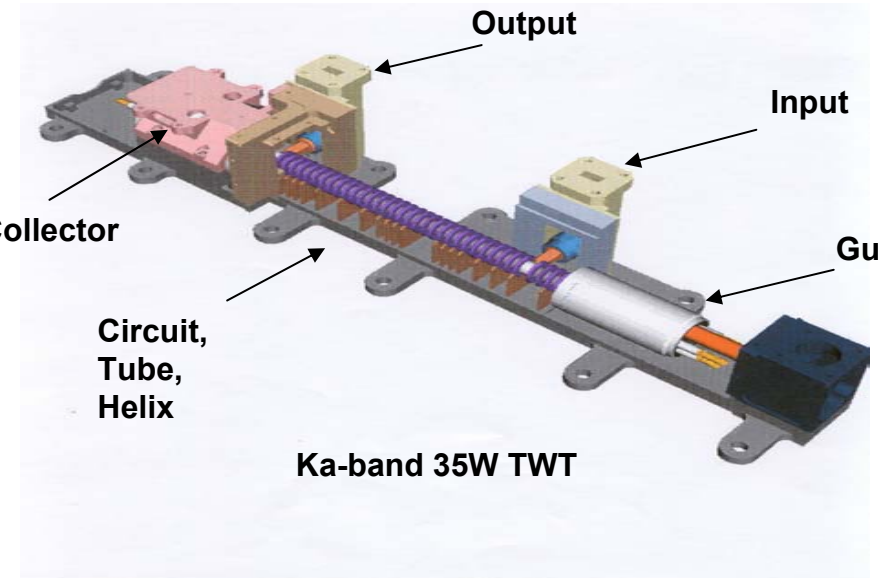
Choose Your Limitation

Two Choices:

- Bandwidth Limited
- Signal/Noise Limited

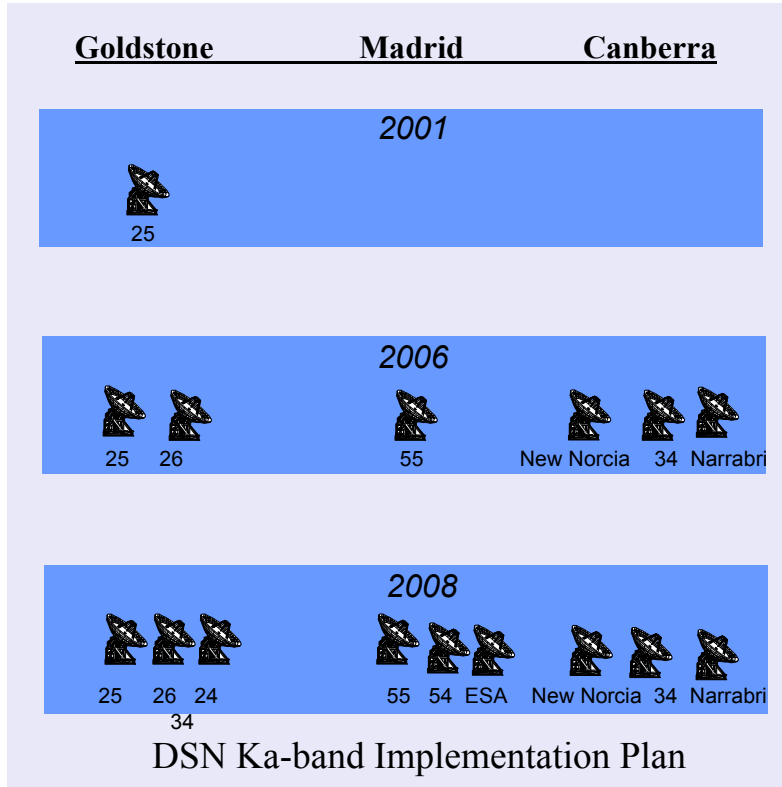
Spacecraft Radio Systems
Ka-Band TWTA

- Critical Design Review of 35W TWTA was delayed to accommodate needs of Mars `05 mission
  - Tube selected for flight on M`05
  - Expanded review will validate consistency with flight requirements
- Review held at contractor facilities
  - TWT: Thales (Thomson) in Velizy, France
  - EPC: Tesat-Spacecom (Bosch SatCom) in Baknang, Germany
- Draft of review material has been received at JPL -- under detail review
- Contractor is continuing with TWTA development as if CDR had been passed
- All indications are that TWTA development and performance are on track
- **Flight qualified model due to be delivered in Aug 02**
- **Code S is providing funding to MRO to fly the Ka band Tx as a demo**



DSN Ka-band Downlink Readiness

- **Today:** First operational DSN Ka-band 34m BWG is already on-line
  - Goldstone DSS 25 supported '98 DS1 Ka demo
  - Now supporting Cassini Radio Science Experiment
- **By MRO arrival (2006):** One add'l 34m BWG w/ Ka-band capability at each complex
  - DSS 26 at Goldstone
  - DSS 55 (new BWG) at Madrid
  - DSS 34 (upgrade) at Canberra
- **Alternate Assets [IACG WG4]:**
  - 34m ESA dish at New Norcia, Australia
  - 49m equivalent dish at Narrabri, Australia
  - 34m dish at Cebreros, Spain [tied to Venus Express]

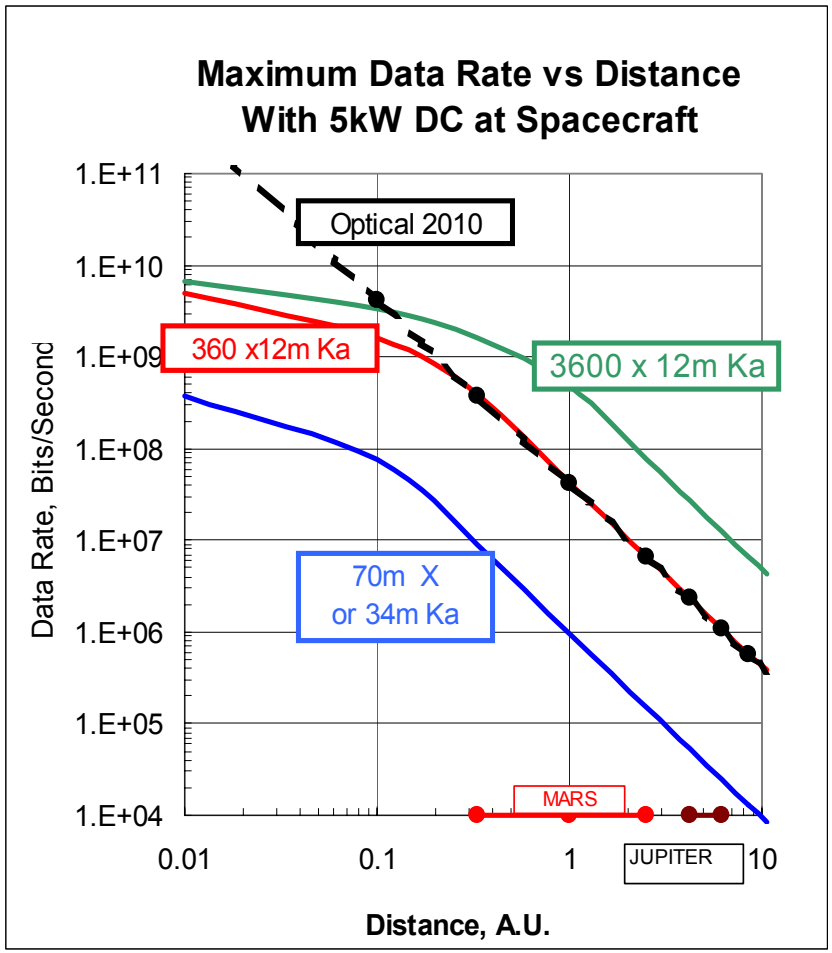


DSN Ka-band Implementation Plan

DSN Array: Working Baseline

- 400 12-m antennas at each of the three DSN longitudes [equivalent of a 240m antenna]
  - Freq range 2-44 GHz
  - Primary use X [8GHz] and Ka [32 GHz for Deep Space]
  - The future in the radio is Ka band

Capturing High Rate Data



To capture these high data rates, need 500 MHz bandwidth of the deep space spectrum.

We're looking for additional Ka band bandwidth to enable a higher science return