The Deep Space Network

Planetary Sciences Advisory Committee

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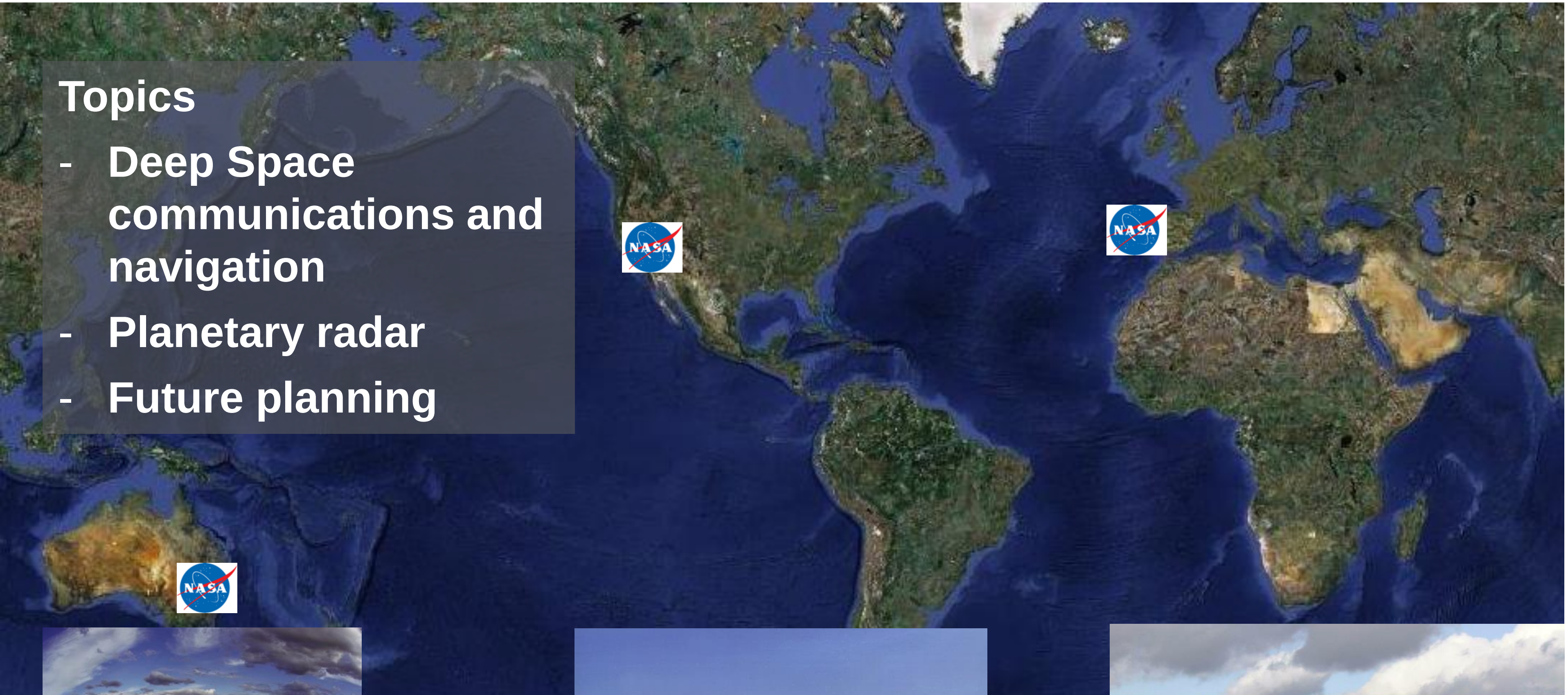
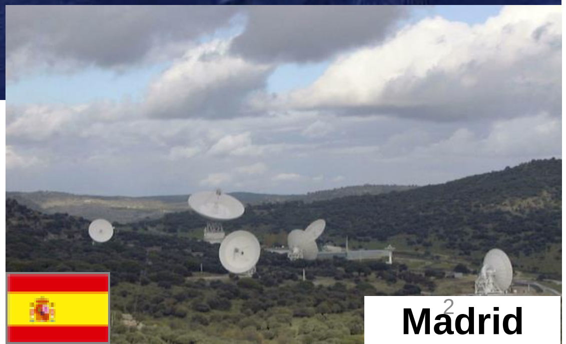
Deep Space Network



Topics
- Deep Space communications and navigation
- Planetary radar
- Future planning

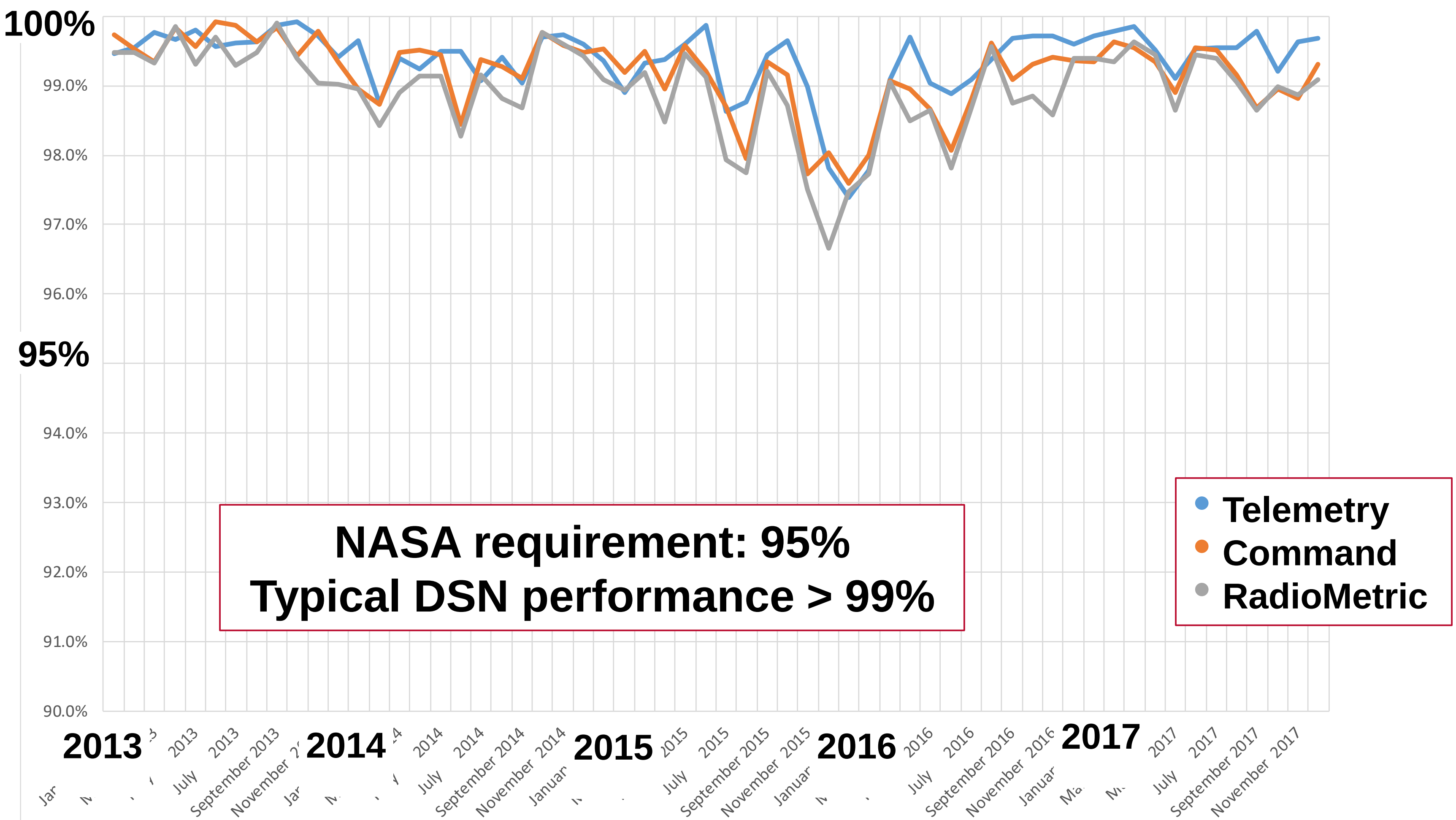


Planetary Sciences-DSN Partnership

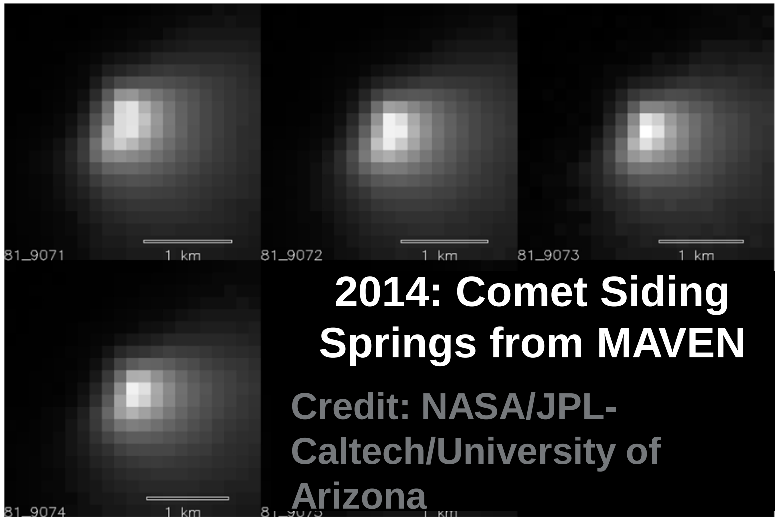
Don’t Leave Earth Without Us!

Telemetry, Tracking, & Command: 5 Year

Monthly Data, Averaged over All Missions



DSN and Planetary Science

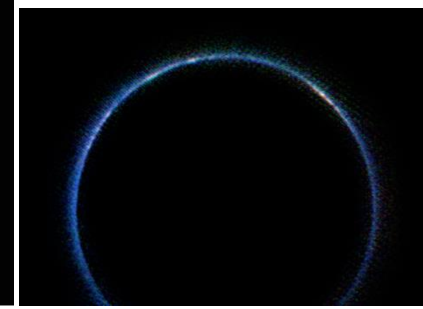


2014: Comet Siding Springs from MAVEN

Credit: NASA/JPL-Caltech/University of Arizona

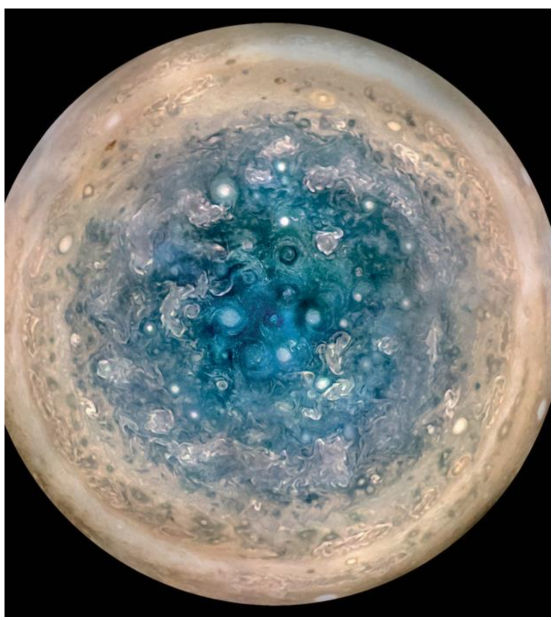
2015: Pluto from New Horizons

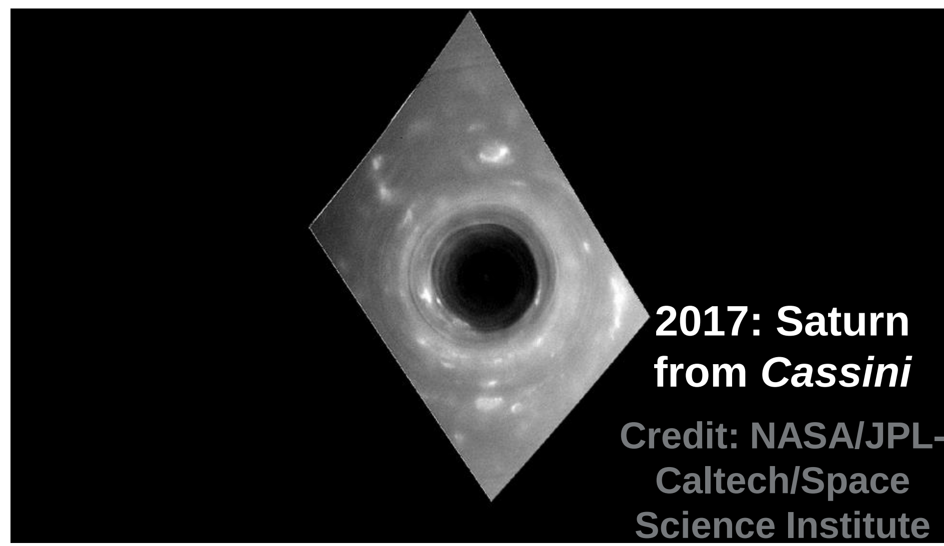
Credit: NASA/JHUAPL/SwRI



2016: Jupiter from Juno

Credit: NASA/JPL-Caltech/SwRI/MSSS/Betsy Asher Hall/Gervasio Robles





2017: Saturn from *Cassini*

Credit: NASA/JPL-Caltech/Space Science Institute

2020--2021 Mars Contention Period Planning

New Mars missions launch in mid-2020 and arrive in early 2021
~ 8-week window

Current Mars Missions

- **TGO 2016 (orbiter) – operating**
- **MAVEN (orbiter) – operating**
- **Curiosity (rover) – operating**
- **InSIGHT (lander) – operating**
- **MRO (orbiter) – operating**
- **MOM-1 (orbiter) – likely operating**
- **MER (rover) – possibly operating**
- **ODY (orbiter) – possibly operating**
- **MEX (orbiter) – possibly operating?**

2020--2021 New Mars Missions with DSN Support

- **NASA Mars 2020 (Rover) (EDL)**

- **ESA ExoMars Rover and Surface Platform (RSP) (EDL)**

- **UAE EMM orbiter (MOI)**

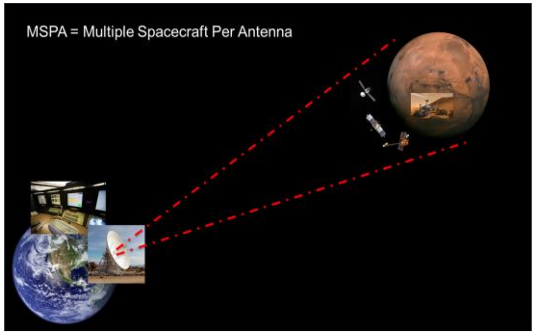
2020--2021 Mars Contention Period Planning

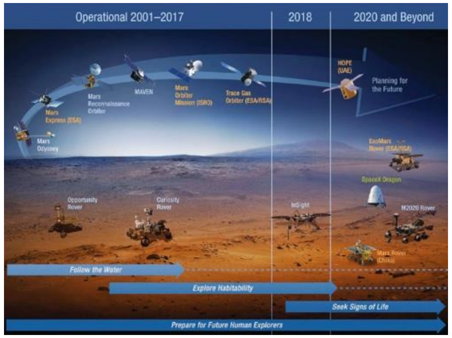
Preliminary Findings I

DSN enabling three new missions at Mars

DSN asset demand will be eminently manageable

- **New landed surface missions will not routinely communicate directly with DSN post-landing – will use relay orbiters**
- **Augmenting DSN with more antennas: new DSN 34 m apertures, Sardinia Radio Telescope, Morehead State Univ., ISRO, JAXA**
- **Adjusting DSN maintenance schedules**
- **Will increase use of MSPA (multiple spacecraft per aperture)**
- **Projections for 2020--2021 in family with 2012--2017 history**





Planetary Radar

The Primitive Bodies

Earth-Based Telescopes

The Arecibo and Goldstone radar telescopes are powerful, complementary facilities that can characterize the surface structure and three-dimensional shapes of the near-Earth objects within their reach of about one-tenth of the Earth-Sun distance. Arecibo has a sensitivity 20 times greater than Goldstone, but Goldstone has much greater sky coverage than Arecibo. Continued access to facilities for the detailed study of near-Earth objects is essential to primitive bodies studies.

National Radar Assets

Goldstone DSS-14 (DSN)
70 m antenna, 500 kW transmitter, 4 cm wavelength (X band)

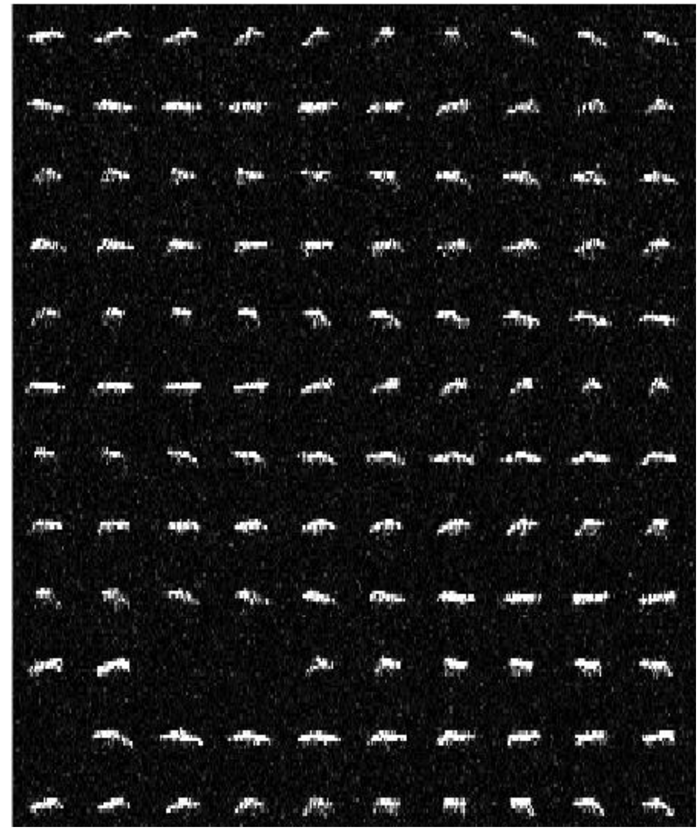
Arecibo (NAIC)
300 m antenna, 1 MW transmitter, 13 cm wavelength (S band)

Green Bank Telescope (GBO)
100 m antenna, no transmitter

Canberra DSS-43 (DSN)
70 m antenna

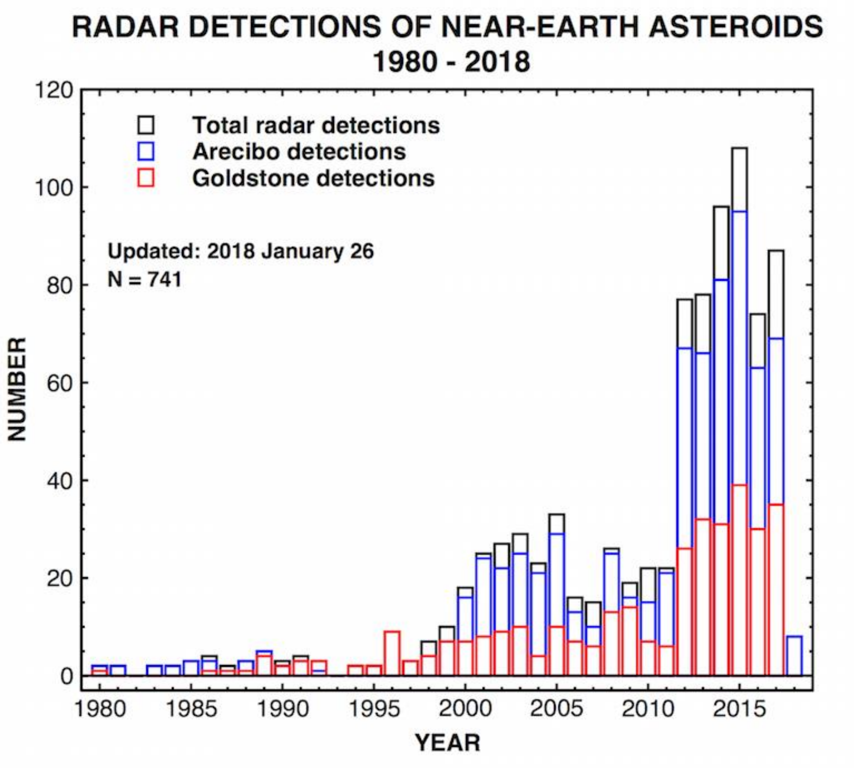
Goldstone Solar System Radar

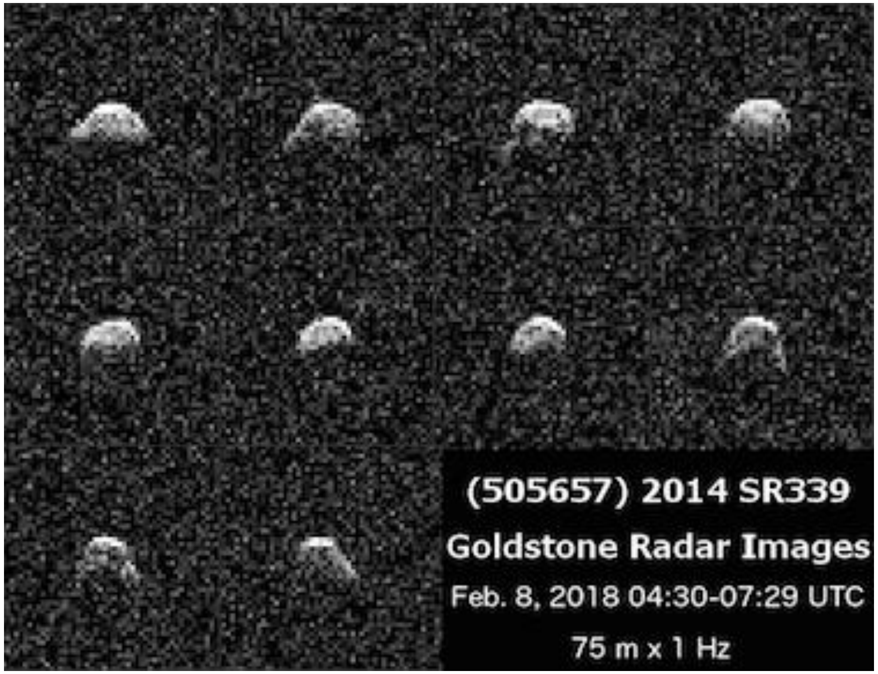
DSS-14: 70 m antenna at Goldstone Deep Space Communications Complex



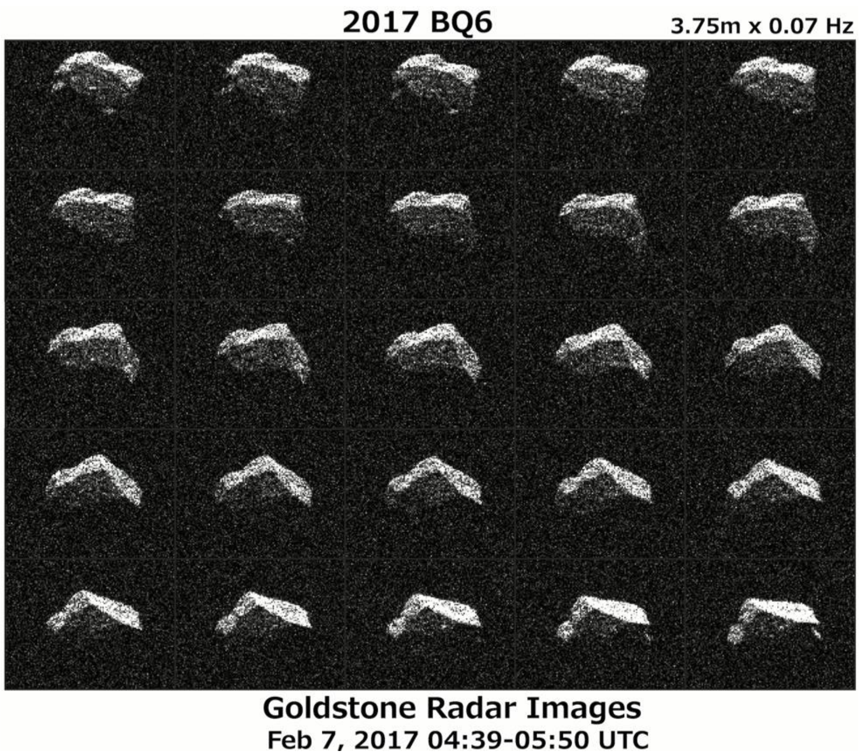
2012 TC4
2017 October

Goldstone Solar System Radar





Goldstone Solar System Radar



New klystron!

Vision and Voyages for Planetary Science in the Decade 2013-2022

The Deep Space Network

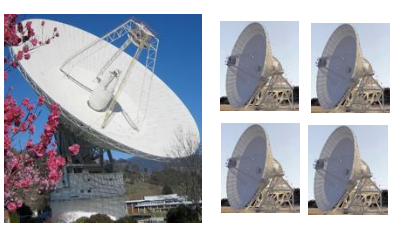
“The DSN is a critical element of NASA’s solar system exploration program. It is the only asset available for communications with missions to the outer solar system, and is heavily subscribed by inner solar system missions as well. As instruments advance and larger data streams are expected over the coming decade, this capability must keep pace with the needs of the mission portfolio. Future demands on the DSN will be substantial. Missions to the distant outer solar system requires access to either 70-meter antennas or equivalent arrays of smaller antennae. The DSN must also be able to receive data from more than one mission at one station simultaneously. If arrays can only mimic the ability of one 70-meter station and nothing more, missions would still be downlink constrained and would have to compete against one another for limited downlink resources.

“Although Ka-band downlink has a clear capacity advantage, there is a need to maintain multiple band downlink capability. For example, three-band telemetry during outer planet atmospheric occultations allows sounding of different pressure depths within the atmosphere. In addition, S-band is required for communications from Venus during probe, balloon, lander, and orbit insertion operations where other bands cannot penetrate the atmosphere. X-band capability is required for communication through the atmosphere of Titan, and also for emergency spacecraft communications. The committee recommends that all three DSN complexes should maintain high power uplink capability in X and Ka-band, and downlink capability in S, Ka, and X-bands. NASA should expand DSN capacities to meet the navigation and communication requirements of missions recommended by this decadal survey, with adequate margins.

Deep Space Network

DSN Aperture Enhancement Project (through 2025)

+ backend digital signal processing



Canberra

Goldstone

Madrid

DSN Futures

DSN Aperture Enhancement Project

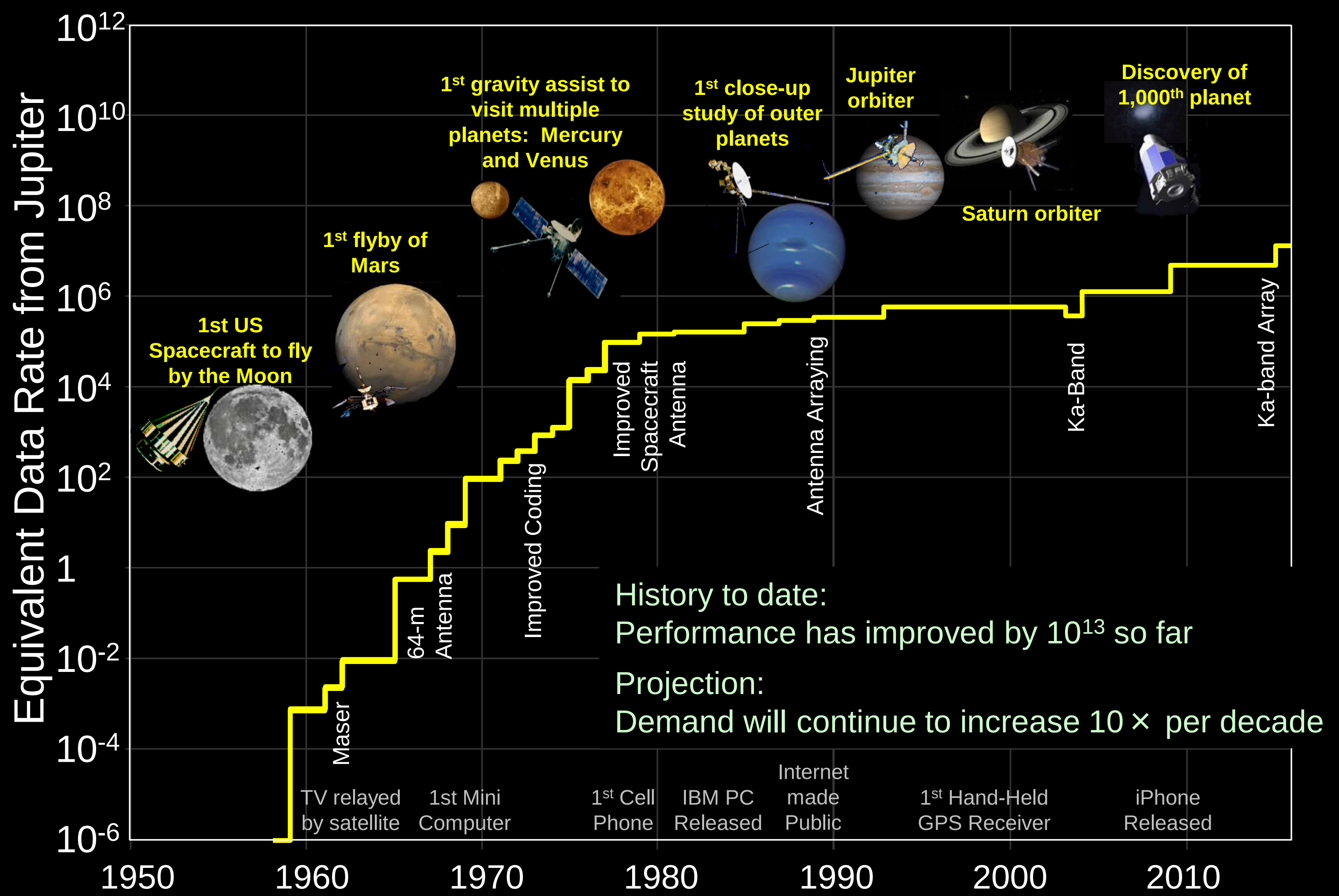
- DSN identified efficiencies to enable construction of additional 34 m antennas
- Provides multiple mission coverage at each Complex
- Addressing Decadal Survey recommendation

Maximize use of non-DSN large antennas

ESA, Sardinia, JAXA, ISRO, Morehead State

DSS-56 foundation in Madrid

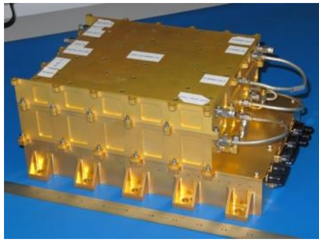
History of Downlink Performance



DSN Future Technologies

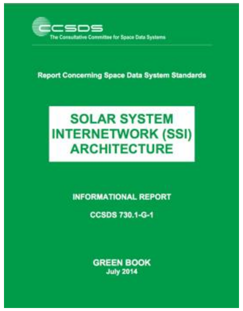
Solid-state power amplifiers for higher uplink rates

New, software-defined radios, associated technologies



Including for smallsats

Next-generation clocks



Standards for cross-agency support and interaction

Decade 0--1: 10× Improvements over Today

Vision for the DSN's Future

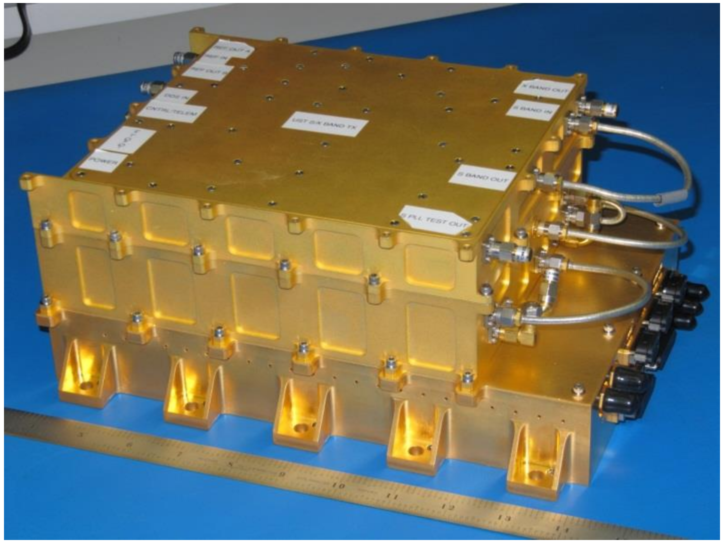
Make upgrades to enhance future Mars orbiter relay capabilities

… and other spacecraft

- **On-board ➔ software-defined radios**
  - **Universal Space Transponder (UST)**
  - **Iris smallsat transponder**
- **On the ground**

  Common Platform signal processor

➢ **On board and ground ➔ Ka band**

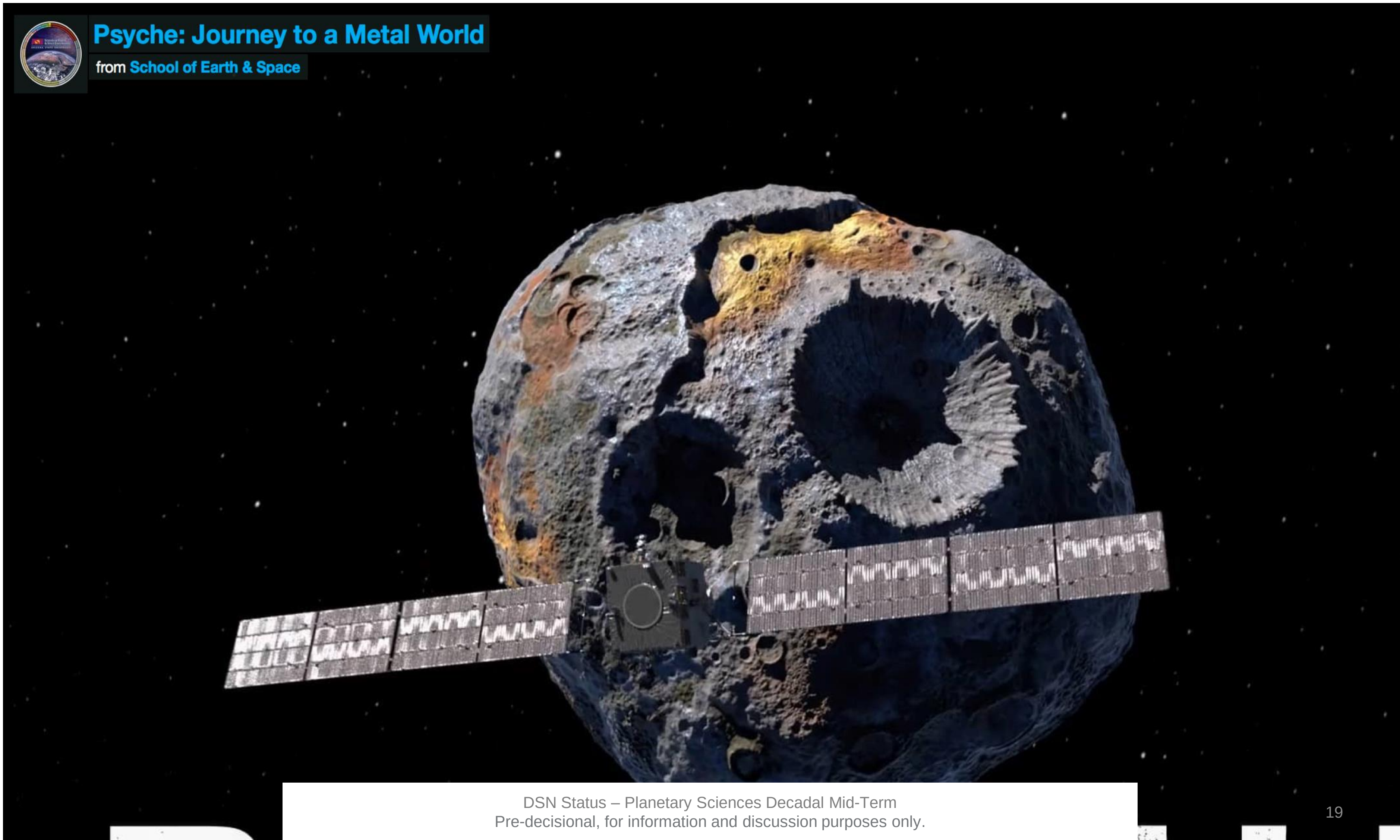


Universal Space Transponder (UST)

new digital backends

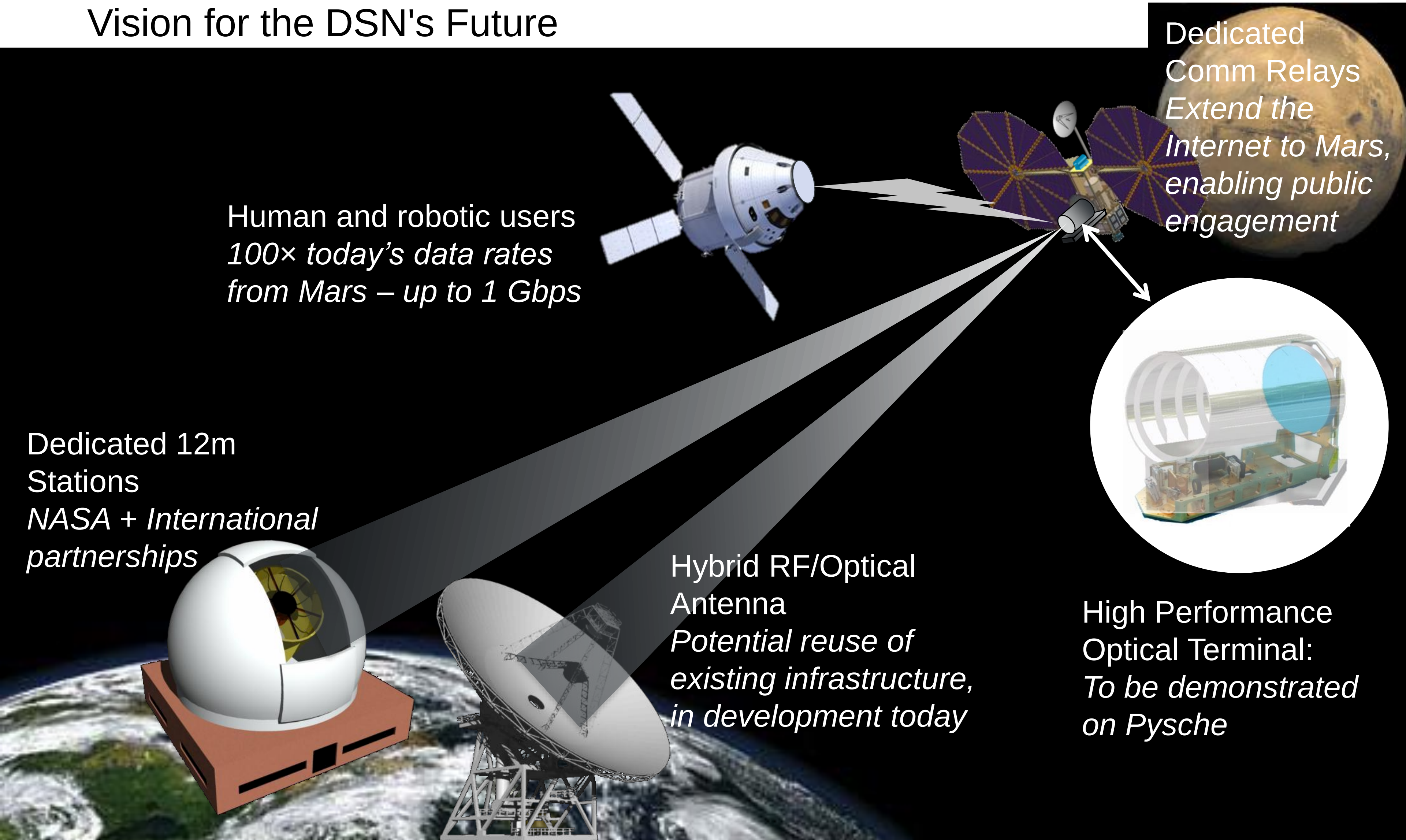
Decade 2+: 100× Improvements over Today

Vision for the DSN's Future



Decade 2+: 100× Improvement over Today

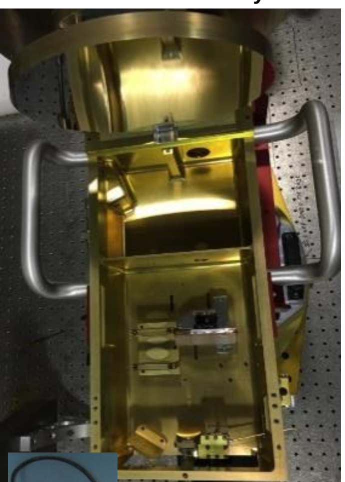
Vision for the DSN's Future

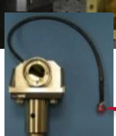


DSOC Technologies & Advances

FLIGHT LASER TRANSCEIVER (FLT)

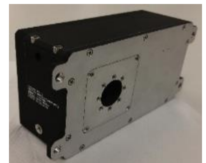
Aluminum Optical Transceiver Assembly

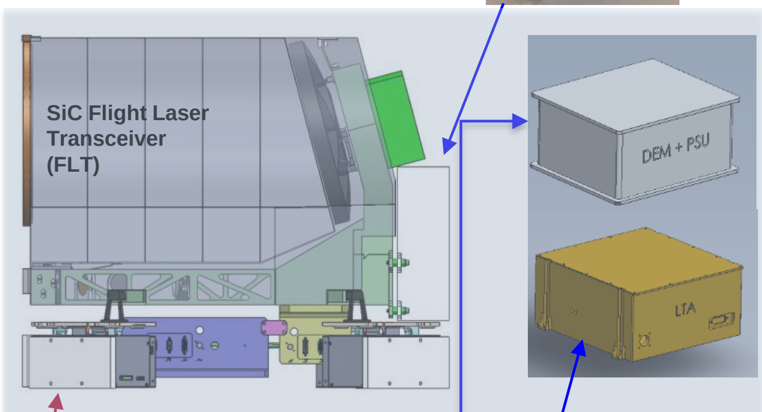




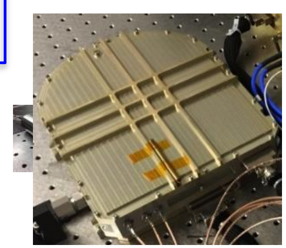
Point-Ahead Mirror

Photon-Counting Camera

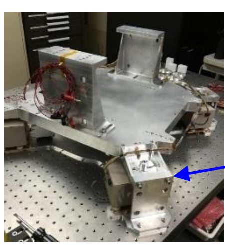




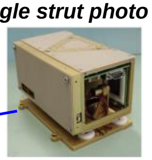
flight-like electronics



Laser Transmitter Average Power 4 W

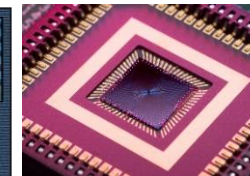


Single strut photo



Isolation Pointing Assembly

GROUND TECHNOLOGY



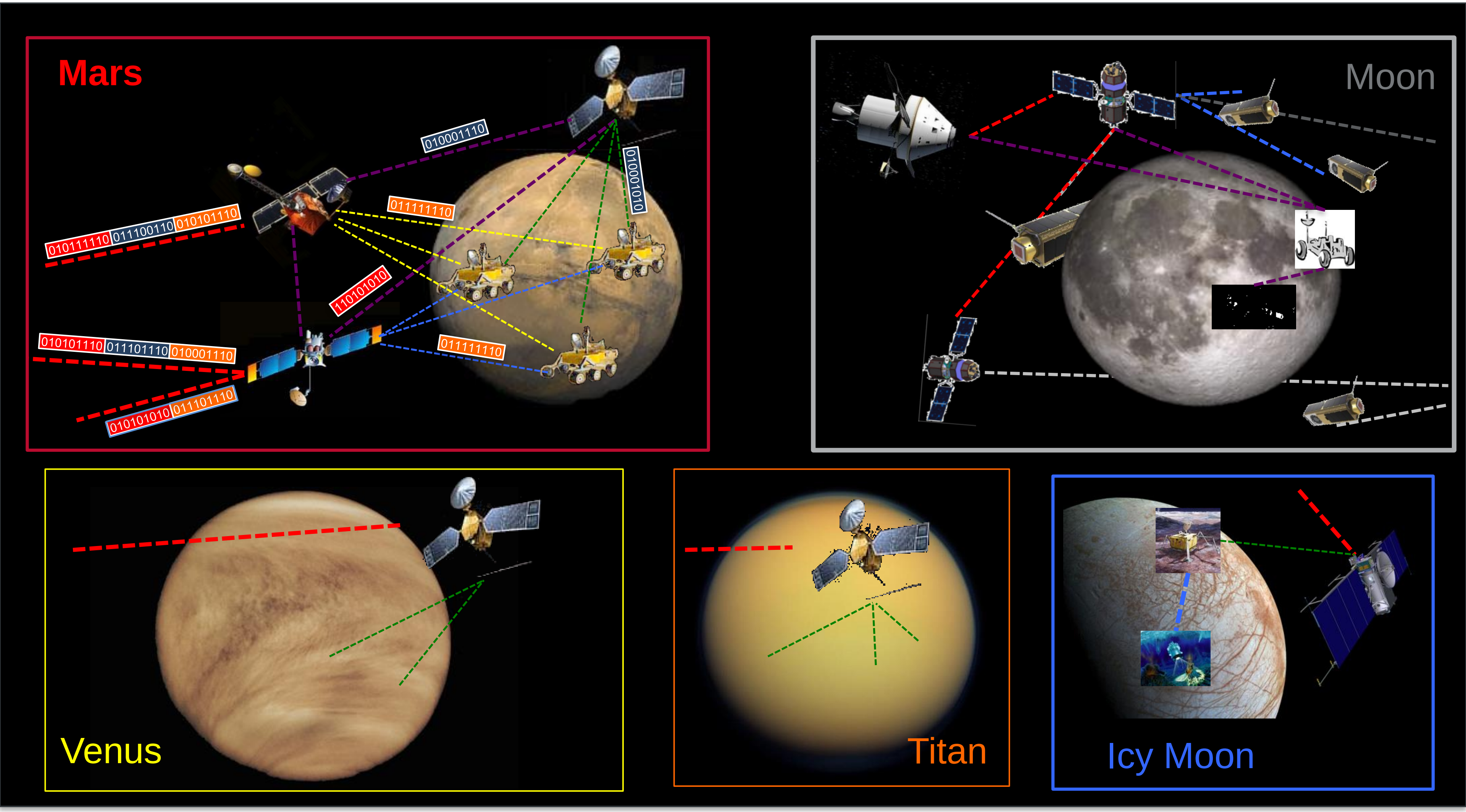
Packaged Nanowire Array

Electron microscope detail of 320 µm active area tungsten silicide (WSi) superconducting nanowire single photon detector (SNSPD) array

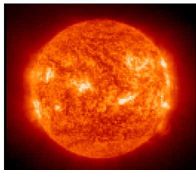
Palomar Observatory/Hale Telescope 5 m

The DSN and the Interplanetary Internet

Vision for the DSN's Future



The Deep Space Network



- ✓ **Enabling 35+ missions**
- ✓ **Maintaining 99% reliability**
- ✓ **Radar contributing to planetary science and planetary defense**
- ✓ **Implementing strategies to continue performance into 2020s and beyond**






backup

DSN Futures

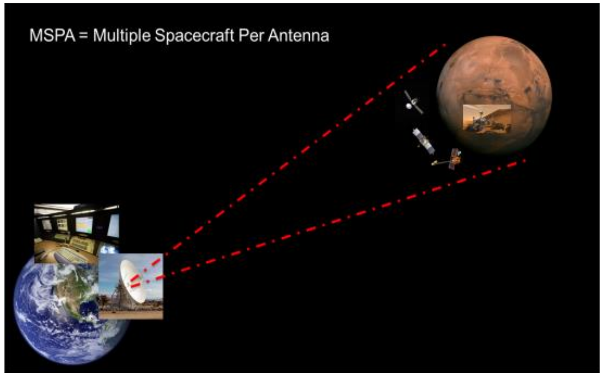
Mitigation and Strategy I

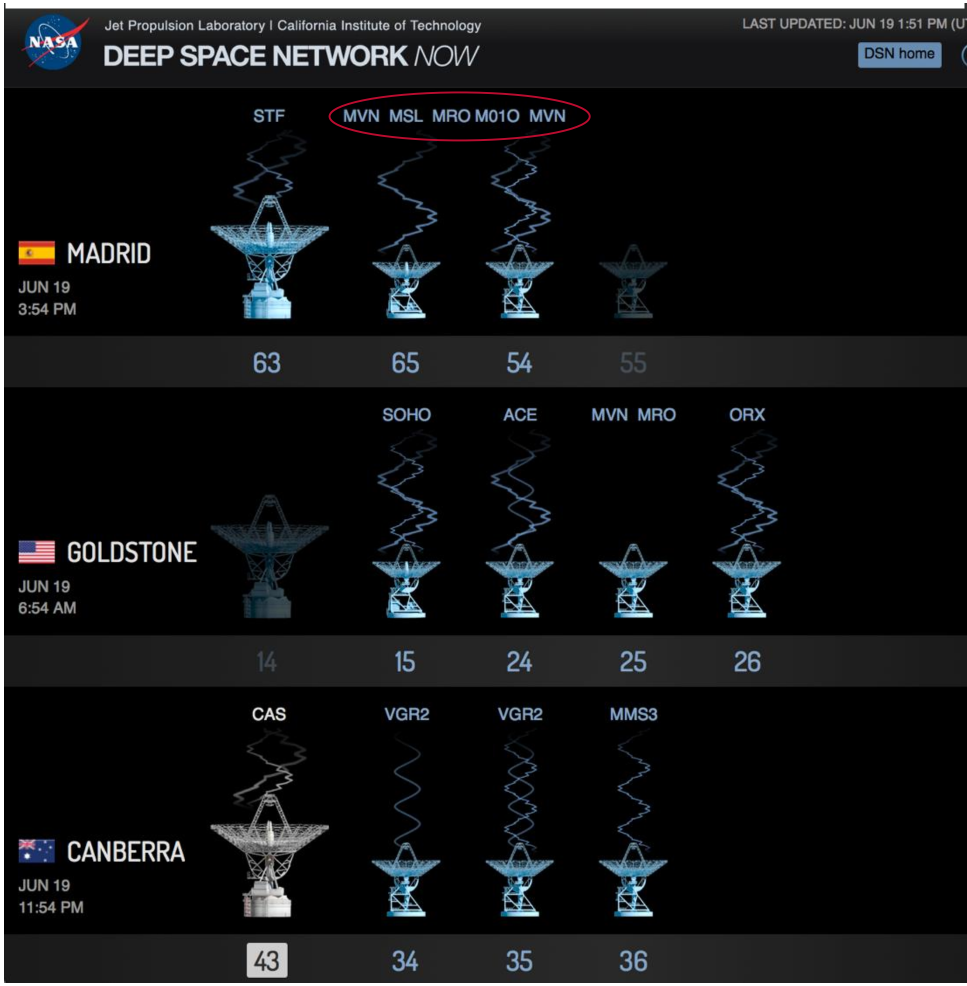
http://eyes.nasa.gov/dsn/dsn.html

Maximize use of Multiple Spacecraft Per Aperture (MSPA)

- up to four at once (downlink)
- Investigating multiple uplink per aperture

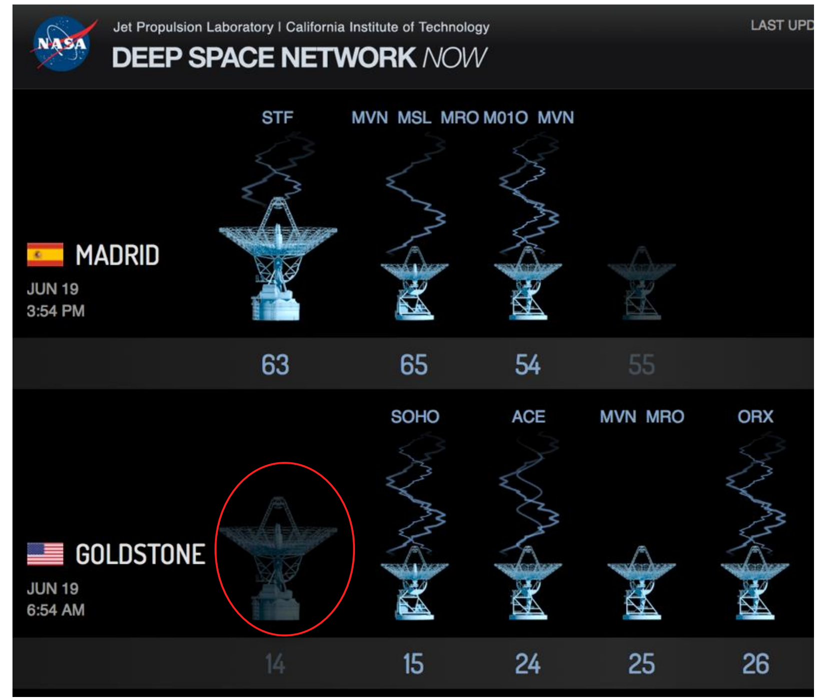
  Likely requires changes to on-board radios





DSN Futures

Mitigation and Strategy III



Modify maintenance schedule to maximize DSN availability during critical periods

(launches, Mars arrivals)

- ➢ **Accelerate some antennas, defer others**

  cf. change car's oil before embarking on long road trip