National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Deep Space Network Strategic Planning

Dr. Les Deutsch
Deputy Director, Interplanetary Network Directorate

June 13, 2016

© 2016 California Institute of Technology. Government sponsorship acknowledged

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

50 Years of DSN Success – What's Next?

On December 24, 1963 William Pickering established the Deep Space Network

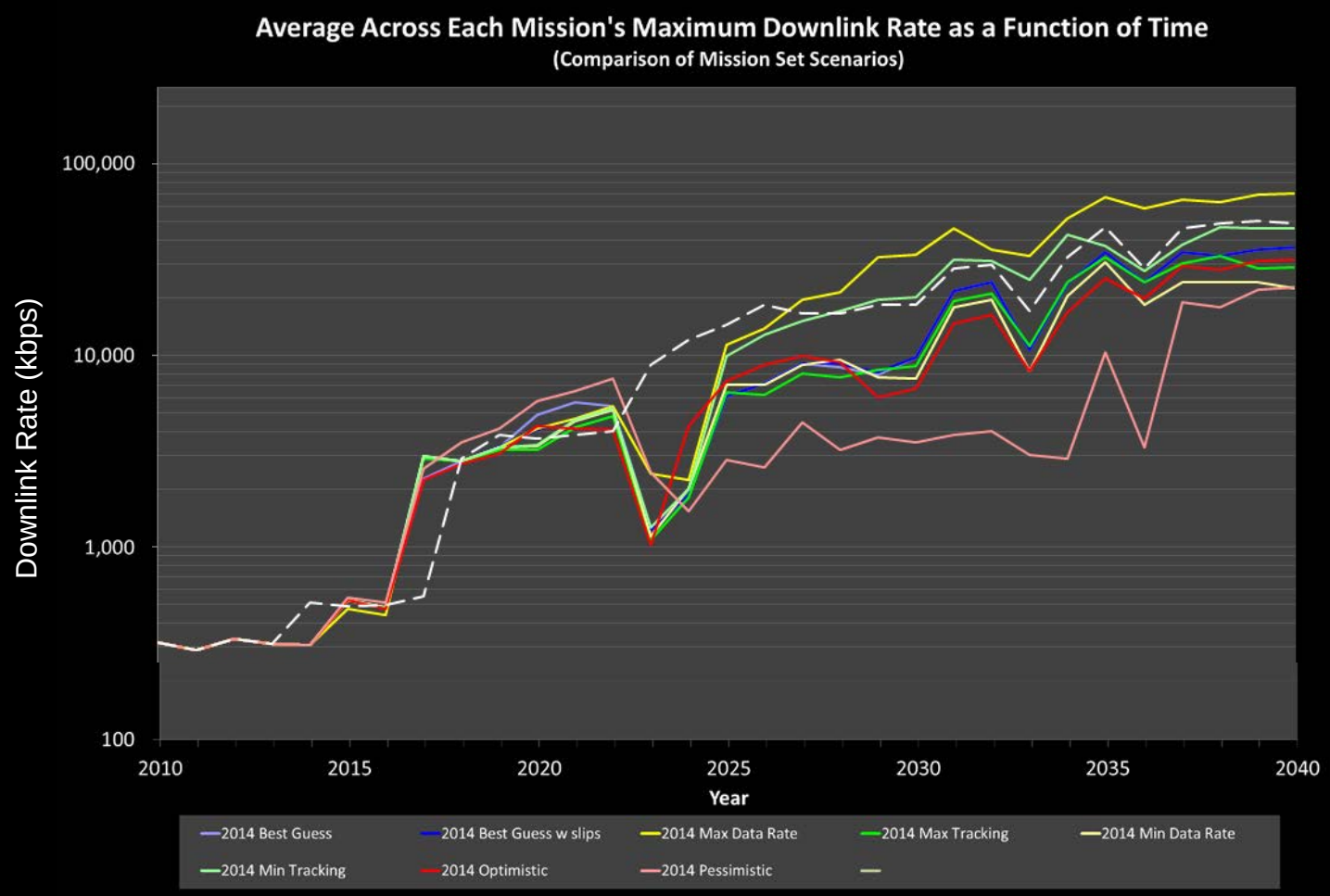
The *Council for the Advancement of Science Writing* published a "top 50 science results list" – starting in 1957. The Deep Space Network was intimately involved with 22!

1. Satellites (1957)
5. Plate tectonics (1961)
6. The environmental movement (1962)
7. Quasars (1962)
9. Big Bang's afterglow (1964)
11. Moon landing (1969)
12. Internet (1969)
14. Medical scanners (1972)
18. Pictures from other planets (1976)
20. Farthest frontier (1977)
24. Killer asteroid (1980)
25. Cosmic inflation (1980)
31. Catching up with comets (1986)
33. Witnessing a cosmic crash (1994)
36. Alien planets (1995)
38. Big bounce on Mars (1997)
39. Dark energy (1998)
43. Age of the universe (2001)
45. Titan revealed: (2005)
46. Planets realigned (2005)
49. Tasting Martian water (2008)
50. Water on the moon (2009)

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Future Mission Data Rate Trends

Mission modeling indicates desire for ~10X data improvement per decade through 2040



National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Plans for the DSN: Antennas

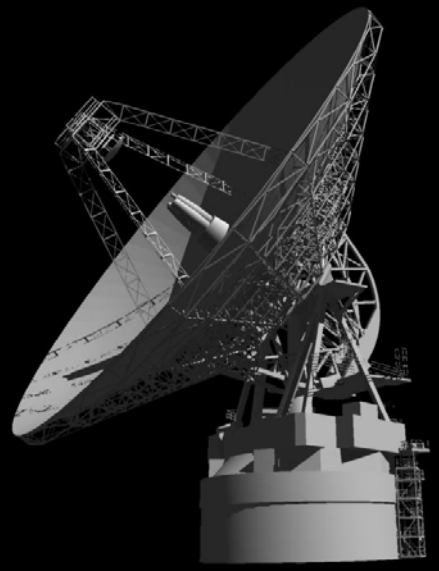
+

+

+

+

=



More DSN capability

More southern hemisphere coverage

More Ka-band

No more 70m single points of failure

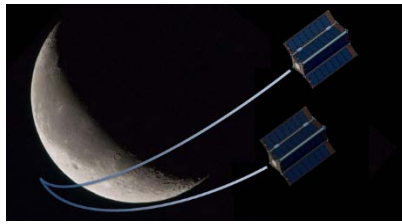
At all DSN locations

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

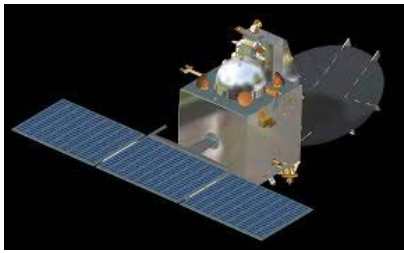
Expanding DSN Markets

- **Human space flight**
  - Ensure DSN is the “network of choice” for HSF
  - Minor upgrades to DSN to support EM-1 and EM-2 flights
  - Migrate HSF deep space missions to X and Ka-band

- **Nanosats**
  - Emplace processes to reduce interface costs to the DSN
  - Fight false perception that DSN tracking is expensive
  - Develop unique flight capabilities for deep space CubeSats including radios, antennas, optical comm, and nav



- **International partners**
  - Build on ISRO/MOM and others – streamline provision of DSN & AMMOS services to partners



- **OGAs**
  - Build on expertise to extract tiny signals from noise

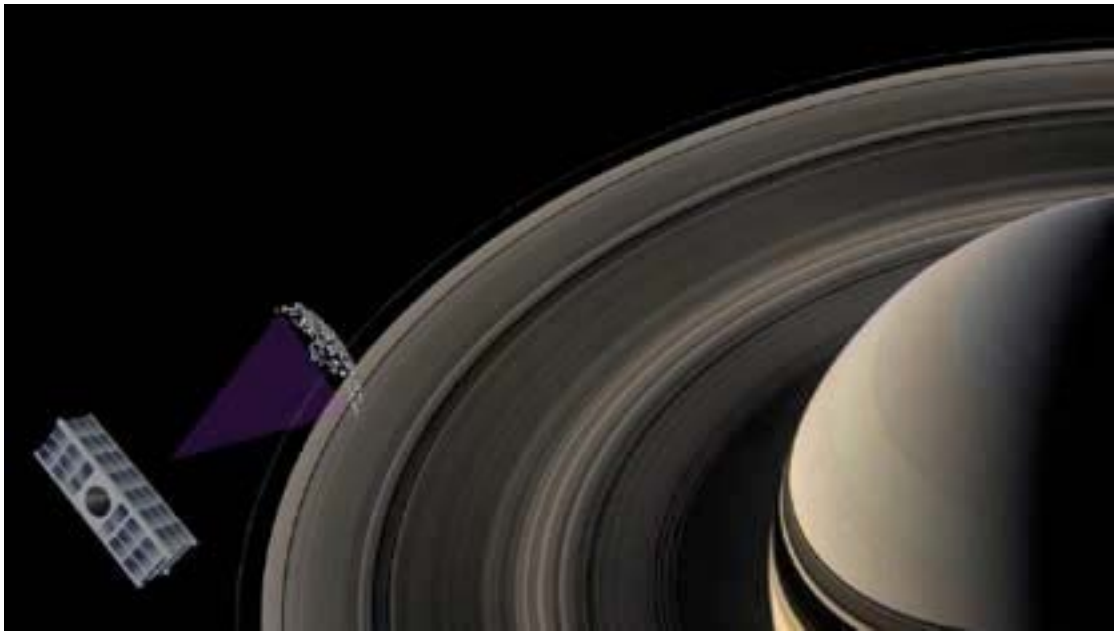
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Vision for Deep Space Nanosats

Definition: *Nanosat:* a spacecraft with mass between 1 and 10 kg

- Includes most CubeSats, but it much more general

Vision: Enable nanosat science missions in deep space by providing cost-efficient technology, capabilities, and operational services for communications, navigation, and mission operations



Daughter nanosat concept at Saturn, from Keck Institute for Space Sciences (KISS) study

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Strategic Nanosat Goals

1. **Be the "broker of choice" for the provision of deep space communication, tracking, and navigation services to NASA-endorsed deep space nanosat missions.**

2. **Develop communication, tracking, navigation and operations technologies and capabilities to enable deep space nanosat missions.**

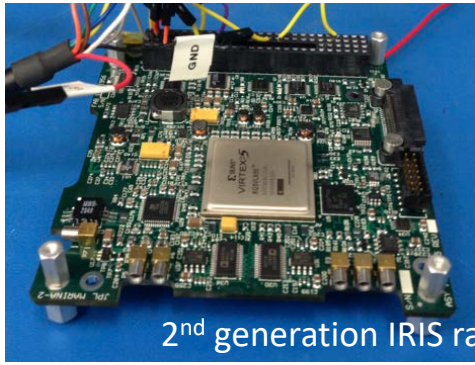
3. **Be the leader in the nanosat community in the establishment of standards for deep space communication, tracking, navigation and operations enabling cost efficient support and cross support.**

4. **Reach out to the nanosat community to ensure mission developers have the relevant knowledge and information they need to achieve success within reasonable cost and schedule**

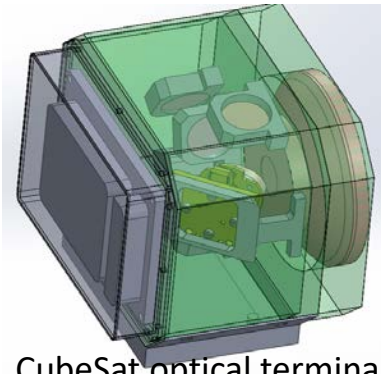
National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Current Nanosat Activities

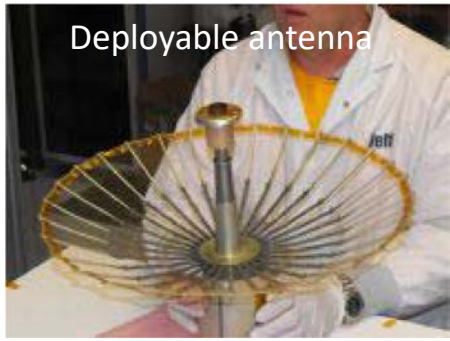
- **Emplaced official POC in Commitments Office**
- **Completed system study on nanosat support**
- **Engaged with many deep space nanosat missions**
- **Delivered AMMOS system for nanosats**
  - AMMOS is part of curriculum at several universities
- **Adding 4MSPA**
- **Demonstrated "opportunistic multiple spacecraft per aperture" (OMSPA)**
  - Provide essentially unlimited number of simultaneously-tracked spacecraft
- **Technology developments**
- **Working with universities to create a federated "extension DSN"**
  - Morehead State University, KY



2nd generation IRIS ra


CubeSat optical terminal

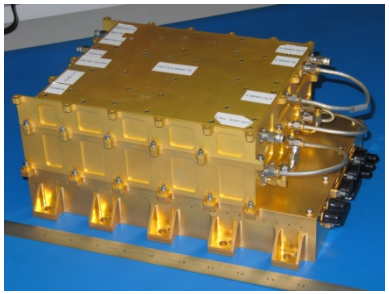
MSU 21m Anetnna


Deployable antenna

National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

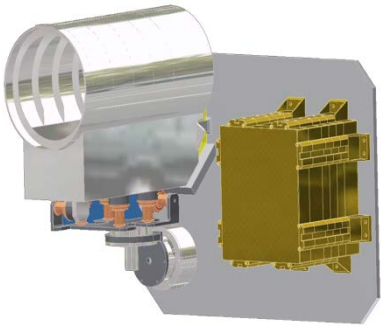
Infuse Enabling Technology

Universal Space Transponder (UST)



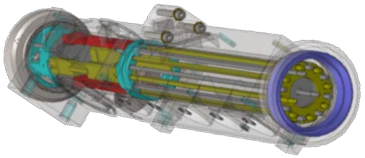
- Nearing completion of 1st unit
- Orders of magnitude communications improvement
- Easy infusion of new capabilities
- Pathway toward “Big Avionics” concept

Deep Space Optical Communications



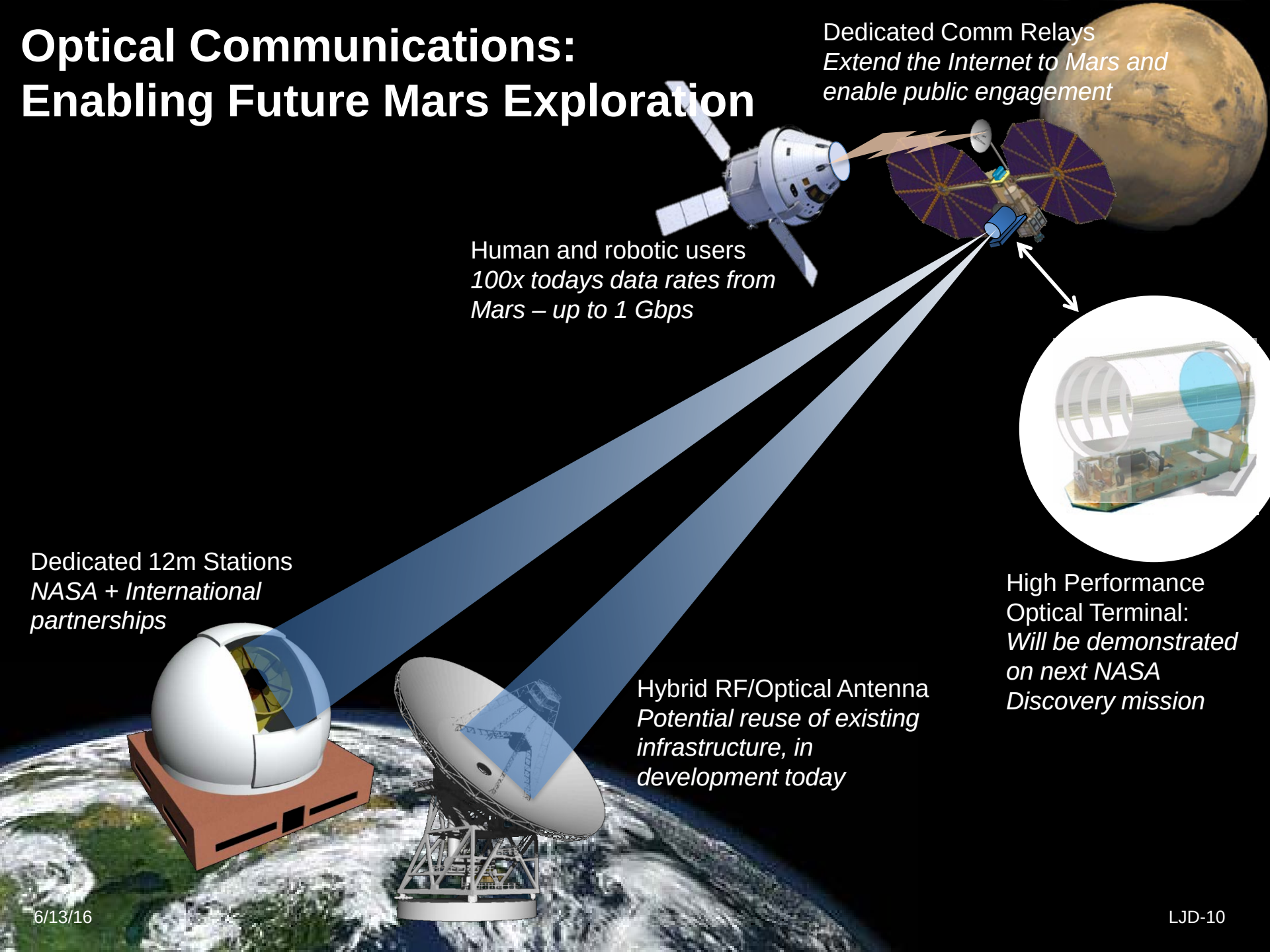
- Extreme bandwidth for data-hungry instruments
- Pathway to human missions to asteroids and Mars
- On path to fly on next Discovery mission in ~2020

Deep Space Atomic Clock (DSAC)



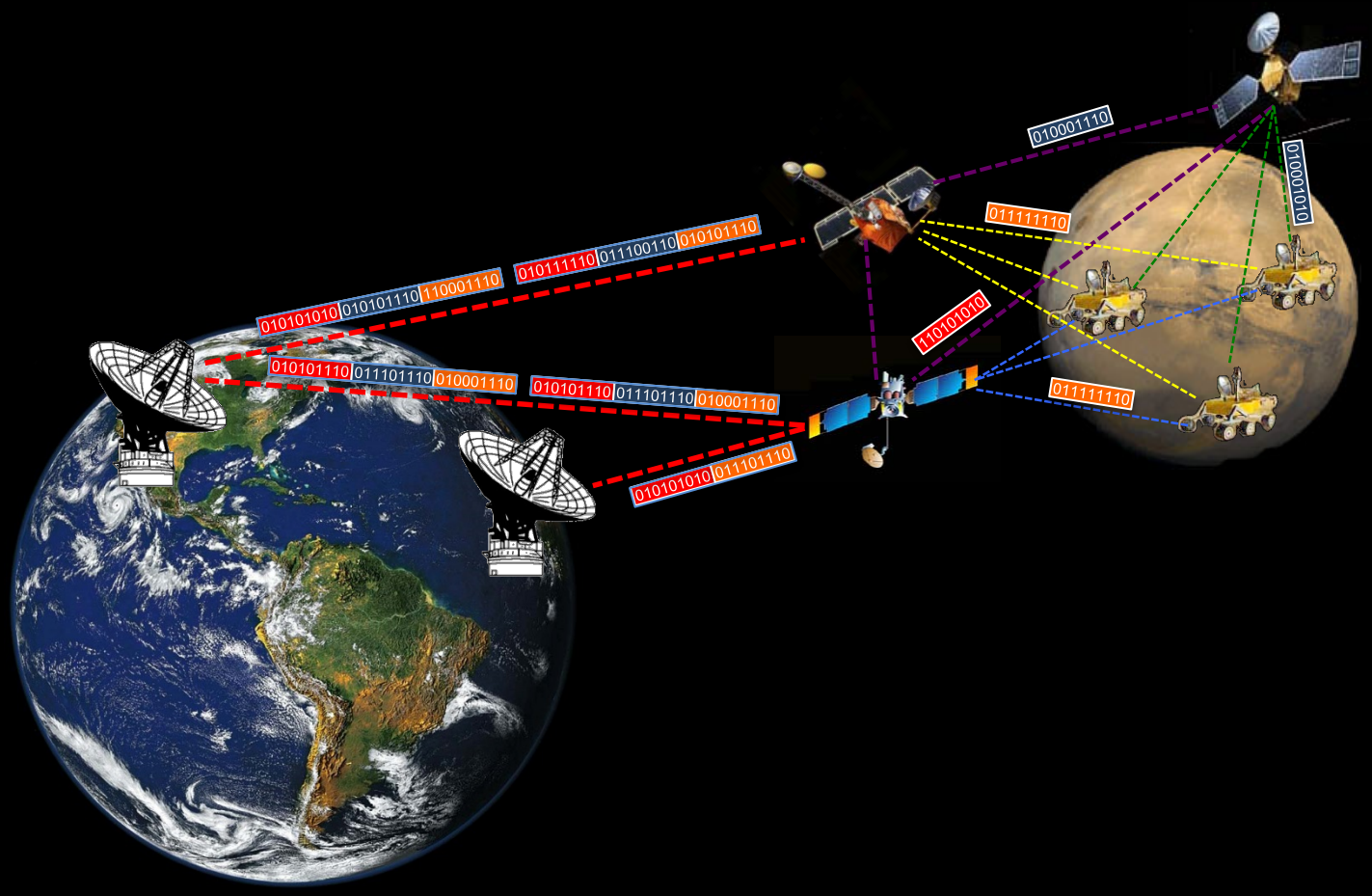
- Technology demonstration to fly next year
- Reduce tracking required for precision navigation
- Simultaneous navigation during MSPA tracking
- Improved radio science
- Pathway to human missions to asteroids & Mars

Optical Communications: Enabling Future Mars Exploration



The DSN enables the Interplanetary Internet

Extends today's Internet across the Solar System to enable a new era in space exploration, including engaging the general public

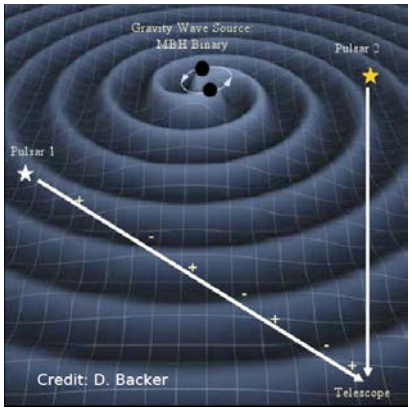


National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Enable New Science

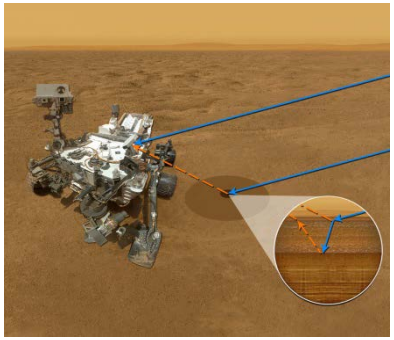
Gravitational waves – detection and study

- Pioneered at DSN
- nHz frequencies from in-spiraling supermassive black holes, complements LIGO



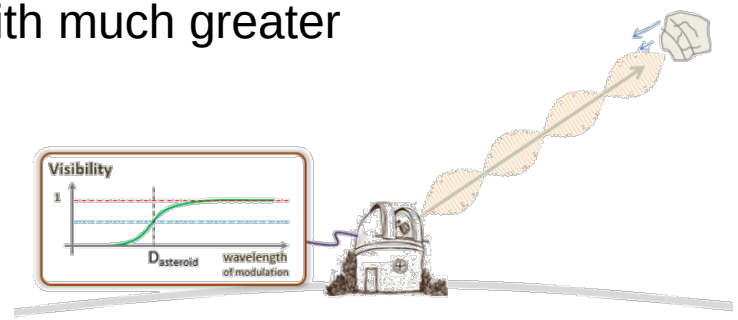
Probing planetary sub-surfaces

- Compare direct signal from DSN and reflected signal from surface and sub-surface
- Technique developed with Earth remote sensing, now transition to planetary bodies



Laser communications science

- Extension of today's "Radio science" but with much greater precision
- New techniques for detecting and studying near-Earth asteroids



National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Conquer Big Data

DSN moves substantial quantities of data

- ~ 2 TB/day

New approaches to data transmission

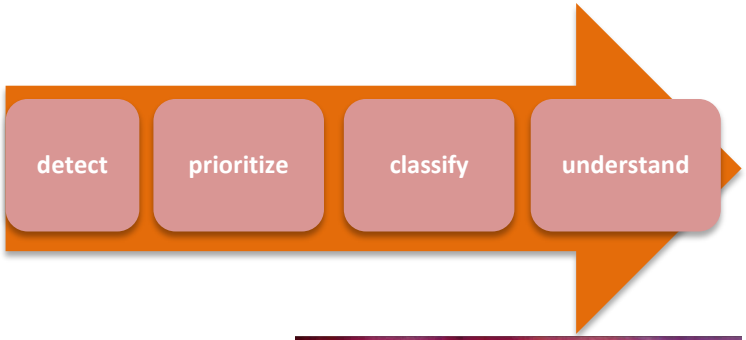
- Identify and transmit only relevant bits
- Requires machine learning approaches

New approaches to data archives and access

- Leverage Directorate's new role in the Planetary Data System
- Leverage recent JPL initiative in data analysis

New approaches to visualization

- Beyond static images to movies and 3-D



National Aeronautics and Space Administration
Jet Propulsion Laboratory
California Institute of Technology

Optimistic Outlook

- **Most dreams of the past decade have now moved into implementation phases**
  - **More DSN antennas and arrays**
  - **New transponder**
  - **Advanced networking**
  - **Optical communications**
- **DSN family is expanding**
  - **Humans moving beyond LEO for the first time since Apollo**
  - **Nanosats bringing a new generation of efficient space exploration**
- **This is an exciting era in which to work with the DSN**