Space Communications and Navigation Overview

National Aeronautics and Space Administration

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Science Subcommittee of the NASA Advisory Committee
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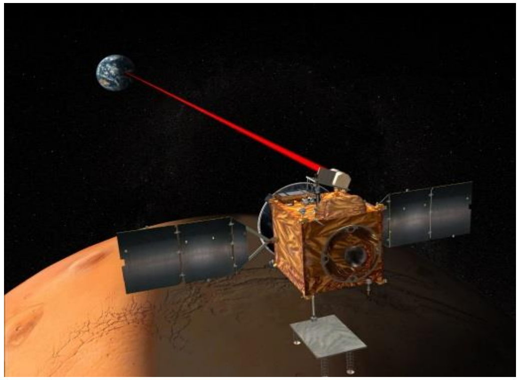
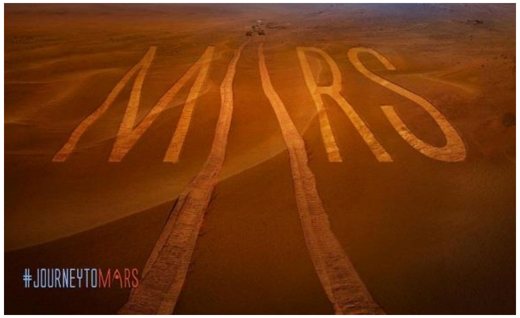
Overview

- SCaN's Responsibilities
- Operations
- Advanced Communication
- Spectrum

SCaN is Responsible for all NASA Space Communications





- Operation, management and development Agency-wide for all NASA space communications capabilities and enabling technology.
- Expand SCaN capabilities to enable and enhance robotic and human exploration.
- Manage spectrum and represent NASA on national and international spectrum management programs.
- Develop space communication standards as well as Positioning, Navigation, and Timing (PNT) policy.
- Represent and negotiate on behalf of NASA on all matters related to space telecommunications in coordination with the appropriate offices and flight mission directorates.

Vision (So Far)

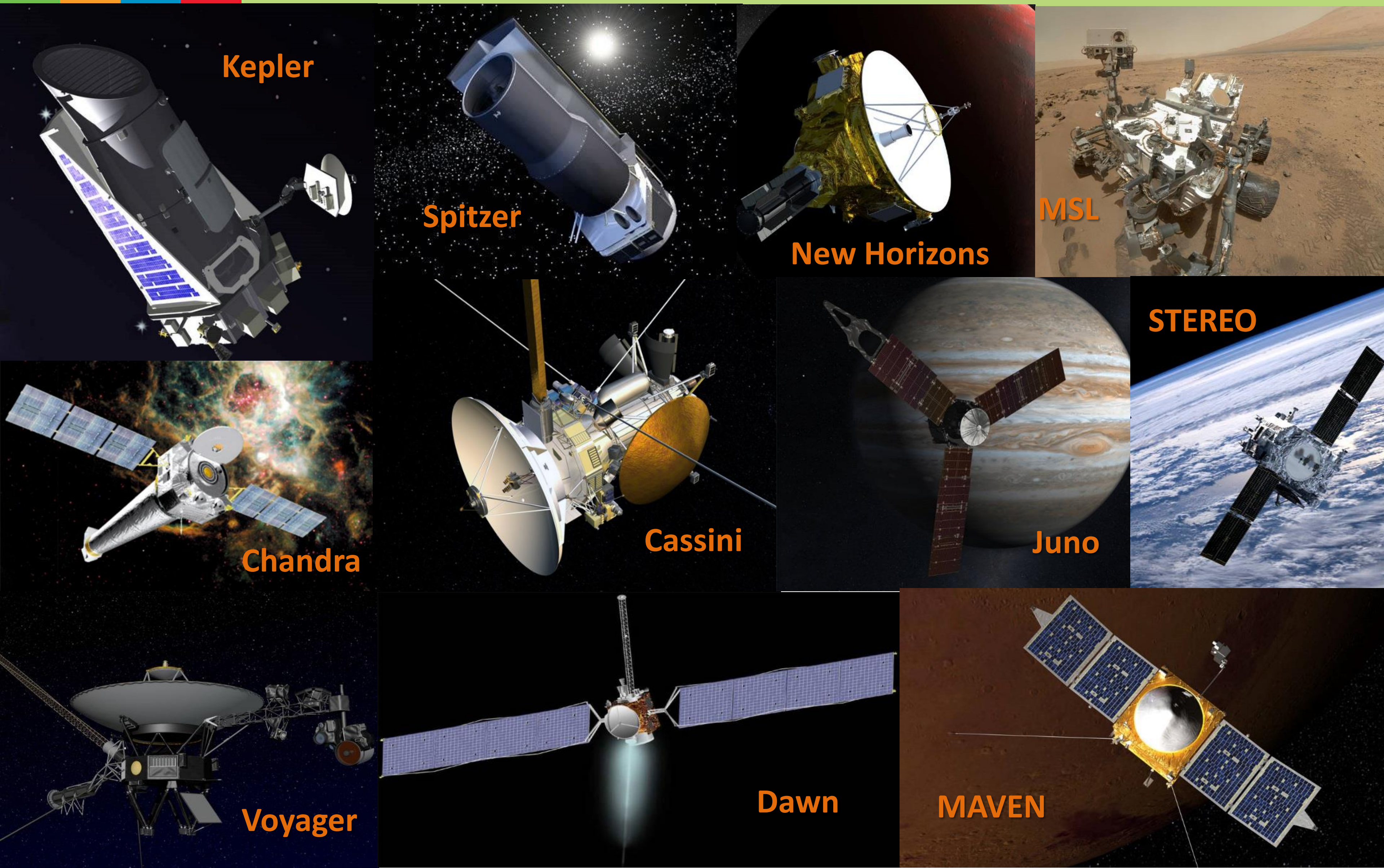
- ***"Shrink" the solar system*** by connecting the principle investigator more closely to the instrument, the mission controller to the spacecraft, and the astronaut to the audience.
- **Improve the *mission's experience*** and **reduce *mission burden*** – the effort and cost required to design and operate spacecraft to receive services from the SCaN Network.
- **Reduce *network burden*** – the effort and cost required to design, operate, and sustain the SCaN Network as it provides services to missions with the collateral benefit of increasing funding for C&N technology.
- **Apply new and enhanced capabilities** of terrestrial telecommunications and navigation to space leveraging other organizations' investments.
- **Enable growth of the domestic commercial space market** to provide – and NASA to use – commercial services currently dominated by government capabilities.
- **Enable greater international collaboration** and lower costs in space by establishing an open architecture with interoperable services that foster commercial competition and can be adopted by international agencies and as well as NASA.

OPERATIONS

NASA Networks Span the Globe


Near Earth Network
Space Network
Deep Space Network

Example: Deep Space Network Supported Missions



Deep Space Network (DSN)

LOCATION: Tidbinbilla, ~35 km southwest of Canberra, Australia

Managed and operated: Commonwealth Scientific Industrial Research Organization (CSIRO)

Operational Antennas: one 70 m, one 34 m HEF, two 34 m BWG, one 34 m BWG under construction

COMPLEX SIZE: ~0.425 square kilometers

STAFF: ~100

LOCATION: Fort Irwin, ~55 km northeast of Barstow, CA

Operated: Harris Corporation
Managed: NASA Jet Propulsion Lab

Operational Antennas: One 70 m, three 34 m BWG, one 34 m HEF, one 34 m HSB, one 34 m R&D antenna, two 34 m educational antennas

COMPLEX SIZE: ~134 square kilometers

STAFF: ~ 165

LOCATION: Robledo de Chavela, ~60 km west of Madrid, Spain

Operated: Ingeniería de Sistemas para la Defensa de España (ISDEFE)
Managed: Instituto Nacional de Técnica Aeroespacial (INTA)

Operational Antennas: one 70 m, one 34 m HEF, two 34 m BWG, one 34 m educational antenna

COMPLEX SIZE: ~ 0.490 square kilometers

STAFF: ~ 105

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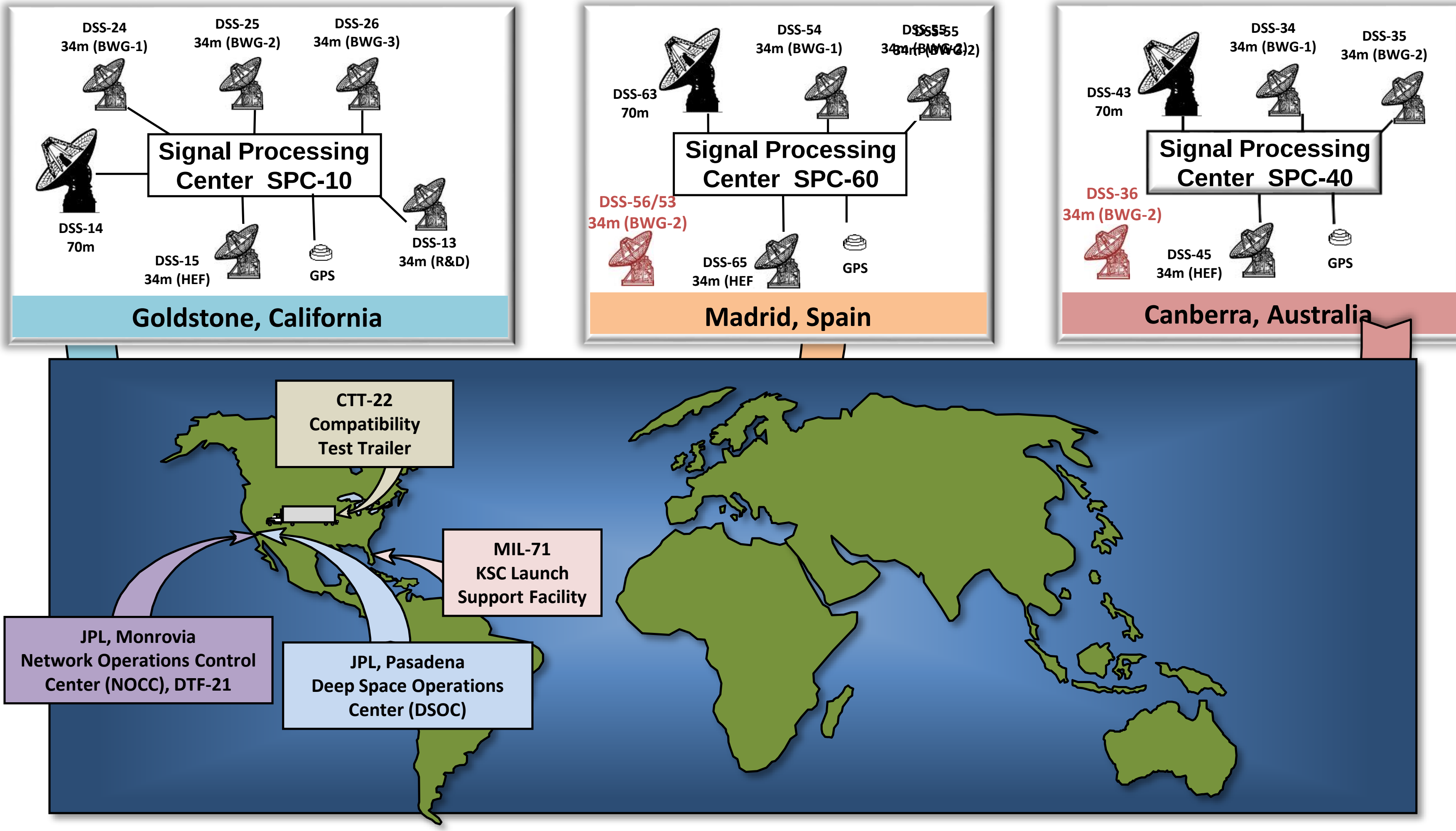
Deep Space Network (DSN) Facilities



DSN Aperture Enhancement Project (DAEP) Summary

DSS– 56
(Madrid, Spain)
Under construction
Scheduled to be completed in 2019

DSS– 36
(Canberra, Australia)
Under construction
Scheduled to be completed in 2016

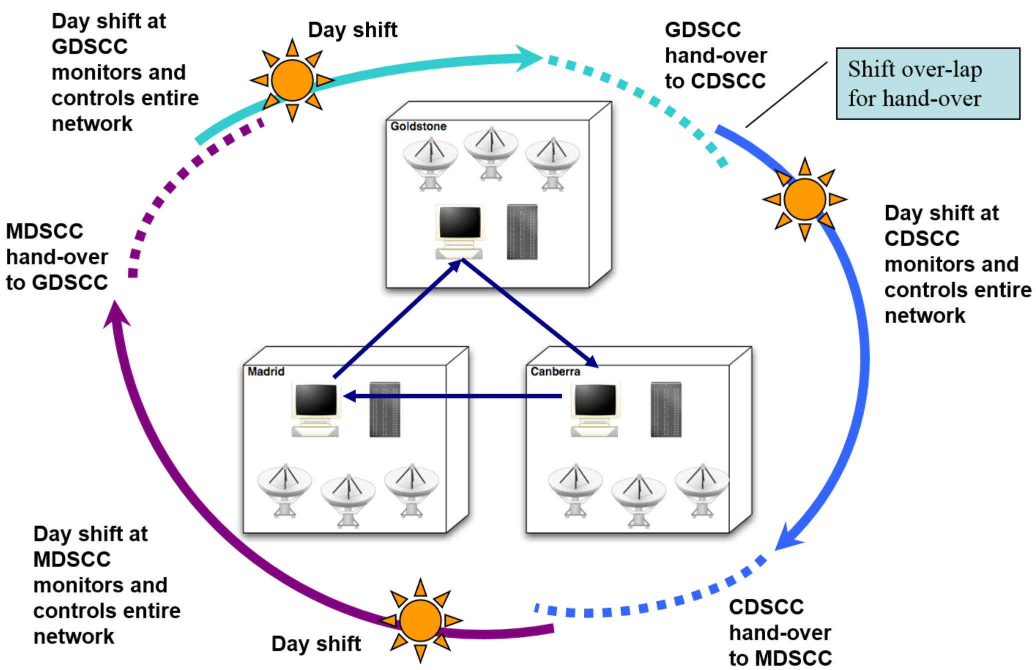
DSS– 35
(Canberra, Australia)
Operational: 1 October 2014

- The Deep Space Network 70 meter antennas are 50+ years old. Maintenance costs are high and continue to increase.
  - These antennas present both physical and technological limitations to potential upgrades needed to support future mission needs.
- New Beam Waveguide (BWG) antenna systems will feature higher reliability, enhanced performance, reduced operations and maintenance costs

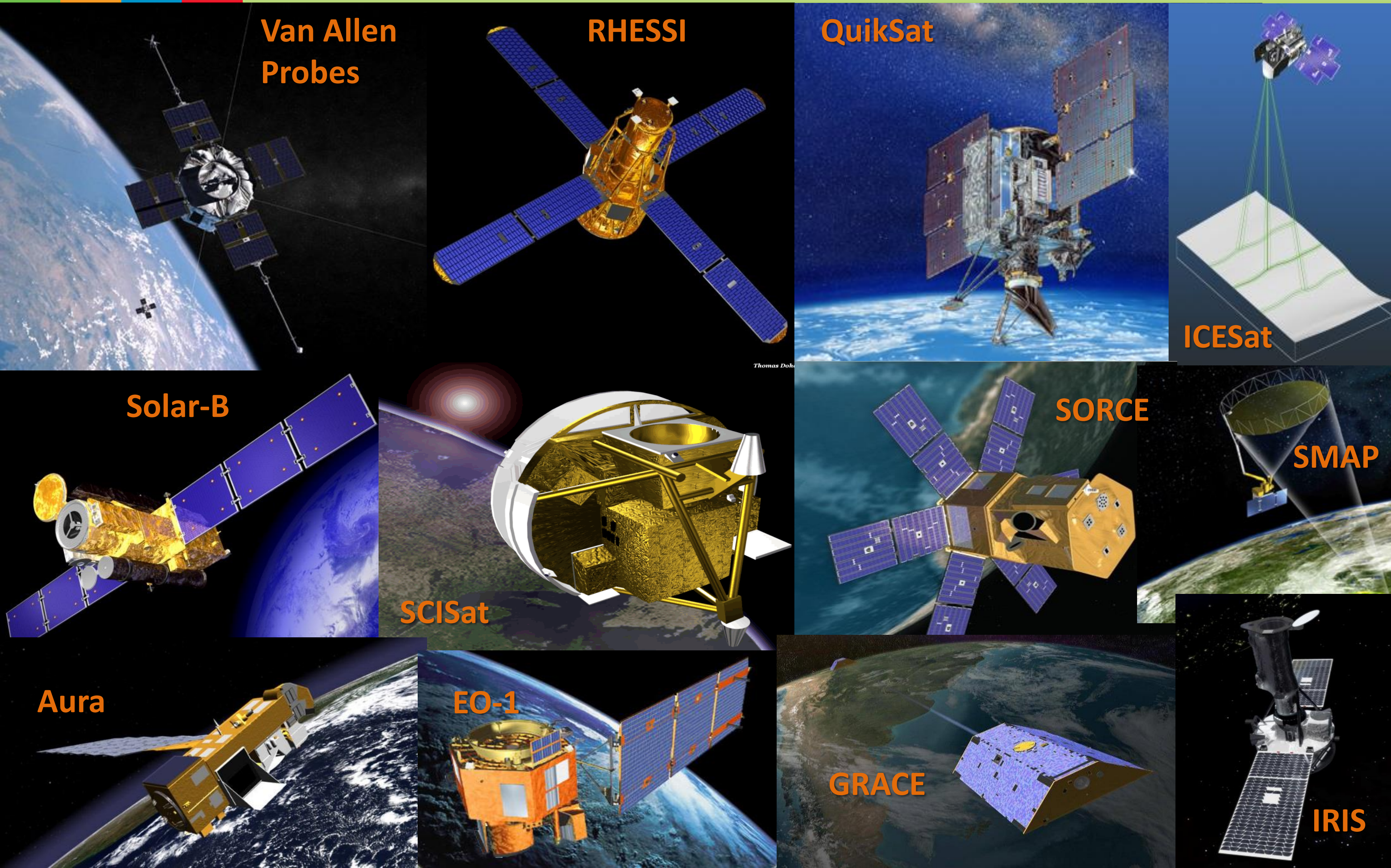
DSS-35	CDSCC	October 2014	Operational
DSS-36	CDSCC	October 2016	Under construction
DSS-56	MDSCC	October 2019	Facility work started
DSSS-53	MDSCC	October 2020	
DSS-33	CDSCC	October 2022	
DSS-23	GDSCC	October 2024	

Follow the Sun

- Moving from three sites at 24x7 to three sites at 9x7 under follow-the-sun operations supported during day-shifts rotating around each deep space communication complex.



Example: Near Earth Network Supported Missions



Near Earth Network (NEN)

NASA Stations

- Alaska Satellite Facility, Alaska (two 11 meter, one 10 meter antennas)
- McMurdo Grounds Station, Antarctica (one10 meter antenna)
- Wallops Ground Station, Virginia (one 5 meter, one 11 meter antennas)
- White Sands Complex, New Mexico (one 18 meter antenna)

Commercial

- Dongara, Australia (Universal Space Network) (one 13 meter antenna)
- Hartebeesthoek, Africa (Satellite Application Center) (one 18 meter antenna)
- Kiruna, Sweden (Swedish Space Corporation – SSC) (two 13 meter antennas)
- North Pole, Alaska (Universal Space Network) (four antennas – 5.4, 7.3, 11, and 13 meter)
- Santiago, Chile (Swedish Space Corporation – SSC) (one 12 meter, one 13 meter antennas)
- Singapore, Malaysia (Kongsberg Satellite Services – KSAT) (one 9 meter antenna)
- South Point, Hawaii (Universal Space Network) (two 13 meter antennas)
- Svalbard, Norway (Kongsberg Satellite Services – KSAT) (two 11 meter, one 13 meter antennas)
- TrollSat, Antarctica (Kongsberg Satellite Services – KSAT) (one 7.3 meter antenna)
- Weilheim, Germany (Universal Space Network) (two 15 meter antennas)

Partner

- Gilmore Creek, Alaska (National Oceanic and Atmospheric Administration – NOAA) (three 13 meter antennas)

Near Earth Network Upgrades

11 meter AS3 antenna installed in Fairbanks, AK at the Alaska Satellite Facility

- Alaska
  - For over 20 years, the ground station at the Alaska Satellite Facility (ASF) has been providing launch, early-orbit, and on-orbit operations to Earth missions utilizing polar orbits.
  - Mission requirements and technology has changed and more sophisticated equipment is needed.
  - New antenna with an S- and X-band system with Ka-band upgrade capability was added in

- Florida
  - New antennas are under construction in order to support launch and early orbit support for future human missions.

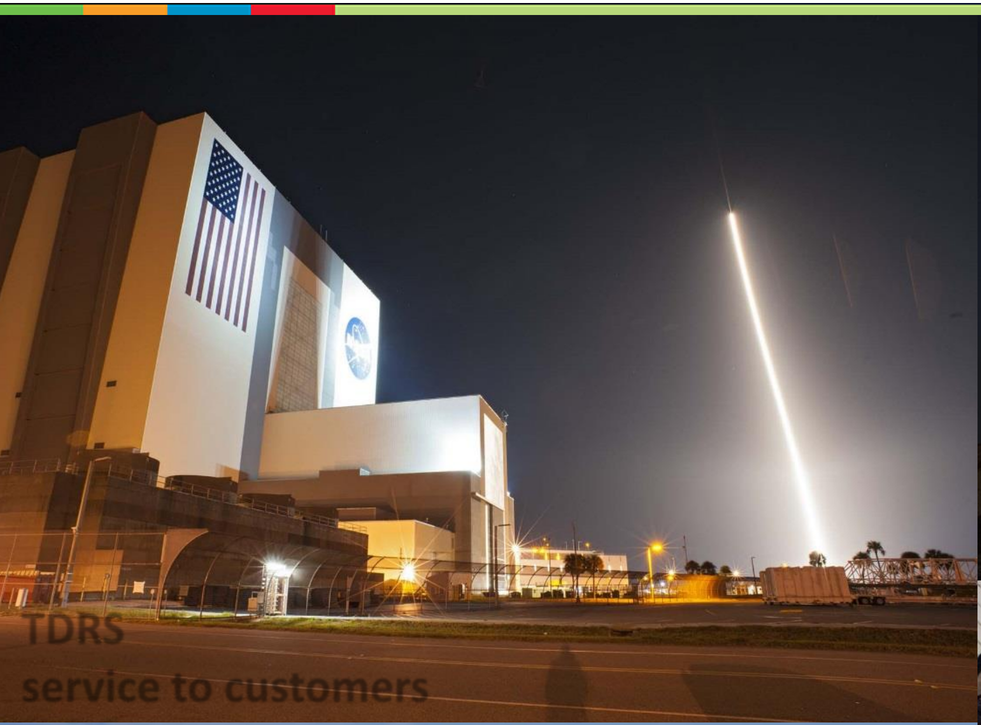
Example: Space Network Supported Missions

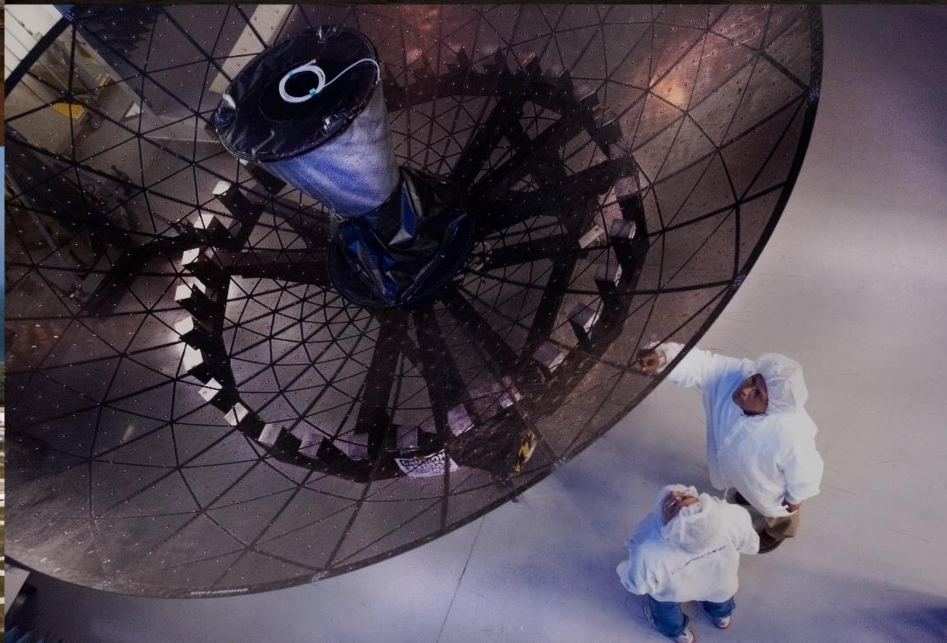
Space Network (SN)
Ground Segment

White Sands Complex
Location: White Sands, NM
Operated by: Harris Corporation
Antennas: three 19 meter, two 10 meter, five 4.5 meter, two 1 meter, three 18.3 meter

Guam Remote Station
Location: Guam Island
Operated by: Harris Corporation
Antennas: one 11 meter, two 16.5 meter, one 4.5 meter, one 5 meter; backup in Dongara, Australia – one 11 meter

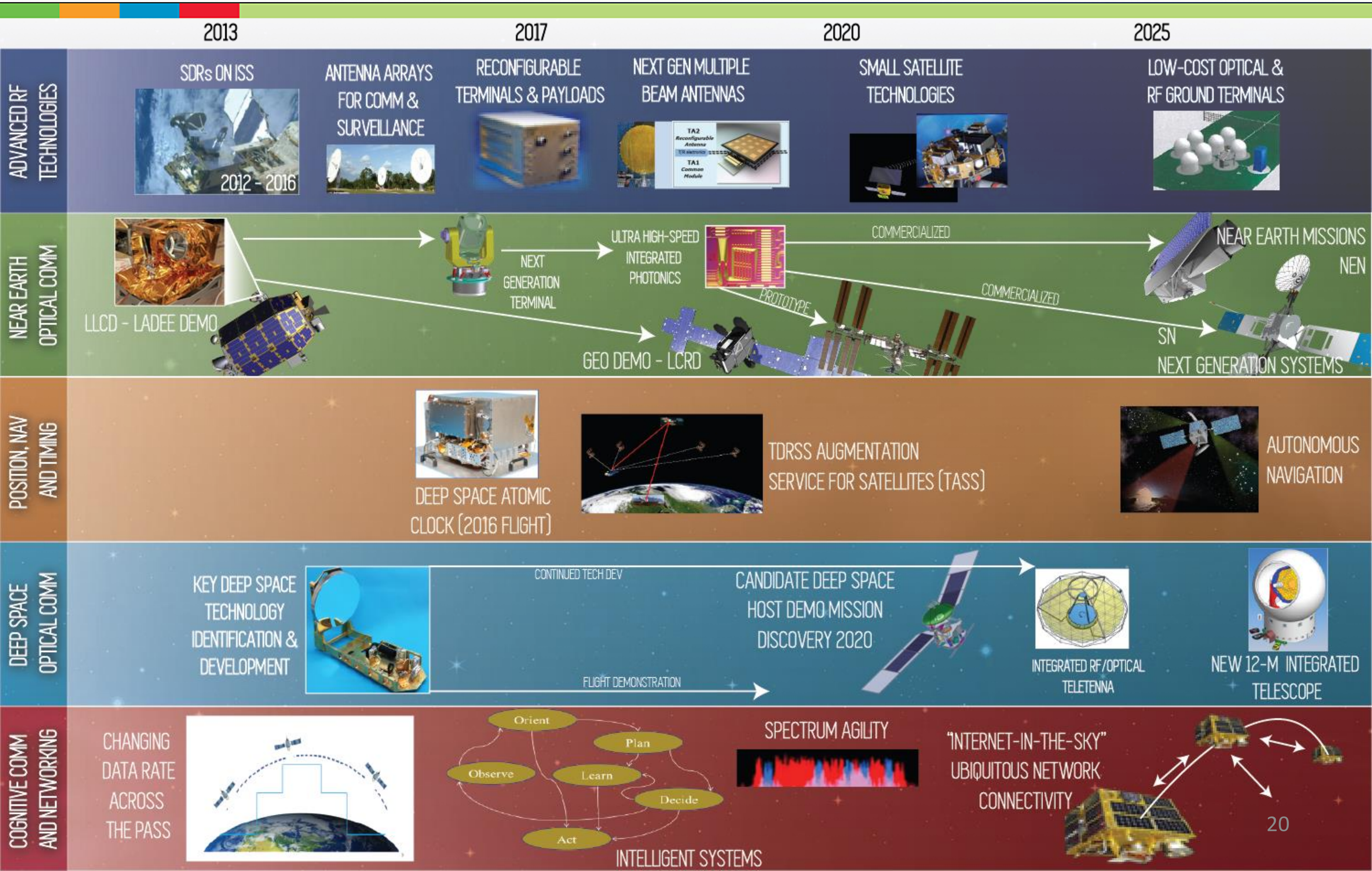
Space Network
Space Segment





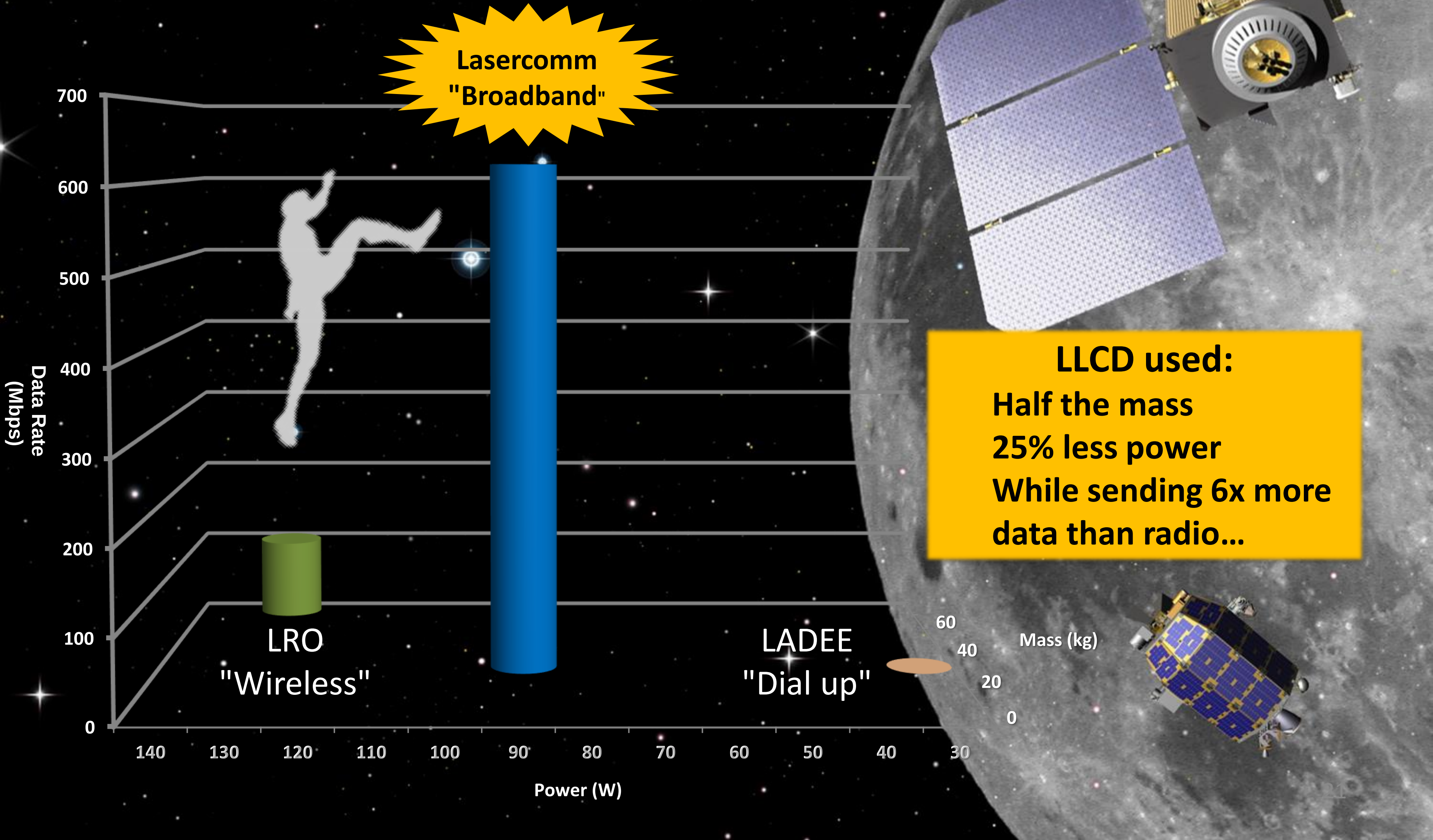
ADVANCED COMMUNICATIONS

SCaN's Future Advanced Communications Capabilities



Laser Communications – Higher Performance AND Increased Efficiency

A Giant Leap in Data Rate Performance for less Mass and Power



Laser Communication Relay Demonstration (LCRD) Mission for 2019

- Joint Space Technology Mission Directorate/ SCaN Mission
- Commercial spacecraft host
- Two to five years of mission operations
- Flight Payload
  - Two LLCD-heritage Optical Modules and Controller Electronics Modules
  - Two Differential Phase Shift Keying (DPSK) Modems with 2.88 Gbps data rate
  - New High Speed Electronics to interconnect the two terminals
  - RFI for "Guest Investigators" revealed significant commercial interest
- Key for Next-Gen TDRS (or equivalent) in 2024 timeframe

FUTURE ARCHITECTURE

Background for Current Studies

- Series of studies done in 2013-2015 defining future NASA Communications and Navigation (C&N) architecture, ConOps, and capabilities
  - Space-Based Relay Study (2013) included an industry RFI

- Current effort intended to complete the process well enough to support budget process including next major acquisitions' justification and cost estimates:
  - Earth Network: TDRS fleet capacity drops enough to require new capacity starting in ~2025
  - Mars Network: In addition to Mars 2022 mission, Mars Network concept must be planned to meet HEOMD and SMD needs
  - Optical communication: Transition joint MD investment in optical communication to Operations

- RFP released to industry for input to ensure thorough assessment of concepts and capabilities before decisions are made
  - Vision and architecture concepts presented today are work in progress

SPECTRUM

WRC-15 Overview

- 2015 World Radiocommunication Conference (WRC-15) took place in Geneva, SW, 2-27 November 2015
  - Over 160 International Telecommunication Union members participated in treaty-based modifications to the ITU Radio Regulations
- Technical preparatory work done in the ITU Radiocommunication Sector Study Groups
- Conference Preparatory Meeting (CPM) report contained approaches (Methods) for satisfying each agenda item (technical basis upon which Administration proposals are made)
- US Regulators oversee conference preparations by Federal Government (NTIA) and private sector (FCC)
- U.S. Delegation to WRC-15 lead by Ambassador Decker Anstrom

Space Science Issues During WRC-15

Short Title	Agenda Item	Goal	Outcome	Rating
EESS uplink in the 7-8 GHz range	1.11	Add a global primary EESS allocation in the band 7190 – 7250 MHz	A global primary EESS allocation in the band 7190 – 7250 MHz with minimal coordination requirements	A+ Full objectives achieved
EESS (active) +600 MHz in the 8-10 GHz range	1.12	Primary allocation of 100 MHz below and 500 MHz above the current allocation with no PFD limit	Primary allocation of 100 MHz below and 500 MHz above the current allocation with acceptable PFD limit restrictions	A Protections of incumbent and adjacent band services is assured
SRS (space-to-space) at 410-420 MHz	1.13	Modify RR No. 5.268 to remove both the 5 km distance limitation and restriction to EVA operation	RR No. 5.268 modified as desired	A+ Objectives achieved while maintaining the pfd limits to protect the terrestrial services

Summary

- SCaN is upgrading NASA's space communications infrastructure to maintain its high level of excellence, while increasing demand for the future requirements for high data return.
- SCaN continues to develop and demonstrate leading edge space communications technologies, including optical communication, in order to meet future mission needs.
- NASA's journey to Mars – both for humans and robotics – relies on these space communications and navigation capabilities.

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