National Aeronautics and Space Administration

NASA

ESC Exploration & SPACE Communications

More than you ever imagined...

NASA's Space Communications

By Dr. Harry Shaw

September 12-13, 2018

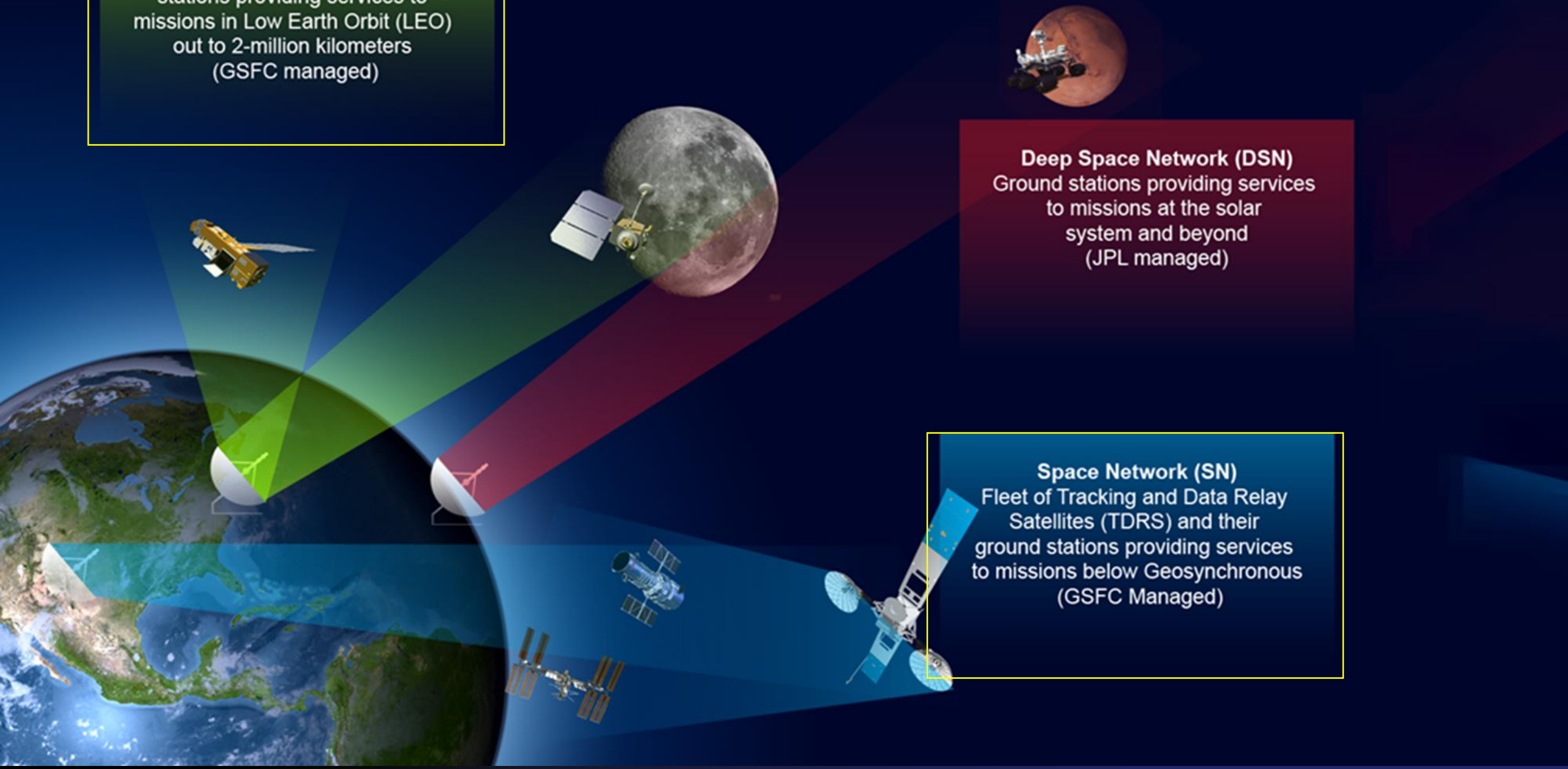
Acronym List

DSN	= Deep Space Network
EM	= Exploration Mission
GRGT	= Guam Remote Ground Terminal
GSFC	= Goddard Space Flight Center
HSF	= Human Space Flight
LCRD	= Laser Communications Relay Demonstration
LEO	= Low Earth Orbit
MBPS	= Megabits Per Second
NEN	= Near Earth Network
RF	= Radio Frequency
SGSS	= Space Network Ground Segment Sustainment
SN	= Space Network
TDRS	= Tracking and Data Relay Satellite
WSGT	= White Sands Ground Terminal

NASA's COMMUNICATIONS NETWORKS

National Aeronautics and Space Administration

Near Earth Network (NEN)
NASA and commercial ground stations providing services to missions in Low Earth Orbit (LEO) out to 2-million kilometers (GSFC managed)



Deep Space Network (DSN)
Ground stations providing services to missions at the solar system and beyond (JPL managed)

Space Network (SN)
Fleet of Tracking and Data Relay Satellites (TDRS) and their ground stations providing services to missions below Geosynchronous (GSFC Managed)

Goddard Space Flight Center

23

launches supported per year on average. Expected to double with increased HSF and CubeSat missions

98%

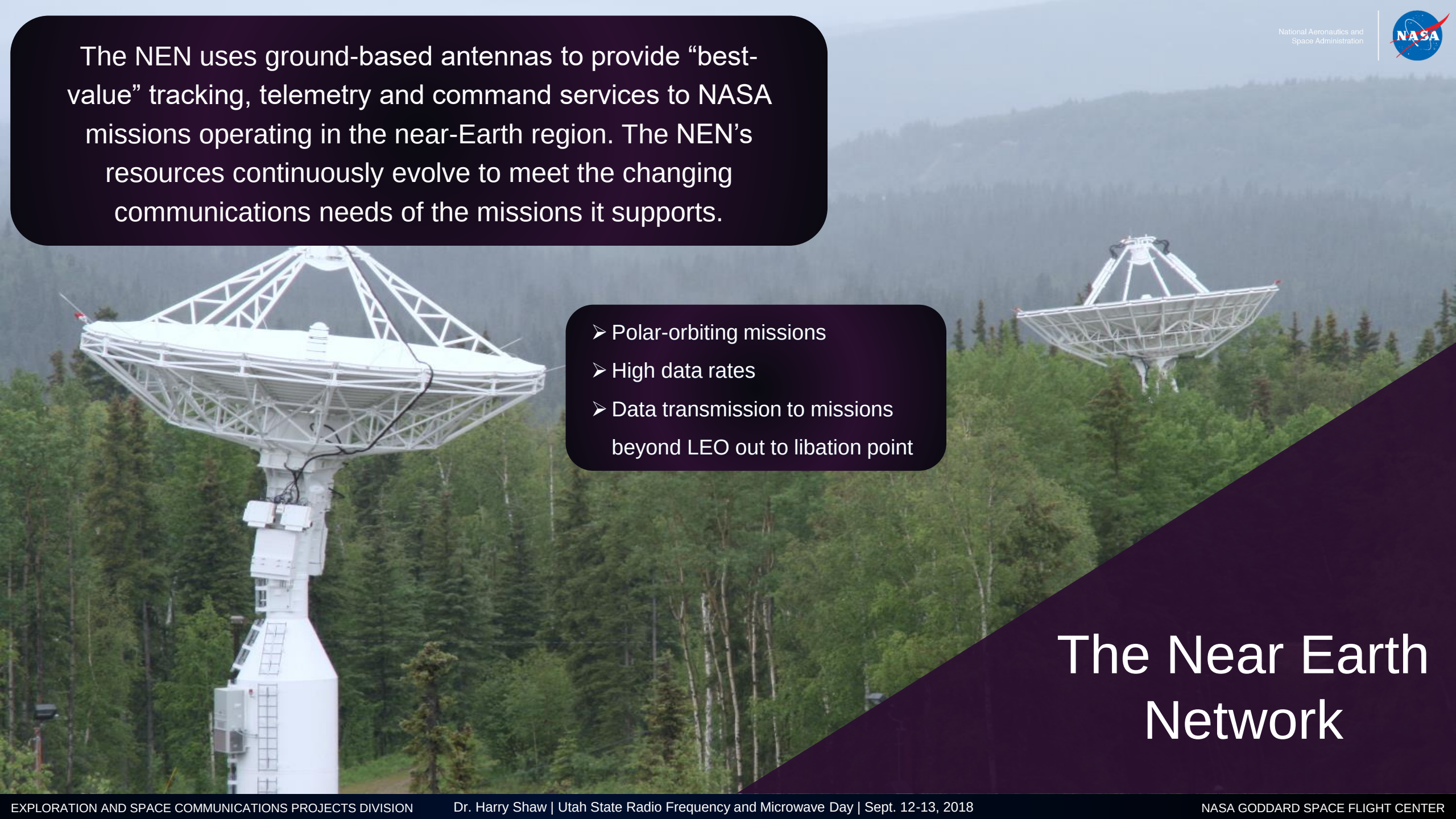
of NASA data transmitted goes through Goddard each day as of July 2016.

1,200

Blu-ray disks worth of data $_{est.}$ equates to the volume that SN and NEN handle every day.

The Near Earth Network

The NEN uses ground-based antennas to provide “best-value” tracking, telemetry and command services to NASA missions operating in the near-Earth region. The NEN’s resources continuously evolve to meet the changing communications needs of the missions it supports.



- Polar-orbiting missions
- High data rates
- Data transmission to missions beyond LEO out to libation point

The Near Earth Network

National Aeronautics and Space Administration

Alaska Satellite Facility
Faribanks, Alaska

NOAA FCDAS Ground Station
Gilmore Creek, Alaska

SSC/USN Alaska
North Pole, Alaska

KSAT Svalbard Satellite Station
Svalbard, Norway

KSAT Singapore Satellite Station
Singapore

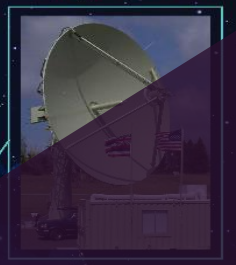
Swedish Space Corporation
Kiruna, Sweden

Wallops Ground Station
Wallops, Virginia

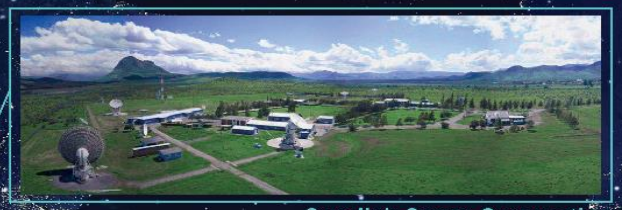
White Sands 1 Antenna
White Sands, New Mexico

Launch Communications Segment
Florida and Bermuda

SSC/USN Australia
Dongara, Australia



SSC/USN Hawaii
South Point, Hawaii



Swedish Space Corporation
Santiago, Chile

KSAT Troll Satellite Station
Troll, Antarctica

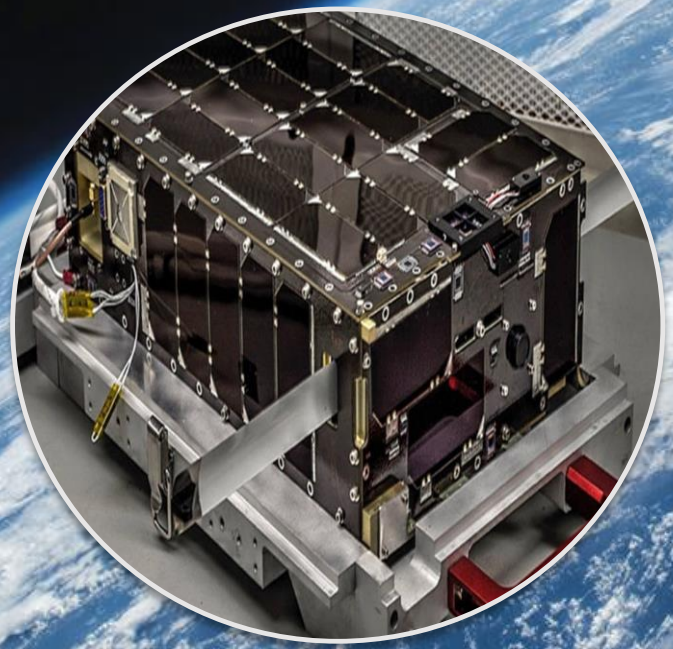
SANSA Ground Station
Hartebeesthoek, South Africa

McMurdo Ground Station
McMurdo Base, Antarctica

Near Earth Network: NASA
Near Earth Network: Partner
Near Earth Network: Commercial

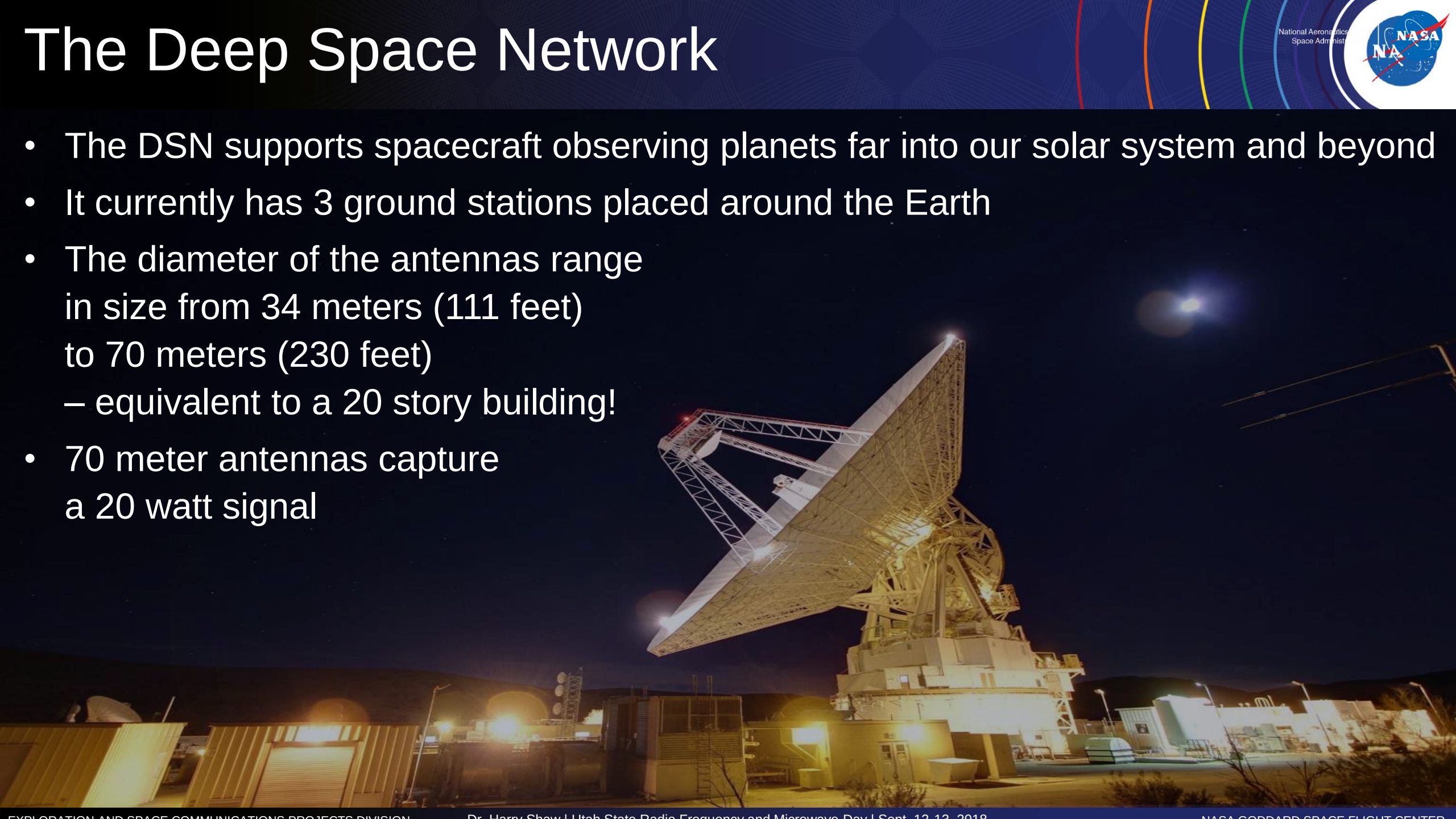
NASA's CubeSats

CubeSats, also known as nanosatellites, offer a low-cost way to get science data from space. These missions typically last 90 days and are intended for small-scale research projects. NASA often partners with universities and schools to create some of these short-term research projects.

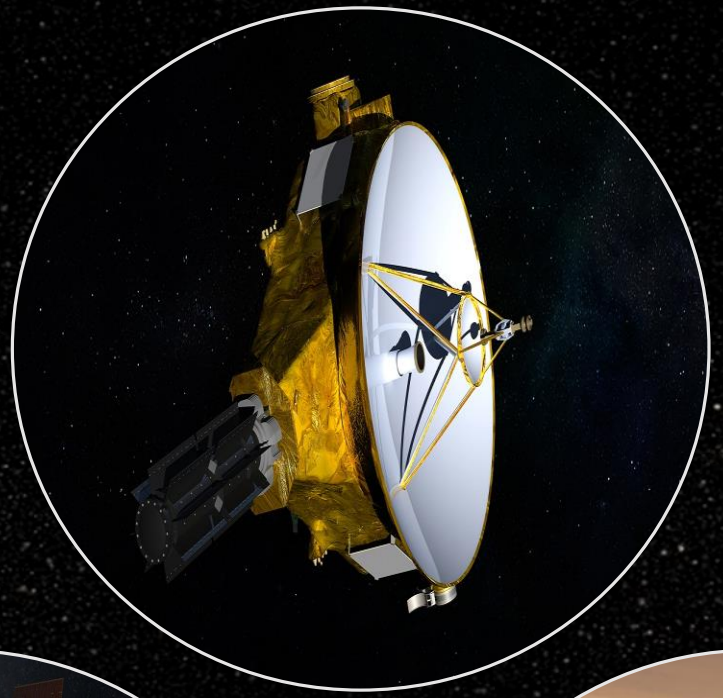


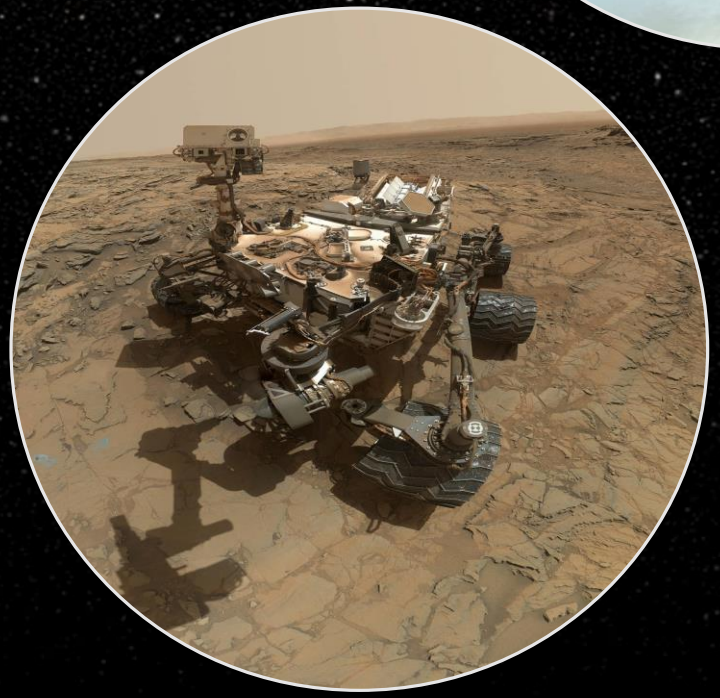
The Deep Space Network

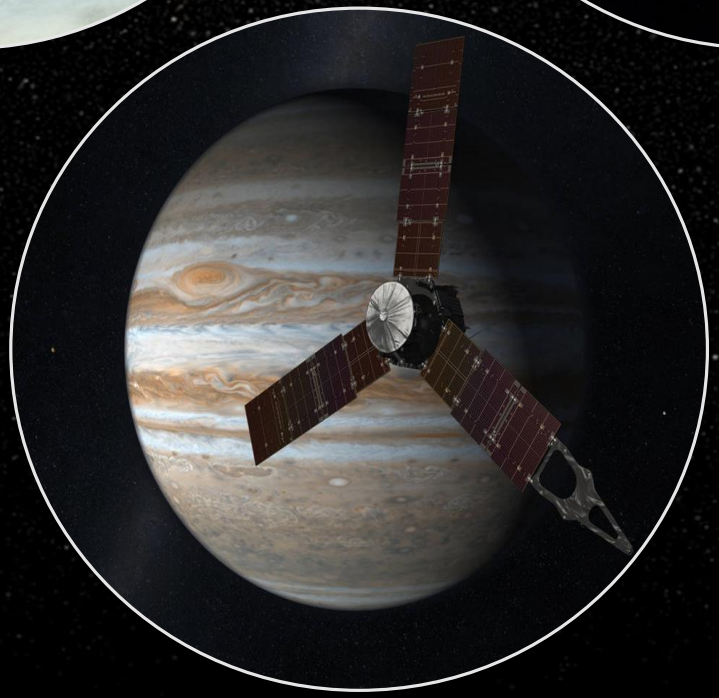
- The DSN supports spacecraft observing planets far into our solar system and beyond
- It currently has 3 ground stations placed around the Earth
- The diameter of the antennas range in size from 34 meters (111 feet) to 70 meters (230 feet) – equivalent to a 20 story building!
- 70 meter antennas capture a 20 watt signal

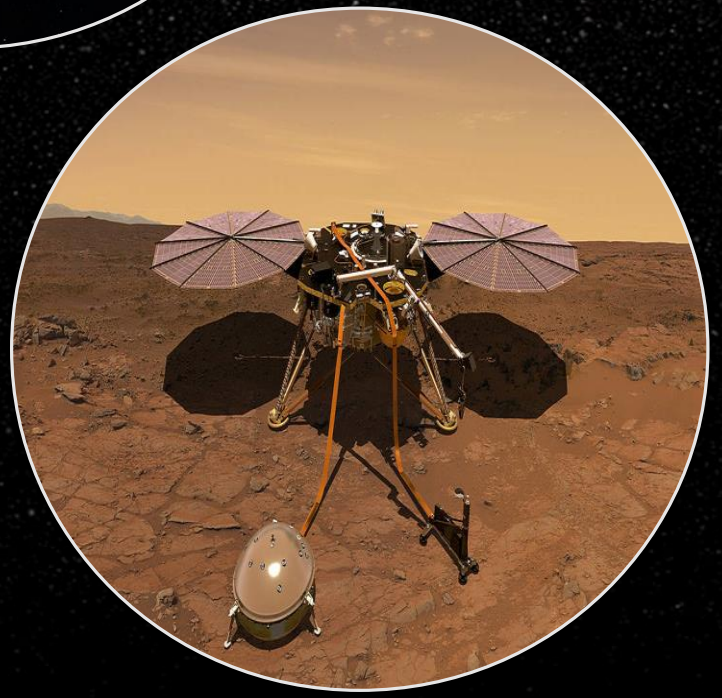


Deep Space Customers









The Space Network

National Aeronautics and Space Administration

Image Placeholder for TDRS Constellation Video

The TDRS Constellation

(Ctrl)

The Space Network

- The Space Network (SN) is a combination of national and international ground stations paired with NASA's Tracking and Data Relay Satellite (TDRS) fleet
- Currently, there are 13 TDRSs geosynchronously orbiting the Earth at 22,000 miles

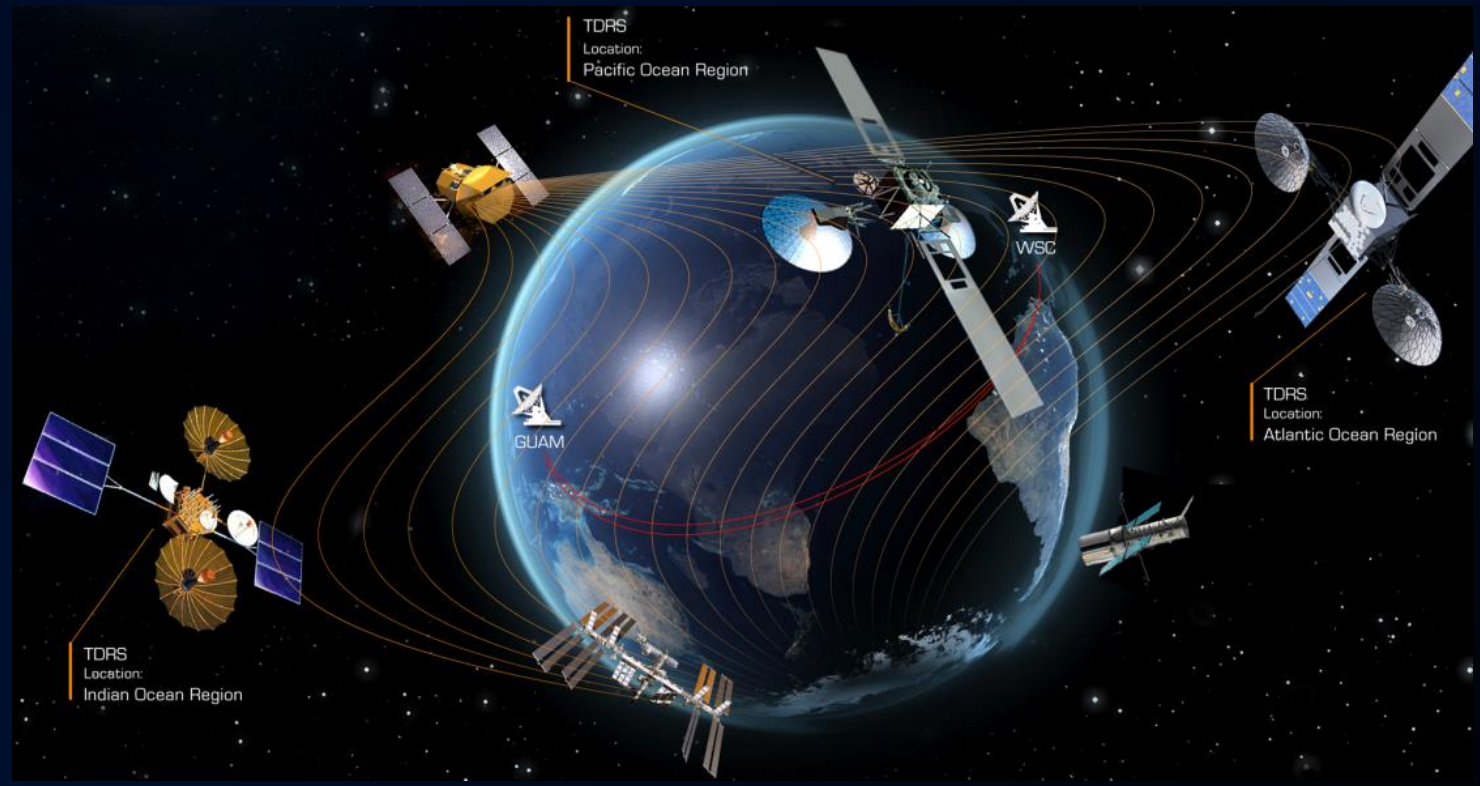
WSGT

GRGT

- Using radio frequency (RF) the SN is capable of transmitting to and receiving data from spacecraft with 100% coverage of the satellites orbit
- Data collected on user spacecraft is sent to a TDRS, which then downlinks the data to the White Sands Ground Terminal (WSGT) or the Guam Remote Ground Terminal (GRGT). This data is then sent to the customer.

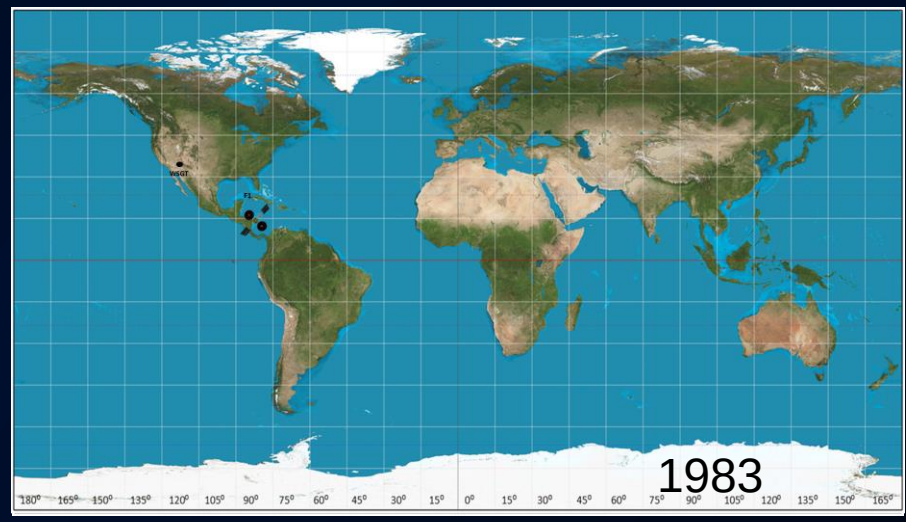
Space Network Capabilities

- S-band RF capabilities
- Increased transmission rates
- Coverage of 3 major oceanic regions
- The SN provides tracking and data acquisition services between low Earth orbiting (LEO) spacecraft and data processing facilities.
- The position, time and frequency data provided by the SN enables users to maintain precise spacecraft orbit prediction, orbit determination and attitude determination and control.

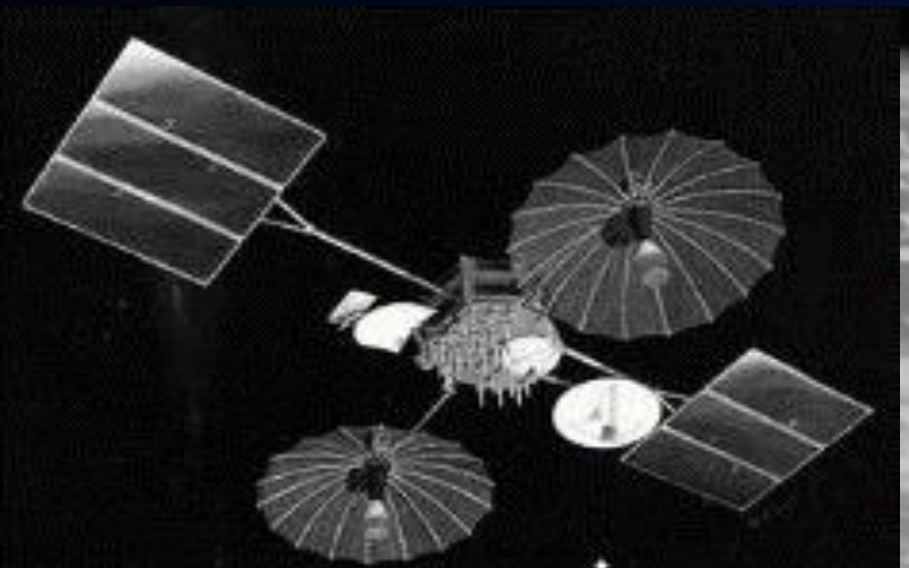


TDRS Replenishment

- The TDRS fleet is comprised of three generations
- There are 13 TDRSs currently in orbit
- New TDRSs are launched to:
  - Replenish outdated TDRSs in LEO
  - Support higher data rates
  - Enhance communications security



First Generation
TDRS-A to TDRS-G



Second Generation
TDRS-H to TDRS-J

Third Generation
TDRS-K to TDRS-M

Space Network Users

Human Spaceflight

TDRS supports Human Space Flight (HSF) missions bringing humans to new frontiers in Earth's orbit and beyond

Earth Science Missions

TDRS supports Earth Science missions that explore Earth events and processes vital to human civilization. Together, they offer Earth science researchers the necessary data to address key questions about global climate change and the future of the Earth system.

Space Science Missions

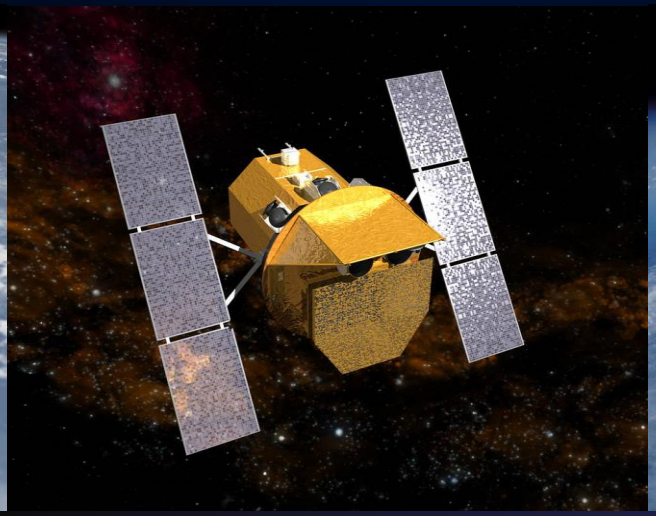
TDRS supports Space Science missions that investigate the farthest reaches of space. Through them, we learn new information about the scope and scale of the cosmos.

Launch Vehicles

TDRS provides a variety of support services to the launch vehicles NASA uses to send missions into space.

TDRS Customers

- Magnetospheric Multiscale Mission
- Swift Gamma-Ray Burst Mission
- International Space Station
- Hubble Space Telescope
- Global Precipitation Measurement Mission



TDRS-M

- Launched on August 18, 2018 at 12:29 pm
- Launch vehicle was an Atlas 5 designated AV-074 401
- Launched from Kennedy Space Center in Cape Canaveral, Florida
- Weight at liftoff was 745,000 pounds
- Height is 191 feet (58 meters)
- TDRS-M is the 13th and final TDRS

Image Placeholder for TDRS-M Launch video

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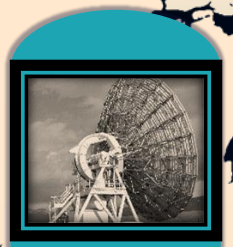


White Sands Complex

Guam Remote Ground Terminal

Recent Space Network Enhancements

- Integrate ground equipment to support new waveform for Orion services at WSGT and GRGT
- Targeted locations for new equipment based on EM-1 requirements
- Modified monitor and control software
- Developed new operator consoles to configure ground equipment
- Developed software to deliver newly formatted tracking data messages directly to Johnson Space Center
- Reduce SN obsolescence issues until SGSS integration at WSC

Space Network 2018 Summer Interns

The Future of Space Communications

New communications systems will continue enabling NASA to support tremendous volumes of data at higher rates with quicker response times.

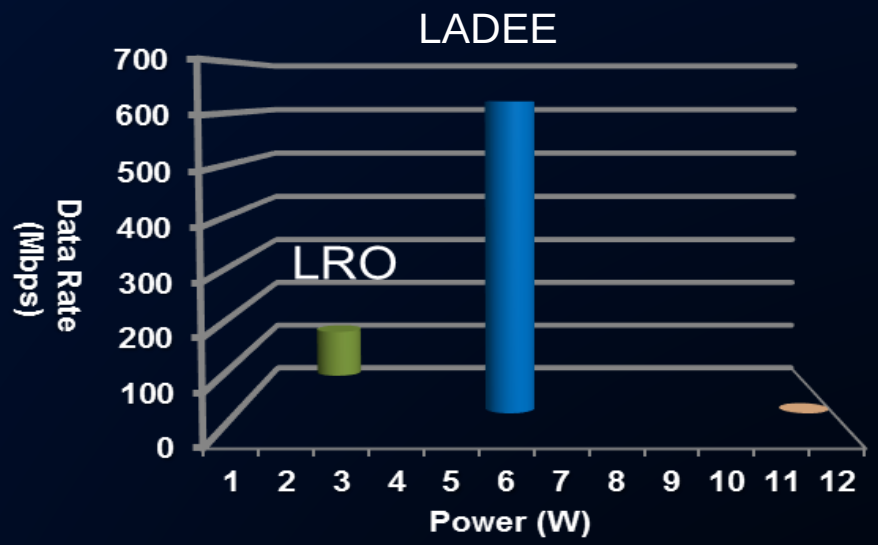
Goddard Space Flight Center is developing and testing optical communications technology to enhance communications and navigation activities and services for the user.

Optical Communications

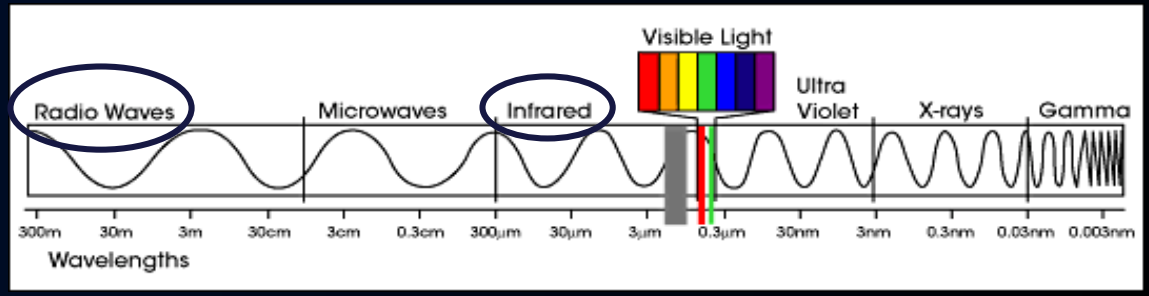
Optical communications systems are under development to enable unprecedented volumes of data return with quicker response times.

Optical communications will enable:

- Greater Speed and Volume
- Less SWaP
- Greater Availability



SWaP

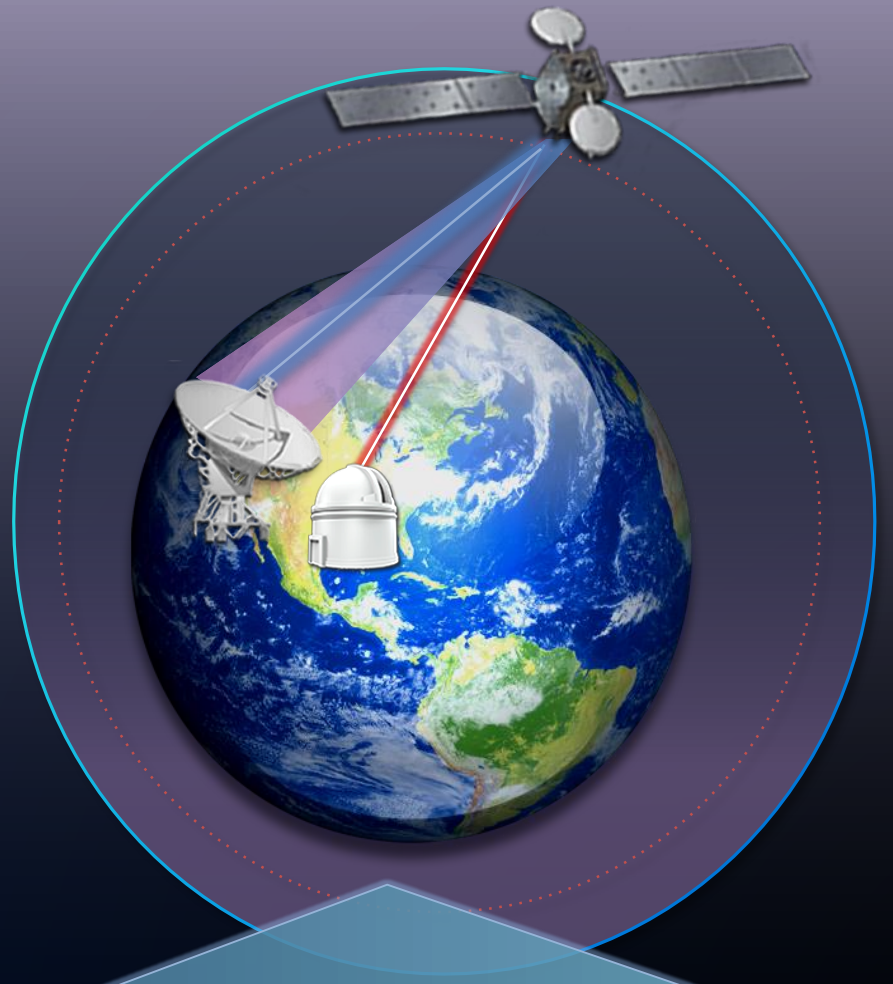


Advantages of Optical

Faster

40% more

Higher Data Rates

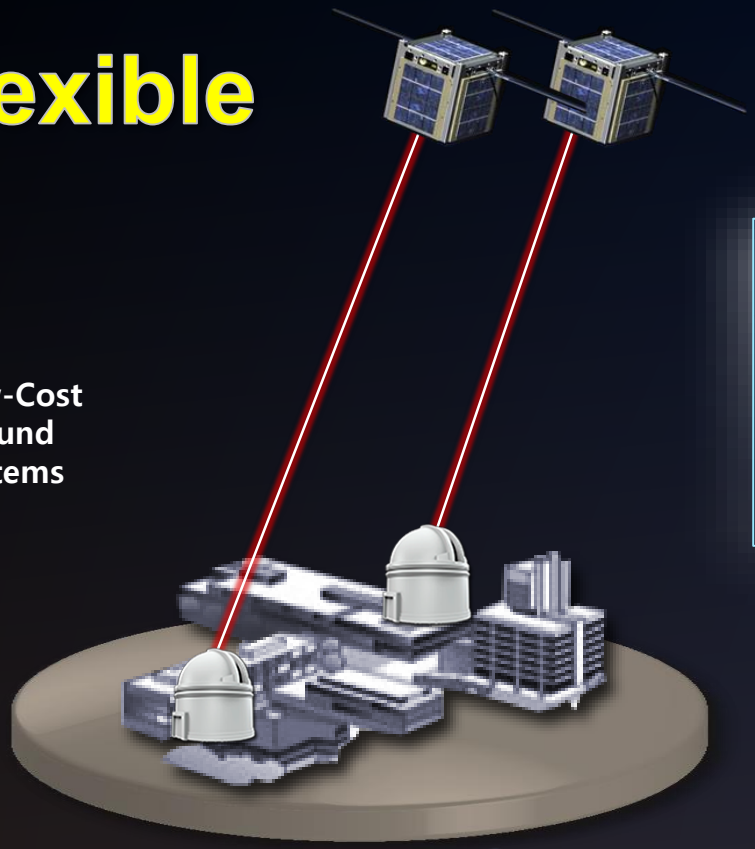


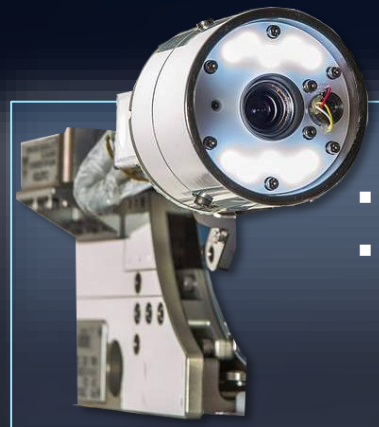
Higher bandwidths enable mission data to be downloaded using shorter contact times, decreasing the number of relay terminals and ground sites.

Advantages of Optical

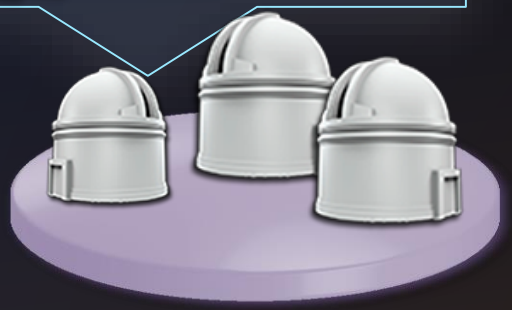
Flexible

Low-Cost Ground Systems





- 100 Gb/sec
- COTS-Based Solution



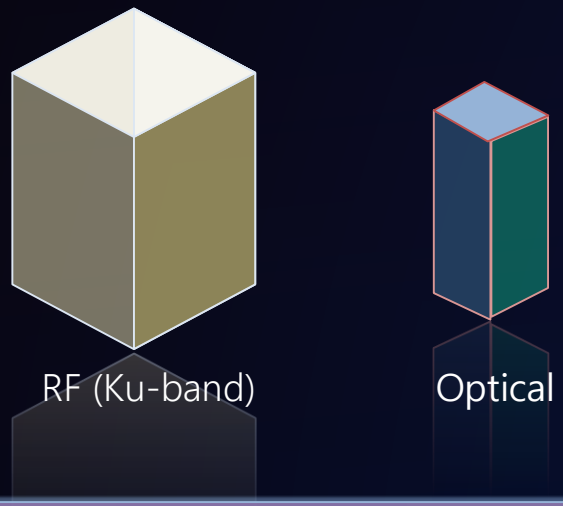
Low-cost ground segments located at mission sites or data centers lower costs, enable direct control and create decreased ground data transport expenses.

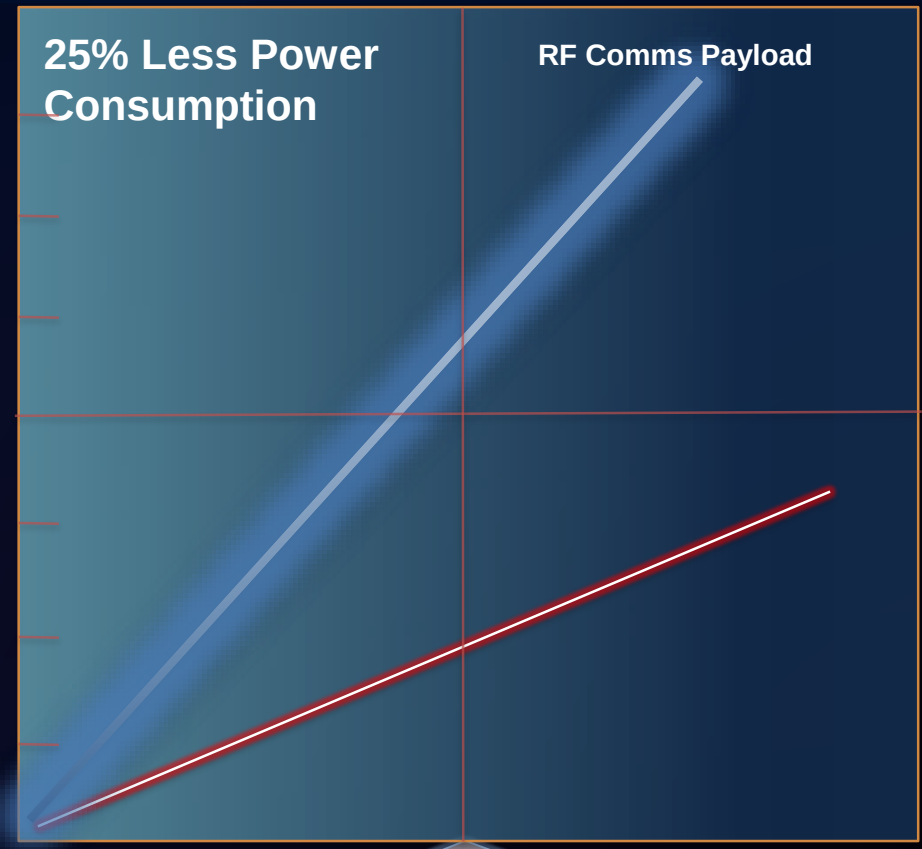
Advantages of Optical

Lighter

50% less Mass

SWaP





Laser communications allow for smaller, lighter flight communications systems that require less power cost savings for missions.

2013: LLCD
Lunar Laser Comm Demo

2019: LCRD
Laser Comm Relay Demo

2022: DSOC
Deep Space Optical Comm

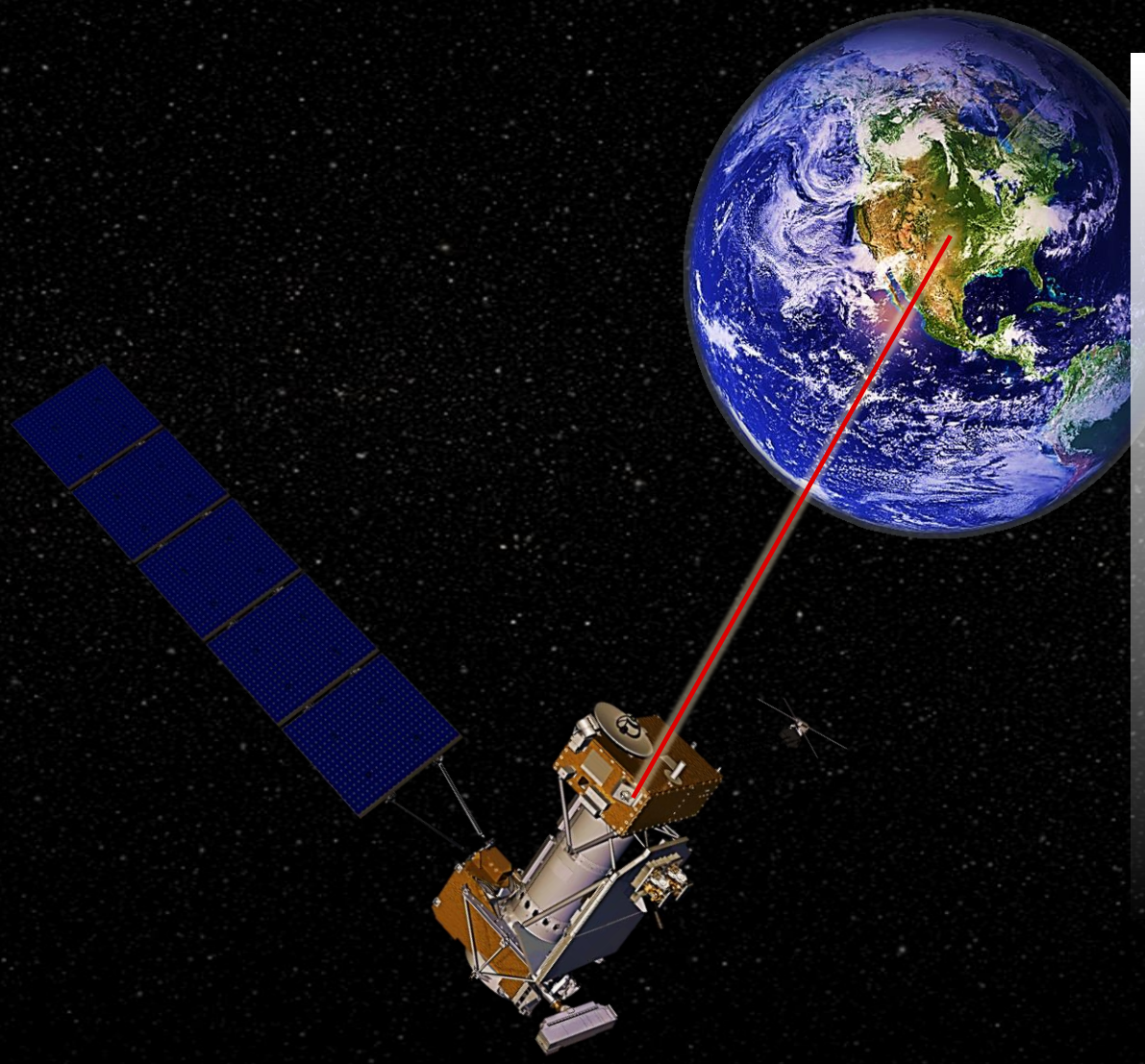
Optical Communications In Action

2014: OPALS
Optical PAyload for Lasercomm Science

2021: ILLUMA-T
Integrated LCRD LEO User Modem and Amplifier - Terminal

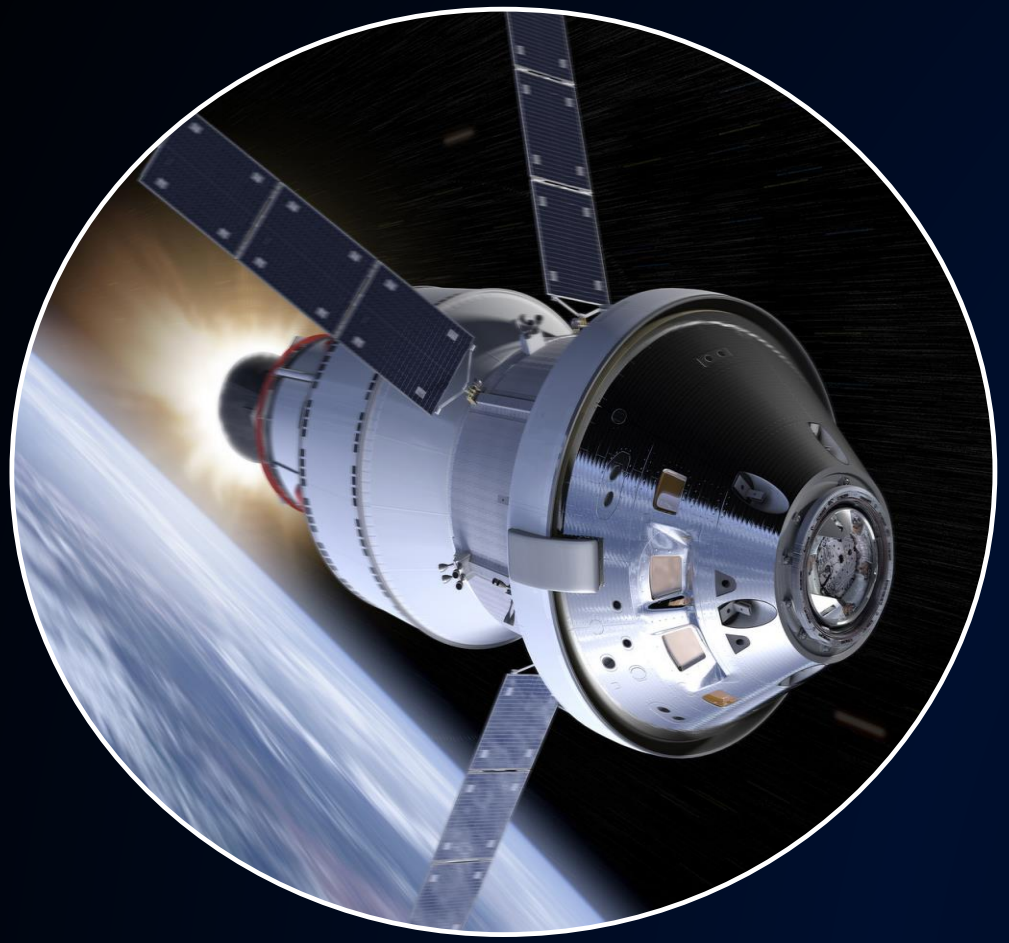
2022: O2O
Optical to Orion

Laser Communications Relay Demonstration



The Laser Communications Relay Demonstration (LCRD) will provide at least two years of continuous high-data-rate optical communications from geosynchronous orbit. The relay demonstration will evaluate technologies for both LEO and deep-space applications. The demonstration will leverage existing systems and designs with minimal modifications to gain operational experience while minimizing cost. The demonstration will showcase a reliable, capable and cost-effective optical communications technology for infusion into future operational systems

Orion Exploration Mission-2



Orion EM-2 will be the first spacecraft in over 30 years to take astronauts beyond the moon.

EM-2 will use optical communication to downlink data to science users and mission control at Johnson Space Center.

EM-2 will enhance upon the capabilities of its predecessor EM-1, which will be using radio frequency.

An Optical Communications Terminal for the Orion Spacecraft

Optical to Orion EM-2

RETURN OPTICAL RATES

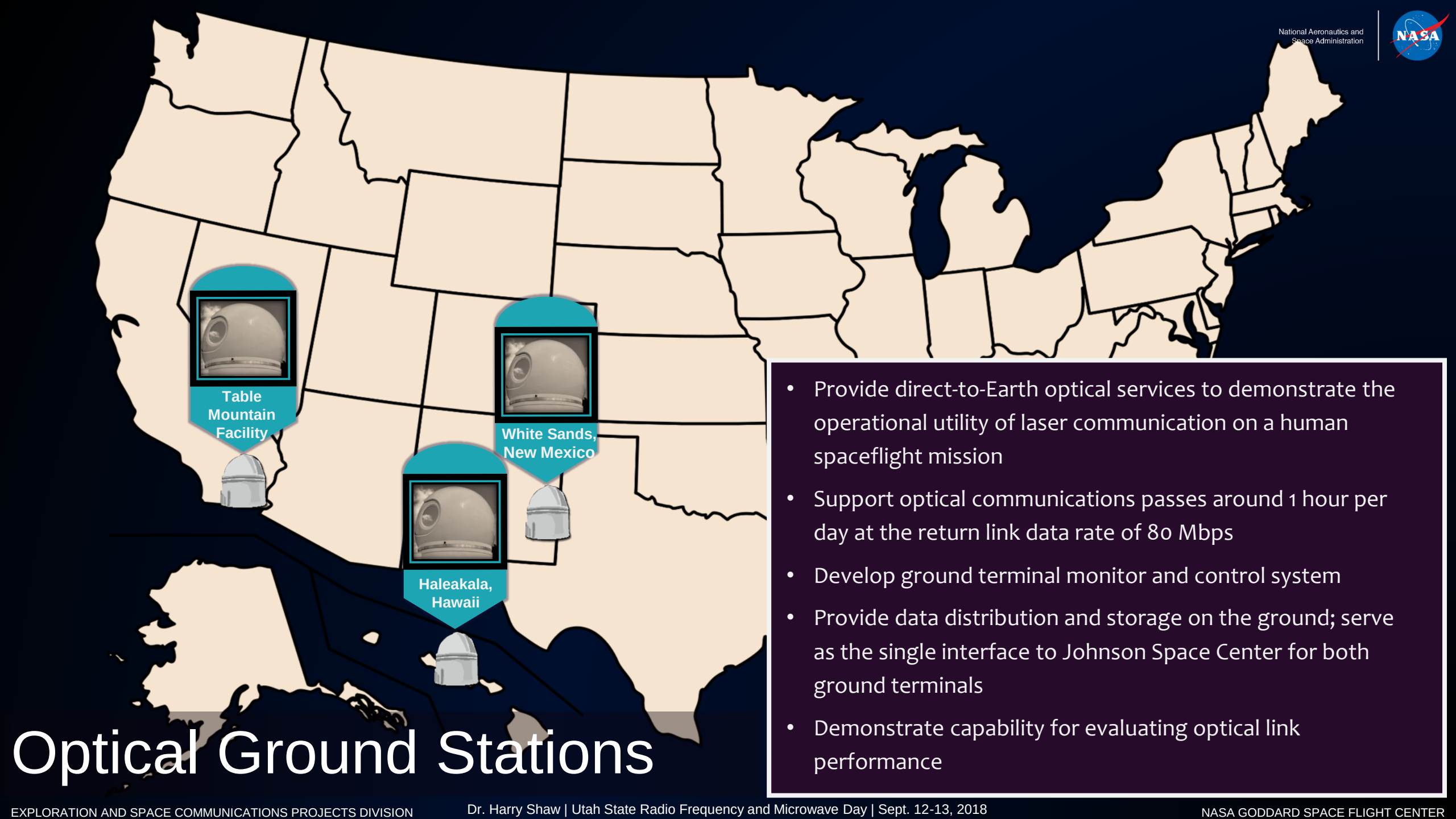
256 MBPS

THAT'S EQUIVALENT TO DOWNLOADING 8 SONGS PER SECOND

GET:

ULTRA HD IMAGES AND VIDEOS

UNCOMPRESSED OPERATIONS PRODUCTS



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Optical Ground Stations

- Provide direct-to-Earth optical services to demonstrate the operational utility of laser communication on a human spaceflight mission
- Support optical communications passes around 1 hour per day at the return link data rate of 80 Mbps
- Develop ground terminal monitor and control system
- Provide data distribution and storage on the ground; serve as the single interface to Johnson Space Center for both ground terminals
- Demonstrate capability for evaluating optical link performance

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- twitter.com/NASA_TDRS