NASA SCaN Overview and Ka-band Activities

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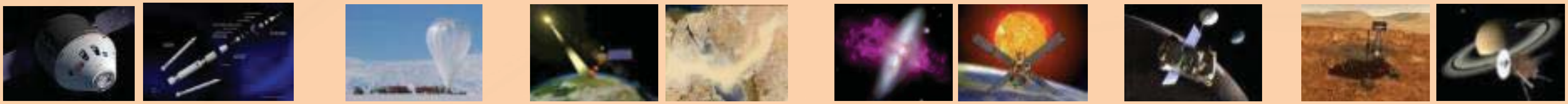
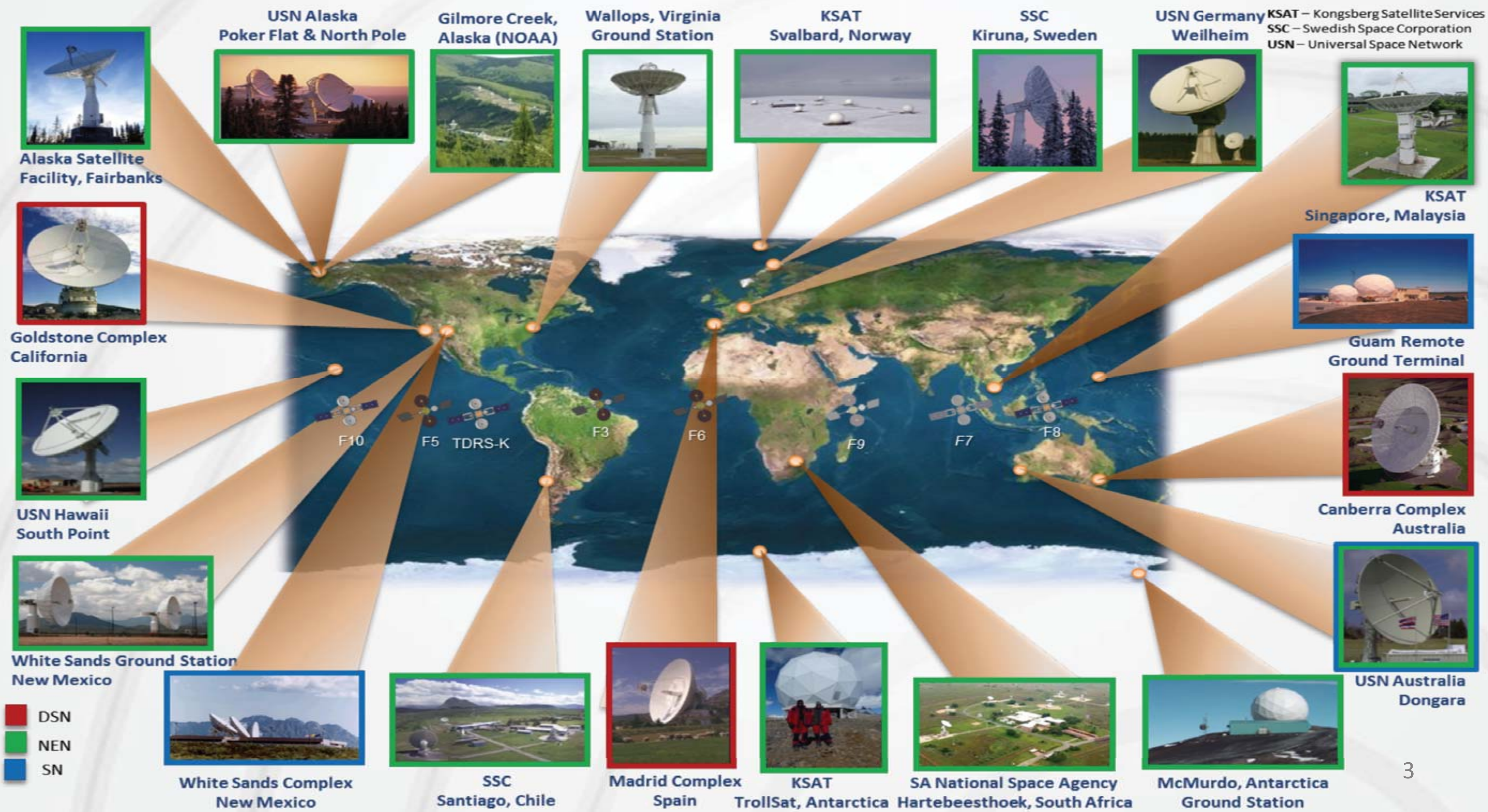
SCaN's Vision

To build and maintain a scalable integrated mission support infrastructure that can readily evolve to accommodate new and changing technologies, while providing comprehensive, robust, cost effective, and exponentially higher data rate space communications services to enable NASA's science, space operations, and exploration missions.

Today's SCaN Networks

Human Spaceflight Missions | Sub-Orbital Missions | Earth Science Missions | Space Science Missions | Lunar Missions | Solar System Exploration





Overview of the Three Networks

Deep Space Network	Near Earth Network	Space Network
		
Three-station global network of large-scale antennas (34 and 70 meter) Focused on detecting and differentiating faint signals from stellar noise Optimized for data capture from deep space distances orders of magnitude above near Earth	World-wide network of stations Evolved from fully NASA-owned to a 50/50 % owned assets and procured commercial services Surge capability through partnerships (e.g., NOAA) Optimized for cost-effective, high data rate services	Global orbital satellite communications fleet with ground control stations Optimized for continuous, high data rate communications Critical for human spaceflight safety and critical event coverage Critical support to missions with low latency requirements
Government owned, JPL managed and sustained; contractor operated and maintained	50% government, and 50% commercial owned and managed. Government portion is operated and maintained by contractors	Government owned; contractor operated and maintained
Kepler, Cassini, Mars Rovers and Orbiters , Mars Science Laboratory (Curiosity) Voyagers 1 and 2, Spitzer Space Telescope, etc. Examples of future missions: MAVEN, SELENE-2, etc.	Aqua, Aura, Lunar Reconnaissance Orbiter, Landsat, Radiation Belt Storm Probes, etc. Examples of future missions: OCO-2, GPM, SMAP, etc.	International Space Station ISS Resupply: NASA CoTS, ESA ATV, JAXA HTV Terra, Fermi Gamma-ray Space Telescope, Hubble Space Telescope; etc. Examples of future missions: JPSS, GOES-R, GPM, IceSat-2, etc.

Deep Space Network (DSN)

Canberra Deep Space Communications Complex

Goldstone Deep Space Communications Complex

Madrid Deep Space Communications Complex

NASA's Deep Space Network (DSN) was established in December 1963 to provide a communications infrastructure for all of NASA's robotic missions beyond Low Earth Orbit.

Near Earth Network (NEN)

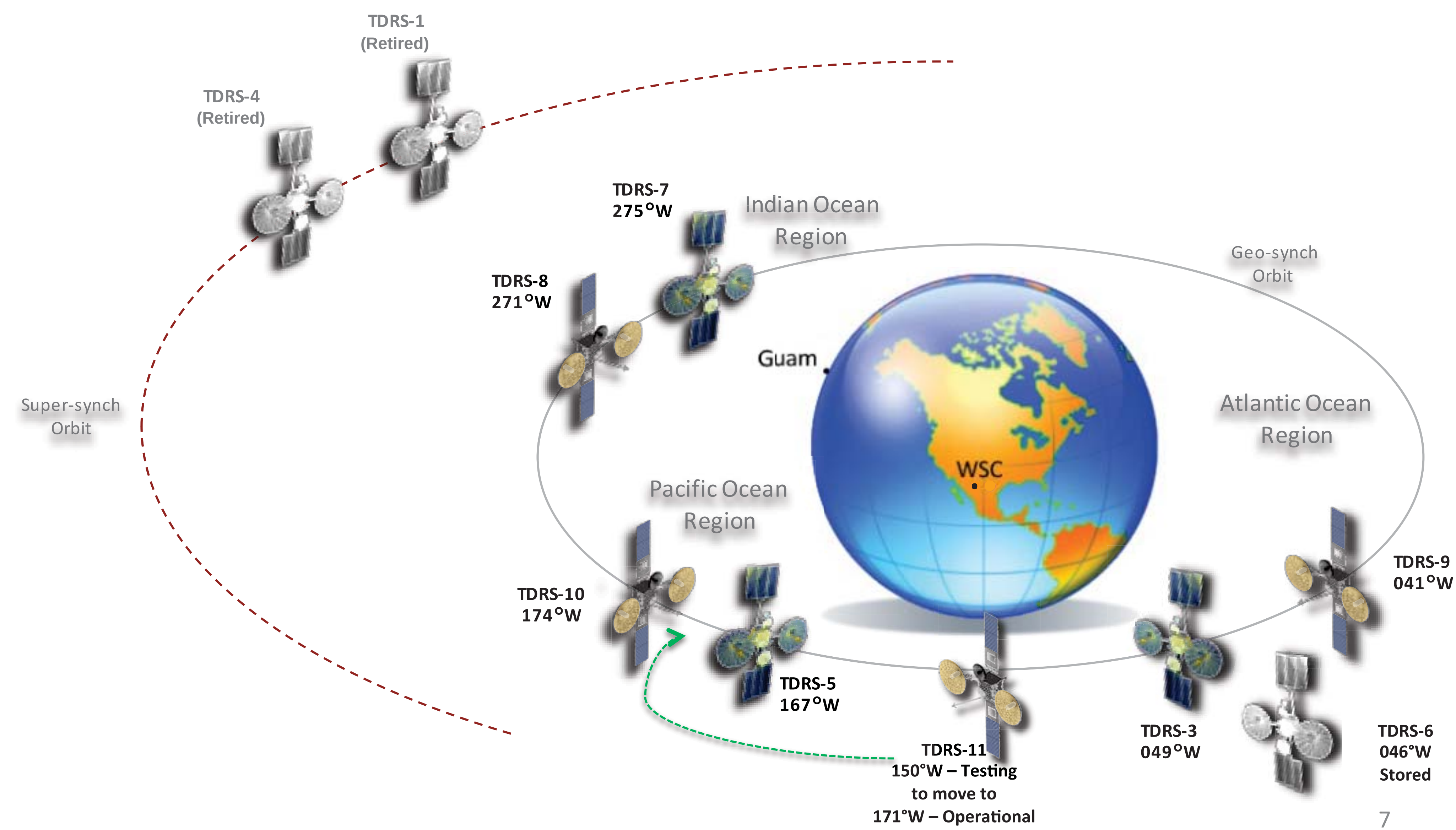
Svalbard Ground Station

McMurdo Ground Station

WS1 Antenna at White Sands

Wallops Ground Station (WGS)

Space Network
Tracking and Data Relay Satellite Fleet



Historical Ka-Band Activities and Roles NASA

Ka-Band Propagation Research – Glenn Research Center

Mission Integration Activities – Jet Propulsion Laboratory

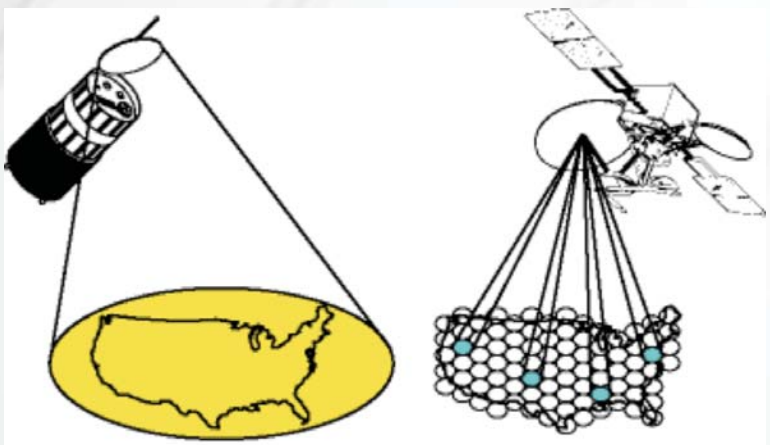
Development and Operations – Goddard Space Flight Center

Ka-Band and Science – NASA Headquarters

ACTS
Glenn Research Center

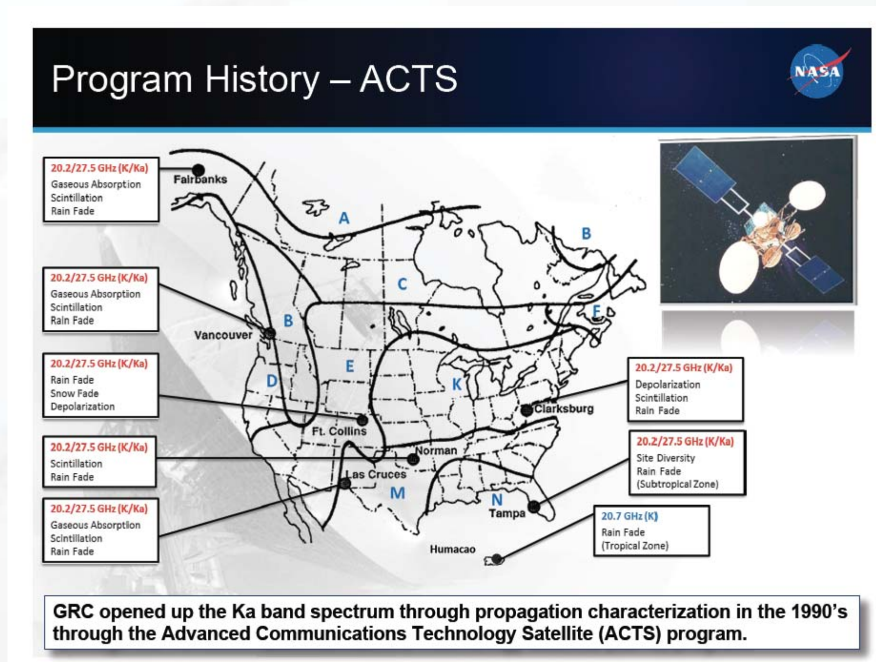
ACTS was developed as an experimental on-orbit, advanced communications satellite test bed, bringing together industry, government, and academia to conduct a wide range of technology, propagation, and user application investigations. NASA Glenn Research Center awarded in August 1984 the ACTS contract to an industry team consisting of:

- Lockheed Martin, East Windsor, NJ for system integration and the spacecraft bus;
- TRW, Redondo Beach, CA for the spacecraft communications payload;
- COMSAT Laboratories, Clarksburg, MD for the network control and master ground station;
- Motorola, Chandler, AZ for the baseband processor; and
- Electromagnetic Sciences, Norcross, GA for the spot-beam forming networks.

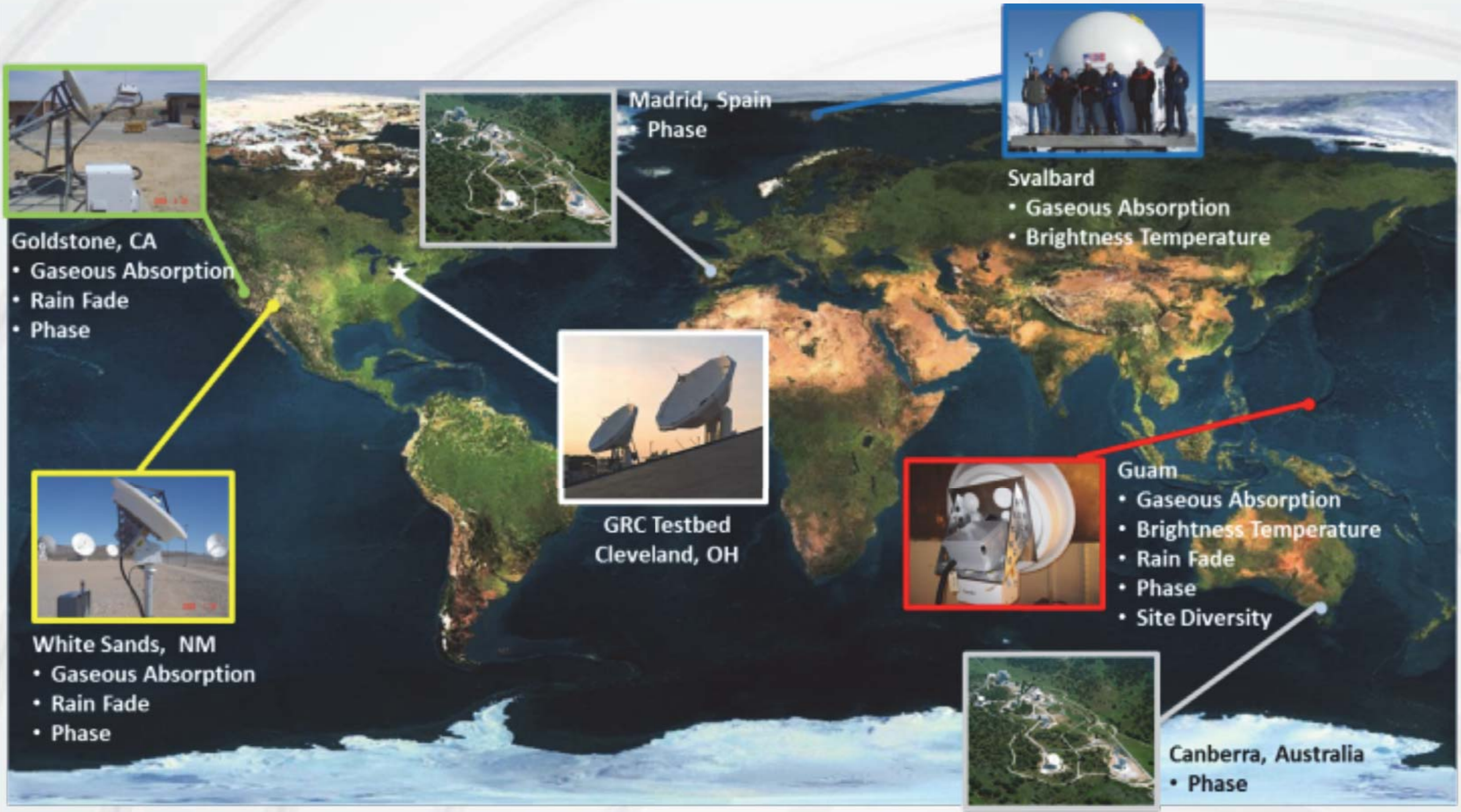


Conventional satellite single-beam broadcast.

ACTS spot beam and switching.

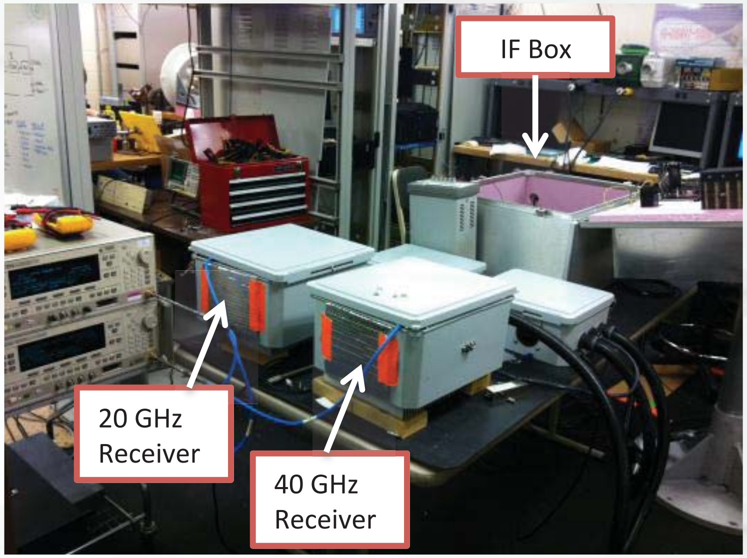


Propagation Research
Glenn Research Center (1/2)



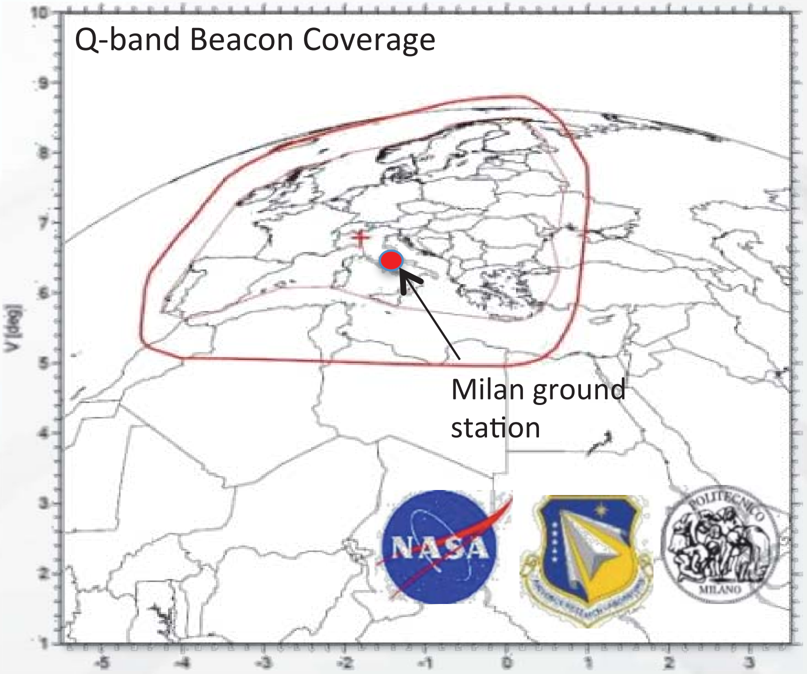
Propagation Research Glenn Research Center (2/2)

- International collaboration with AFRL and Politecnico di Milano (POLIMI) to characterize 40 GHz propagation effects (up to 99.9% availability)
  - GRC to provide Alphasat propagation terminal
  - AFRL to provide radiometer system and funding for operations and maintenance
  - POLIMI to provide operation support and additional site data



Status:

- AFRL established EOARD grant with university to fund operations and provide radiometer
- Ka/Q-band terminal fabrication completed and undergoing laboratory testing
- Relevant environment (rooftop) testing to commence August 19, 2013
- Site survey planned during Ka-band conference in October 2013
- Installation of terminal planned for December 2013



Issues:

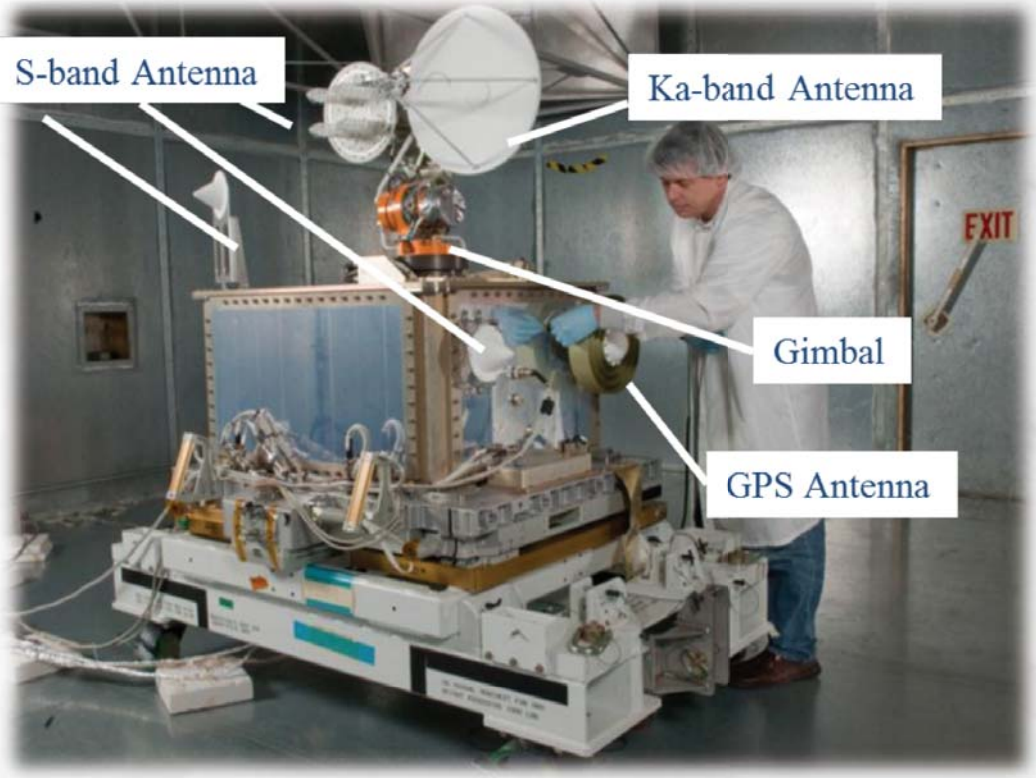
- Still working on establishing MOA with AFRL on funding support for operations and maintenance of Alphasat terminal

SCaN Testbed Background

- NASA is studying the development, testing, and operation of software defined radios (SDRs) for the space environment

- NASA has built an on-orbit, reconfigurable testbed comprised of SDRs

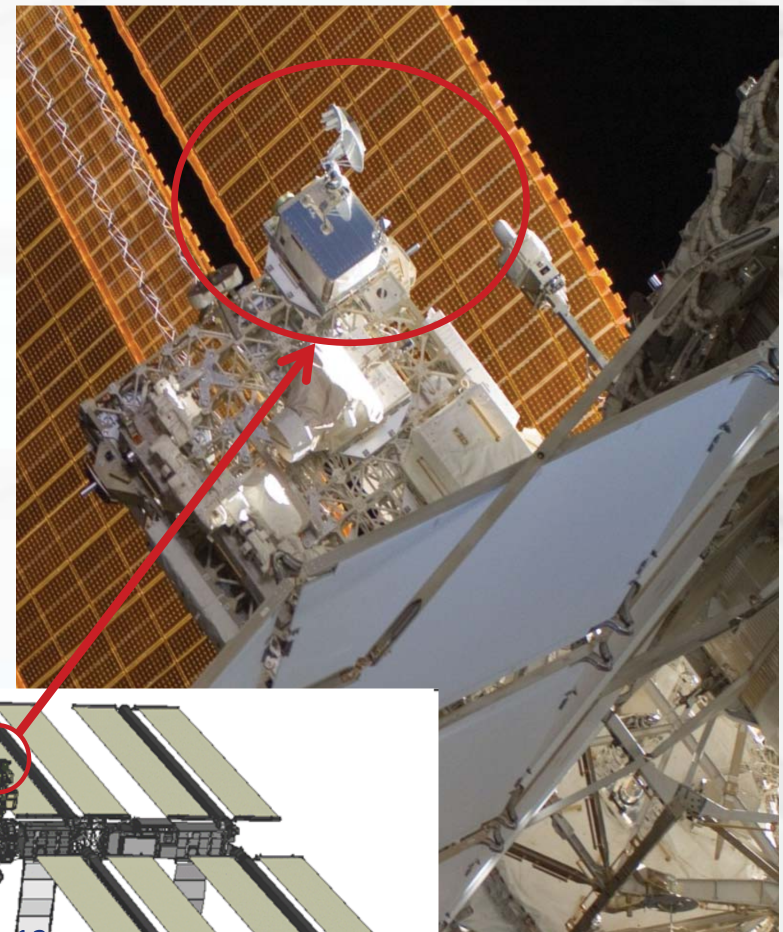
- SCaN Testbed
  - 3 SDRs
  - Space Telecommunications Radio System (STRS)-compliant
  - L-band, S-band, Ka-band

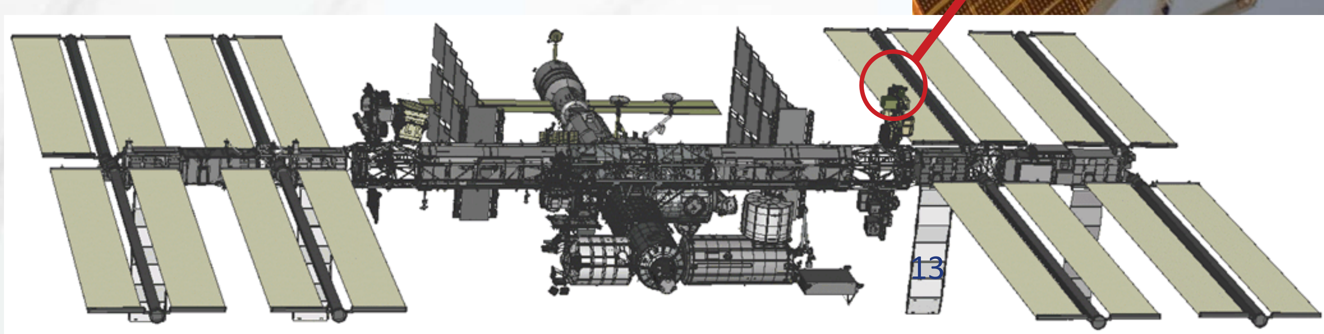


SCAN Testbed Mission Objectives

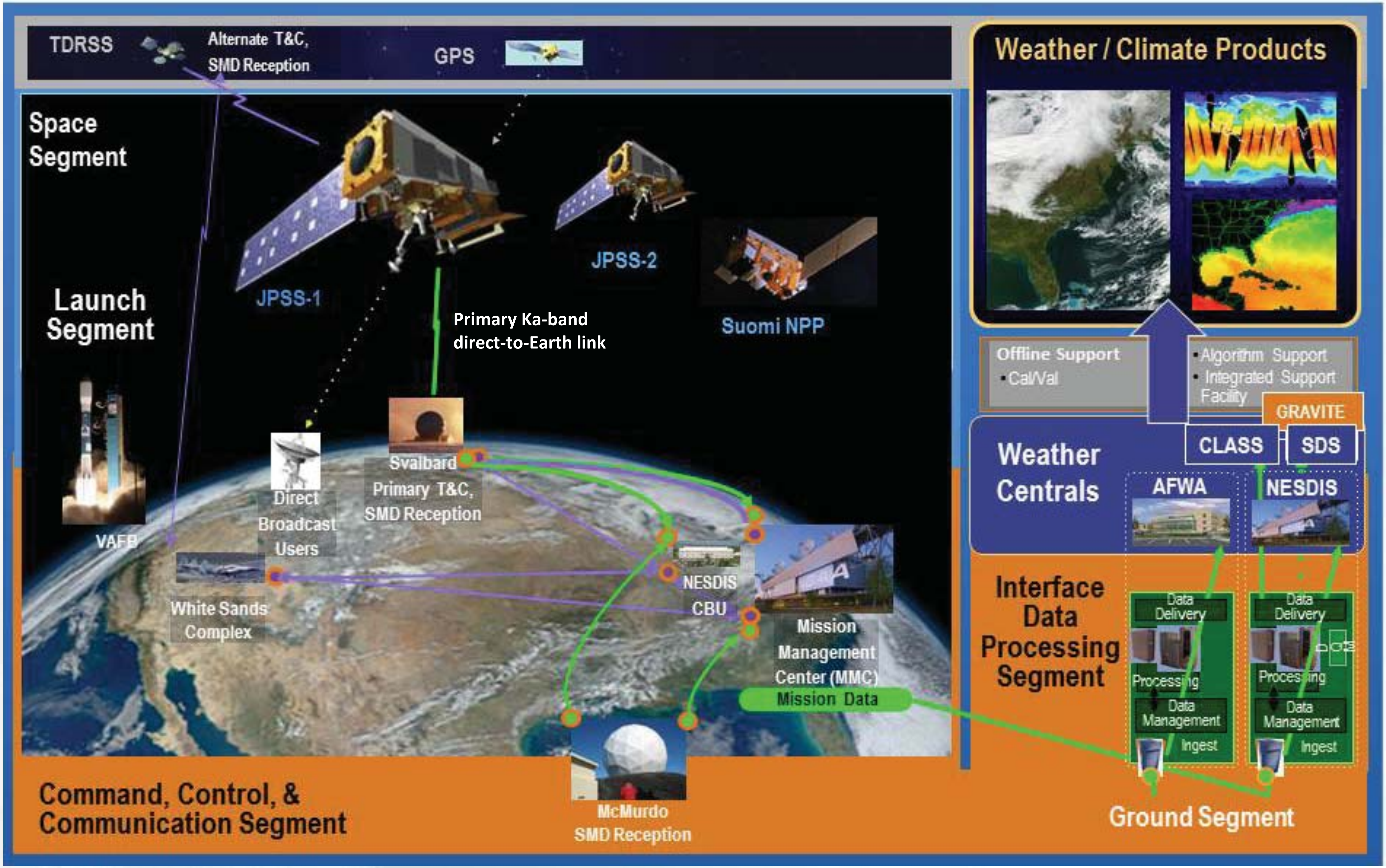
- **Mature Software Defined Radio (SDR) technologies and infrastructure for future SCaN architecture and NASA Missions**
  - Ready for space use/verification/reconfiguration/operations/new software aspects
  - Advance the understanding of SDR Standard, waveform repository, design references, tools, etc for NASA missions

- Conduct Experiment's Program
  - Portfolio of experiments across different technologies; communication, navigation, and networking
  - Build/educate a group of waveform developers and assemble repository of waveforms
- Validate Future Mission Capabilities
  - Representative capabilities; S-band, Ka-band, GNSS



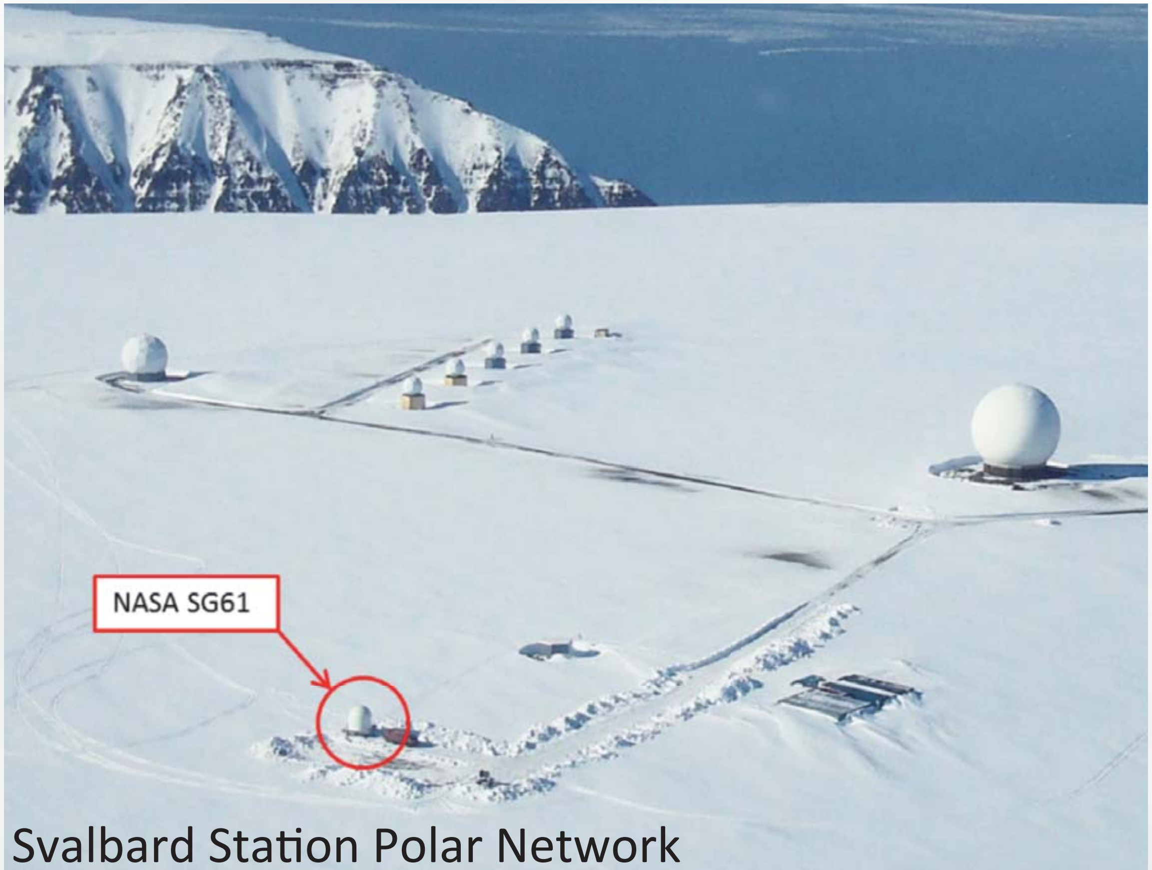


Joint Polar Satellite System (JPSS)

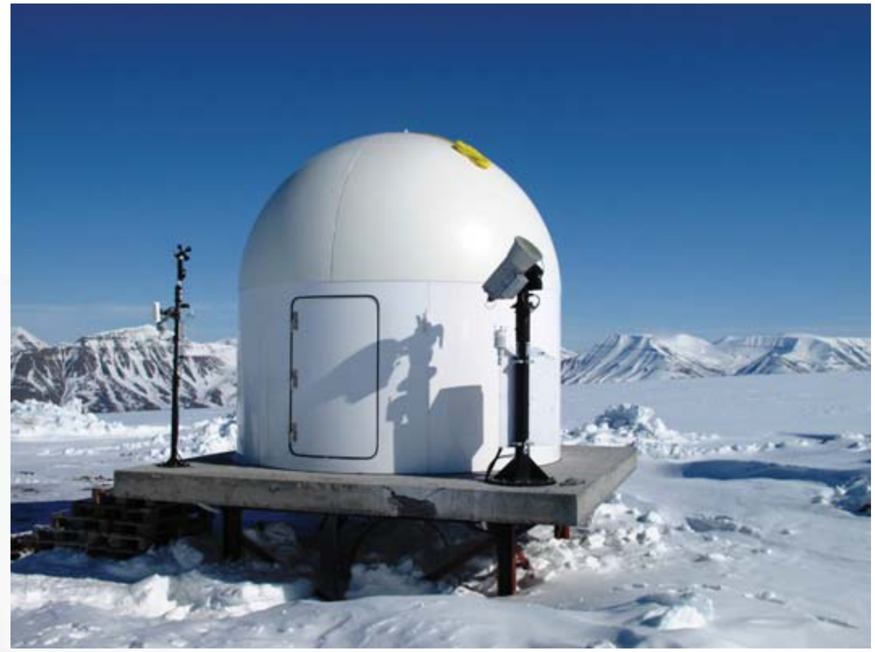


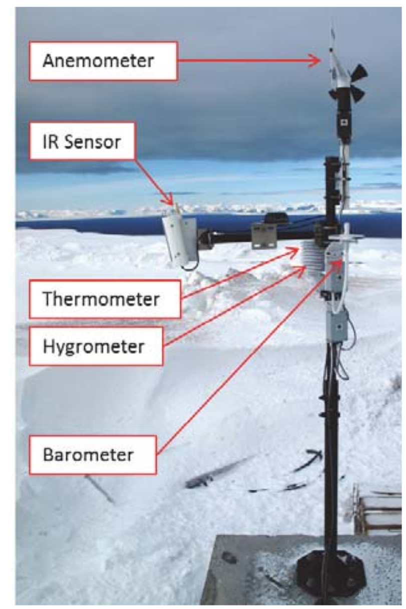
Site Characterization: Ka-band in the Polar Atmosphere

Svalbard



Svalbard Station Polar Network





<u>Approach</u>

As the first Near Earth Network (NEN) site to be upgraded to operational Ka-band, NASA GRC was tasked with characterizing the propagation effects of Ka-band in a northern latitudes environment.

Measurements initiated in 2011 to measure passive radiometric attenuation in polar atmosphere to determine system planning requirements for Ka-band upgrades

Ka-Band Mission Integration JPL (1/2)

- Mars Observer – Launched in 1992, Lost in 1994
  - Active Ka-band campaign 1993-1994
  - Included telemetry demonstration, ranging demonstration and long term tracking experiment
  - First demonstration of a deep-space communications link in 32-35 GHz band
  - Experimental results demonstrated 4 to 7 dB advantage

- Surfsat-1 – Launched in 1995 (23711U)
  - Active Ka-band campaign 1995-1997
  - Provided operational experience acquiring Ka-band data. Exercised servo upgrades on 34-m performance

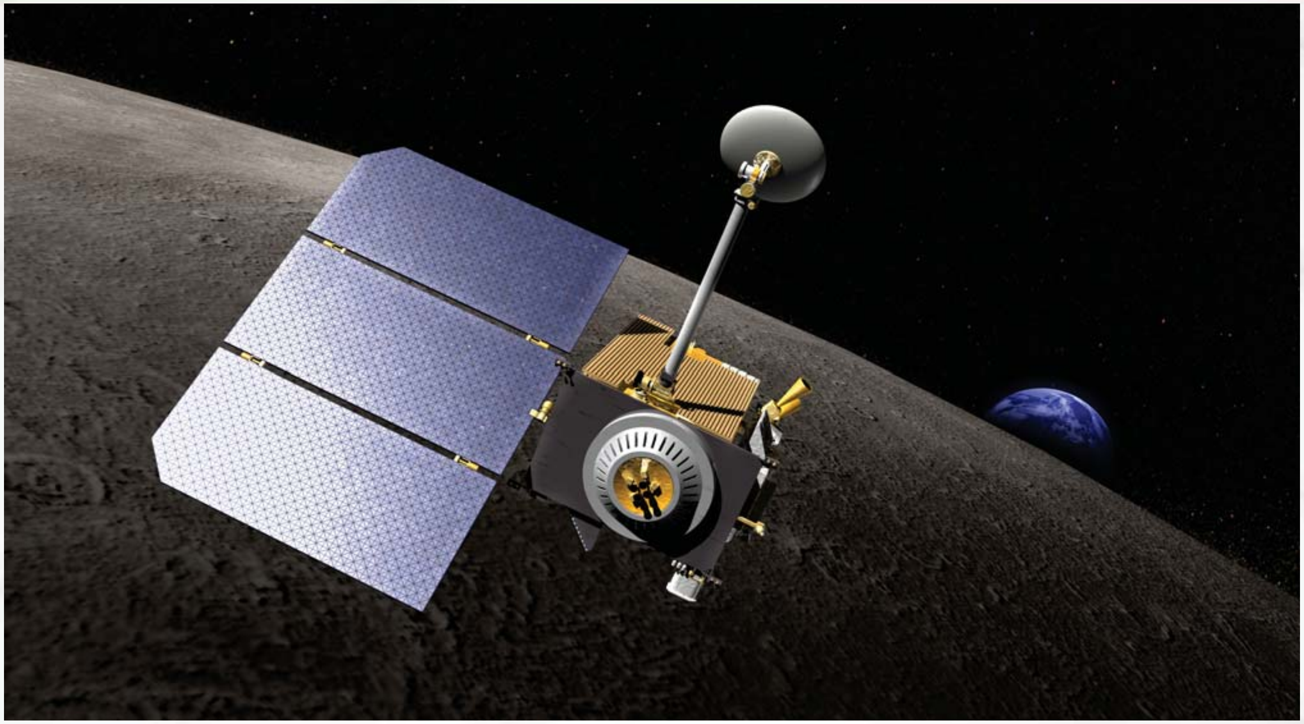
- Mars Global Surveyor – Launched in 1996
  - Active Ka-band campaign 1997-1999
  - Pc/No for X- and Ka-band acquired over a wide range of station elevation angles, weather conditions, and solar elongation angles.
  - The carrier measurements suggested that Ka-band could increase data capacity by at least 3 times (5 dB) vs. X-band

Ka-Band Mission Integration JPL (2/2)

- Cassini (Various engineering studies)
  - 1997–2004: Cruise (solar conjunctions and troposphere), 2004 – Present: Saturn orbit (limited engineering studies)
  - Ka-band carrier used for various engineering studies including troposphere propagation
- Deep Space 1 - Launched in 1998
  - Limited Ka-band studies
- Mars Reconnaissance Orbiter - Launched in 2005
  - Active Ka-band campaign 2005 – 2006
  - EIRP Study - Received Pt/No at short range distances consistent with HGA being on point within 1 dB of predict.
  - Detailed Ka-band Telemetry Study
  - Navigation data types found to be consistent with expectations
- Kepler - Launched in 2009
  - Limited Ka-band engineering tests using Goldstone and Madrid DSN stations 2010
- JUNO – Launched in 2011

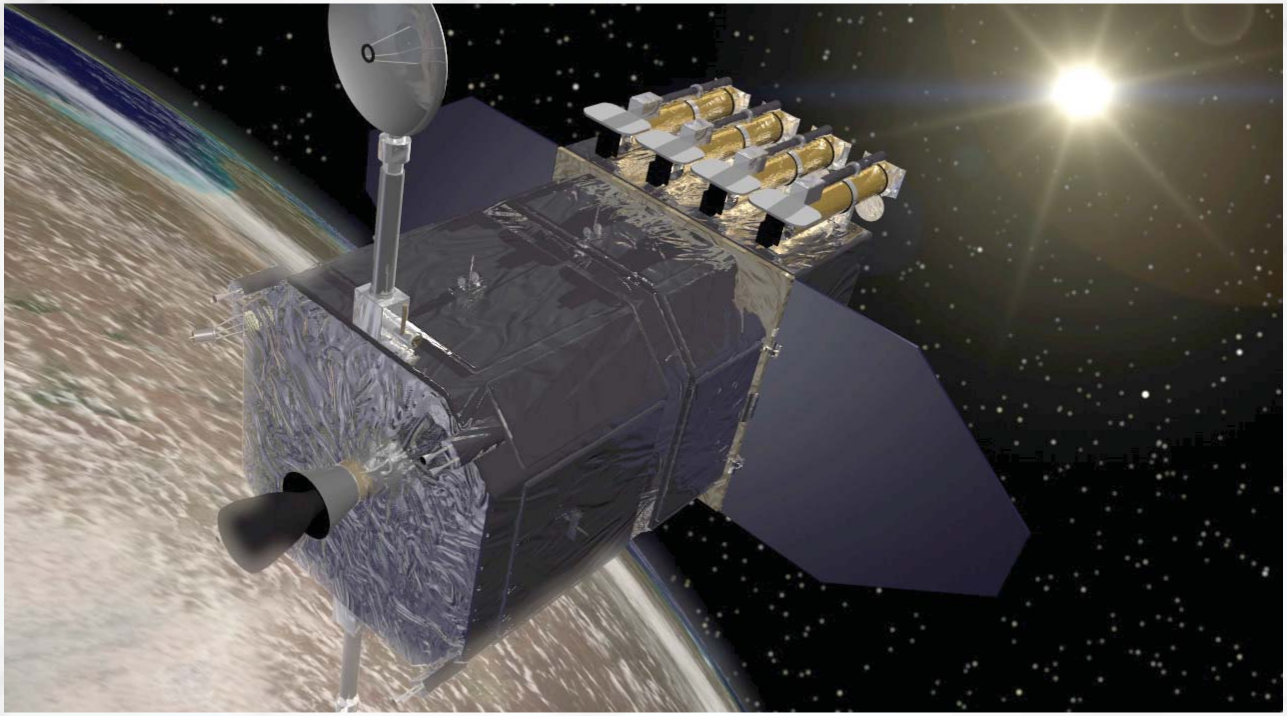
- Mars 2016 - Will launch in 2016

Goddard Space Flight Center
Lunar Reconnaissance Orbitor[LRO]



– Supported Ka-Band from the moon
– Provided the ability to return high-resolution surface maps due to high data rate provided by Ka-Band
– Perfected antenna failover processes with SDO

Goddard Space Flight Center
Solar Dynamics Observatory [SDO]



- Dedicated pair of of dual ka-/s-band antennas
  - Ka-band: science telemetry
- Three instruments with capture rate requirements of 92% of all possible data
- 2 simultaneous 150M data streams 24x7 for a minimum of 5 years
- Best source data selection in real time – 1.8 sec antenna to delivery net latency

- Approach
  - Provide results-focused support to development, implementation, operations and sustaining mission and ground-based communications
    - Flight **and** Ground deliverables
  - Three major thrusts:
    - Forward-looking research to provide answers before the questions get asked – *Example: NEN Gateway*
      - *Focus*: ***Disruptive Evolution and Revolutionary Prototyping***
    - Identification of alternatives addressing design and implementation challenges – *Example: McMurdo TDRSS Relay System (MTRS)*
      - *Focus*: ***Elegantly simple, tested technical options***
    - Analysis and Recommendation for Operations and Sustaining activities – *Example: Demand Access System*
      - *Focus*: ***Cost-driven, proven refresh and evolution choices***

- Future mission target list
  - Destynl
  - Hysperl
  - PACE
  - ISS
- Future Ground Terminal Target list
  - North Pole
  - South Pole

KaBOOM

NASA recently stood up the Ka-Band Objects Observation and Monitoring (KaBOOM) system, a three-antenna capability demonstration radar array at the Kennedy Space Center.

The goal of KaBOOM is to mature capabilities and operational techniques that will allow future systems to characterize near-Earth objects in terms of size, shape, rotation/tumble rate, and porosity and to determine the trajectory of those objects. Radar studies can determine the trajectory 100,000 times more precisely than can optical methods.

Current NASA radar systems are limited in both resolution and the distance at which they are effective. KaBOOM is the penultimate, low-cost step before proceeding with a high-power, high-resolution radar system. NASA expects this proof of concept to be completed in about two years.

Earth Regime Network Evolution Study ERNESt

- Defining the next generation architecture
- Supporting NASA and our users 2014 through 2040 time span
- Incorporating on ramps for transitioning capability such as optical comm, new S/C design
- Enabling increased flexibility in user concepts of operation

. . . in order to realize SCaN's vision for an Internet-like capable suite of user services

For more information visit NASA:

www.nasa.gov

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Space Communications and Navigation (SCaN):

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