



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



USN Alaska
Poker Flat & North Pole



Gilmore Creek,
Alaska (NOAA)



Wallops, Virginia
Ground Station



KSAT
Svalbard, Norway



SSC
Kiruna, Sweden



USN Germany
Weilheim



KSAT – Kongsberg Satellite Services
SSC – Swedish Space Corporation
USN – Universal Space Network



KSAT
Singapore, Malaysia



Guam Remote
Ground Terminal



Canberra Complex
Australia



USN Australia
Dongara

Alaska Satellite
Facility, Fairbanks



Goldstone Complex
California



USN Hawaii
South Point



White Sands Ground Station
New Mexico



White Sands Complex
New Mexico



SSC
Santiago, Chile



Madrid Complex
Spain



KSAT
TrollSat, Antarctica



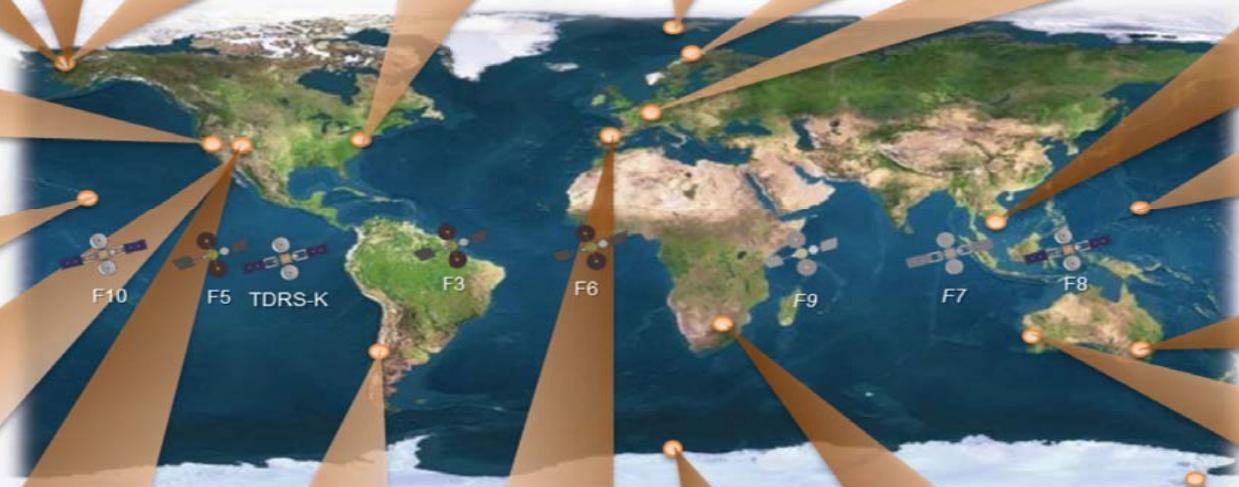
SA National Space Agency
Hartebeesthoek, South Africa



McMurdo, Antarctica
Ground Station



- DSN
- NEN
- SN





Overview of the Three Networks



Deep 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

Government owned, JPL managed and sustained; 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.

Near Earth Network



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

50% government, and 50% commercial owned and managed. Government portion is operated and maintained by contractors

Aqua, Aura, Lunar Reconnaissance Orbiter,
Landsat, Radiation Belt Storm Probes, etc.
Examples of future missions:
OCO-2, GPM, SMAP, etc.

Space Network



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; contractor operated and maintained

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.⁴



Deep Space Network (DSN)



Canberra Deep Space Communications Complex



Madrid Deep Space Communications Complex



Goldstone 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



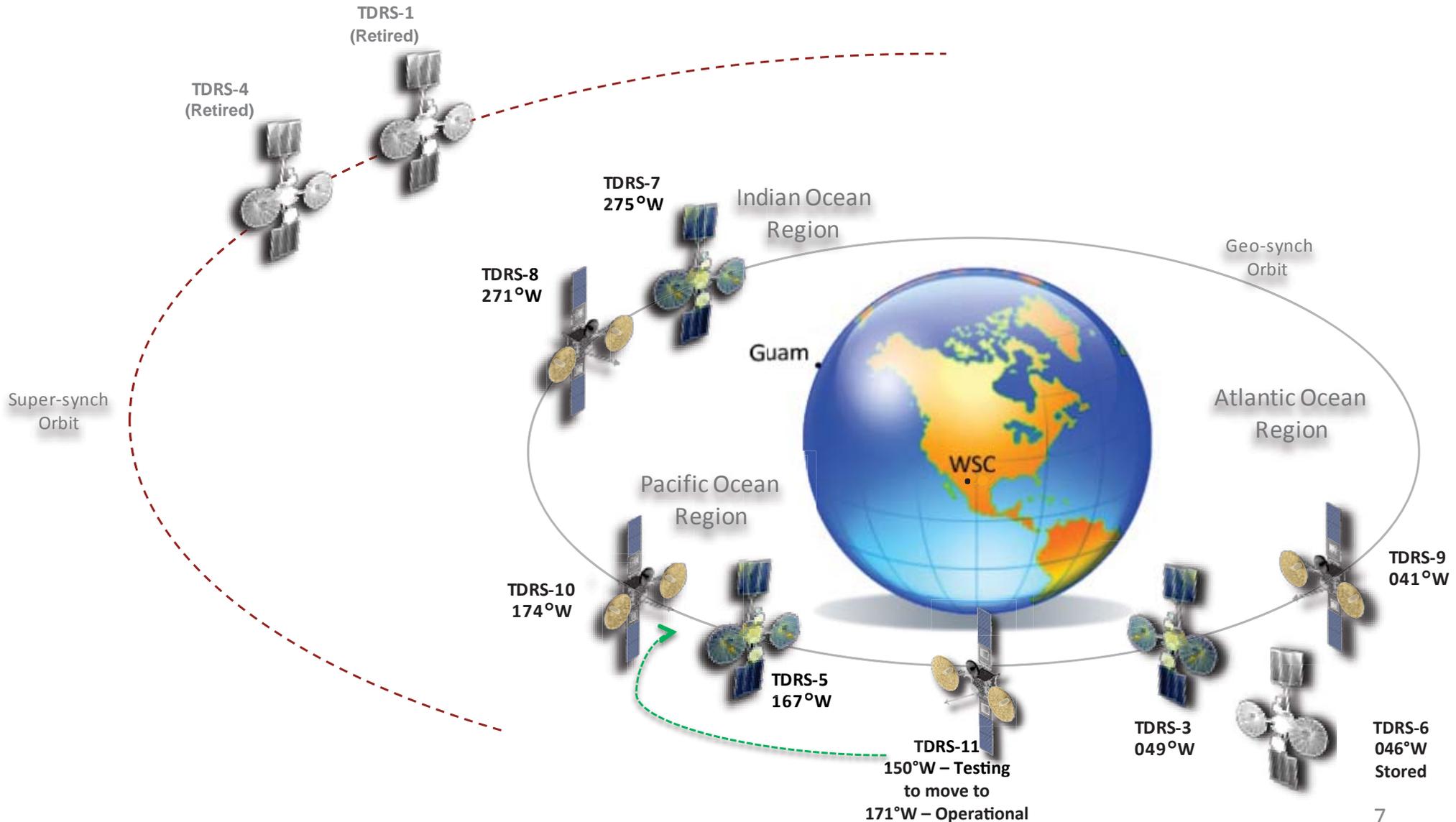
WS1 Antenna at White Sands



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

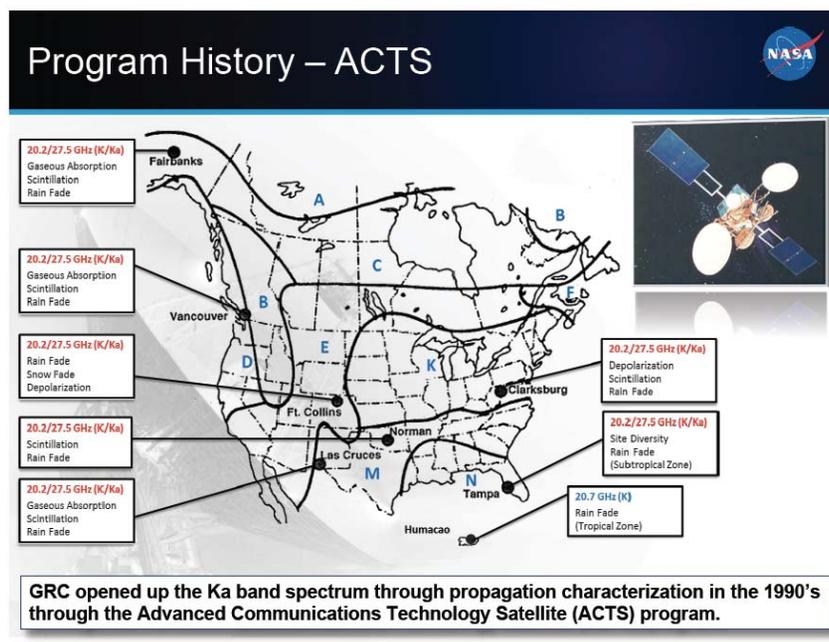
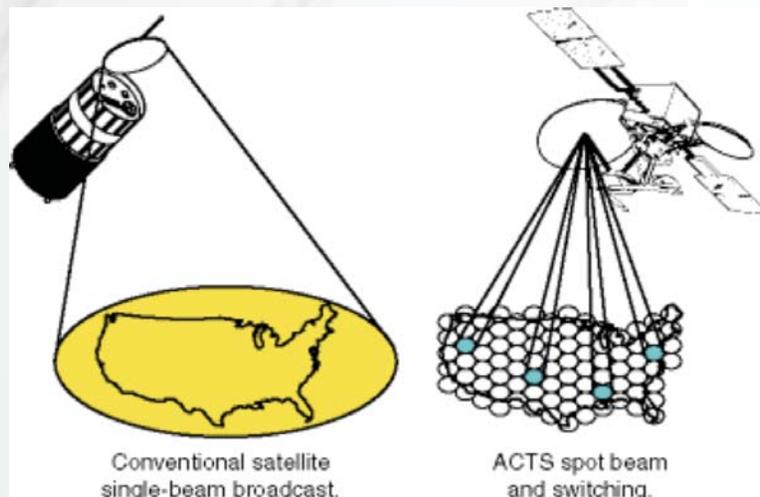


ACTS Glenn Research Center



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.





Propagation Research Glenn Research Center (1/2)





Propagation Research Glenn Research Center (2/2)



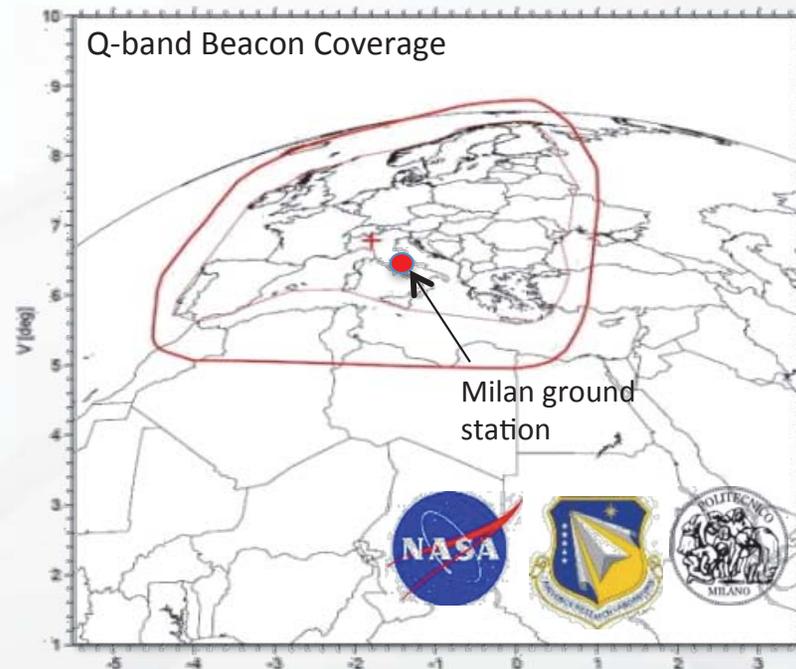
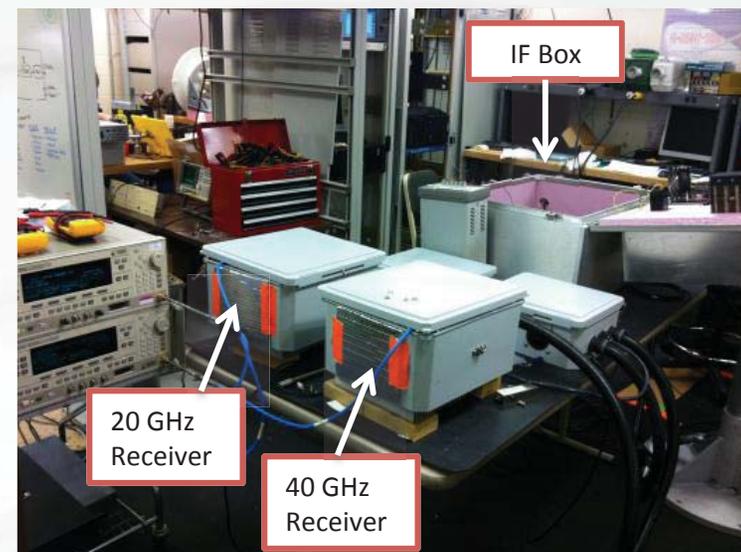
- International collaboration with AFRL and Politecnico di Milano (POLIMI) to characterize 40 GHz propagation effects (up to 99.9% availability)
 - GRC to provide Alphasat propagation terminal
 - AFRL to provide radiometer system and funding for operations and maintenance
 - POLIMI to provide operation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

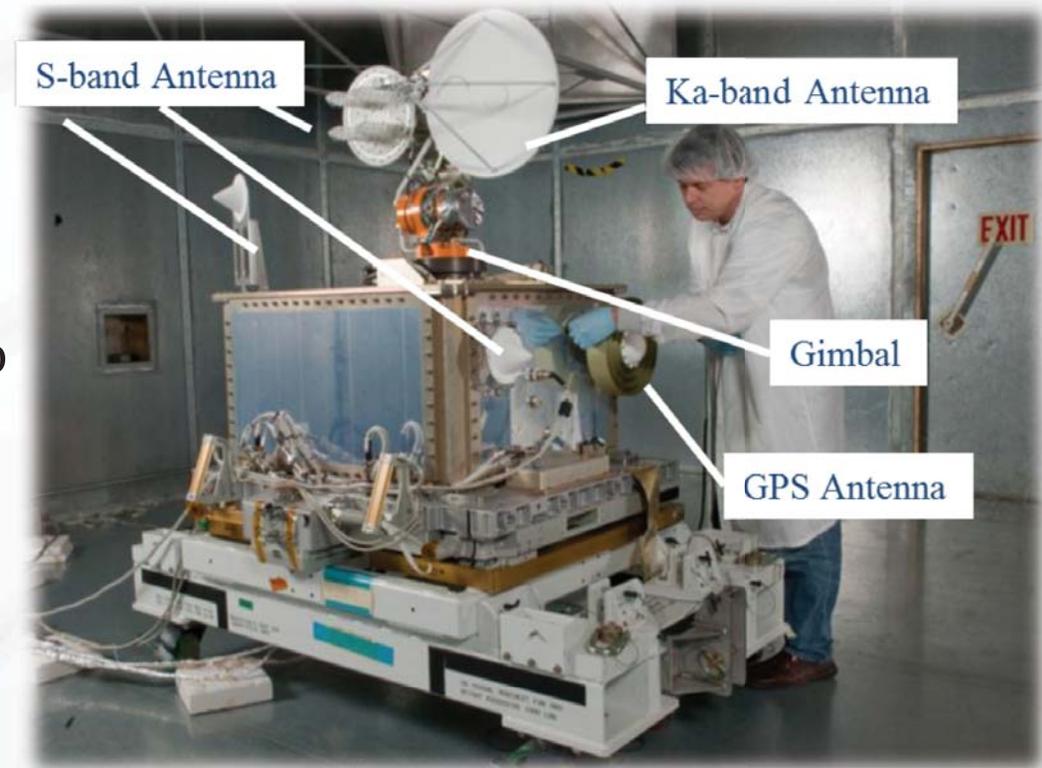




SCaN Testbed Background



- 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

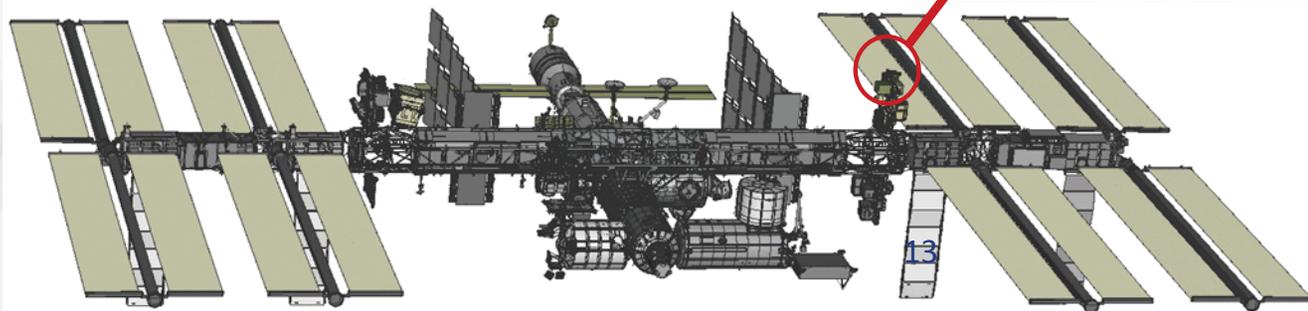
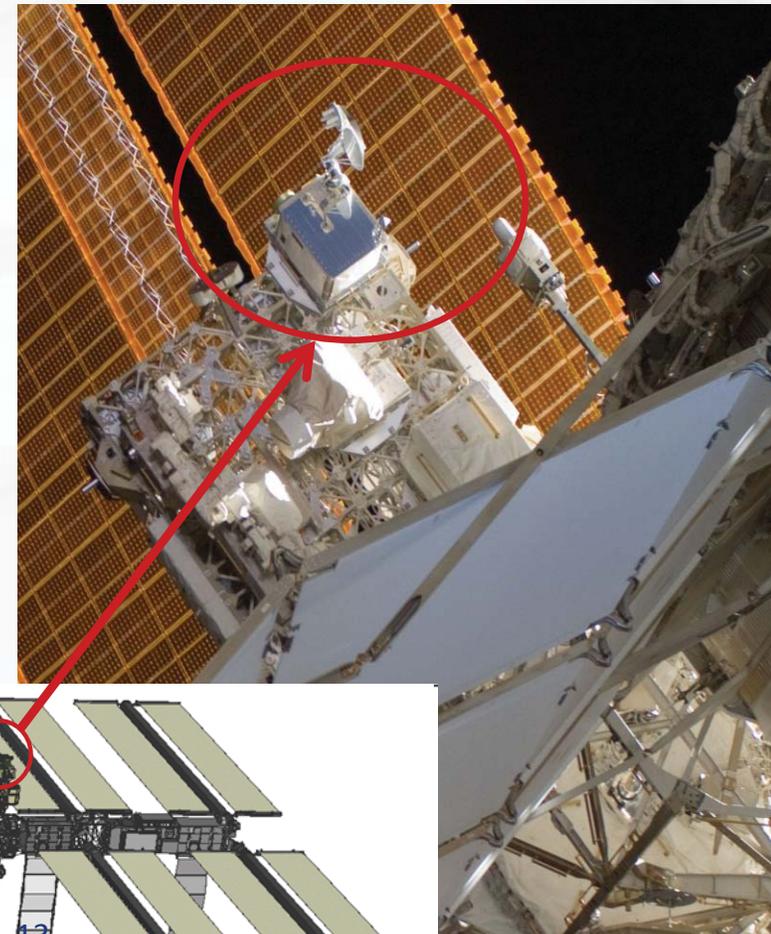




SCAN Testbed Mission Objectives

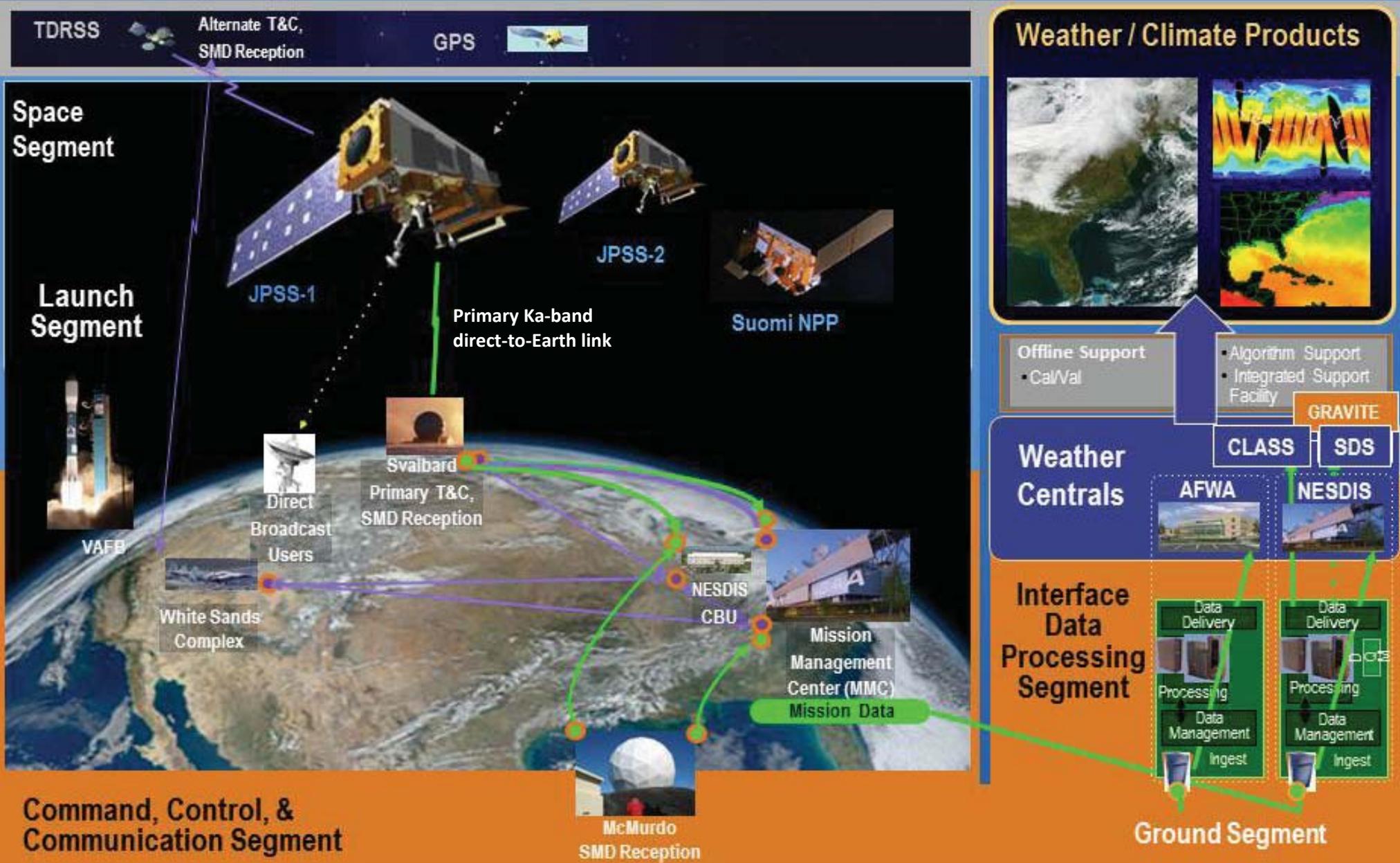


- **Mature Software Defined Radio (SDR) technologies and infrastructure for future SCaN architecture and NASA Missions**
 - Ready for space use/verification/reconfiguration/operations/new software aspects
 - Advance the understanding of SDR Standard, waveform repository, design references, tools, etc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





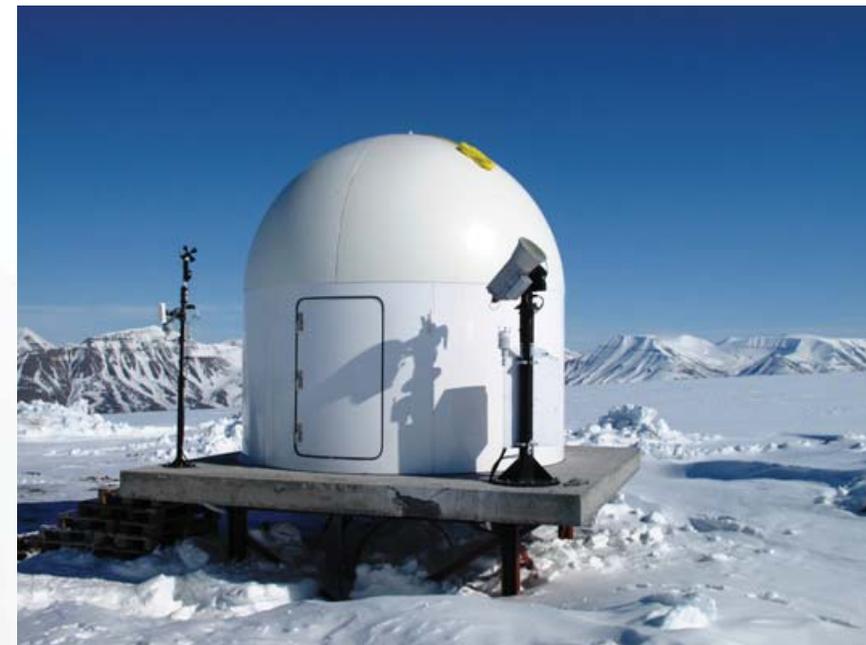
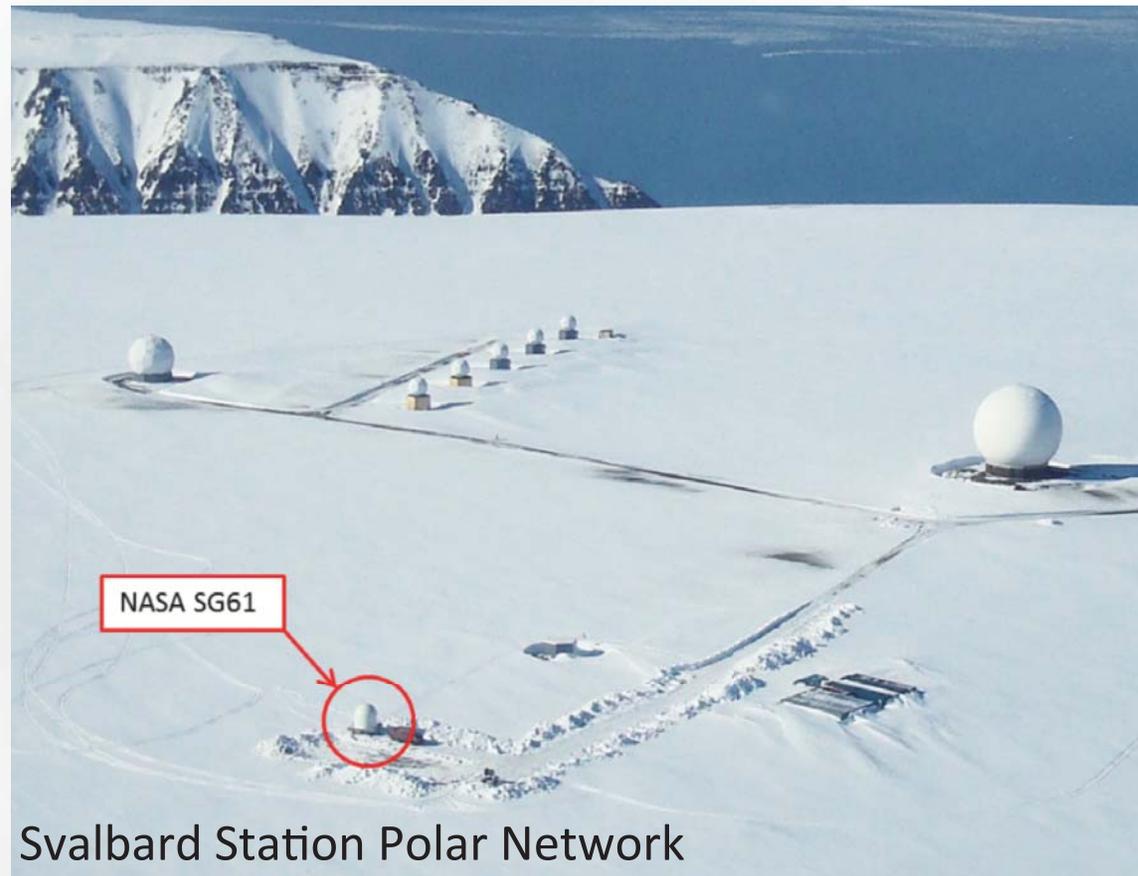
Joint Polar Satellite System (JPSS)





Site Characterization: Ka-band in the Polar Atmosphere

Svalbard



Svalbard Station Polar Network

Approach

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 Orbiter[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 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



Goddard Space Flight Center



- 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**



Goddard Space Flight Center



- 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



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