

A detailed 3D rendering of a satellite in the background. The satellite has a central body with various instruments and antennas, and two large, rectangular solar panel arrays extending outwards. The panels are blue with a grid pattern. The central body is white and grey with various colored components.

# **Space Communication and Navigation SDR Testbed, Overview and Opportunity for Experiments**

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*NASA John H. Glenn Research Center  
Cleveland, Ohio*

Wireless Innovation Forum Technical Conference  
Washington D.C.  
January 2013



# Overview

- Communications & Navigation Space Domain Introduction
- Role of Software Defined Radio in Space
  - Space Telecommunications Radio System (STRS)
    - SDR Forum Space Applications Study Group 2002-2007
- SCaN Testbed
  - What is it?
  - How can I use it?
  - How do I get started?
  - Call for Experiments & Available Funding

Work Sponsored by NASA's  
Space Communications and Navigation Program



# INTRO: THE SPACE DOMAIN



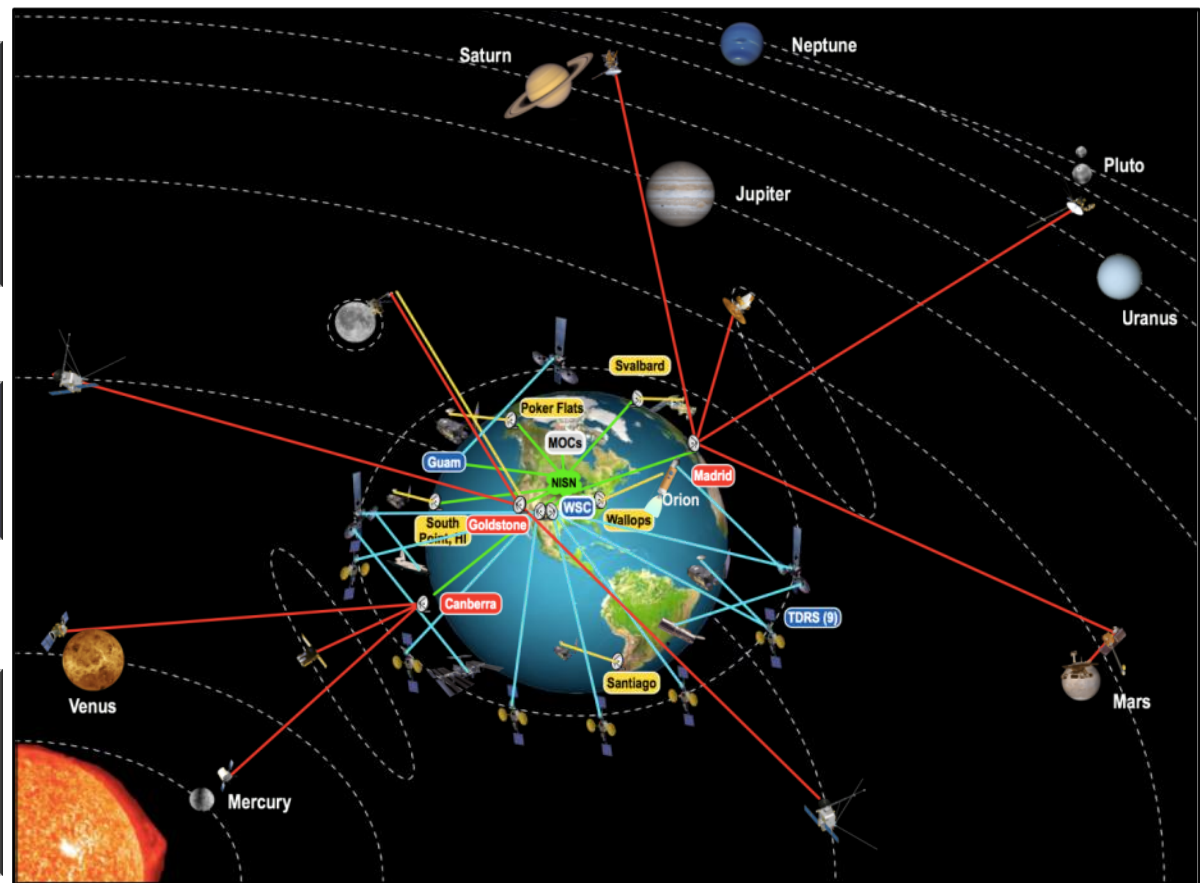
# Space Communications and Navigation Space Architecture

The current NASA space communications architecture embraces three operational networks that collectively provide communications services to supported missions using space-based and ground-based assets.

• **Near Earth Network** – NASA, commercial, and partner ground stations and integration systems providing space communications and tracking services to orbital and suborbital missions

• **Space Network** – constellation of geosynchronous relays (TDRSS) and associated ground systems

• **Deep Space Network** – ground stations spaced around the world providing continuous coverage of satellites from Earth Orbit (GEO) to the edge of our solar system







# Space Communications and Navigation Network

•Manned Missions



•Sub-Orbital Missions



•Earth Science Missions



•Space Science Missions



•Lunar Missions



•Solar System Exploration



•USN Alaska



•Gilmore Creek Tracking Station



•Wallops Ground Station



•Kongsberg Satellite Services



•Swedish Space Corporation



•German Space Corporation



•DSN  
•NEN  
•SN

•Alaska Satellite Facility



•Goldstone Complex



•USN



•White Sands Complex



•White Sands Ground Terminal



•USN Chile



•Madrid Complex



•Trollsat Kongsberg Satellite Services



•Satellite Applications Center



•McMurdo Ground Station



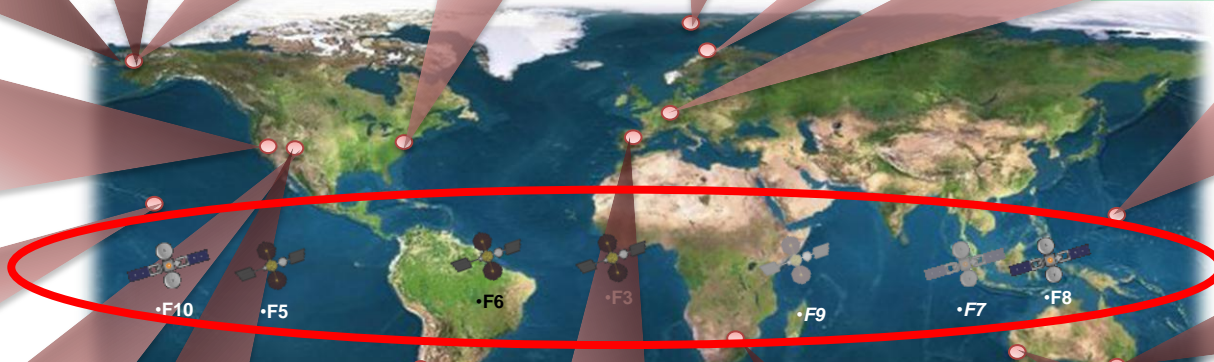
•Guam Remote Ground Terminal



•Canberra Complex



•USN Australia





# ROLE OF SDRS

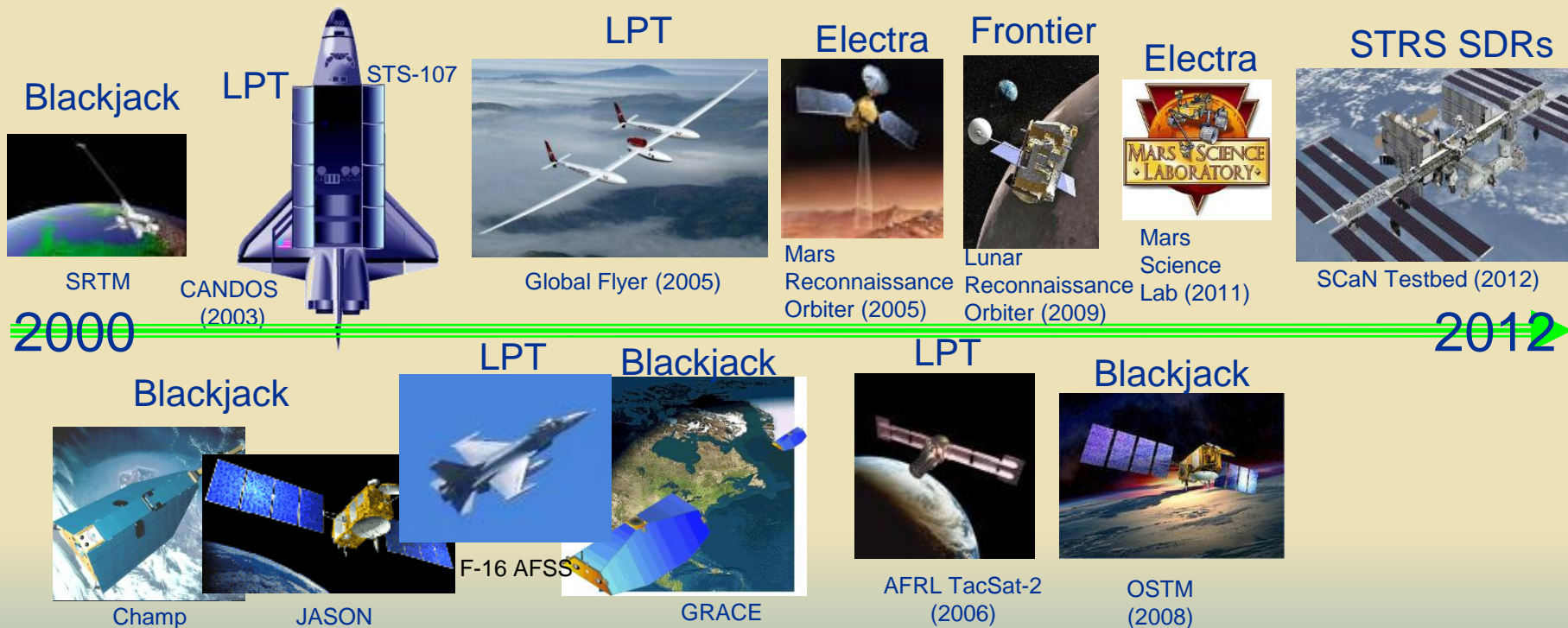


## ...Many Aspects of SDRs for Space

- Flexible, Reconfigurable
  - Accommodate New Requirements during development
  - Fix Problems during development and on-orbit
  - New Conops – adjust operations depending on mission findings
- New software/firmware development
  - Dependence on Platform Developer (role for open architecture)
  - Development Tools/Expertise
  - Verifications of new software/firmware for Flight
- Hardware Modules (technology lag for space)
  - Lower box cost/limited flexibility
  - Susceptible to upsets
  - More power (more system cost)
- vs culture of “what worked last time”...lowest risk...

# Space Software Defined (Reconfigurable) Radio Technology in Flight

SDR in Missions



SDR Architecture

Proprietary  
SDR Architectures

Space  
Telecommunications  
Radio System  
2012





# STRS Architecture Standard Evolution

## SDR/WINN FORUM

### INITIAL DRAFT

2006



### COMMENTS

2007



### FORMAL RELEASE

2008/2010

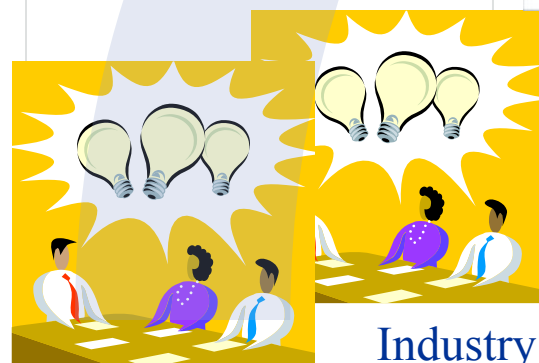
2007-2012  
SDR Space  
Flight System  
Development

NASA OCE  
STANDARD  
~2013



2013-?  
SDR Space  
Flight  
Experiments

INDUSTRY  
STANDARD  
~2014?



NASA Workgroup  
via SDR Forum/OMG  
Industry Workgroup

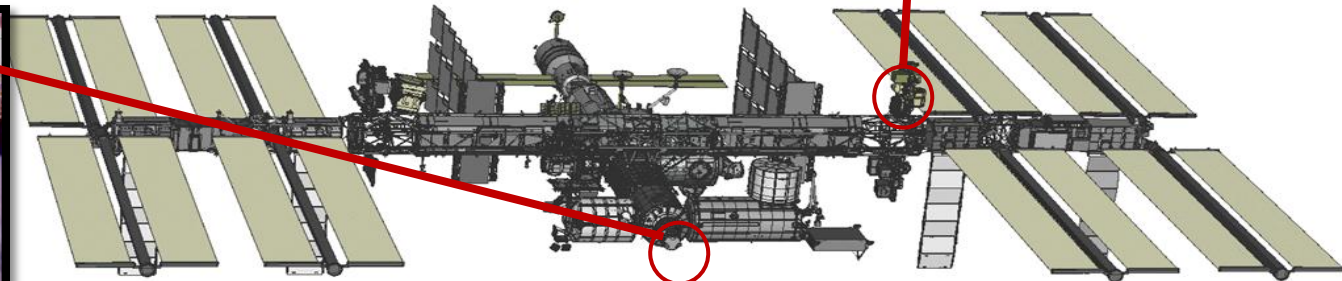
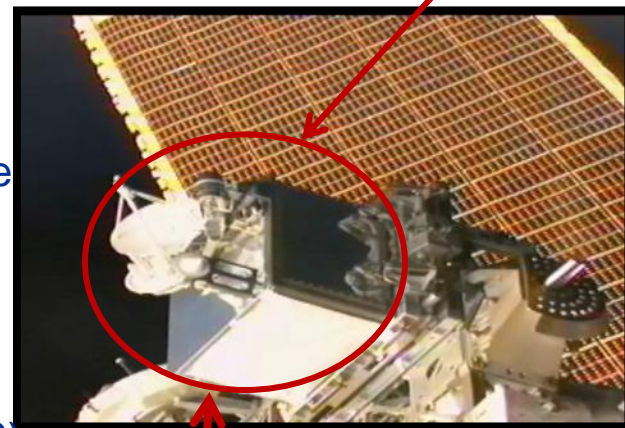
Look for STRS Tutorial  
on Thursday (Session 5D)!

# SCAN Testbed Mission

## Research & Technology Objectives

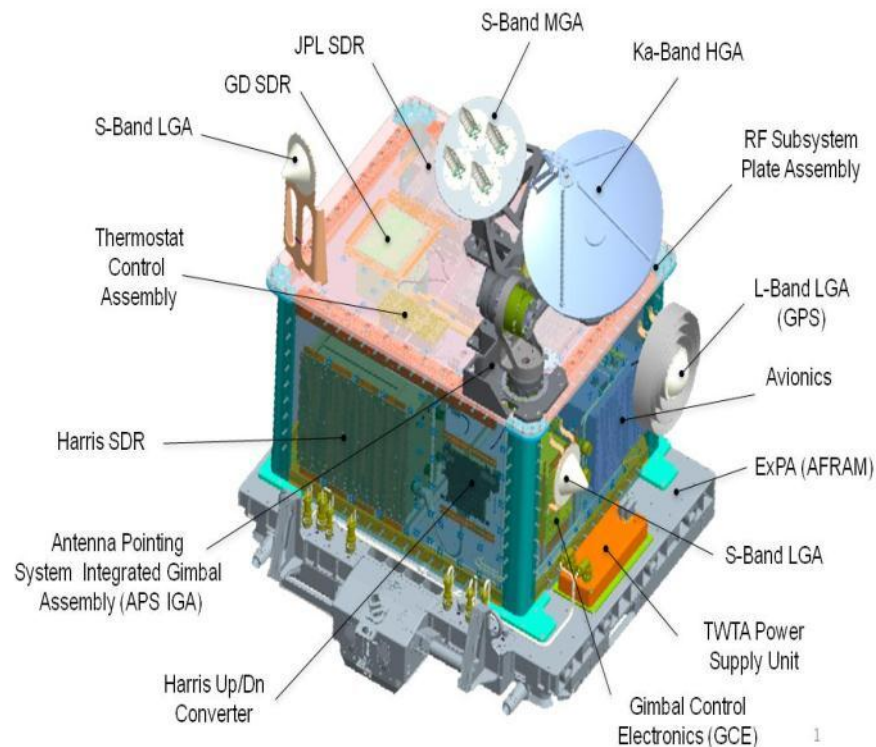
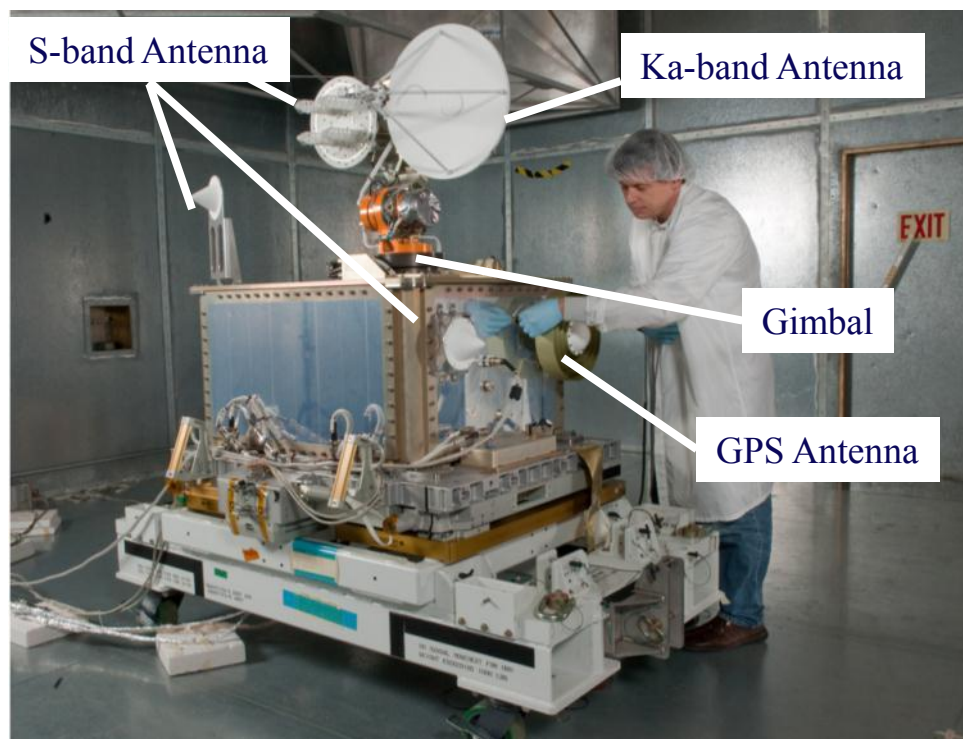
- **Investigate the application of SDRs to NASA Missions**
  - Mission advantages and unique development/verification/operations aspects
  - SDR reconfiguration, on-orbit reliability
- **Develop SDR platform hardware & waveform firmware/software compliant to STRS to TRL-7**
  - Promote development and Agency-wide adoption of NASA's SDR Standard, STRS
  - Flight-like ground EM and other equipment to enable the development, integration and operations of new SDR software on ISS.
- **Validate Future Mission Capabilities**
  - Capability representative of future missions (S, Ka, GPS)
  - Communication, navigation, networking experiments

SCAN Testbed



Launched to ISS on JAXA's H-II Transfer Vehicle (HTV3) on July 20, 2012 [www.nasa.gov](http://www.nasa.gov) 10

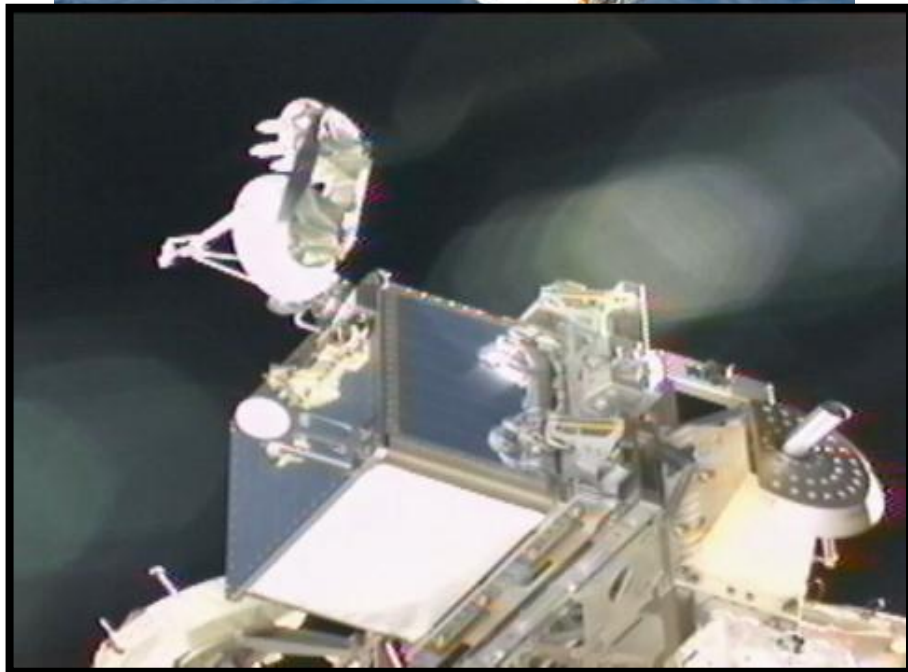
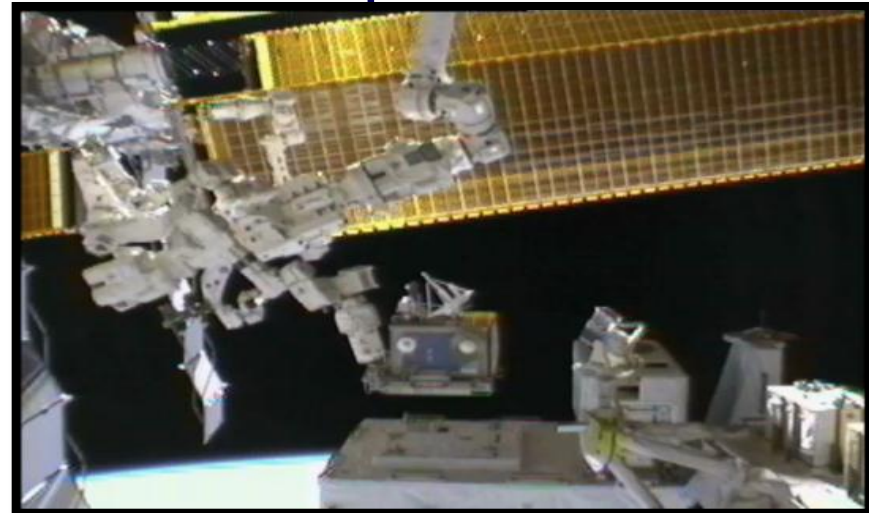
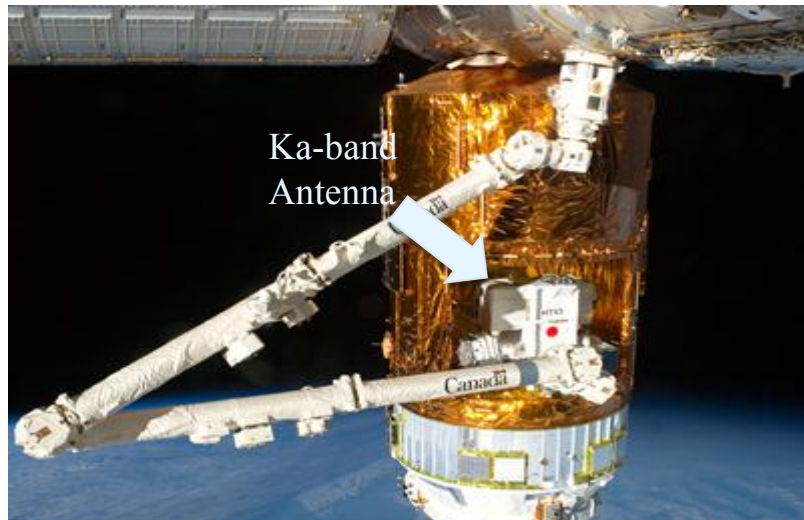
# SDR Testbed - Communication System



- **SDRs - Two S-band SDRs (One with GPS), One Ka-band SDR**
- **RF - Ka-band TWTA, S-band switch network**
- **Antennas - Two low gain S-band antennas, One - L-band GPS antenna, Medium gain S-band and Ka-band antenna on antenna pointing subsystem.**
- **Antenna pointing system - Two gimbals, Control electronics**
- **Flight Computer/Avionics**



# Pictures of Installation and First Operations



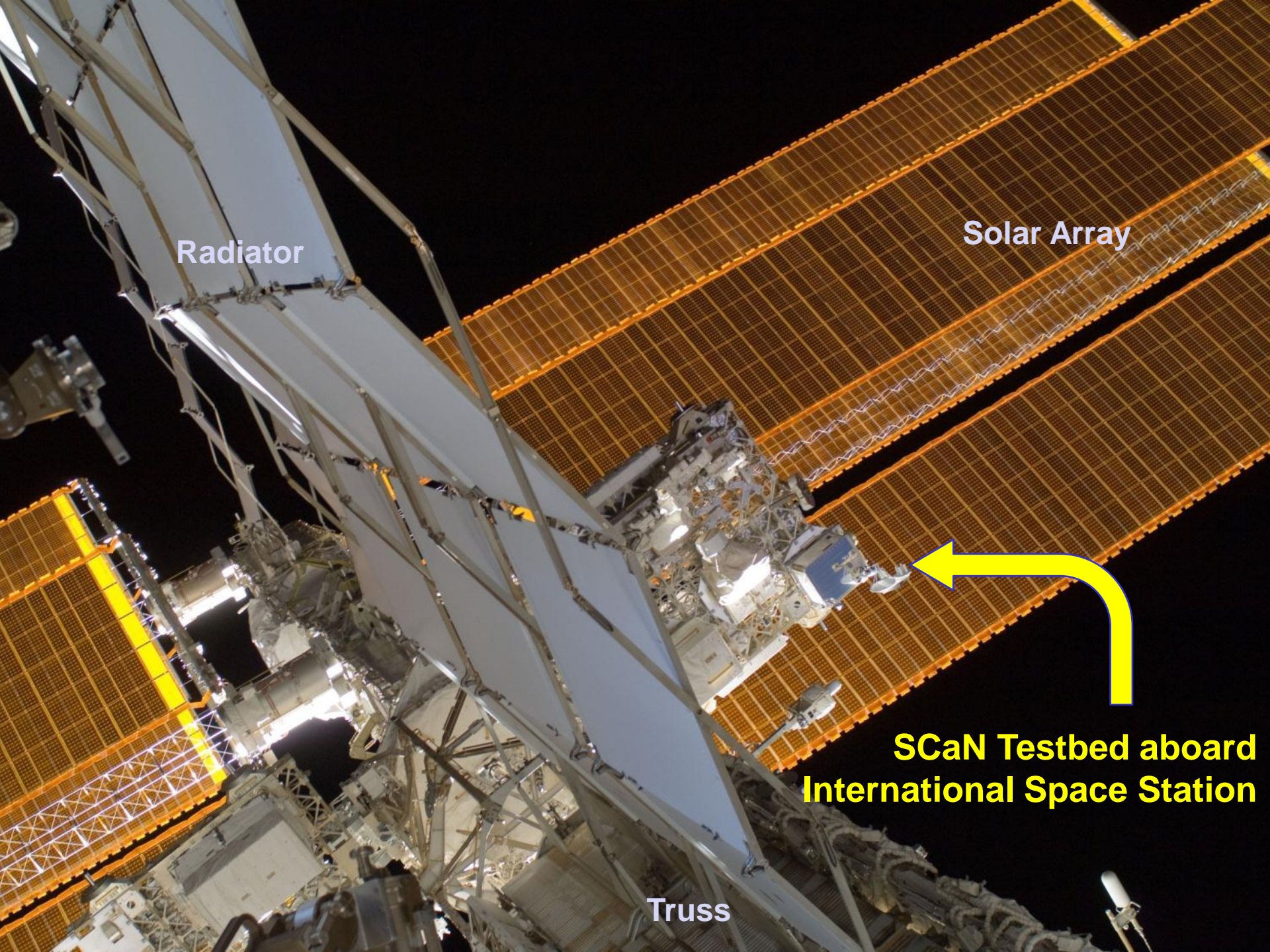


Radiator

Solar Array

**SCaN Testbed aboard  
International Space Station**

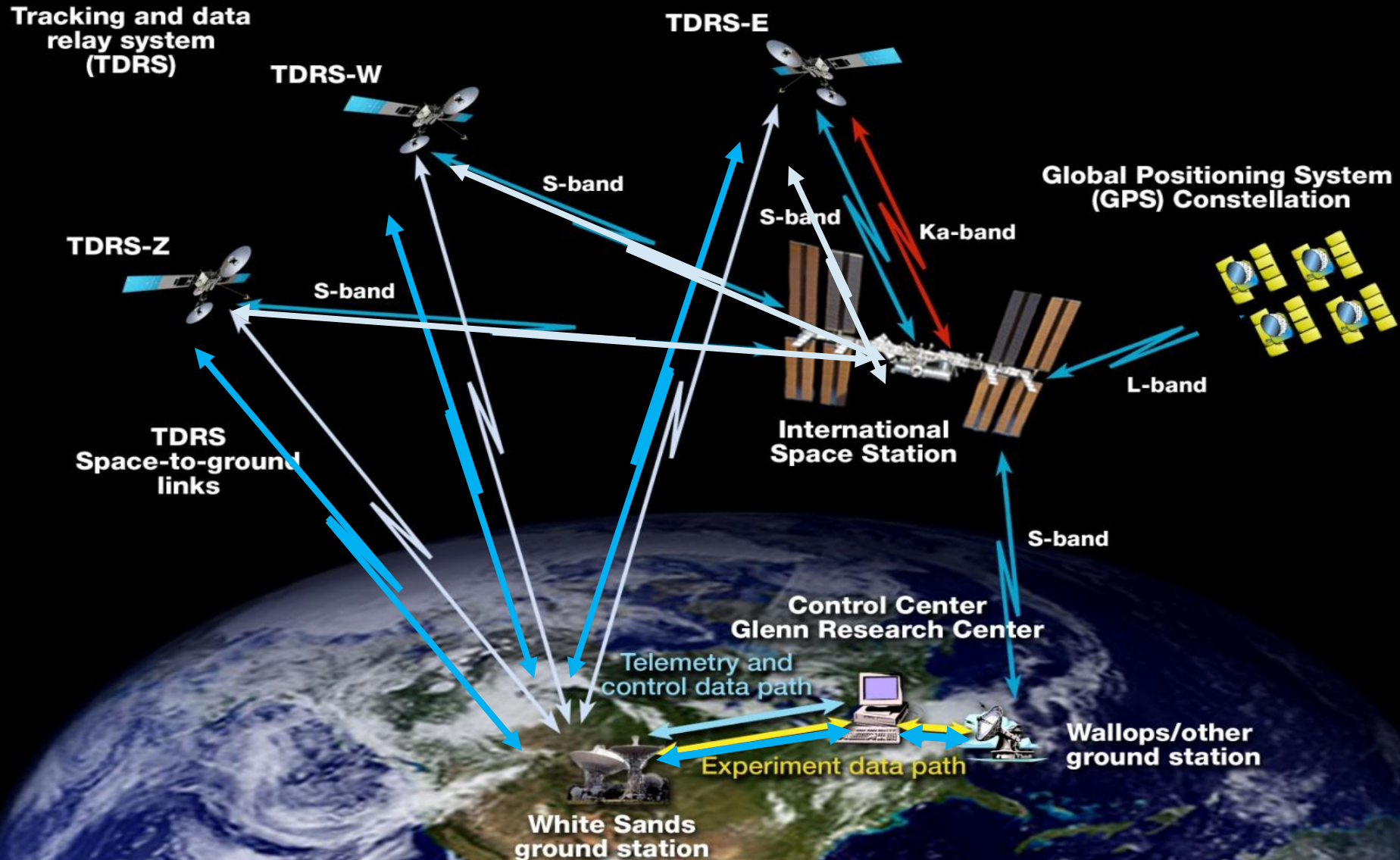
Truss







# SCAN Testbed System Architecture



# SCaN Testbed Operations and Experiment Center at Glenn Research Center





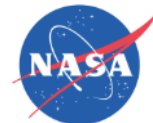
# EXPERIMENT PROGRAM



# Advancing the Field of SDRs in Space

- Experiment Program seeks participation by NASA, industry, academia, and OGA to use the SCAN Testbed
- Broad participation will create a forum to exchange ideas and results, create new experiments, new partnerships, and disseminate results
- Increase the base of STRS experts —Agency personnel, sw and hw providers, and the user and operations communities—all knowledgeable of the common standard. Build WF Repository.
- Publish understanding of system performance and SDR operations in a mission context
- Reduce the (perceived?) risk of infusing SDRs and their applications (comm, nav, networking) into NASA missions

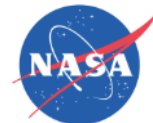




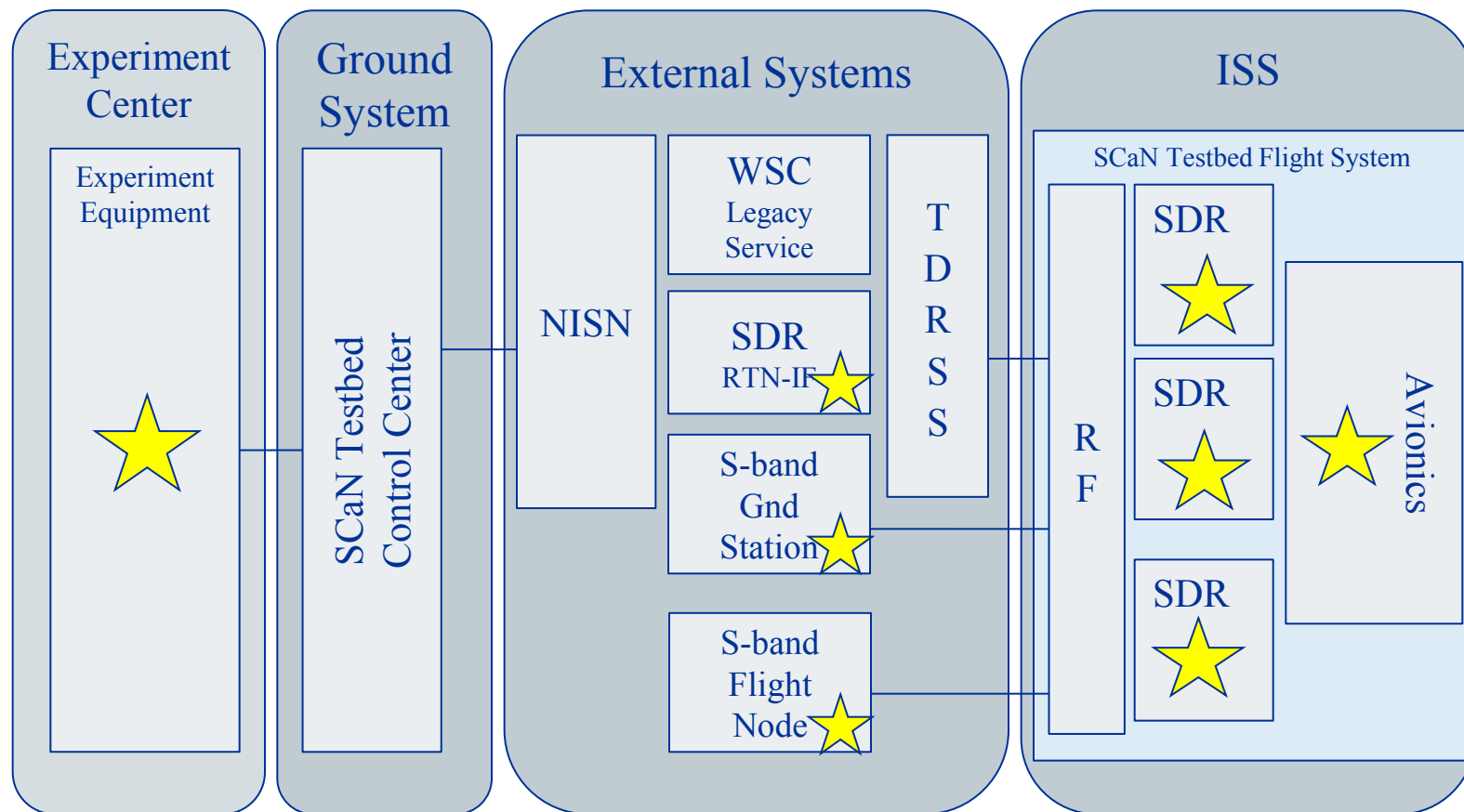
# What Experiment Can I Do?

- Research & Technology or New Product Developments: raise technology readiness level (TRL)
  - Spectrum Efficient Techniques (new modulations and coding)
  - Adaptive Waveforms and Cognitive Radio
  - GPS enhancement demonstrations (L1/L2, L5, TDRS Augmentation)
    - First L5 space receiver
  - Networking including DTN (store/forward), adaptive routing, new routing protocols, sensor web applications, formation flying, relative comm/nav
- Architecture
  - Unique system access in space with compatible ground station and Space Network
- Conops
  - Use on-orbit processing capacity in new and different ways





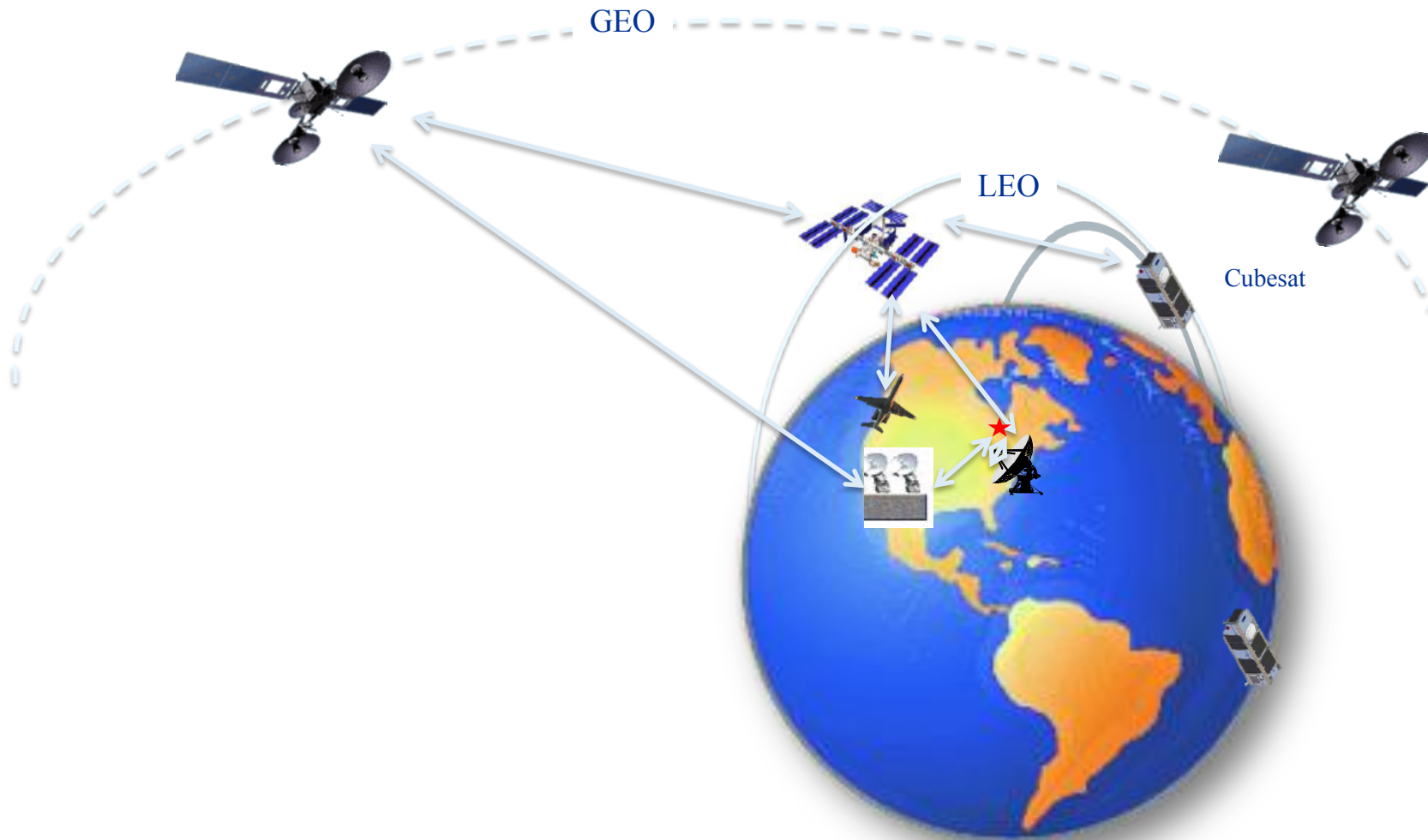
# Experimenter Access Points within SCaN Testbed System



★ = Experimenter Access Point (e.g. sw, fw, or hw component)

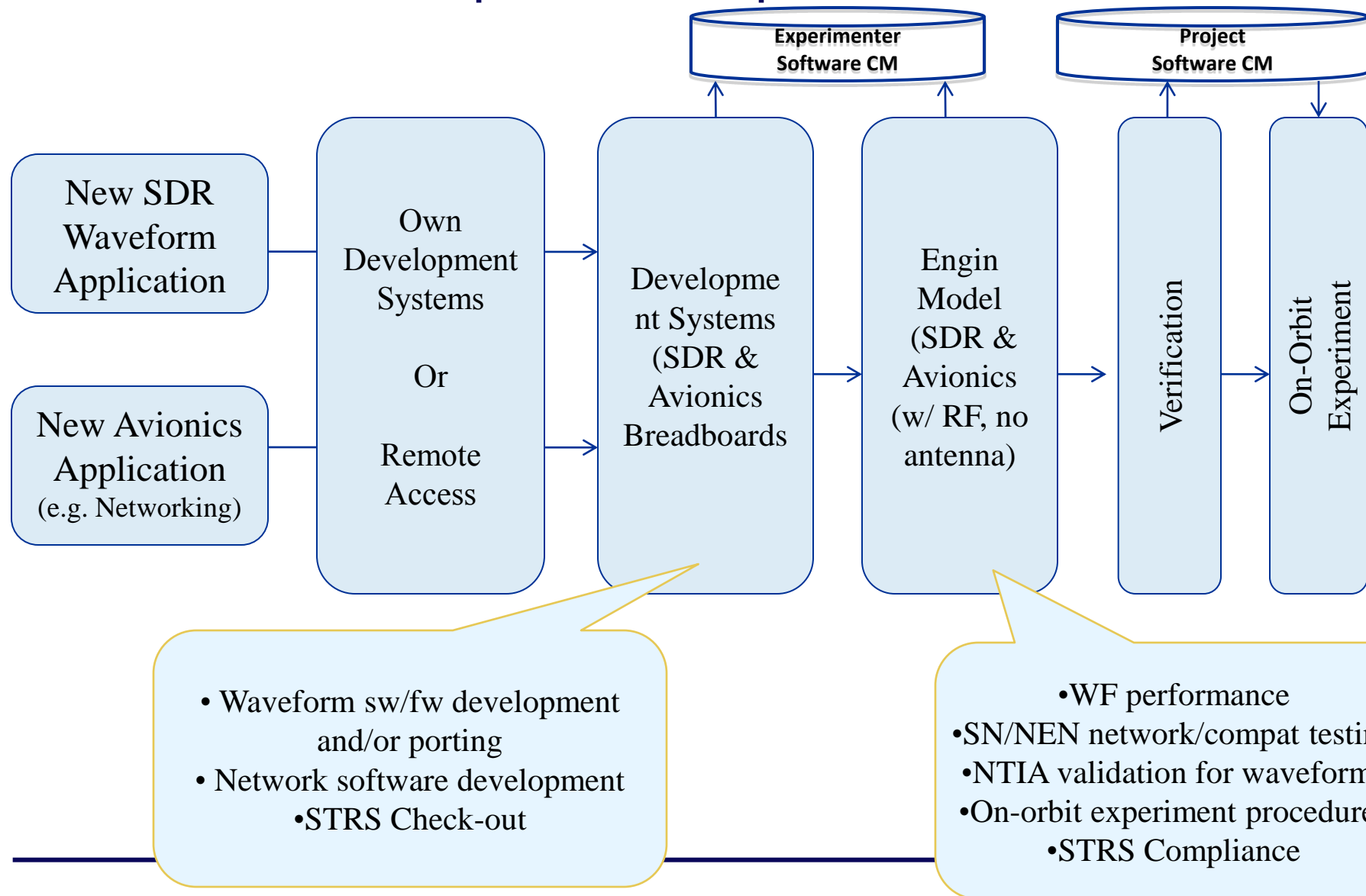
Experimenters have access to  
Flt SDRs, avionics, Gnd SDR, various ground points

# Architecture Concept Example

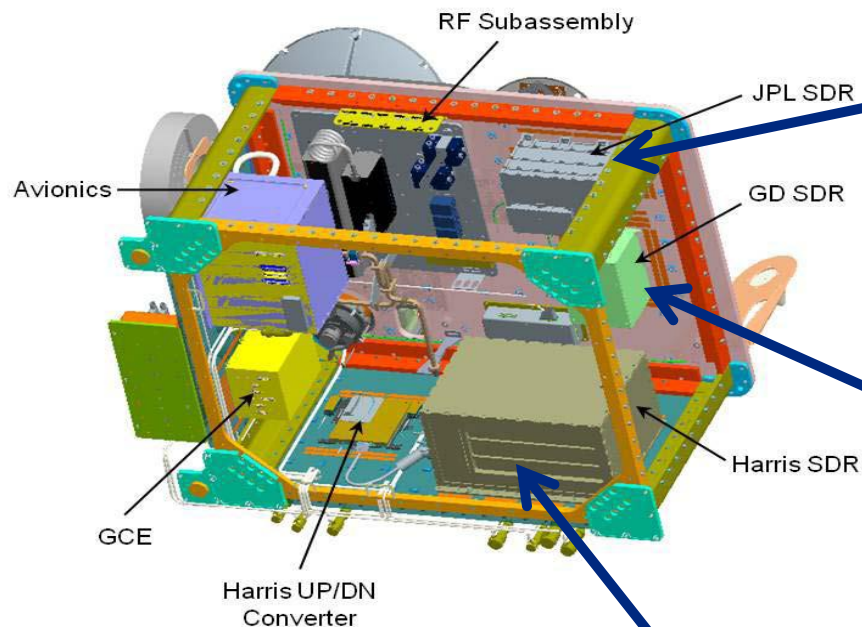




# New Experiment Development to Operations Flow



# Software Defined Radios are the “Instruments” of the SCaN Testbed



## JPL/L-3 CE

- S-band SDR
  - 6 MHz wide channel
- L-band receive (GPS)
- Virtex II, Sparc Processor, RTEMs
- 10 Mbps Class
- STRS Compliant



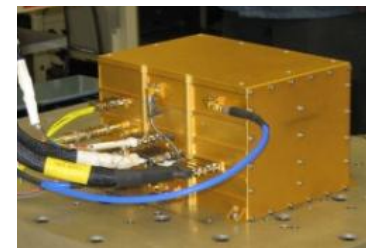
## Harris

- Ka-band SDR
  - 225 MHz wide channel
- Virtex IV, PowerPC Proc, DSP (1 GFLOP), VxWorks
- >100 Mbps Class
- STRS Compliant



## General Dynamics

- S-band SDR
  - 6 MHz wide channel
- Virtex II, ColdFire Processor (60 MIPS), VxWorks, CRAM (Chalcogenide RAM) Memory
- 10 Mbps Class
- STRS Compliant





# EXPERIMENT PROCESS




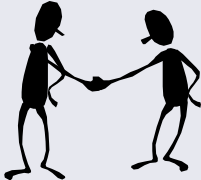




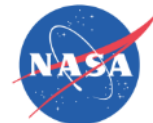
# Introduction to Experiments

- Call for Experiments! Industry and Academia Welcome!
- Experiment Selection Process
  - Experiment Board: Co-PIs from each Center; GRC, GSFC, JPL, JSC, HQ
  - Operations Team: Assess effort required to execute the experiment
- Experiment Team – This means You!
  - Defines Experiment Requirements, develops SDR sw/fw, ground and space configurations, and conducts real time and post flight analysis of exp't data.
- The SCaN Testbed Project Team
  - Support experimenter, access to ground systems, assist with on-orbit exp't
  - Plan and schedule mission support services, both ground and in space
  - Command/control, software upload, and file maintenance
- SCaN Testbed Control Center/SCaN Testbed Experiment Center
  - @ John H. Glenn Research Center, Cleveland, Ohio



# Experiment Calls - Comparison

Intended Org	Call	Proposal	Evaluation	Agreement	Available Funding
University	Cooperative Agreement Notice (CAN)	Submitted via NSPIRES to Principal Investigator	Three review periods (proposal due dates): Sept, Jan, May	Cooperative Agreement	
Commercial	Experiment Opportunity (EO)	Submitted directly to Project Principal Investigator/Experiment Board Chair.	Ongoing/Open –may synch-up with CAN	Space Act Agreement	
NASA/ OGA	Experiment Opportunity  Internal Process	Submit directly to Principal Investigator/ Experiment Board Chair	Review cycle or call Exp. Board as-needed	MOU	
Small Biz Commercial	SBIR	Submit to NASA SBIR annual call	NASA review, per SBIR process	Contract	



# NSPIRES Website

NSPIRES - Solicitations Open - Windows Internet Explorer

http://nspires.nasaprs.com/external/solicitations/solicitations.do?method=open&stack=push

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NSPIRES - Solicitations Open

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**NSPIRES** NASA Solicitation and Proposal Integrated Review and Evaluation System

NSPIRES Time: Nov 06, 2012 02:14PM EST

**NASA Research**

- Solicitations

**View Solicitations**

- Future
- Open
- Closed/Past Selected

**Solicitations**

**Open Solicitations**

Solicitation Title	Solicitation #	Released	NOI Due	Proposal Due
Announcement of Flight Opportunities (AFO)	<a href="#">NOCT110</a>	12/21/2010	--	12/21/2012
Game Changing Opportunities In Technology Development	<a href="#">NNL12A3001N</a>	02/10/2012	--	02/09/2013
NASA ARMD Research Opportunities in Aeronautics (ROA-2011)	<a href="#">NNH11ZEA001N</a>	08/26/2011	--	08/01/2013
NASA Earth and Space Science Fellowship 2013	<a href="#">NESSF13</a>	11/01/2012	--	(See Announcement)
NASA Earth and Space Science Fellowship 2013	<a href="#">NESSF13</a>	11/01/2012	--	(See Announcement)
NASA Earth and Space Science Fellowship 2013	<a href="#">NESSF13</a>	11/01/2012	--	(See Announcement)
NASA Earth and Space Science Fellowship 2013	<a href="#">NESSF13</a>	11/01/2012	--	(See Announcement)
NASA Earth and Space Science Fellowship 2013 Renewal	<a href="#">NESSF13R</a>	11/01/2012	--	(See Announcement)
NASA Earth and Space Science Fellowship 2013 Renewal	<a href="#">NESSF13R</a>	11/01/2012	--	(See Announcement)
NASA Earth and Space Science Fellowship 2013 Renewal	<a href="#">NESSF13R</a>	11/01/2012	--	(See Announcement)
NASA Earth and Space Science Fellowship 2013 Renewal	<a href="#">NESSF13R</a>	11/01/2012	--	(See Announcement)
NASA Space Technology Research Fellowships (NSTRF)-Fall 2013	<a href="#">NSTRF13</a>	10/10/2012	--	12/04/2012
Ocean Observation - 2010, 2012	<a href="#">NNH09ZEC001U</a>	12/10/2009	--	12/13/2012
Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions	<a href="#">NNJ12ZSA002N</a>	07/30/2012	--	(See Announcement)
Research Opportunities in Space and Earth Sciences (ROSES) - 2011	<a href="#">NNH11ZDA001N</a>	02/18/2011	--	12/15/2012
Research Opportunities in Space and Earth Sciences (ROSES) - 2012	<a href="#">NNH12ZDA001N</a>	02/14/2012	(See Announcement)	(See Announcement)
Research Opportunities in Space Biology	<a href="#">NNH12ZTT001N</a>	09/30/2012	--	(See Announcement)
Second Stand Alone Missions of Opportunity Notice (SALMON-2)	<a href="#">NNH12ZDA002N</a>	02/07/2012	--	02/06/2017
Use of the Space Communications and Navigation (SCaN) Testbed: A Communications, Navigation and Networking Reconfigurable Testbed	<a href="#">NNC12ZRH002C</a>	08/10/2012	--	01/31/2013

Internet | Protected Mode: On 140%



# Federal Business Opportunity WebSite

Opportunities - Federal Business Opportunities: Opportunities - Windows Internet Explorer

https://www.fbo.gov/index?s=opportunity&mode=list&tab=list

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Opportunities - Federal Business Opp...

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Keyword / Solicitation #:  [TIPS](#) Posted Date:

[Search by Agency, Set-aside, State, and Type](#) [Search by Classification, NAICS code, Recovery actions, and more](#)

1 - 8 of 8 Sort By  Showing  per page

Opportunity	Agency/Office/Location ▼	Type ▼ / Set-aside ▼	Posted On ▲
<a href="#">A--SNOW AND ICE DISTRIBUTED ACTIVE ARCHIVE CENTER</a> RFI-2012SnowandIceDAAC A -- Research & Development	National Aeronautics and Space Administration Goddard Space Flight Center Office of Procurement	Sources Sought (Modified)	Oct 16, 2012
<a href="#">66--SCANNING ELECTRON MICROSCOPY HOLDER</a> NNC12045004Q 66 -- Instruments & laboratory equipment	National Aeronautics and Space Administration Glenn Research Center Office of Procurement	Award	Sep 26, 2012
<a href="#">A--EXPERIMENT OPPORTUNITY FOR USE OF THE SCAN SPACE COMMUNICATIONS AND NAVIGATION TESTBED</a> SCANTestbed2012 A -- Research & Development	National Aeronautics and Space Administration Glenn Research Center Office of Procurement	Special Notice (Modified)	Sep 14, 2012

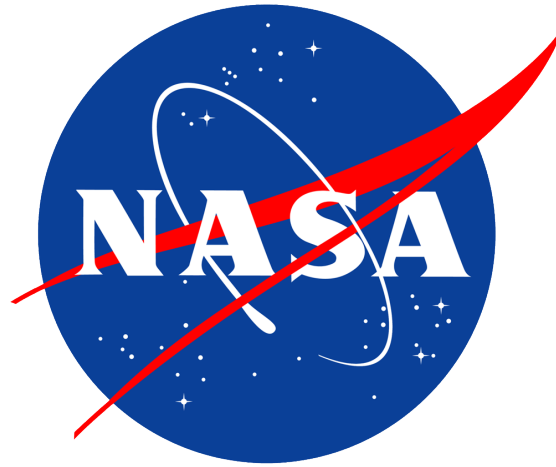
Internet | Protected Mode: On



## Summary

- Space-based SDR SCaN Testbed launched, on-orbit and ready for operation!
- SCaN Testbed available to commercial, university, and other partners for experiments
  - Experiment proposals welcome to demo new products/technologies and reduce risk of SDRs
  - e.g. when do SDRs make sense for use in Space Missions?
- Come see us in the Exhibit Area for information

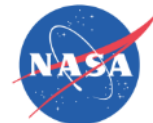






# SCaN Testbed Point of Contacts

- Project Website
  - <http://spaceflight systems.grc.nasa.gov/SOPO/SCO/SCaNTestbed>
- Technical Contacts
  - Principal Investigator
    - Mr. Richard Reinhart
    - [richard.c.reinhart@nasa.gov](mailto:richard.c.reinhart@nasa.gov)
    - 216-433-6588
  - Deputy Principal Investigator
    - Ms. Sandra Johnson
    - [sandra.k.johnson@nasa.gov](mailto:sandra.k.johnson@nasa.gov)
    - 216-433-8016
- Programmatic Contact
  - Project Manager
    - Mr. Dave Irimies
    - [david.p.irimies@nasa.gov](mailto:david.p.irimies@nasa.gov)
    - 216-433-5979



# STRS and SCaN Testbed References

- Space Telecommunication Radio System Rel 1.02.1
  - NASA/TM—2010-216809/REV1
  - [http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110002806\\_2011001718.pdf](http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20110002806_2011001718.pdf)
- SDR/Winn Forum: Comments on NASA Space Telecommunications Radio System (STRS)
  - <http://groups.winnforum.org/Recommendations>
  - SDRF-07-R-0013-V1.0.0
- SCaN Testbed Overview, Documents, Links
  - <http://spaceflightsystems.grc.nasa.gov/SOPO/SCO/SCaNTestbed/Candidate/>



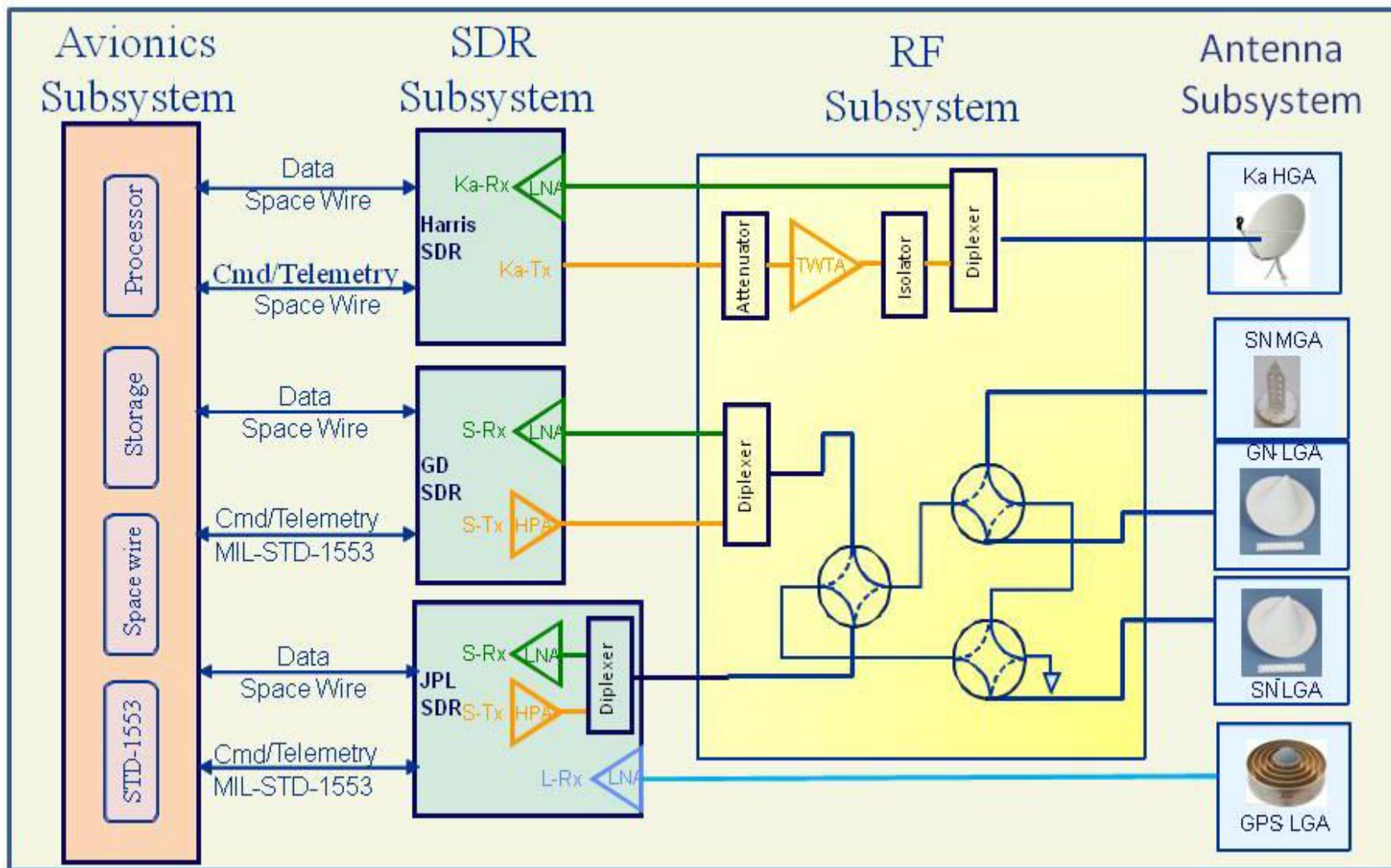
# Call For Experiment Information

- University
  - NSPIRES:  
<http://nspires.nasaprs.com/external/index.do>
- Commercial/Non-profit
  - FedBiz Ops: <https://www.fbo.gov/>
- Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR)
  - <http://sbir.gsfc.nasa.gov/SBIR/SBIR.html>



# Backup

# SCaN Testbed Flight System Connections





# SCaN Testbed Ground Systems

