RapidScat: A "Rapid" GDS to Help RapidScat Capture Ocean Winds on the ISS

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RapidScat Overview

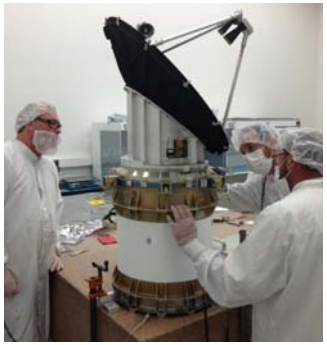
- **ISS-RapidScat : International Space Station Rapid Scatterometer**
  - Purpose: Provide near-surface wind vectors over the ocean

    Provide cross-calibration for other ocean wind satellites

    To observe the variation of ocean winds as a function of time of day
  - Payload: Existing SeaWinds engineering model (EM) and flight spare assemblies modified for accommodation on ISS

    Note: EM sitting on the shelf for over 10 years!
  - Launched: September 20, 2014

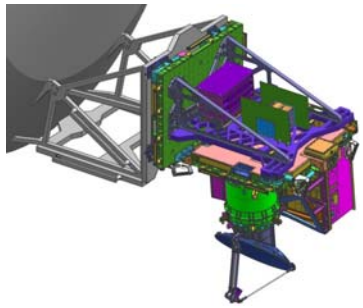
    SpaceX (CS-4) Falcon-9 from Cape Canaveral



RapidScat Overview

- Transferred to ISS on a SpaceX Dragon trunk

- Finally installed on the ESA Columbus Module on the ISS

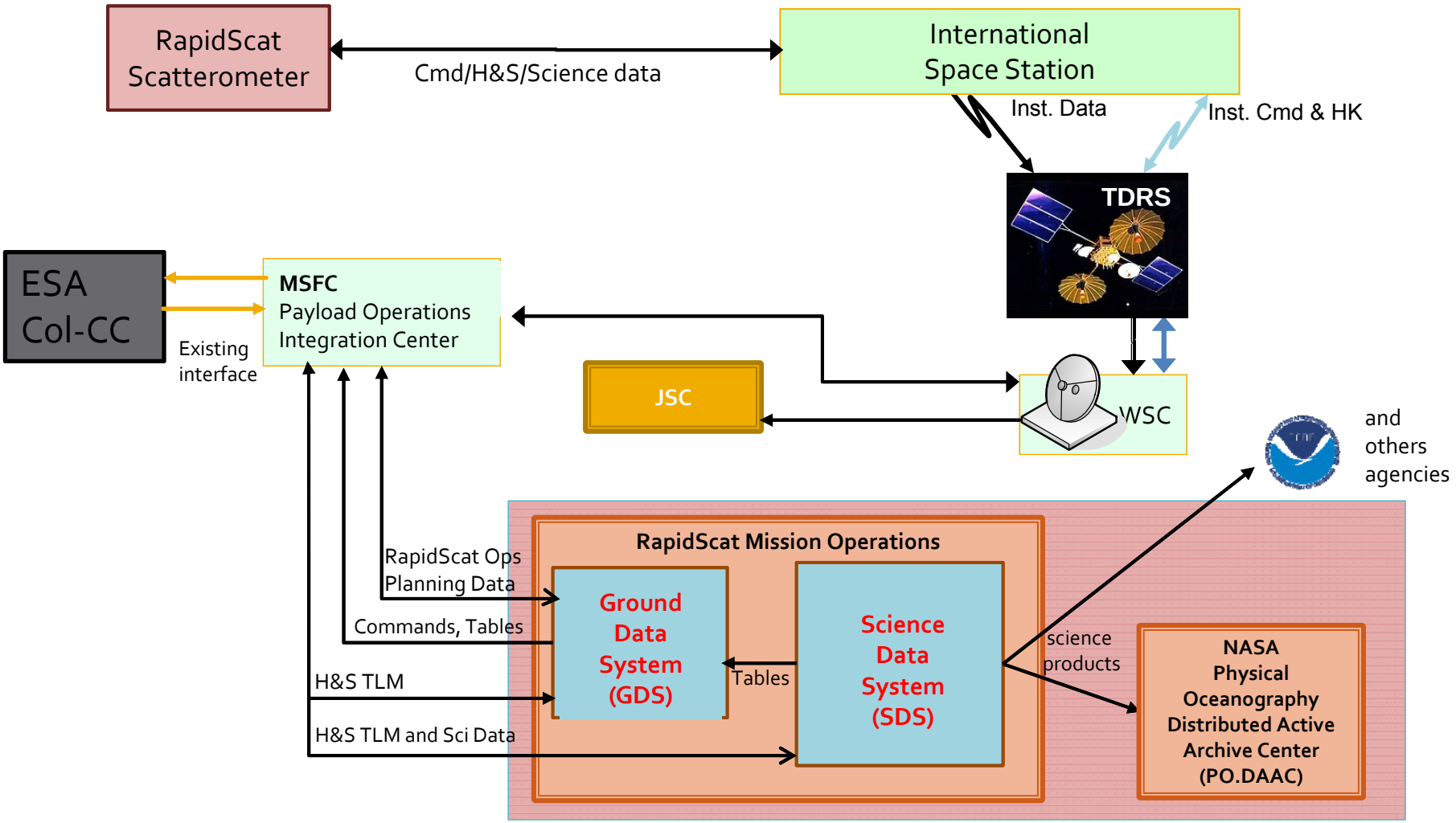


- Operational: October 1, 2014
- Status: Still in orbit and providing wind data!

Why "Rapid"-Scat?

- Why "Rapid"-Scat
  - To quickly provide ocean wind data to mitigate the loss of QuikSCAT and OSCAT spacecrafts to scientists and weather forecasters
    - Entails
      - Using ISS versus "free-flying" spacecraft
      - "Free-ride" to ISS on ISS resupply mission (CS-4)
      - Reusing spare radar hardware (aka Seawind EM) circa 1999
        - RapidScat-to-ISS mounting bracket (Nadir Adapter), interface hardware and software, and antenna dish were new
  - Timeframe: Approximately 2 years (2012 – 2014)
    - GDS started approximately in early 2013
    - Original launch date was scheduled for June 2014
    - Actual launch was on September 20, 2014

GDS "High-Level" Overview

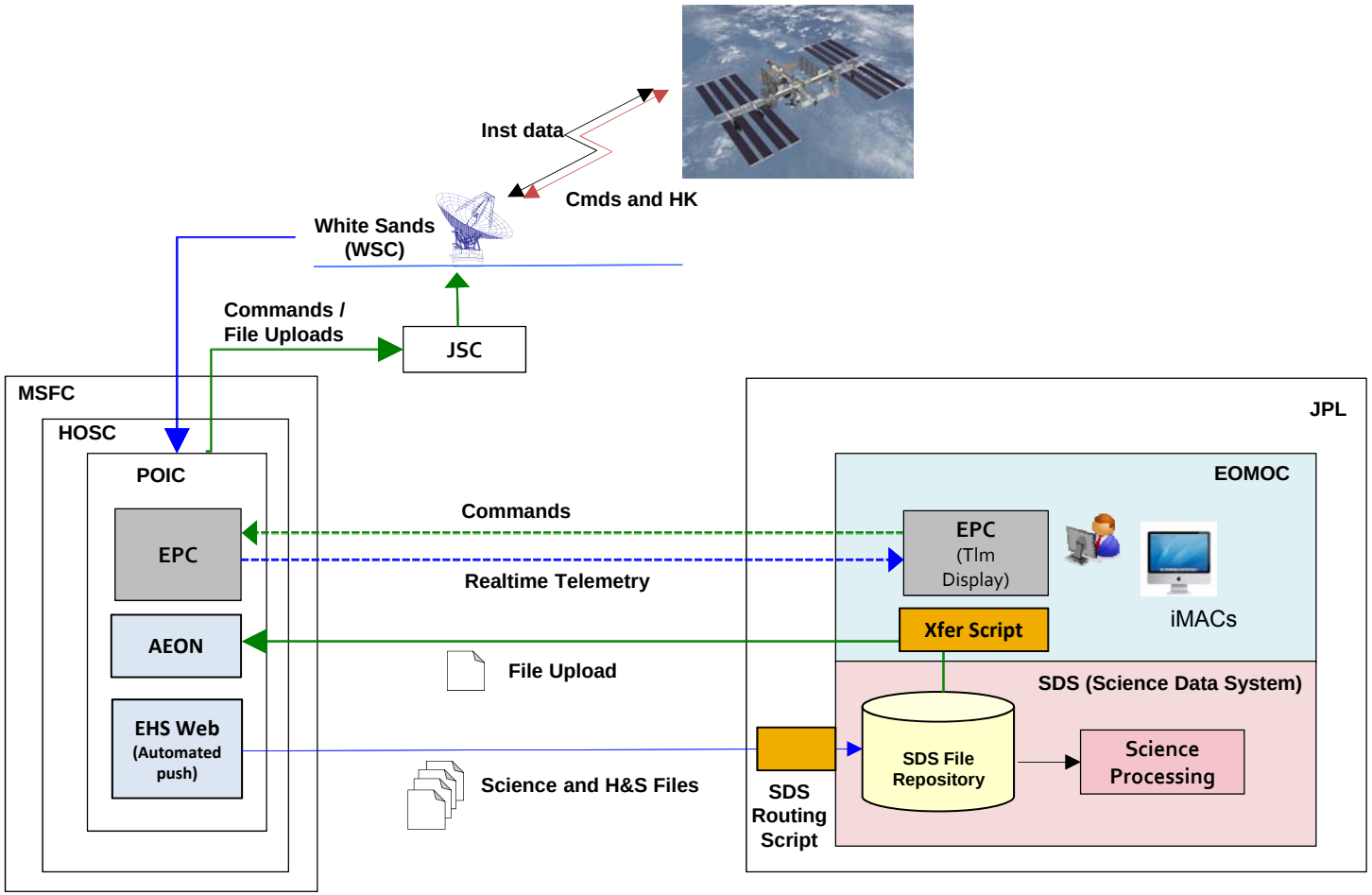


Design Overview

RapidScat GDS is based upon using available tools and services to achieve a low cost ground data system in the shortest available time

- **POIC** (**P**ayload **O**perations **I**ntegration **C**enter) tools and services include the following:
  - POIC **E**nhanced **HOSC** (**H**untsville **O**perations **S**upport **C**enter) **S**ystem (**EHS**) Services
    - Command services
    - Telemetry processing
    - Alarm Limit Monitoring
  - POIC Tools
    - EPC (Enhanced HOSC System Personal Computer)
      - Commanding and Telemetry Display for Operations
    - EHS Web
      - NRT Telemetry Query, Cmd Log, Custom Telemetry Pckt generation
    - TReK (Telescience Resource Kit)
      - Command and Telemetry tool for I&T
- By selecting the POIC Tools, the RapidScat OPS team was able to exercise their (actual operational) ground tools in the test phase as they would have been used in operations
- Inherit JPL software
  - File transfer and notification script from QuickScat with modifications for RapidScat
  - ESMC scripts and programs already used for other Earth Science missions

GDS High-Level Data Flow



HOSC Tools

Tool	Services
	• Data Services – retrieve, process, record, playback, forward, and display data (ground based data or telemetry data). • Support for various data interfaces such as UDP, TCP, and Serial interfaces. • Command – create, modify, send, and track commands. • Command Management -- Configure one TReK system to serve as a command server/filter for other TReK systems. • Database – databases are used to store telemetry and command definition information. • Application Programming Interface (API) – ANSI C interface compatible with commercial products such as Visual C++, Visual Basic, LabVIEW, Borland C++, etc. The TReK API provides a bridge for users to develop software to access and extend TReK services. • Environments –development, test, simulations, training, and flight. Includes standalone training simulators. • Forward work to include support for CFDP and DTN.

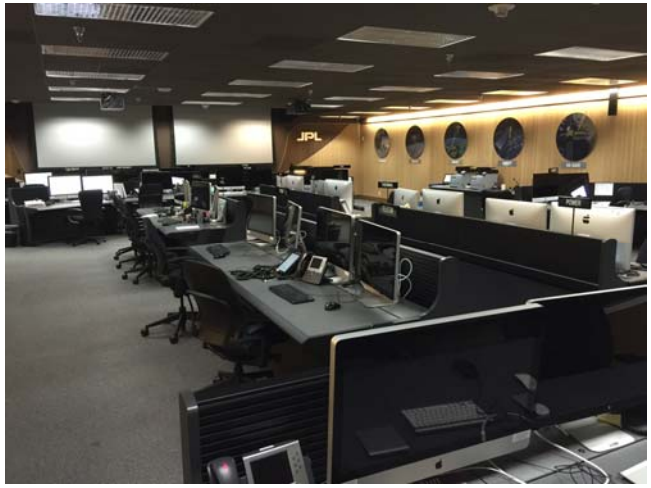
	• Rich toolset to provide point and click creation to:
	  • Receive and display telemetry data on a user-defined display
	  • Perform computations on the received telemetry values
	  • Continuously monitor specific telemetry parameters to detect anomalies
	  • Update and uplink commands to the spacecraft
	  • Track and verify command uplinks
	  • Extensive scripting language for automated telemetry acquisition, command updates, and command uplinks
	• Can be combined with TReK to provide comprehensive processing of payload science and health and status data


Web and Portal
	• Secure access to mission support tools including:
	  • Programmatic access to Near Real-Time Data
	  • Command tracking and post-analysis
	  • Custom telemetry stream generations (GSE Packets)
	  • Mission configuration management (PIMS)
	  • Mission support tools (console log tool)

Chart provided by MSFC

EOMOC

- EOMOC (Earth Orbiting Missions Operation Center)
  - Multimission MSA (Mission Support Area)
    - Commissioned in March 2014 (Brand spanking new!)
      - GDS test schedule and implementation had to accommodate MSA availability
    - RapidScat was the first operational project to use it
    - Currently supports RapidScat and SMAP projects
  - Facility was "free" for RapidScat to use
  - Provided iMac workstations
    - NOTE: POIC tools were PC based
      - Started out with Parallels
      - Ended up with Bootcamp



Different Culture…

- ISS (MSFC)
  - More "man-in-the-loop" science support
  - Payload processing performed on as-needed basis
  - Tight person-to-person interaction between payload and MSFC (HOSC)
    - Commanding (Payload team with PRO)

  Note: RapidScat was their first operational payload rather than a science experiment payload
- JPL (RapidScat)
  - Basically…. "lights out" operation
  - RapidScat is taking wind data 24/7
  - Project was on a "tight budget" and couldn't support round-the-clock flight team
  - Data had to be provided to forecast agencies within 3 hours
    - NOAA, international meteorological agencies

Bridging the Culture…

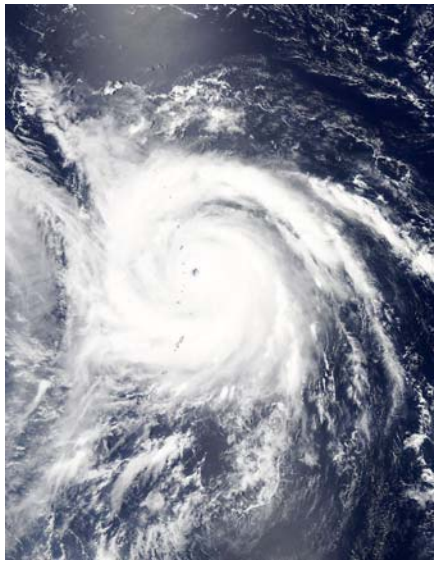
- Work with the HOSC team to implement automation where possible
  - Automated telemetry file transfers from HOSC to JPL
    - Utilized EHS Web "cyclic" telemetry file transfer capability
      - Only limitation was on file sequence number rollover
        - Note: RapidScat was the first ISS payload to utilize the "cyclic" capability in the round-the-clock manner. Other payloads would utilized this capability on a more limited scope; therefore, they didn't run into this issue
  - Automated Table File transfer from JPL to HOSC on daily schedule
    - Generated transfer script (JPL) to automatically send table files to HOSC on daily schedule
      - EPC developer (HOSC) provided valuable support in developing the interface component of the script
    - Once table was uplinked to the ISS, HOSC used JPL-generated script to transfer the table file to RapidScat itself (using HOSC proprietary language)

Team Work

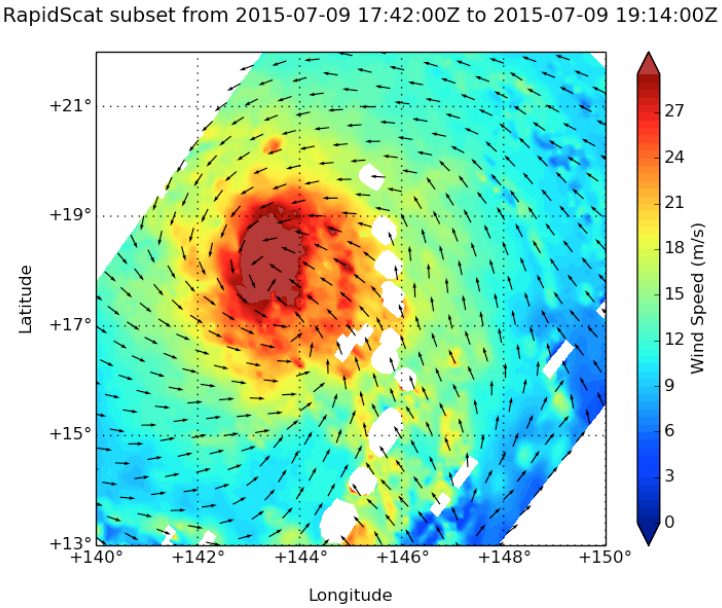
- **Outstanding GDS teamwork between JPL and Marshall**
  - Marshall team …
    - Provide excellent support
      - Note: Customer Service Representative (CSR) was extremely valuable as our JPL-to MSFC interface
    - Professional
    - Had great attitude
    - Knowledgeable
  - Overall..
    - Great rapport between the teams from development to operations!

Results

- Tropical Storm Nangka (July 9, 2015)



Aqua spacecraft view



RapidScat View

- RapidScat currently provides ocean wind measurements to NOAA, Eumetsat, ISRO, and other meteorological agencies forecasting weather and tracking storms

Summary

- Working with Marshall and JPL teams, RapidScat was able to design and implement a GDS to support operations in a short timeframe (early 2013 to June 2014)
- RapidScat is still operational and providing ocean wind data on a 24/7 basis
- RapidScat GDS model is being used for upcoming ISS payloads