JOINT POLAR SATELLITE SYSTEM (JPSS) COMMON GROUND SYSTEM (CGS) USE OF SPACE LINK EXTENSION (SLE) PROTOCOL

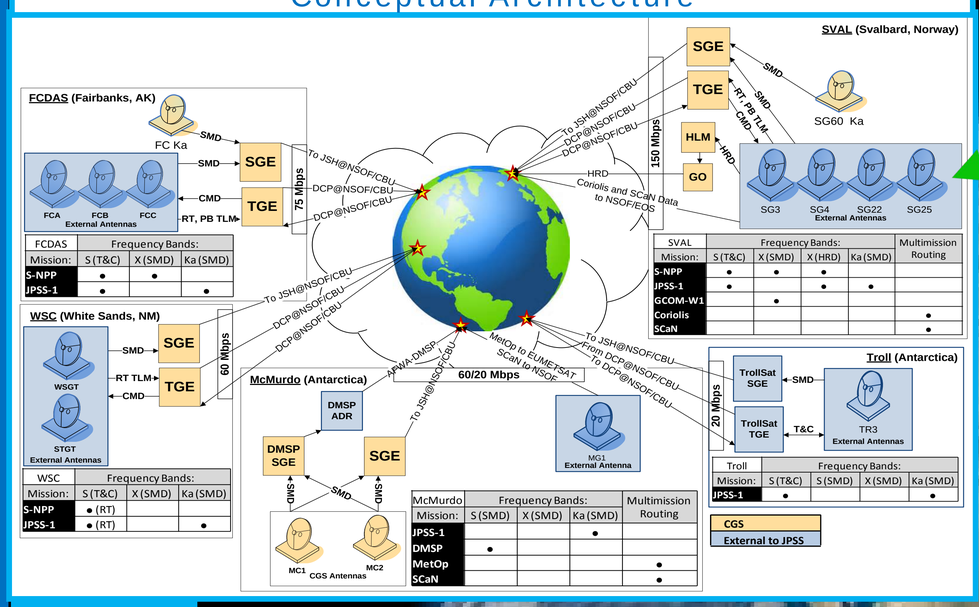
Lindsay Johnson and Chris Tillery, Raytheon Co., Aurora CO

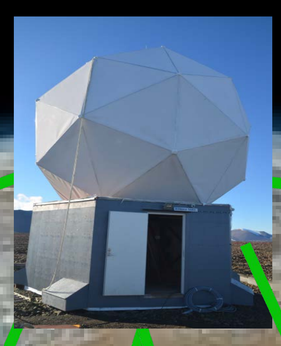
Guy Cordier, JPSS Ground Project Office, Greenbelt MD

Michael Jamilkowski, Raytheon Co, Greenbelt MD

NOAA and NASA are jointly acquiring the next-generation civilian operational weather and environmental satellite system: the Joint Polar Satellite System (JPSS). JPSS will contribute the afternoon orbit component and ground processing system to replace the current Polar-orbiting Operational Environmental Satellites (POES) managed by NOAA and the ground processing component of the POES. The JPSS satellites will carry a suite of sensors designed to collect meteorological, oceanographic, climatological, and solar-geophysical observations of the earth, atmosphere, and space. The ground processing system for JPSS, known as the Common Ground System (JPSS CGS), provides command, control, communications, data processing and product delivery. The CGS currently flies the Suomi National Polar-orbiting Partnership (S-NPP) satellite and acquires, routes and processes S-NPP mission data to provide Environmental Data Records (EDRs) to NOAA and DoD processing centers operated by the U.S. government, generating multiple terabytes per day across more than two dozen environmental data products. New Space Link Extension (SLE) capable ground hardware will provide a standardized and reliable data delivery interface. Implementation of CCSDS Standardized Space Link Extension (SLE) data delivery protocol for JPSS Stored Mission Data and Low Rate Telemetry provides benefits such as a new interface using TCP/IP guaranteed data delivery protocol (which reduces the number of ground recoveries and chance of data loss) and a standard interface allowing easy integration of new SLE-compliant COTS with minimal-to-no NRE required from the COTS supplier. Upgrade features such as the SLE protocol are part of the CGS's new, flexible architecture which facilitates multimission capabilities that offer significant opportunities for cost reduction and improved information integration across missions.

JPSS CGS Space-Ground Communications Node (SGCN) Conceptual Architecture

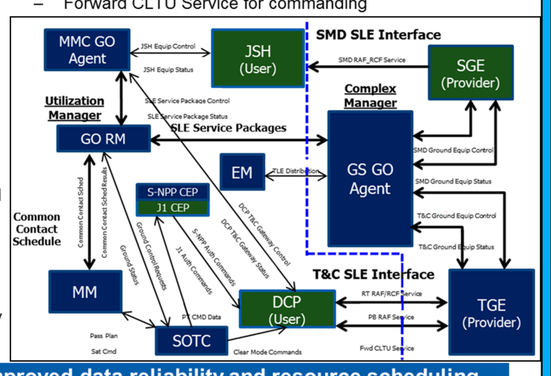




JPSS CGS Space Link Extension Overview

JPSS Common Ground System — Raytheon Intelligence, Information and Services

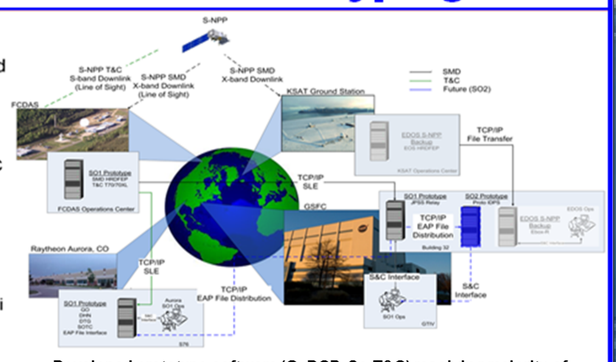
- Space Link Extension
  - CCSDS AOS Space Data Link Protocol standard (701.0-B-3-S) for Ground Station to Data Center communication
  - Removes Proprietary Formats and moves to Industry Standard interfaces
  - Increased Interoperability
  - Implemented in SGE and JSH for SMD, TGE and DCP T&C Gateway for T&C
  - SLE Services require two way authentication in Bind and Start SLE Service data distribution
  - Applicable for S-NPP, J1, and GCOM-W1
- SLE Service Management
  - Used to provision SLE services from the ground station and coordinated ground resource management
  - Leverages the Common Scheduling approach described within CCSDS 910.11
  - Utilization Manager (GO) receives Common Contact Schedule (CCS) from MM to create Service Packages to be executed at the ground stations
  - Complex Manager (GO) Executes CCS Service Packages autonomously and assesses ground resources for availability and deconfliction
  - Two Return Services:
    - Return All Frames (RAF) – nominal for SMD and TLM
    - Return Channel Frames (RCF) – scheduled recoveries
  - Three Delivery Modes:
    - Complete Online (SMD, PB-TLM)
    - Timely Online (RT-TLM)
    - Offline (SMD and TLM recoveries)
  - Forward CLTU Service for commanding



CGS SLE architecture provides improved data reliability and resource scheduling

SLE SMD and TLM Prototyping

- To facilitate SLE risk reduction and design, Support Order 1 prototyped multiple SLE SMD and T&C architectures
- Procedure
  - Shadowed S-NPP and GCOM passes from FCDAS and routed SMD and TLM to GSFC and Aurora
  - Performed quality checks on results from Svalbard contacts
- Results
  - No data dropped via SLE TCP/IP
  - 2 SMD passes per day Mon-Fri since March 2013
    - ~360 passes
  - 3 Telemetry passes per day Mon-Fri since Jan 2013
    - ~620 passes
  - Reduced risk and lifecycle cost
  - Scaled down software development needs



- Developed prototype software (G ,DCP, So T&C) resolving majority of issues and identifying key functions that need further development and optimizations
- Uncovered interface and processing limitations that would not otherwise have been detected until the formal integration
- Down selected to Spacetec HRDFEP (SLE SMD Provider) + JSH (SLE SMD User/Provider), Ingenicomm (SLE T&C User), and RT Logic (SLE T&C)

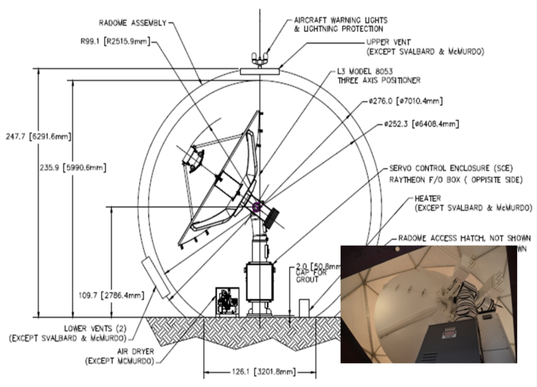
Prototyping effort reduced design risk to produce a robust SMD architecture

CGS Multi-Mission Global Ground Station Architecture

JPSS Common Ground System — Raytheon Intelligence, Information and Services

- JPSS CGS provides two Ka-band and two Ka/S-band receptors for J1 and DMSP
  - **J1:** Ka-band: 26.7 GHz
  - **DMSP:** S-band: 2.2 - 2.3 GHz
- JPSS CGS supports ½ Orbit SMD dumps for J1

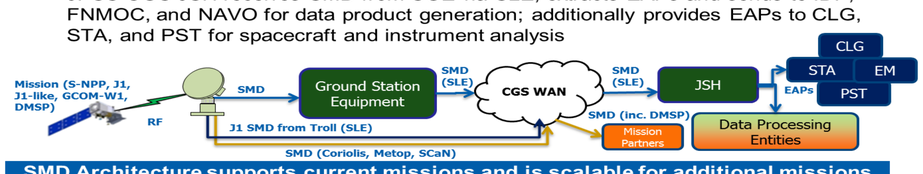
Site	Type	Mission	Install Date
McMurdo	Ka/S-band Ka/S-band	J1, DMSP	MC1: 2/2011 MC2: 2/2012
FCDAS	Ka-band	J1	FCKa: 7/2013
Svalbard	Ka-band	J1	SG60: 8/2013



SMD Data Flow

JPSS Common Ground System — Raytheon Intelligence, Information and Services

- JPSS CGS supports missions through Managed Missions, Data Acquisition, Data Routing, Data Processing and is designed to be scalable for future mission growth
- JPSS CGS acquires mission data from five ground stations hosted and operated by JPSS CGS and mission partners
- For missions where ground processing is performed, the JPSS C3S Ground Station Equipment implements CCSDS AOS Space Link Extension (SLE) protocols within the SMD Ground Equipment (SGE)
- JPSS CGS network provides the scalable high rate data paths through the JPSS CGS WAN for transferring SMD to the Management and Operations Node and data processing entities; implements WAN acceleration to maximize throughput efficiency
- JPSS CGS JSH receives SMD from SGE via SLE, extracts EAPs and sends to IDP, FNMOC, and NAVO for data product generation; additionally provides EAPs to CLG, STA, and PST for spacecraft and instrument analysis

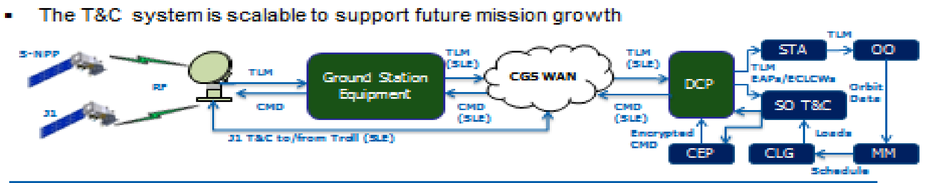


SMD Architecture supports current missions and is scalable for additional missions

Telemetry and Command Thread

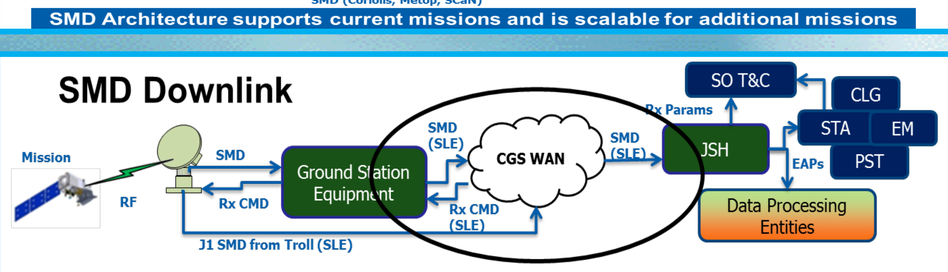
JPSS Common Ground System — Raytheon Intelligence, Information and Services

- JPSS CGS acquires S-NPP and J1 telemetry and sends commands from one primary ground station (Svalbard) and three backup sites (FCDAS, WSC using the Space Network, Troll for J1 only)
- All T&C antennas are external to JPSS CGS where contacts and utilization are planned and scheduled through the MON at the NSOF/CBU
- Telemetry includes Real-time Telemetry (for Operator visibility during contact) and Playback Telemetry (for analysis and memory management)
- Commanding includes Real-time Commanding (execution by S/C during contact), Table Loads (for back orbit execution) and Software Loads (for S/C and instrument upgrades); Commands are encrypted with the CEP subsystem using Caribou for S-NPP and AES CCM for J1 and transmitted to the ground station using SLE Forward CLTU Services
- The T&C system is scalable to support future mission growth

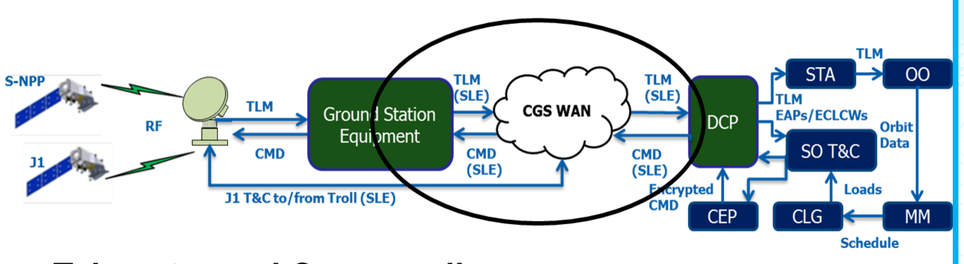


C3S provides T&C for multi-mission/site telemetry and command capabilities

SMD Downlink



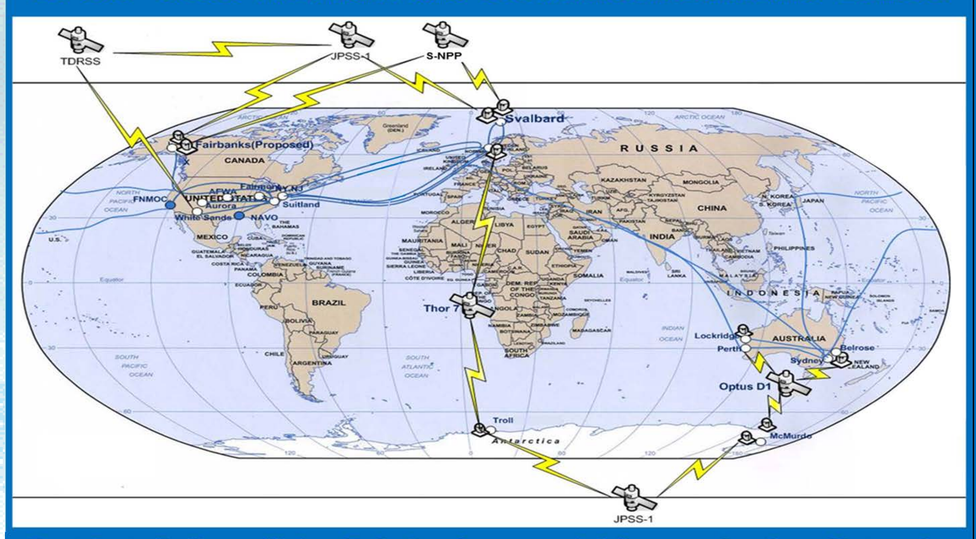
SLE



Telemetry and Commanding

- *Implementation of CCSDS Standardized Space Link Extension (SLE) data delivery protocol for Stored Mission Data and Low Rate Telemetry; Benefits:*
  - *New SLE interface utilizes TCP/IP guaranteed data delivery protocol reducing number of ground recoveries and chance of data loss*
  - *Standard interface allows easy integration of new SLE compliant COTS with minimal to no NRE required from the COTS supplier*
- *B2.0 C3S Design provides significant architectural improvements over current B1.2 operations*
  - *Centralized SMD distribution and guaranteed delivery*
  - *SLE management of T&C and SMD data transfers*
  - *Redundant Ops environments and backup sites for data acquisition*
  - *Upgraded Software Items to increase operational capability*

JPSS CGS Worldwide Communications Lines



Fast Data Delivery Using Existing Commercial Communications Networks

- *SLE data delivery prototyping via Support Order #1 completed including processing of live S-NPP and GCOM – W1 data for updated TLM and SMD SLE HW*
  - *Subcontracts definitized with Kongsberg Spacetec (KSPT), RT Logic, and Ingenicomm*
  - *Onsite witnessing of factory verification of subsystem requirements prior to delivery to JPSS program*

Major C3S Changes for JPSS CGS Block 2.0

System Evolution	Description	Advantage over Block 1.2
CCSDS Space Link Extension (SLE) Services	Reliable SLE data transfer services for Mission, Telemetry and Command Data site to site transfer	• Ease future mission integration due to industry standard design • Simplified GCOM SMD data acquisition • SLE protocol provides enhanced status
JPSS SMD Hub	Centralized SMD distribution Hub with direct TCP/IP connections to Ground station data sources and consumers	• Simplified data routing and retrieval • Guaranteed delivery protocol • Increased reliability via HW COTS solution • Removal of 2 SW subsystems simplifies long-term maintainability
B/CBU Ops Strings	Added fully operational capable, redundant equipment Strings	• Simplified maintenance upgrades • Increased access to simulation capabilities • Satisfied COOP requirements
Receptor Additions	J1 uses Ka-band SMD downlink Frequency	• Reduced downlink interference • Future Mission Expansion Opportunities
Additional Ground sites	Troll (Antarctica), FCDAS (Alaska)	• Backup ground sites at both poles to cover ground anomaly, maintenance or downlink interference outages • Increased system availability

- *Successful Block 2.0 Prototyping Activities demonstrated data flows from S-NPP to GSFC*
  - *T&C AOS CCSDS Space Link Extension (SLE) Protocol Integration*
  - *Reliable SMD Data Transfer System Redesign Right on!*

Copyright © 2014 Raytheon Company. All rights reserved