



The Space Network Ground Segment Sustainment (SGSS) Project:

Developing a COTS-Intensive Ground System



Frank Herman, Linda Esker, Madeline Diep, Kathleen Dangle: Fraunhofer USA

Jeremy Jacobsohn, GMV

Rick Saylor, NASA GSFC

Constance Hoffman, General Dynamics

Agenda

- **Project Overview**
- **Project Approach**
- **Studies and Results**
- **Experiences of a COTS Supplier**
- **Boundaries of Product and Project**
- **On-Going Issues**
- **Key Success Factors**



Project Overview

Project: Space Network
Ground Segment
Sustainment (SGSS)

Purpose: Implement a new modern ground segment that will enable the NASA Space Network (SN) to deliver high quality services to the SN community for the future



Key SGSS Goals:

- Re-engineer the SN ground segment
- Enable cost efficiencies in the operability and maintainability of the broader SN.

Project Approach

- **Consider a more COTS-based solution alternative to the current custom ground system.**
- **Prepared by conducting key studies:**
 1. **A replacement options study**
 2. **A COTS applicability study**
 3. **Quick studies conducted by several companies on how the Space Network ground system could be replaced with a new architecture within the existing facilities**



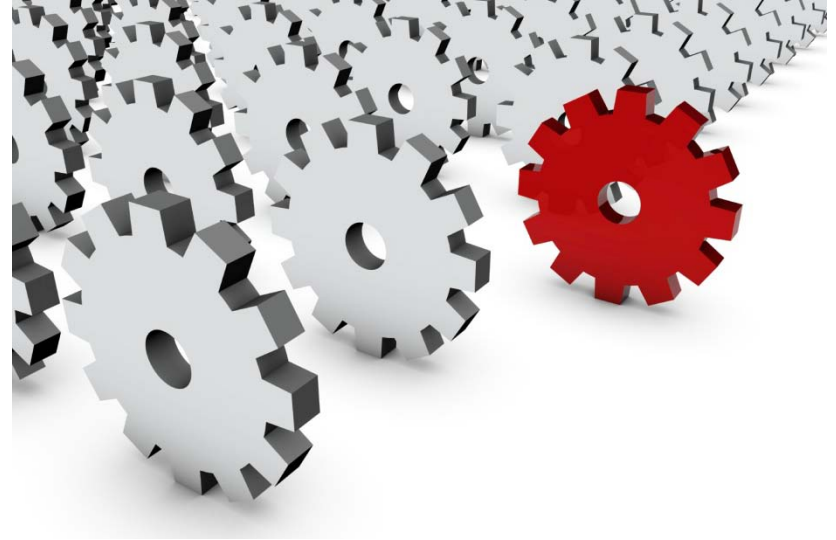
1. Study Results-Replacement Options Study

- **Purpose:** Evaluate options for how the current functions could best be replaced, developing candidate operations concepts and architecture approaches and provided input to a COTS applicability study.
- **Results:**
 - Validated the feasibility of migration from serial to Internet Protocol-based network and analog to digital data processing and distribution
 - Provided a logical top-level grouping of functions/capabilities that would enable management of acquisition of SGSS system



2. Study Results-COTS Applicability Study

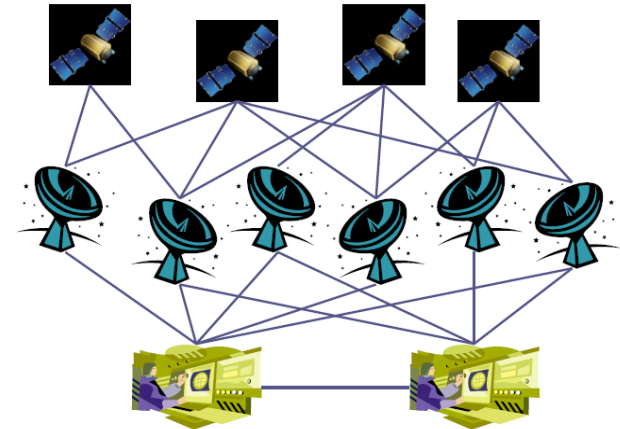
- **Purpose:** To conduct a survey on COTS availability/ applicability for the modernized ground system.



- **Results:**
 - Provided recommendations for where COTS hardware and COTS software tools may be appropriate and which specific tools might apply
 - Identified risks associated with using those COTS products, and provided recommendations for how to mitigate those risks

3. Study Results-Architecture Studies

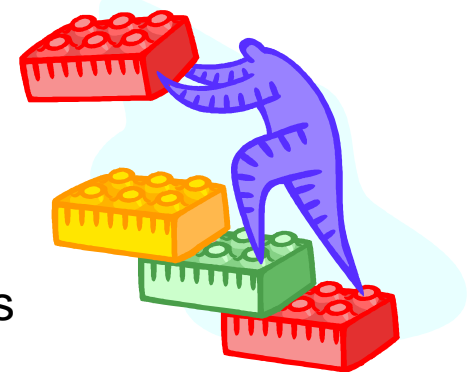
- **Purpose:** To task several companies to conduct quick study on how the SN ground system could be replaced with a new architecture within the existing facilities.



- **Results:** Concluded that the objectives of SGSS were achievable with technology generally available within industry with some custom extensions
 - Most provided scalable, open architecture with an emphasis on COTS, though some proprietary solutions were proposed
 - Proposed a number of COTS products that could be incorporated into the overall solution
 - Showed architecture approach can help with COTS integration
 - Using standards for interfaces and virtual machines (VM) help isolate product dependencies

Going Forward with COTS

- **At RFP submittal, the SGSS SOW specifically required the contractors to use COTS hardware and software unless shown not in the best interest of the Government.**
- **SGSS Project is currently implementing a modern ground system**
 - Little custom hardware
 - Many COTS/MOTS hardware and software suppliers.
 - Service Oriented Architecture (SOA) principles to enable software modules to be more easily updated or replaced in future planned technology refresh cycles.
 - System PDR completed
 - Element/Subsystem CDRs currently underway
- **Gaining valuable experiences adapting and integrating many COTS products**
 - Modification is required for unique COTS products such as TTC and Scheduling.



Experiences of a COTS Supplier: GMV

- One of the key COTS suppliers for SGSS
- Providing the SGSS project with COTS products for
 - Fleet and Ground Management (FGM) including the *hifly*® TTC system and the *archiva* data storage and trending system
 - Schedule Management (SM) including the *flexplan* planning and scheduling engine
- Participating in a full project lifecycle for development of product extensions based on the COTS products



GMV—Matching COTS to SGSS

- **Matching COTS to SGSS is challenging**

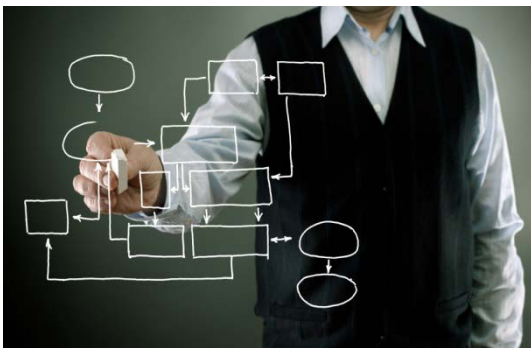
- **Original TDRS are highly specialized platforms**

- Many unique features compared to typical geosynchronous earth orbiting (GEO) satellites
- No future market – can't develop platform on investment dollars



- **SGSS operations concept is highly integrated**

- Sophisticated concepts for software management not seen in most control center installations
 - **Automated installation and upgrade of TTC clients and servers**
 - **System state managed by other systems (schedulable resources)**
- Operations include both satellite housekeeping and payload control
 - **Simultaneous activities must be interleaved**



GMV—Matching COTS to SGSS

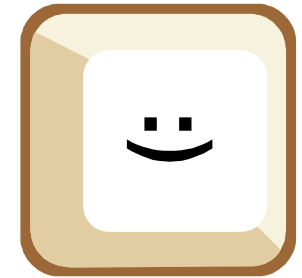
- **Matching COTS to SGSS is challenging (cont.)**
 - Tension between open APIs and security requirements
 - Product has Corba and SOAP interfaces designed for open access
 - SGSS has complex security requirements to lock down access points



At the Boundary: GMV Product and Project

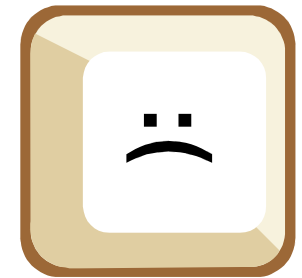
• The easy part

- COTS TTC software has existing adaptation points
 - Scripting language to automate command and telemetry operations
 - Facility for computing telemetry-derived parameters
 - External API to exchange data with external systems
- Some functions are entirely Project code
 - Conversion of legacy satellite databases and historical data archives
 - Perhaps would not have been needed if standards had been used in legacy systems
 - Conversion of existing paper or automated operational procedures



• The hard part

- Mission unique requirements that need to fit 'inside' the product
 - Example: specialized command upload verification that requires tight binding between command formatting and telemetry processing
- Requires code changes to COTS to enable custom code integration



At the Boundary: GMV Product and Project

- **Divide and Conquer**

- Some features require the COTS to provide a new ‘hook’
 - Addition to existing external API (e.g. SOAP)
 - Library refactoring to provide an externally callable function or extension by sub-classing
- Work is divided into:

COTS **Product** upgrade

- **Product** change becomes a permanent part of the codebase
 - Required to maintain compatibility when **product** upgrades occur
- **Product** change is funded by internal investment
 - Vendor maintains Intellectual Property (IP) rights to **product** codebase

Project specific extension

- **Project** code does not become part of the **product** codebase
 - Is deliverable to the **project** including all required libraries and build infrastructure
- **Project** code is funded by end customer
 - Customer maintains IP rights and can maintain/extend independently

On-Going Issues

1. Each COTS in the system has a set of prerequisites for development and runtime. These may conflict with the prerequisites of other COTS, or with licensing policies.



- System-level runtime and build environments need to be nailed down early in the project, and maintained as development proceeds. This includes:
 - i. Base OS (to the specific version and processor architecture choice)
 - ii. Optional packages from the OS distribution
 - iii. Third-party packages in the build environment
 - iv. Third-party packages in the test environment
 - v. Third-party packages in the runtime environment
- Compatibility with anticipated build, runtime and licensing environments should be a factor in COTS selection
 - i. This may need to be iterative, because the set of candidate COTS may influence the selection of environment

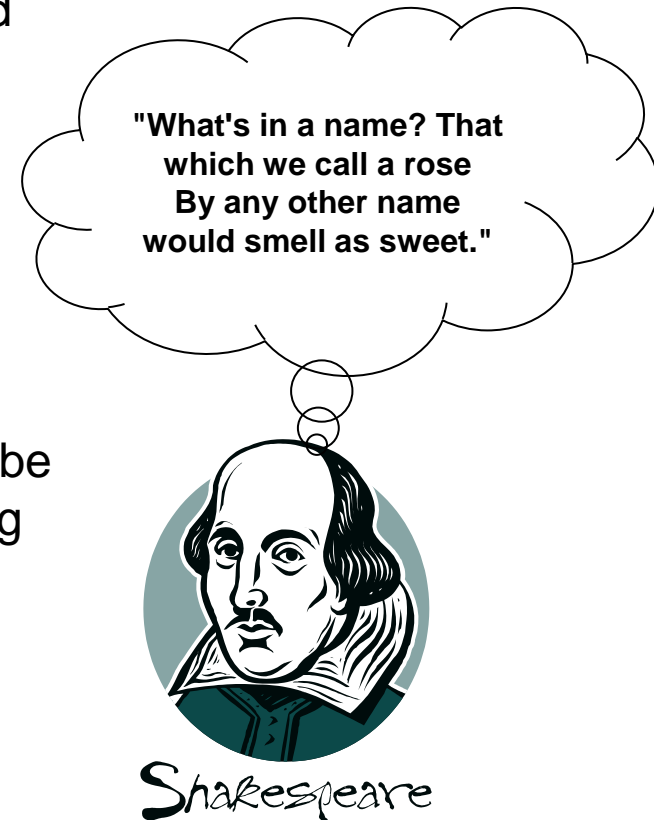
On-Going Issues

2. Nomenclature

- COTS tools have a set of terms used in UIs and documentation
- These terms may differ from terms in use in legacy systems or other COTS
- Modification of the COTS would cause incompatibility with future releases, or inconsistency with documentation
- Where small number of users are involved can be handled with system documentation and training

Example: What WSC calls a schedule request is represented in *flexplan* by an event

- This is visible only to a small number of planner/schedulers at WSC
- Space Network Users can continue to use their existing names



Key Success Factors

• Teamwork

- SGSS project team needs wide expertise
 - Subject Matter Experts on TDRS and legacy ground system, experts on individual COTS, components, custom developers,...
 - Systems Engineering to tie it all together
- COTS suppliers have critical roles
 - Provide feedback during requirements allocation
 - Systems engineers need to understand how to use COTS optimally or where a requirement should not be allocated to COTS
 - Advise design team on use of COTS extension points
 - Offer services for project-specific development and testing
 - Cost effective for project due to training and experience with COTS product



• Early prototyping or hand-on interaction with the COTS

- Can't wait until after the design is complete to procure COTS
- COTS spec sheets can't always provide all the needed information

Questions?



Contact Information

- **Frank Herman:**
 - fherman@fc-md.umd.edu
- **Linda Esker:**
 - lesker@fc-md.umd.edu
- **Jeremy Jacobsohn:**
 - jjacobsohn@usa.gmv.com
- **Rick Saylor:**
 - Richard.S.Saylor@nasa.gov
- **Constance Hoffman:**
 - Constance.Hoffman@gdc4s.com



Acronyms

Acronym	Definition
API	Application Program Interface
CDR	Critical Design Review
Corba	Common Object Request Broker Architecture
COTS	Commercial Off-the-Shelf
FGM	Fleet and Ground Management
GEO	Geosynchronous Earth Orbiting
IP	Intellectual Property
MOTS	Modified Off-the-Shelf
OS	Operating System
PDR	Preliminary Design Review

Acronym	Definition
SGSS	Space Network Ground Segment Sustainment
SM	Schedule Management
SN	Space Network
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
TTC	Telemetry, Tracking, and Command
TDRS	Tracking Data Relay Satellite
UI	User Interface
VM	Virtual Machine
WSC	White Sands Complex