Development of a Ground System Architecture Test Bed Array

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Background and Objectives

• Background
  – Harris has developed Ground System capabilities which have been leveraged on NOAA, NASA, FAA, DoD, Commercial and Proprietary activities over the past 25 years
  – Ground system defined as “management of vehicle operations, payload operations, ground equipment and ground operations to efficiently achieve user specified mission objectives

• Main Objectives
  – Develop candidate Ground System Architecture (GSA) suitable for use on a variety of systems
  – Demonstrate proven Ground System technologies a realistic processing environment
  – Provide a Operations Concept (OPSCON) lab to rapidly develop ground system technologies thereby increasing the Technology Readiness Level (TRL)
**Ground Systems Architecture Goals**

- **Capture current solution capabilities**
  - Low risk transition from existing system to new system accommodating significant increases in data throughput
  - Ease of integration with other products and systems
  - Adaptability to evolving customer operations concepts
  - Low operations and maintenance costs
  - Extensibility to meet future needs

- **Goals for new GSA**
  - Very high speed data processing and delivery
  - Efficient control of a fleet of diverse space vehicles or a constellation of satellites
  - Incorporation of array combining for effective long range communications
  - World class security including multi-level information assurance
  - Extremely low latency and high throughput product generation

- **Enables collaboration with diverse internal and external customer communities**
  - Common lexicon

- **Other Factors**
  - Minimal system development risk
  - Assured space vehicle and payload operations
  - Improved product generation and exploitation
  - Rapid data/product distribution
  - Low operational costs
Ground System Architecture (GSA): Methodology

- Standard architecture development process used to develop GSA
  - Elicitation of design drivers based on stakeholder needs
  - Critical Success Factors
  - Other Constraints

- Development of Architectural Views
  - Operational
  - System
  - Functional
  - Data
  - Hardware
  - Software
  - Components

- Requirements and threads also developed
  - Wiki used to manage architecture concepts, elements and requirements
Design Drivers - Process

• Elicitation process
  – Meet with technical POC
  – Group functionality into
generic buckets to
eliminate domain specific
references
  – Identify key elements
• Functional Analysis
  – Reduce and combine
results
  – Combine to identify drivers
across multiple programs
Design Drivers

• Generate products in real time with low latency, high reliability
• Provide flexible archive capability
  – Include TT&C as well as user data
  – Short, medium and long term storage management
• Manage WAN circuit scheduling for bandwidth optimization:
  – On a per mission/usage basis
  – Support scheduled distribution of data to customers
• Control multiple sites individually or as a collective entity
  – Multi-antenna arraying for receive and transmit
  – Coordinate and schedule hundreds of antennas (data and pointing)
• Provide the capability to provide for user communications across disparate mission control centers
• Perform beamforming to improve signal receiving
### Criteria

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>Distributability – support collocation of any/all elements and geographic distribution of any/all elements</td>
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<tr>
<td>2.</td>
<td>Space Vehicles – support multiple space vehicles.</td>
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<tr>
<td>3.</td>
<td>Ground Facilities – support multiple ground facilities (e.g. ground terminals, operations centers, processing centers)</td>
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<td>4.</td>
<td>Latency – support high-bandwidth, low-latency data distribution</td>
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<td>5.</td>
<td>Arraying – support arraying of multiple ground terminals to improve transmit and receive capability.</td>
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<td>6.</td>
<td>Long Life – produce systems that have a 20+ year life span</td>
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<td>7.</td>
<td>COTS – utilize COTS components where feasible</td>
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<tr>
<td>8.</td>
<td>Standardization – use industry standards where feasible to support interoperability with other systems</td>
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<td>9.</td>
<td>Availability – support development of ground systems that are highly available</td>
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<td>10.</td>
<td>Scalability – support a variety of systems with highly varied processing and communications workloads</td>
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Architecture Constraints

- Must be based on SOA framework
  - Replaces monolithic architecture with smaller modular components
  - Modules communicate through open, published service interfaces
  - Consultative Committee for Space Data Systems (CCSD) “Green Book” (CCSDS 520.0-G-2) identified concept for Mission Operations (MO) Services Framework
- Reuse of previous work on several other IR&D’s
The Harris Ground System (HGS) supports operations and maintenance of air and space vehicles, which collectively are referred to as the flight vehicles. A flight vehicle includes a flight control system, and may also include sensors as well as communications transponders. The systems architecture for the HGS concerns itself with the various components of the ground system and how they are related.
Operational Threads

- Flight Vehicle Maneuver Request
- Download Existing Product
- Flight Maneuver Request from Data
- Instrument Request
- Obtain Data Per Standing Order
- Comm Satellite Function – Uplink/Downlink
Operational Thread – Flight Maneuver Request from Data

1. Telemetry Downlink from Flt Veh
2. Process Telemetry
3. Check Telemetry
4. Analyze Telemetry
5. Maneuver Req sent to Veh Planer
6. Cmd sched sent to schedule executor
7. Command sent to telemetry processor
8. Telemetry uplink sent to signal transmitter
9. Command sent to flight vehicle
Architecture & Requirements
<table>
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<tr>
<th>Antenna Terminal Equipment</th>
<th>Desktop IT Equipment</th>
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<tr>
<td>Signal Processing &amp; RF Equipment</td>
<td>Wifi Equipment</td>
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<tr>
<td>Data Networking Equipment</td>
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<tr>
<td>Computer Processing and Data Storage Equipment</td>
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<tr>
<td>Patch-Panel and Rack Equipment</td>
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<tr>
<td>Environmental Sensor &amp; Surveillance Equipment</td>
<td></td>
</tr>
<tr>
<td>Power &amp; Power Distribution Equipment</td>
<td></td>
</tr>
<tr>
<td>Shelter, Lighting, HVAC, and Physical Safety/Security</td>
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Distributability
Multiple vehicles
Multiple Terminals
High-bandwidth, low latency
Terminal arrays
Long life, 20+ years
COTS/Reuse
Standardization
Reliability
Scalability
Standards View

- CCSDS 311.0-R-1, “Reference Architecture for Space Data Systems”, Jan 07
- CCSDS 520.0-G-2, “Mission Operations Service Concept”, Aug 06
- CCSDS 701.0-B-3, “Advanced Orbiting Systems, Networks and Data Links”, Jun 01
- CCSDS 660.0-R-2, “XML Telemetric and Command Exchange (XTCE): Draft Recommended Standard”, Dec 05

- Standards form outline for development of Data View and databases

TV-1 in DoD-AF Terminology
Data View: Mission Control Data
Flight Data Functional View

Analyze Flight Performance

- Flight Data
  - Calibrate & Check Telemetry

- Operator
  - Operator
  - Operator
  - Operator
  - Operator
  - Operator
  - Operator
  - Operator

- Orbit Display
  - Limits Deviation
  - Track Display
  - Maneuver Constraint Violation
  - Display Attitude
  - Propellant Status
  - Collision Prediction

- Check Orbit
  - Determine Ground Track
  - Check Maneuver Constraints
  - Determine Vehicle Attitude
  - Monitor Propellant Usage
  - Collision Prediction

- Object Ephemeris
  - Maneuver Plan
  - Propellant Usage
  - Sun-line display
  - Maneuver Request

- Operator
  - Generate Maneuver Plan
  - Generate Maneuver Plan
  - Propellant Usage
  - Sun-line interference
  - Generate Uplink Request

- Operator
  - Flight Vehicle Status
  - Flight Vehicle Status

- Operator
  - Celestial Body Ephemeris
  - Thruster Calibration
  - Input Celestial Body Ephemeris

- Operator
  - Flight Vehicle Status

- Operator
  - Analyze Instrument Performance

- Operator
  - Manage Enterprise

- Flight Vehicle Status
### Ground Systems Market Segments

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<td>Universal data ingest, storage, and retrieval from heterogeneous environments. Usually characterized by high data rates, high availability, and high security.</td>
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Leverages the efforts of other active research areas including Information Assurance, Integrated Information Systems, Communications Infrastructure, Avionics, and Data Links.

Provides the foundation upon which to build solutions for Asset Management, Biometrics, Intelligence, Surveillance, & Reconnaissance, and Mapping & Visualization.
Harris Ground System Architecture

**Exploitation Services (Intelligence Community)**
- Discovery services
- Collaboration services
- Community of interest support

**SOA Foundation and Common Services (NCES)**
- Distributed operations
- Remote access & operation
- Strong security foundation
- Simplified integration
- Reduced system O&M
- Simplified technology refresh
- Platform agnostic
- Highly scalable
- Web services

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**Ground System Services (DoD, Commercial and IC)**
- Improved automation
- Complex product generation
- Complex systems planning & operation
- Antenna array planning & management
- XTCE, CCSDS and GMSEC support

**Archive Services (National Archives)**
- Improved archive management
- Distributed data access
- Metadata management
- Subscription services
- Strong search capability

**Data Exploitation Workflow**
- Ingest
- Processing/Exploitation
- Analysis
- Production
- Dissemination

**Archive Workflow**
- Content Ingest
- Document Template Mgmt
- Records/Preservation Mgmt
- Search & Discover
- Subscribe/Alerts/Notification
- Access Review

**SOA Foundation and Common Services**
- Collaboration Platform
- Mobile Platform Delivery
- Information Mgmt
- Governance

**Archive Services**
- Improved archive management
- Distributed data access
- Metadata management
- Subscription services
- Strong search capability

**Leverages experience from multiple customer communities**
**Provides common architecture for multiple types of Ground Systems**
Summary

• A common Ground System Architecture (GSA) has been defined
• Followed standard Harris architecture development process to provide solid foundation
• Meeting requirements from several customer communities
• Leverages investments made across the Corporation
  – SOA foundation pulls in work from various areas (synergy)
• Applying the architecture to multiple customer missions

OPSCON Lab Provides Efficient Means to Demonstrate GSA Capabilities