
*Development of a Ground System
Architecture Test Bed Array*

Howard D. Gans, Ph D, PE
Lennis Bearden
Eric Hertzog
Royce Hall
Allan Dianic
Erik Cotton
Brad Kizzort

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)



- 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

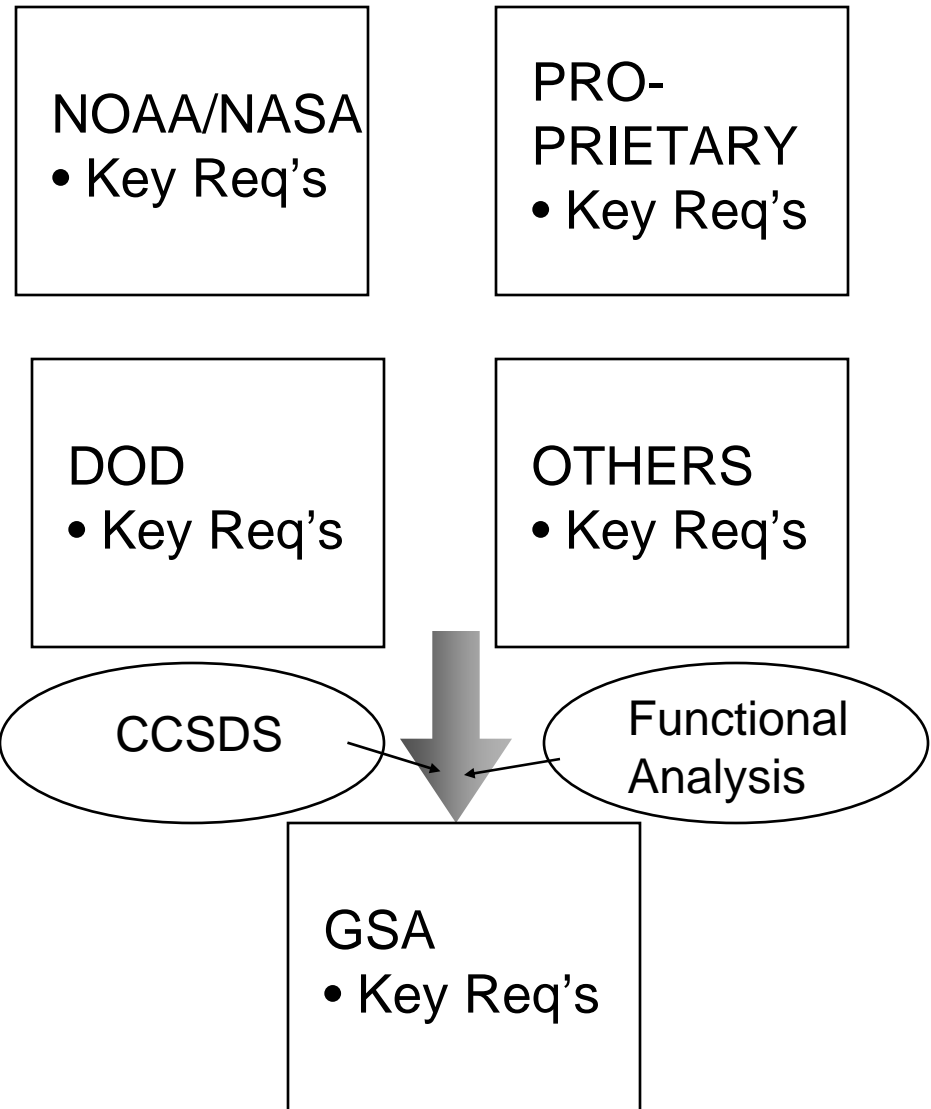


- Standard architecture development process used to develop GSA
 - Elicitation of design drivers based on stakeholder needs
 - Critical Success Factors
 - Other Constraints
- Development of Architectural Views
 - Operational
 - System
 - Functional
 - Data
 - Hardware
 - Software
 - Components
- Requirements 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



- 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

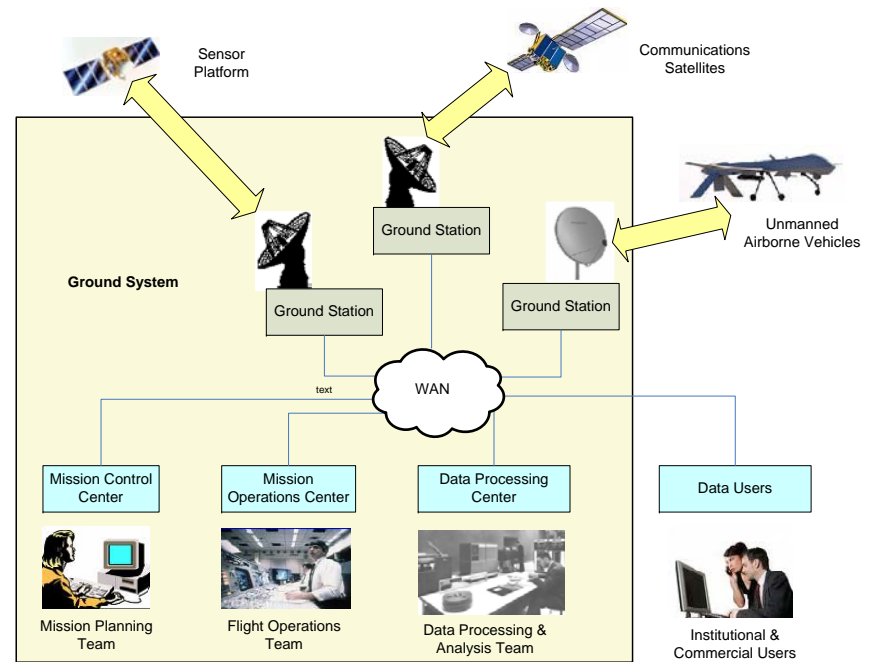
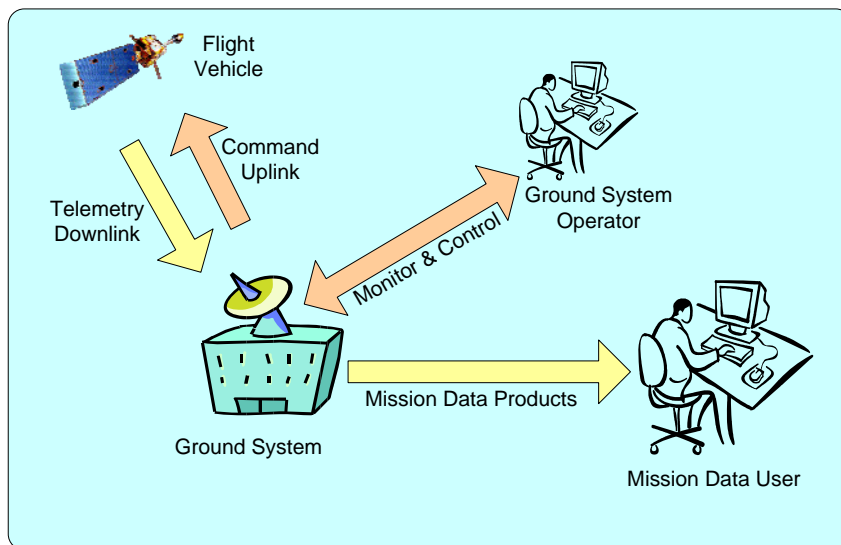
Critical Success Factors



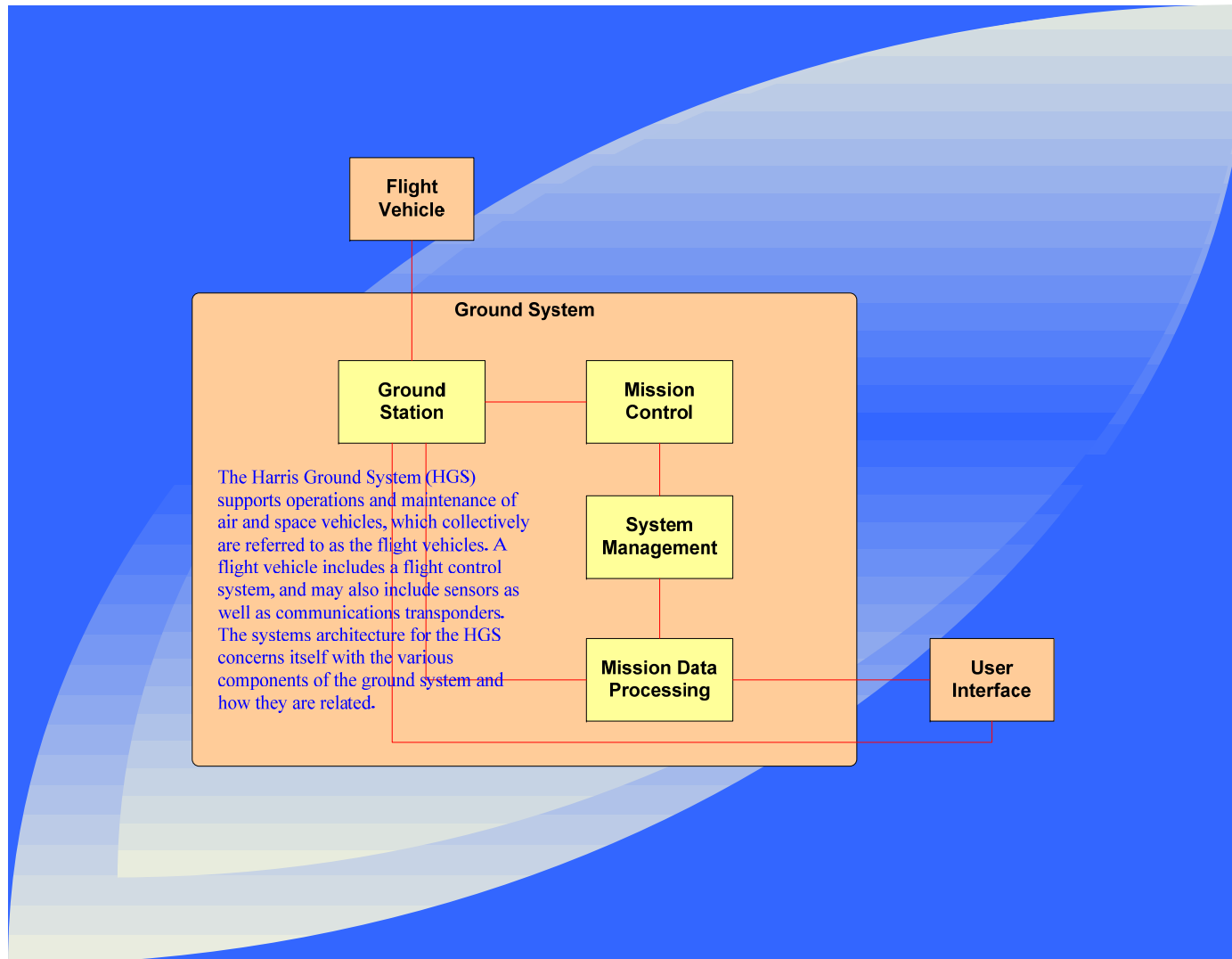
| Criteria |
|---------------------------------------------------------------------------------------------------------------------------|
| 1. Distributability – support collocation of any/all elements and geographic distribution of any/all elements |
| 2. Space Vehicles –support multiple space vehicles.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

- 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

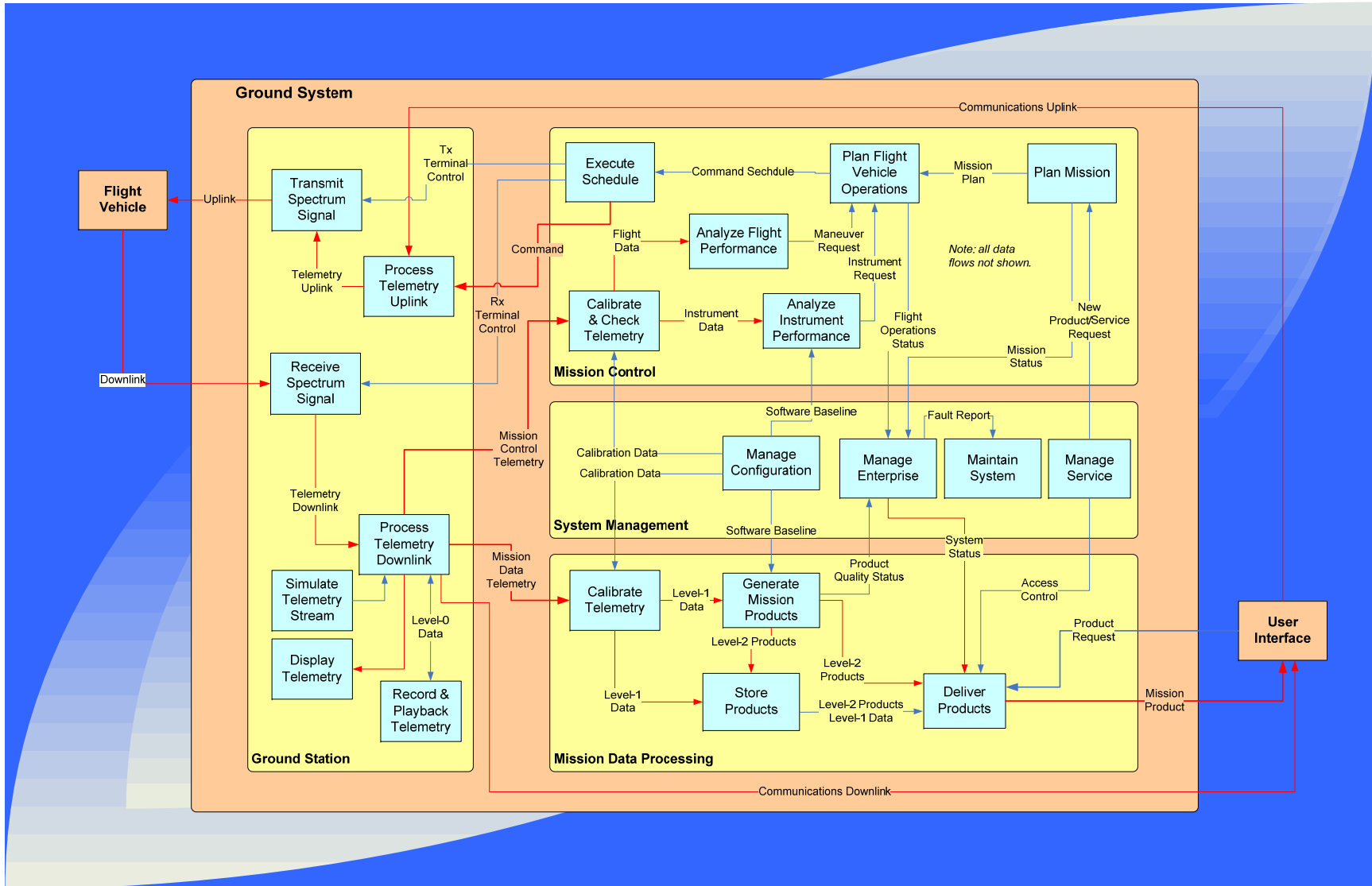
Architecture Elements: Operations Concept View



Introduction: System View Level 0

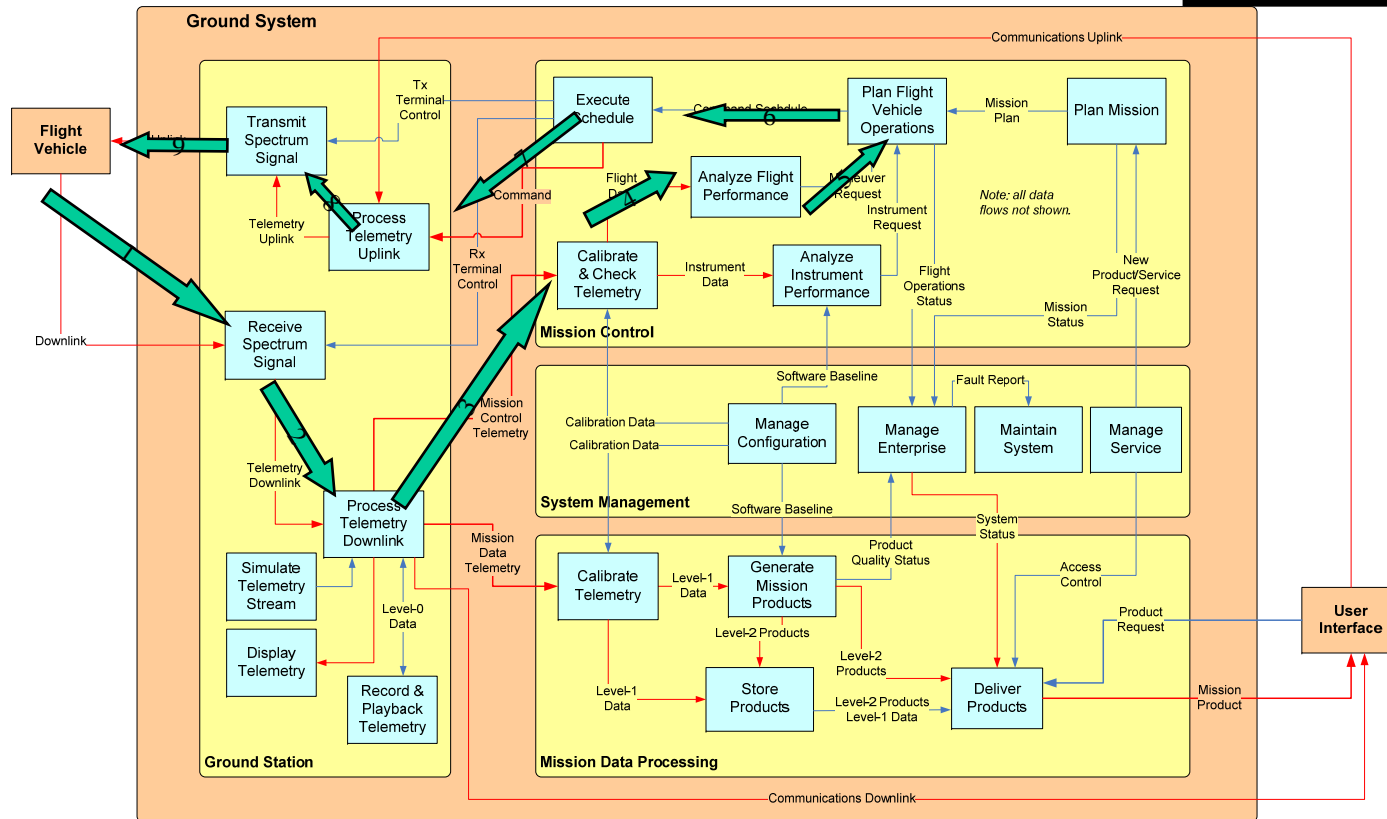


Functional View



- 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



Analyze Flight Performance - Weather Wiki - Microsoft Internet Explorer

article discussion edit history

Analyze Flight Performance

These requirements are intended to provide for orbit and attitude maintenance of the flight vehicle. Real-time capabilities include state of health assessment of on-board orbit estimation and attitude. Off-line capabilities supported include orbit determination, control and prediction, and definitive attitude determination and prediction.

The figure depicts a notional software component implementation for the requirements.

The HGS shall perform real-time evaluation of orbit data using predicted ephemeris.

The HGS shall automatically detect and notify operators when orbital parameters deviate from established limits.

The HGS shall perform real-time attitude estimation using sensor data.

The HGS shall generate the definitive ephemeris of the flight vehicle.

The HGS shall generate maneuver plans in support of orbit maintenance, calibration, and sensor operations.

The HGS shall automatically identify and report maneuver constraint violations during maneuver planning.

The HGS shall maintain the flight vehicle ground track.

The HGS shall calibrate flight vehicle thrusters.

The HGS shall monitor and predict propellant usage.

The HGS shall determine the probability of an object colliding with the flight vehicle given the ephemeris of the object.

The HGS shall accept a sun, lunar, and planetary predict ephemeris from an external source and uplink the predicts.

The HGS shall monitor on-board sensor calibrations and re-calibrate, as necessary to meet absolute attitude accuracy requirements.

The HGS shall specify and generate attitude maneuver sequences.

The HGS shall specify and generate attitude sensor calibration maneuver sequences to provide sufficient sensor data to derive sensor alignment & calibration coefficients meeting mission

Click on image for larger version

Hardware View

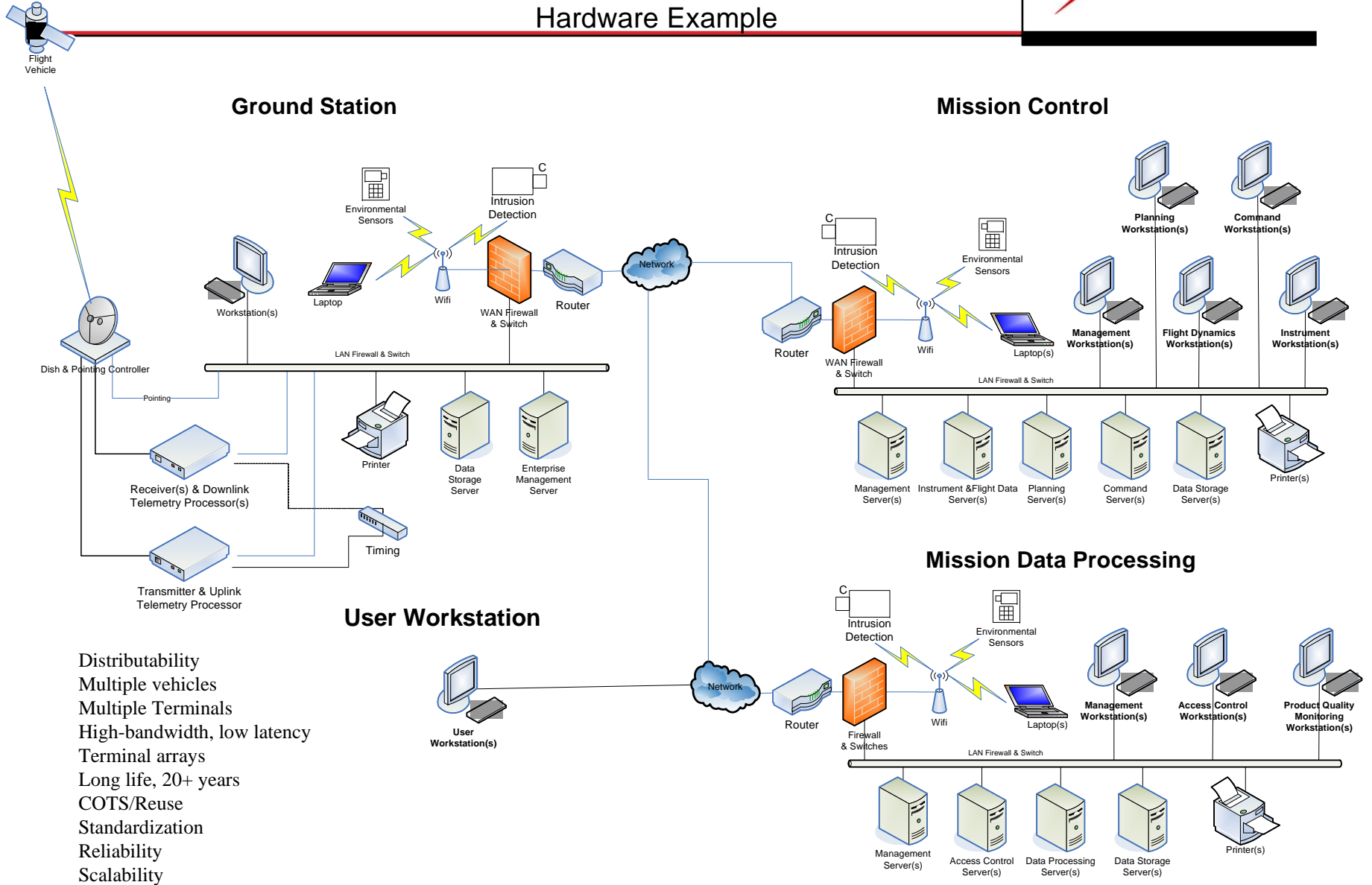


| | |
|--------------------------------------------------------------|-----------------------------|
| Antenna Terminal Equipment | Desktop IT Equipment |
| Signal Processing & RF Equipment | Wifi Equipment |
| Data Networking Equipment | |
| Computer Processing and Data Storage Equipment | |
| Patch-Panel and Rack Equipment | |
| Environmental Sensor & Surveillance Equipment | |
| Power & Power Distribution Equipment | |
| Shelter, Lighting, HVAC, and Physical Safety/Security | |

Hardware View

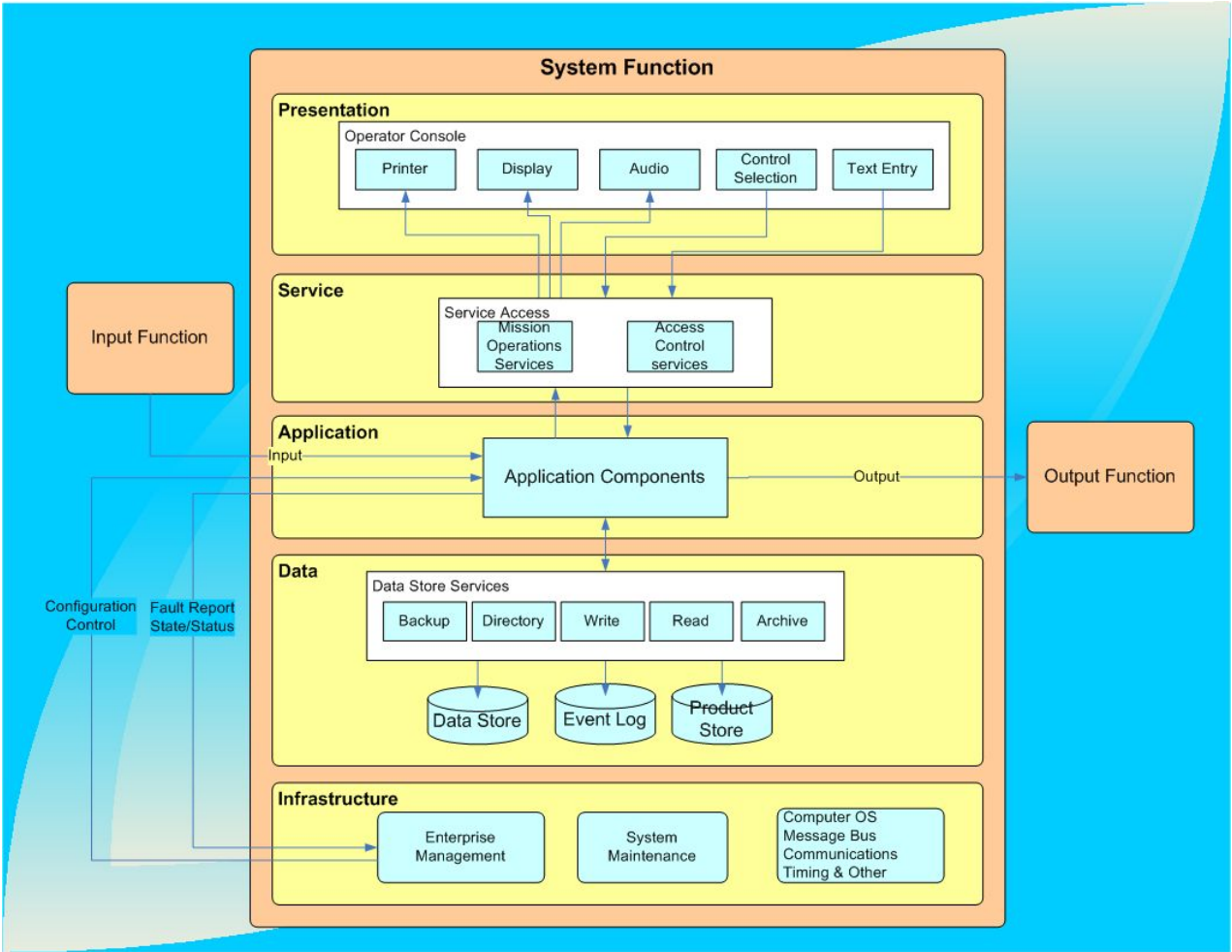


Hardware Example



- Distributability
- Multiple vehicles
- Multiple Terminals
- High-bandwidth, low latency
- Terminal arrays
- Long life, 20+ years
- COTS/Reuse
- Standardization
- Reliability
- Scalability

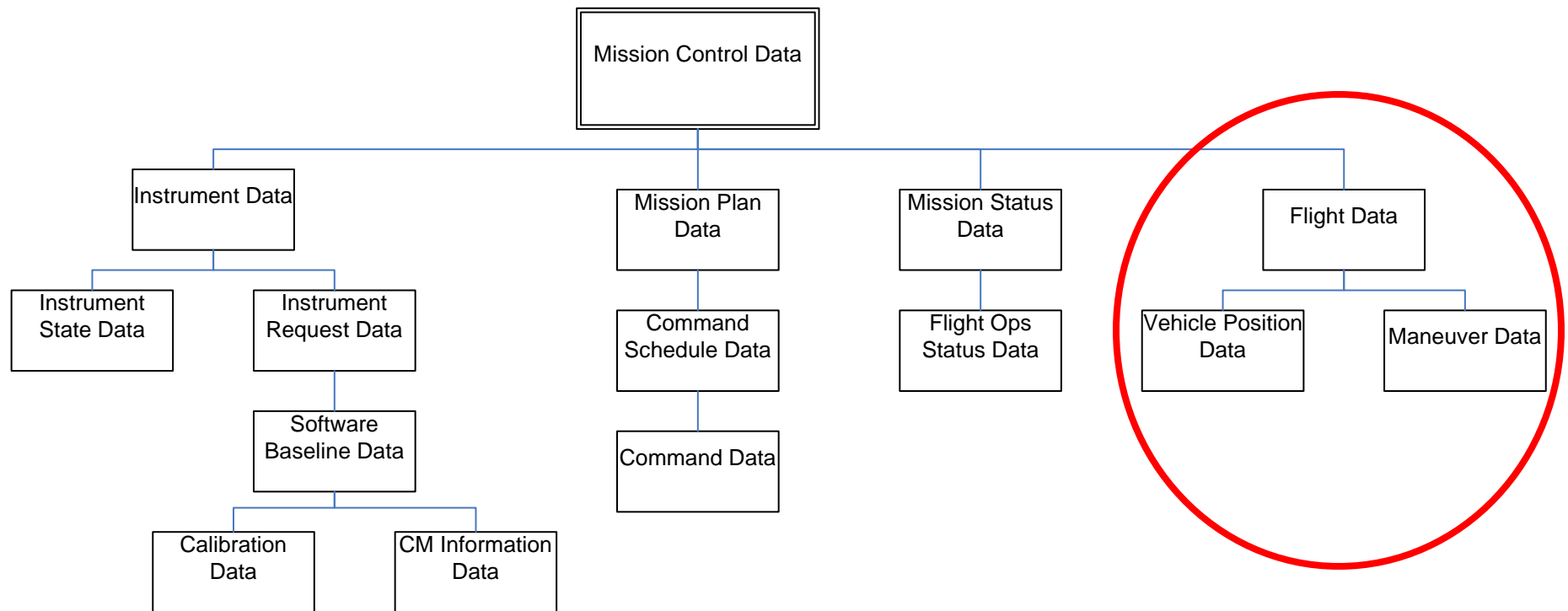
Software View



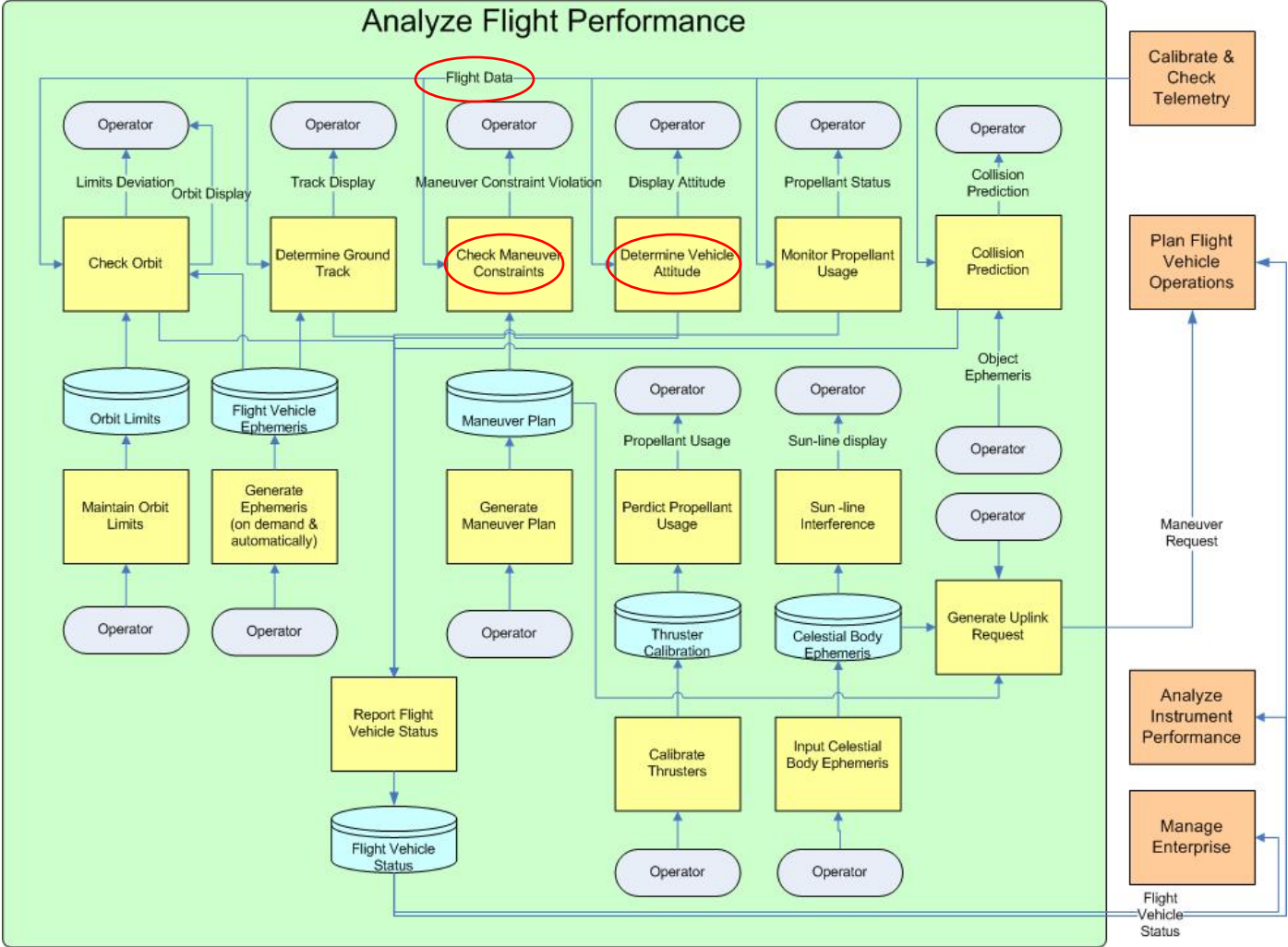
- CCSDS 311.0-R-1, “Reference Architecture for Space Data Systems”, Jan 07
- CCSDS 520.0-G-2, “Mission Operations Service Concept”, Aug 06
- CCSDS 701.0-B-3, “Advanced Orbiting Systems, Networks and Data Links”, Jun 01
- CCSDS 660.0-R-2, “XML Telemetric and Command Exchange (XTCE): Draft Recommended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

TV-1 in DoD-AF Terminology

Data View: Mission Control Data



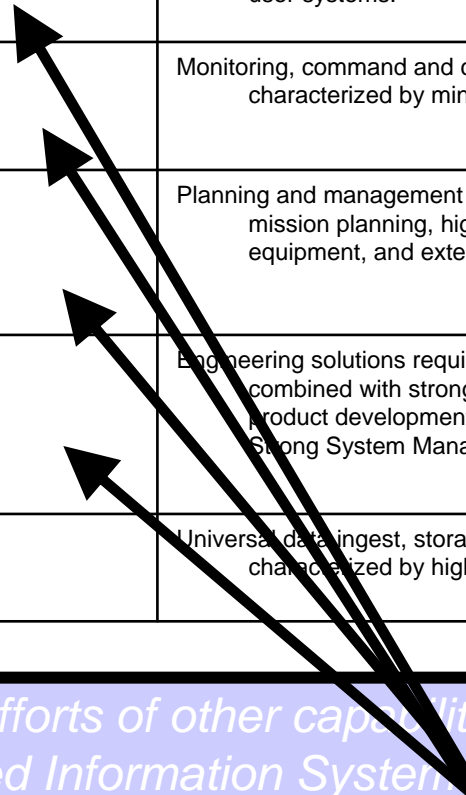
Flight Data Functional View



Ground Systems Market Segments

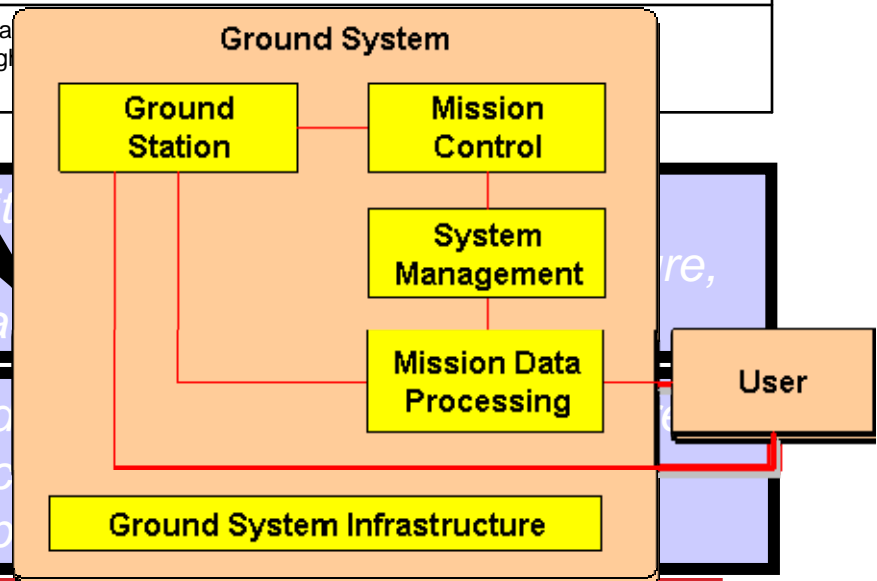


| | |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>High Speed Distribution</i> | Low-latency, guaranteed delivery of very high rate data to mission data processing and/or end-user systems. |
| <i>Platform Control Systems</i> | Monitoring, command and control capability for platforms, instruments and test sets. Usually characterized by minimal mission data processing and limited system management. |
| <i>Complex System Control</i> | Planning and management of complex ground systems. Complexity may arise due to complex mission planning, highly varied missions, highly distributed systems, extensive ground equipment, and extensive numbers of platforms and/or very low signal/noise ratios. |
| <i>Complex Product Generation</i> | Engineering solutions requiring in-depth domain (science/algorithm) specific knowledge combined with strong software and systems engineering expertise. Science/algorithm product development requires extensive collaboration with teammates and customer. Strong System Management, Product Generation and Product Distribution content. |
| <i>Universal Data Store</i> | Universal data ingest, storage and retrieval. Characterized by high capacity and low latency. |



Leverages the efforts of other capabilities including Assurance, Integrated Information Systems, Avionics, and Data

Provides the foundation upon which to build including Asset Management, Biometric Reconnaissance, and Mapping



Ground Systems Market Segments



| | |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>High Speed Distribution</i> | Low-latency, guaranteed delivery of very high rate data to mission data processing and/or end-user systems. |
| <i>Platform Control Systems</i> | Monitoring, command and control capability for platforms, instruments and test sets. Usually characterized by minimal mission data processing and limited system management. |
| <i>Complex System Control</i> | Planning and management of complex ground systems. Complexity may arise due to complex mission planning, highly varied missions, highly distributed systems, extensive ground equipment, and extensive numbers of platforms and/or very low signal/noise ratios. |
| <i>Complex Product Generation</i> | Engineering solutions requiring in-depth domain (science/algorithm) specific knowledge combined with strong software and systems engineering expertise. Science/algorithm product development requires extensive collaboration with teammates and customer. Strong System Management, Product Generation and Product Distribution content. |
| <i>Universal Data Store</i> | Universal data ingest, storage, and retrieval from heterogeneous environments. Usually characterized by high data rates, high availability, and high security. |

Leverages the efforts of other active research areas including Information Assurance, Integrated Information Systems, Communications Infrastructure, Avionics, and Data Links

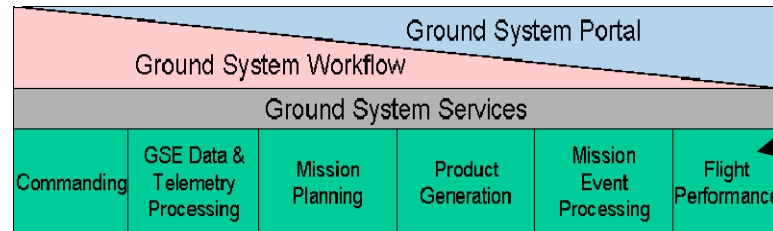
Provides the foundation upon which to build solutions for Asset Management, Biometrics, Intelligence, Surveillance, & Reconnaissance, and Mapping & Visualization

Harris Ground System Architecture



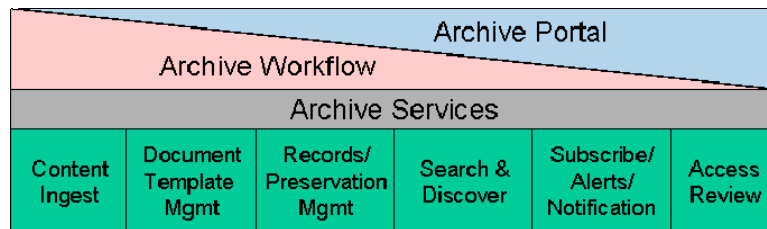
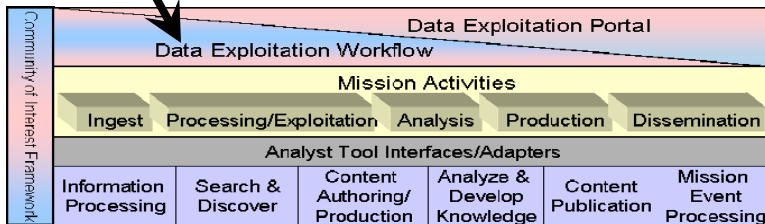
Exploitation Services (Intelligence Community)

- Discovery services
- Collaboration services
- Community of interest support



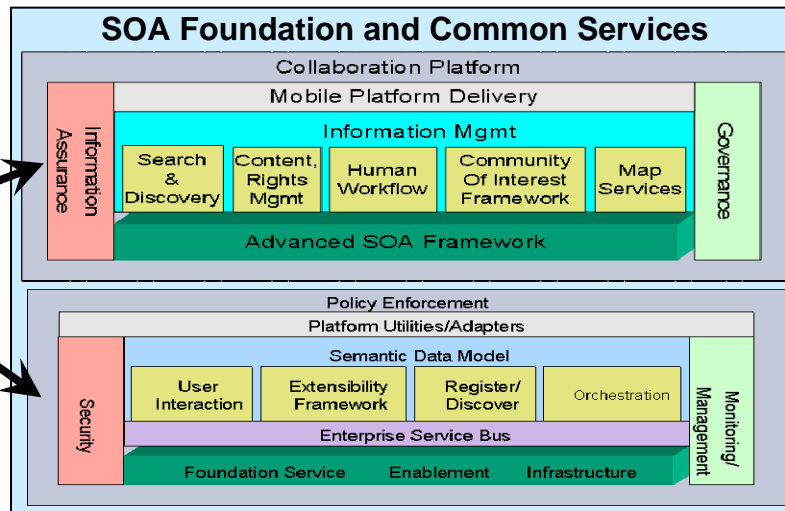
Ground System Services (DoD, Commercial and IC)

- Improved automation
- Complex product generation
- Complex systems planning & operation
- Antenna array planning & management
- XTCE, CCSDS and GMSEC support



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



Archive Services (National Archives)

- 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

- 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