Key Mission Systems Engineering Trades For Determining Satellite System Architecture

GSAW 98

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Introduction

- Presentation will focus on the common key mission system engineering tradeoffs that must be performed for determining the best space, ground and operations architecture for a satellite system

- Mission system engineering is the single most effective measure a project can undertake to lower the total system cost

- Mission system engineering aims at finding the overall optimum system design solution

Strategies and Techniques For Low Cost Space Mission Operations

Mission System Engineering

- Develop a vision for the system
  - Vision lays out the mission system engineering trades in a “perfect world”
- Develop guiding principles for the system that define system constraints and key design/operating rules
  - World is no longer “perfect” but must take into account constraints
- Develop a concept of operations from which requirements can be generated
  - Should be developed prior to the requirements, so can define trades which affect requirements development
- Define the Mission System Engineering architecture trades
  - Satisfying mission objectives for operations, space, and ground at lowest cost

Operations Concept Trade Development

- Determine mission operations functions to be performed **(What & Why)**
  - Identify options for accomplishing functions **(How & Where)**
  - Consider the degree of automation or autonomy to be implemented and what organization or teams will be responsible for each function **(Who)**
  - Identify if functional capability exists or must be developed
- Develop operations scenarios based on options, including timelines **(When)**
  - Assess candidate operations concepts based on utility, complexity, performance, reliability and cost
  - Select a baseline operations concept
- Identify derived requirements and cost and complexity drivers
  - Negotiate changes to mission concept

Ground Segment Trade Development

- Establish communications architecture
- Establish number and locations of ground stations
  - account for orbital aspects
  - account for treaties e.g., ABM
  - account for geographic conditions i.e., weather, natural disaster, covert communications interference
- Establish space-to-ground data rates
- Determine required antenna G/Ts and EIRPs
- Determine data flow and data handling
- Establish complete or partial use of service provided ground systems
- Determine the development approach include the following; what will be custom, Off-The-Shelf, evolutionary prototyping, SEE tools

Space Segment Trade Development

- Establish communications architecture
  - space-to-space
  - space-to-ground
- Consider on-board autonomy such as;
  - One or more simple and reliable safe modes triggered on-board
  - autonomous telemetry monitoring and alarming
  - autonomous anomaly detection, correction and reporting
  - autonomous orbit management
  - autonomous memory management
- Mission data processing performed on-board as part of the payload or should it be performed on the ground

Summary Space and Ground Trades

Trade	Objective	Options
S/G Links	Determine GS connectivity to satellites	S-band, SHF/EHF, other; also need to determine bandwidth
Mission Processing	Determine optimal split between space and ground	Space to reports; space to exceedances ground to reports; other
Ground HW Architecture	Determine network and ADPE architecture	Homogeneous vs. Heterogeneous
Mission Management (Scheduling)	Determine concept for multi constellation system	Contractor developed or COTS-based augmentation
Ground Cost Model	Determine cost modeling approach & evaluate CERs	Comparison to like existing systems

Summary Space and Ground Trades (Cont.

Trade	Objective	Options
Ground Entry Points	Determine # required and preferred locations	MGSs - Primary /Backup GEPs - RGFs, RGSs, Commercial terminals
Anomaly Resolution	Required capability and S/G partitioning	Level of Sat autonomy vs. Ground autonomy
Operations and Staffing	Determine preferred concept for ground ops including ops positions and staffing	Integrated vs separated positions and ops
Transition Plan	Define low cost / risk transition path	Existing MGS, MGSB, or contractor facility 1st transition
Ground Survivability	Efficient ground survivability/endurability solution	Mobile Component, Facility Harding, Diverse Geographic Location

Summary Space and Ground Trades (Cont.

Trade	Objective	Options
P4I	Provide efficient ground growth path	Open, distributed COTS-based architectures
Mobiles	Efficient incorporation of endurable mobile missions	Upgrade of existing, new, or hybrid
System Activation	Efficient activation of operations (Partial to full constellation)	Contractor support, MGS, or MGSB activation; Specific procedures
Interfaces (External)	Solid understanding of functional interfaces	Minimal impact except for new products

Mission System Engineering Low Cost Considerations

- Key factors affecting ultimate mission operations cost are:
  - Complexity of the mission being attempted
  - Operability of the S/C performing the mission
  - Operability of the mission operations system
  - Management policies regarding operations (especially risk avoidance)
- General low cost approaches are
  - Eliminating or combining functions
  - Performing functions more efficiently
  - Using lower cost staff
  - Assuming greater risk

Summary

- **Mission System Engineering trades should consider the following cost reduction methods:**
  - Reusing existing facilities which can significantly reduce development and test efforts, and increase system reliability
  - Using COTS components with contractor augmentation where necessary
  - Adhering to standards however, be aware of standards that constrain functionality
  - Leveraging testing and operations commonalities to produce savings due to combined development and reduction in operations training cost