Managing Automation and Autonomy

- Considerations for Space / Ground Architectural Tradeoffs

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Managing Automation and Autonomy

- Overview of Autonomy Technology Infusion
- Functional Components of Operations
  - Monitor and Control
  - Data Processing and Analysis
  - Planning and Scheduling
- Implications of the Autonomous Operations Concept for System Development Processes
- Conclusions

Overview of Autonomy Technology Infusion

- Automation of "reflex" activities
- Moving towards full autonomy
  - Decisions more complex and judgmental
  - Requires sophisticated reasoning
- Distributed autonomy
  - Space versus ground autonomy
  - Need for early determination of distribution of functionality
  - Selection of proper autonomy
  - Verification and validation of autonomous system

Functional Components of Operations

Monitor and Control

- Activities during real-time contact (historically)
  - Command transmission and execution verification
  - Health and safety monitoring
    - » Instantaneous status of system at any point in time
  - Performance monitoring
    - » Measure of how well system executes over time
    - » Requires knowledge of scheduled operations
- Commercial tools to assist operations
  - Monitor and suggest solutions or automatically initiate response
  - Ground based and on-board options available
  - Currently handles known errors only
    - » Still requires help of experts for unknown anomalies

Functional Components of Operations

Data Processing and Analysis

- Will benefit from new Internet-like protocols
  - End-to-end file delivery assured
  - Retransmission of missing or corrupted data handled by protocol (no operators needed)
  - Eliminates need for Level Zero Processing
- New computer technology allows onboard data processing and sorting - downlink only good observations
- GPS technology allows precision real-time orbit knowledge onboard

Functional Components of Operations

Planning and Scheduling

- Determination and processing of payload inputs
- Handling of engineering special requests
  - Maneuvers
  - Anomaly isolation and resolution
- Scheduling / configuration of event driven activities
- Activities performed on periodic basis
- "Smart" agents could factor in need to re-plan and reschedule mission observations

Implications of the Autonomous Operations Concept

Anything not planned for, and therefore not deemed routine, could potentially

GREATLY INCREASE

the cost of keeping a mission flying!

Such as:

Orbit and attitude maneuvers

Flight software maintenance

Implications of the Autonomous Operations Concept

- Population and maintenance of the databases which support the automation is the basic problem
  - As system becomes more sophisticated, more information and interactions must be monitored and controlled
- Completely automated control center must interact with not only the spacecraft, but also with other ground entities
  - Troubleshooting these interfaces today remains a manual operation which depends on verbal coordination between humans at each site

Implications of the Autonomous Operations Concept

- Need to consider how to "manually override" system when necessary (i.e.: anomalies)
- Allocation of functions between space and ground elements of system
  - Turnaround response time required
  - As spacecraft become more automated, they need more ability to direct the ground systems
- Autonomy requires validation of space and ground elements together
  - Will no longer be able to test them separately, then put them together
  - Needs to be incorporated into spacecraft I&T philosophy
  - Single team concept needed to integrate, test and operate system

Conclusions

- Moving towards era where integrating systems will be analogous to today's computing environment
- Once standard interfaces are established, generic subsystem maintenance becomes a real possibility
  - Generic subsystems enable generic command, telemetry, display and monitoring databases
    - » Eliminates need to re-evaluate them for each new project
    - » Self-identifying instrumentation could allow these databases to be built on the fly
    - » Enables small generic team of experts to handle multiple missions at a time

Conclusions

- Gaps in automation technology could drastically impact potential results
- Need for system level test philosophy
  - Test environment must simulate the flight environment, utilizing automation to perform tests
  - Knowledge must be installed into the system to eliminate reliance on humans