Reducing O&M Costs
by
Breaking Paradigms

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Problem Statement

- O&M Costs make up a large portion of system costs
  Realizing serious O&M cost savings requires a shift in philosophy for a group of ultra-conservative people

- We do it to ourselves, we find ways to add cost into the design which also translates to higher O&M in the name of flexibility and risk reduction
  - Both risk reduction & flexibility are desirable, but like everything else, must be taken in moderation

*Today’s technology can significantly reduce O&M costs for space systems*
“We never met a telemetry measurement we didn’t like”
- If it can be measured, then collect it and send it down to the ground
- Just because you bring it down doesn’t mean you have to look at it

Geostationary spacecraft require 24 hour operations
- What else would we do with the ground station and personnel when it wasn’t in communication with the spacecraft?

Leo spacecraft MUST be contacted a minimum of once per revolution or they become lost in space or worse

Maximizing COTS software results in the cheapest possible command & control system, and the easiest to maintain
- How much could a little bit of glue code/”middleware” cost?
- What do you mean you no longer support that version of your product?
An adequate ground system requires a minimum of 10% of the overall program budget

• You want me to command and control my extremely expensive space vehicle on a PC architecture!?

Never, ever let the spacecraft enter into autonomous mode regardless of how great the autonomous mode design

Always let the spacecraft enter autonomous mode regardless of how competent the operators are

Spacecraft require live operations personnel to be present as much as possible (usually 24 hours a day) to monitor and prevent the following activities:

• Initiation of spacecraft autonomous modes and/or redundancy switching
• The ground based expert system detecting a problem and initiating action without operator intervention
• We’re looking for someone to blame this on
The Technology Exists Today

- **Lights out ground terminal**
  - Automatic real-time diagnostics and fail-over to redundant units
  - Reliable communications links to/from remote ground terminals

- **Unmanned/Partially manned command and control centers**
  - Rule based expert system in the front room to replace cheap operators
  - Spacecraft engineers in the back room can be on call or at the factory

- **Spacecraft and/or ground system calling for help**
  - Put a cell phone antenna on the spacecraft have it call for help
  - Ground expert system pages spacecraft/ground anomaly team

- **Autonomous spacecraft operations**
  - Multi-level safe modes
  - Autonomous switching to redundant equipment
  - House keeping (e.g. momentum unloading)
  - Upload of ephemeral data from ground for auto sun tracking
On board telemetry monitoring & reduction
- Record all telemetry on board for TBD time period
- Dump selected telemetry (yellow/red OOL) to ground and discard the rest
- Only send down telemetry on change

Autonomous ground operations
- Autonomous switching to redundant equipment
- Ground expert system pages spacecraft/ground anomaly team

PC based C&T systems
- Pentium/Pentium II with telemetry and command processing cards
  - Adequate processing speed, storage and memory exists as of yesterday
  - Fraction of the cost of COTS C&T software
  - Require no long term maintenance contracts at 25 - 35% annually, if it breaks throw it away, and use the spare
- Anomaly response team can respond 24 hours a day from anywhere a pager and modem equipped lap top PC can go
Thoughts on Breaking Paradigms

Cost Trade Analysis
- Is the level of additional outage worth the savings?
- How much is that additional .1 to 5 percent availability worth?

Spacecraft designed to take care of themselves probably will if we let them
- If we can’t bring ourselves to do so, then why not offset the additional O&M cost with a reduction in the amount of on-board autonomy, especially in the case of GEO or other highly eccentric orbits

Move away from building systems that provide “Just in Case” solutions towards systems that provide “Just in Time” solutions

Can we adopt any part of the Iridium commercial solution to fit DoD/NASA needs?
- First to Market - no time for complexity
- Bare bone basics for O&M - high S/C to operator ratio
- At this per vehicle cost we can afford to lose a few - On orbit spares