

Dan Smith
Interview Questions
May 24, 2007
FINAL DRAFT

1. Please describe GMSEC. What are its most important aspects?

The Goddard Space Flight Center (GSFC) in Greenbelt, Maryland, USA is responsible for most of NASA's sub-orbital and low-earth orbit (LEO) scientific satellites. GSFC also manages several missions in higher and deep space orbits. Each satellite mission team has traditionally developed its own mission control center, sometimes basing their approach on that of an earlier mission. NASA engineers have built great new software applications, but the use was limited to single missions due to integration difficulties caused by unique mission system designs.

By 2000 it was becoming clear that budget restrictions at NASA could not support the old approach. In addition, commercial products were becoming more mature, satellite fleets were being considered, missions were talking about new operational concepts, and new development approaches were becoming common outside of the space industry.

The Goddard Mission Services Evolution Center, or GMSEC, was started in 2001 to create a new standard approach for managing GSFC missions. Standardized approaches in the past involved selecting and then integrating the most appropriate set of functional tools. Assumptions were made that "one size fits all" and that tool changes would not be necessary for many years. GMSEC took a very different approach and has proven to be very successful.

The core of the GMSEC architecture consists of a publish/subscribe message bus, standardized message formats, and an Applications Programming Interface (API). The API supports multiple operating systems, programming languages and messaging middleware products. We use a GMSEC-developed free middleware for low-cost development. A high capacity, robust middleware is used for operations and a messaging system with a very small memory footprint is used for on-board flight software. Software components can use the standard message formats or develop adapters to convert from their native formats to the GMSEC formats. We do not want vendors to modify their core products. Over 50 software components are now available for use with the GMSEC architecture. Most available commercial telemetry and command systems, including the GMV hifly® Satellite Control System, have been adapted to run in the GMSEC labs.

A new level of situational awareness is realized by having all components publish keep-alive and status messages which are merged for display and analysis. New display tools show messages from across the functional areas of a control center. By requiring components to accept control directives over the bus, automation tools can be developed which analyze status messages and take appropriate actions when conditions are recognized. The GMSEC automation tools allow for combinations of status messages and temporal conditions to trigger multi-step actions.

GMSEC systems have been in operations since 2005. The first three missions to use GMSEC each selected a different telemetry and command system and yet they selected the same automation and paging systems. Two selected the same trending systems. The GMSEC automation tools have allowed the Tropical Rainfall Mapping Mission (TRMM) to reduce the number of operational shifts per day. Other missions using GMSEC have operated totally "lights out" for periods of up to several weeks.

The number of components compatible with GMSEC continues to grow. The GMSEC architecture is planned for use on most of GSFC's missions now under development, is operational or under evaluation at other NASA Centers and is being used to re-engineer older mission control centers and the GSFC flight dynamics system. GMSEC has allowed commercial products to be easily integrated with other NASA tools, has allowed in-house tools to be applied to many different missions, has allowed for the exchanging of software components with NASA and with outside organizations and has significantly reduced system integration time.

2. Please describe some of the work of the CCSDS which you have been involved with. What role will standards and interoperability play in the future of space systems?

CCSDS continues to be the primary source for space-ground communications standards for NASA missions. Most recently, I have been involved with XTCE, SLE and SM&C definition or planning.

The XML Telemetry and Command Exchange (XTCE) standard is becoming the first joint standard between CCSDS and the Object Management Group (OMG) organizations. XTCE provides a standard data exchange format for master telemetry and command list information. I expect it to be widely accepted across commercial products. Control centers which today have a mix of in-house software and vendor products often need telemetry or command lists defined in multiple custom formats. We are moving towards XTCE as the common format for inputting the data into all of our tools. In addition, NASA has begun specifying its use in new proposal requests.

CCSDS Space Link Extensions (SLE) will simplify the routing and distribution of science and engineering data directly from the remote ground stations. Multiple end-users can effectively subscribe to data streams of interest. Eventually, the SLE standards are to be extended to allow a common approach for ground terminal scheduling and configuration across NASA and non-NASA assets – greatly reducing the amount of custom interface software now needed for different NASA systems and commercial. Should Internet Protocols become widely used for space-ground communications, it may be possible to have the SLE routing capabilities handled directly by the IP communications protocol.

The Spacecraft Monitor & Control (SM&C) effort involves defining a standard Service Oriented Architecture to allow space Agencies, including NASA and ESA, to have common applications software components and standard interfaces. NASA is increasing its effort in this area with an initial emphasis on the interoperability benefits it could bring.

Overall, I feel that standards in the areas of space-ground communications and interoperability will continue to be critical. As more ambitious missions are deployed and international partnerships become the norm, the need for clear interoperability standards increases. Across the industry right now, however, is also a major debate about whether ground systems themselves should be the topic of standards. Several groups are now developing Service Oriented Architectures with the belief that many integration and reuse issues will be solved if industry matches to their approach. I don't think we are to that point yet, and would like to see industry continue to advance their systems per their own business models for their own competitive advantages while maintaining compliance with emerging space industry communications and interoperability standards.

3. What role do GMSEC and standards play in NASA's Exploration Initiative?

NASA's Exploration Initiative will require a wide range of space and ground assets to be deployed over the next twenty or more years. Many of the GMSEC concepts and lessons learned are being planned into the Exploration Systems, although the extent to which GMSEC will be used directly is not yet clear. Our Exploration teams are working on publish/subscribe concepts between space and ground assets and ways to increase commonality across data systems while avoiding vendor or product lock-in and allowing for technology advancement over many years. These are all areas where the GMSEC efforts are of particular value.

Already, we have GMSEC labs established in many NASA Centers and connected over NASA networks to support Exploration integration testing and the evaluation of proposed standards and new conceptual ideas.

Many of the CCSDS standards are being specified for Exploration, including the recent XTCE standard for telemetry and command lists and CFDP for file transfers. Exploration requirements and the use of IP will require the creation of new standards to better specify routing, delay tolerance, quality of service, publish/subscribe subject naming and other communications management attributes. With Exploration representing such a large portion of the overall NASA effort, I expect that approaches adopted by Exploration will spread to other NASA missions and then to non-NASA and non-U.S. missions and then into commercial products.

4. What are the biggest challenges facing satellite ground systems today? What are the possible ways of addressing these challenges?

I think the challenge of the past decade was to architect ground systems to simplify integration by creating clean external interfaces and efficient ways to meet mission-specific needs. I believe the industry has done a good job in this area.

I think the next challenge is to adapt to the needs for much more efficient operations. Can the ground system handle everything itself and just notify us if there is a problem? Can fleet operations of dissimilar satellites become the norm? Can the operators configure their systems and add automation rules themselves? Can I split operations between the satellite experts and students at a local university? Can I easily transition my system from the integration-and-test phase into operations? Can my system interact with someone else's system to coordinate activities? Can event or alarm messages include body text or attachments like e-mail does to keep me better informed?

I think industry needs to be proactive in developing solutions to these issues. Today's systems have nicer displays and more modern underlying software languages, but much of the basic functionality is as it was many years ago. I believe the current architectures are ready to support new capabilities and the user community is ready to confidently take advantage of the new approaches waiting to be developed.

5. There has been a fair amount of discussion regarding the future of space systems and how a satellite will simply become a TCP/IP router in the sky. What do you think the impact of this would be on satellite ground systems?

First, using IP and space routing is not simple. There are many technical issues with time delays, error rates, disruptions and long-duration outages, limited bandwidth, dynamic routing based on relative orbital positions and the need for one-way links. All of these issues are being worked on and prototyped at NASA labs. Despite the challenges, IP still looks very promising. With an on-board network, commands could be directly routed to devices. Science and engineering telemetry data could be routed through the ground station to different users. Eventually, satellites or even a moon base could route data to other nearby or visible nodes.

The initial impact to the ground systems may be very low. If IP is considered the packet transport mechanism and protocol, then a well-layered ground system architecture should have isolated the impacts. The contents of many of the telemetry or command packets may stay relatively unchanged and the processing could be the same as with today's packetized processing.

6. What is the role of industry in the evolution of satellite ground systems, in your opinion?

Standards, users' long-term visions and commercial product vendor innovations all work together to advance the state of our industry. Commercial product vendors are in the best position to understand the trends taking place across the wide variety of satellite operators. The vendors are also in position to leverage ideas from one user for the benefit of another.

I would like to see more interaction between all user and vendor communities to openly discuss future directions. All groups have a vested interest in the future directions and there are many sharp people able to help set new directions. Actual product implementation decisions still need to be based on contract requirements or sound business model decisions.

It also seems that telemetry and command systems are becoming commodities, where any of several vendors' products can perform reliably. I would like to see more diversification between the commercial vendors. For this to happen, a company really needs to push into new areas such as model-based operations, automation, dynamic discovery or extensive fleet operations.

Dan Smith

***NASA Goddard Space Flight Center (GSFC)
Information Systems Division
Senior Engineer, Satellite Ground Systems***

Dan Smith has nearly 30 years of experience developing satellite ground systems for missions as diverse as Hubble Space Telescope, NOAA's 5-satellite GOES weather satellite system, and Globalstar's constellation of commercial communications satellites. He joined NASA in 2001 as the project manager for the Goddard Mission Services Evolution Center developing a standards- and message-based ground systems architecture now operational on multiple GSFC missions. For the past 2 years he has also

been a member of a NASA-wide team developing common data system requirements and specifications for the Exploration Initiative. Prior to joining NASA, Mr. Smith worked for major aerospace companies in the Washington, D.C. area in positions of lead architect, technical leader and project manager. He has a BS in Computer Science from the University of Maryland and an MS degree from George Washington University (GWU) and taught software courses at both the University of Maryland and at GWU.