MILSATMAGAZINE.COM

November 2008 -- COMM OPS

Commercial Processes & Reliability
Can the U.S. Government Leverage the Benefits?

by Chris Hoeber, Senior Vice President, Program Management and System Engineering Space Systems/Loral

As the U.S. Government (USG) comes under increasing pressure to contain costs for all types of space programs, the question of whether or not commercial providers can meet the needs of government programs has taken on new relevance. This is particularly true in the case of satellite communications, where the demand for capacity has continually outstripped the supply. By the time a new program launches its capacity is often already insufficient. This, along with typical schedule delays, necessitates gapfiller programs and reliance on commercial infrastructure for much of the communications demand. Gapfillers, decade-long programs, and multi-billion dollar cost growth for major system developments dramatically drive up the cost of USG communications while never fully meeting the demand. In contrast, commercial satellite operators develop, test and launch multiple satellites per year with ever increasing capabilities.

The status quo and high costs are sometimes rationalized based on the critical quality and reliability requirements of USG space programs. However, commercial communications satellite programs routinely produce and field systems with equally high quality and reliability in two to three years and at 20-30 percent of the cost. These programs are executed on a fixed price basis and are incentivized for on-time delivery and on-orbit performance and reliability. The design, manufacturing, testing and quality practices of these programs are equivalent to those of their government program counterparts and the government already relies, successfully, on such commercial satellites to cover its communications capacity shortfall.

While there is a core capacity that requires levels of survivability, radiation hardness and interference protection not routinely provided by commercial systems, a large percentage of the demand for USG spacecraft could be filled by taking advantage of commercially available capabilities. It is encouraging that more and more government organizations are beginning to take a closer look and are discovering that fixed-price, commercial-like procurements may well be a viable option.

Characterizing Commercial Programs

Commercial satellite programs have provided some of the world's largest, highest-power, and longest-life spacecraft. These spacecraft are an indispensable part of the world's communications infrastructure, and actually serve approximately 80 percent of the USG's communications needs today. Most commercial communications satellites perform functions that are critical to the success of their operators' business plans and are designed with very high reliability and for long on-orbit life. Typical commercial satellites provide greater than 0.9999 availability, ensuring continuity of service to the operators' customers. For a direct broadcast operator, losing the signal during the Super Bowl could be disastrous to its business.

Commercial satellites are no longer limited to a few frequency bands and simple C- and Ku-band "bent-pipe" payloads. Today, manufacturers such as **Space Systems/Loral (SS/L)** are providing very complex satellites with 20-kW power capability, steerable spot beams, 18-meter unfurlable antenna reflectors, Ka-, X-, S-, L- and UHF-band payloads, nearly 100 Gbps communications throughput, and ground-based beam forming.

Product Focus vs. Process Focus

Typical commercial satellite manufacturers are able to complete three to eight spacecraft or more per year with a product-line approach that uses heritage building blocks that can be configured to meet the satellite operators' needs. Every satellite follows a disciplined process which is the same for each program. The details of this process vary from manufacturer to manufacturer, but the key to reliability is repetition, which allows the manufacturer to learn from missteps and make continuous process improvements.

Technology advances are developed in advance of the programs and incrementally inserted into the time-tested subsystems. This evolutionary process enables commercial operators to keep pace with innovation over time with far less risk than programs where multiple systems require simultaneous development.

When payload requirements demand developments, these are implemented with technologies that permit qualification within the commercial program timeframe. By focusing on a satellite's performance requirements and on the shortest path to a product solution, commercial operators can leverage the efficiency of existing capabilities and processes to meet a broad range of customer needs.

Think of buying an extremely powerful and reliable luxury car. You wouldn't go to Rolls Royce or Mercedes Benz and say, this is how I want you to build my car. You would trust that the company has its own rigorous processes to deliver the automobile that meets your requirements. You would trust that an automobile manufacturer knows more about how to design and assemble your Lexus than you do

In the same way, commercial satellite manufacturers have established robust processes, testing, and mission assurance requirements that are repeated for every satellite program independent of the customer's identity. Because these known processes are repeated on multiple programs with many years of on-orbit operational experience, they have been refined for maximum efficiency and designed to uncover issues early. Many lessons learned are applied to every procurement, and problems, when they occur, do not continue to show up on later programs. As operators insure their satellites, the insurance rates depend on the proven and consistent reliability of each manufacturer's satellites.

Operators are not reluctant to switch satellite providers and manufacturers are driven by the attitude that "You're only as good as your latest spacecraft."

This is in direct contrast to the unique Mission Assurance Requirements (MAR) for each government agency. These requirements can even differ from program to program within the same agency thereby eliminating of repeated processes. Historically, when the USG contracts with a satellite manufacturer, it is purchasing a development process as much as it is buying a product. But the customized MARs might not add significant value. Analyses of SS/L's mission assurance and design standards, derived and evolved from the old MIL standards, shows that they are as stringent as new MARs being developed by government organizations, and in some aspects more so. However because they are uniformly and routinely applied, they do not impact cost or schedule.

As a satellite program is executed, sometimes the ultimate goal for the satellite and the way it will be used seems to become secondary in importance to the very specific processes, procedures and tools demanded by USG programs The unique requirements of each USG procurement mean that the manufacturer is in many cases "reinventing the wheel" and not benefiting from previous experience. Because manufacturers are reimbursed for hours billed, there is little motivation on the manufacturers' side to improve the efficiency of this process and there is less opportunity to incorporate lessons learned or to benefit from previously designed systems.

Recently, this practice is being reexamined. In an effort known as **Operationally Responsive Space (ORS)**, the U.S. Air Force is studying ways that it can streamline the process for ordering both LEO and GEO satellites as well as meeting urgent short term needs using microsatellites, existing on-orbit satellites, hosted payloads and a variety of alternative approaches. The U.S. Department of Defense commitment to improving the nation's ability to more affordably and quickly acquire and employ space capabilities makes it certain that commercial processes will be examined.

Security
For most government satellite procurements, security is extremely important and when satellite features are mission-revealing, protection measures can impact the speed and cost of program execution. But most commercial manufacturers already have the capability to provide these protections while preserving the consistency and robustness of the processes that underlie their cost-effective and timely program execution. Unique aspects of payloads and spacecraft can be designed, built and tested in a compartmentalized fashion and integrated under appropriate conditions to support security needs while still realizing the major benefits of the commercial approach.

Mission Assurance

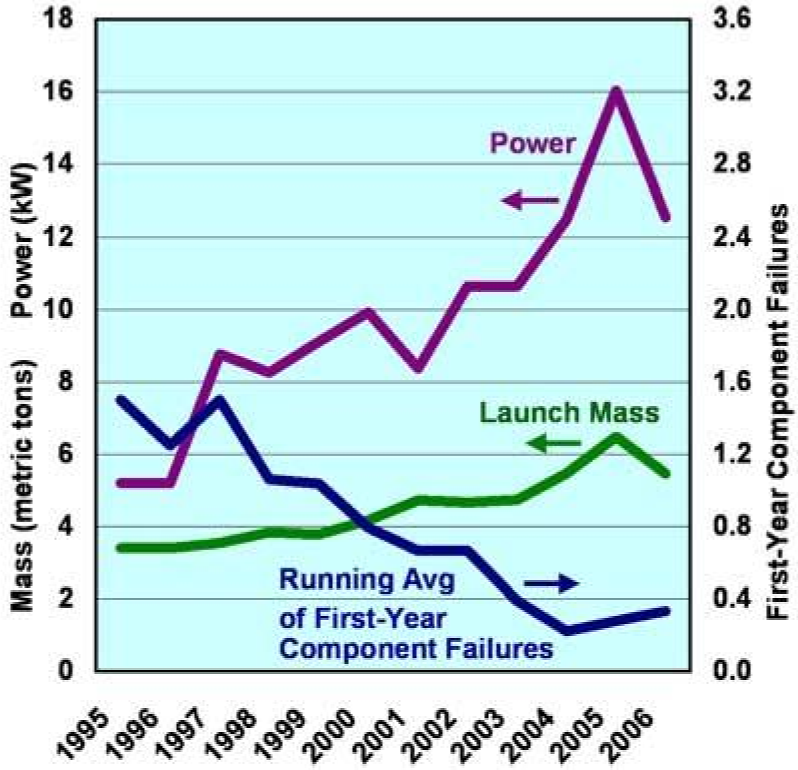


Figure A
Space Systems/Loral Satellites Have Had Decreasing First Year Component Failures as Size and Complexity have Increased. Note that component failures seldom directly impact satellite operation due to redundancies. Reliability is of ultimate importance to the military and most government agencies. However, reliability and availability have been shown to be equally if not more important to commercial satellite operators, whose business success hinges on reliable service. In highly competitive commercial procurements, reliability is scrutinized as a key criterion for selection. Commercial manufacturers are further incentivized for Mission Assurance through orbital incentive payments that typically cover all of the profit and even some of the program cost and are only received as long as a satellite delivers the contracted on-orbit performance. If a failure does occur, insurance may replace the operator’s satellite, but it does not cover the lost revenue while the new satellite is being built, and it does not compensate the manufacturer for its program losses.

At Space Systems/Loral, statistics show that even as the company has delivered increasingly larger and more complex satellites, reliability has also increased. In general, the first year on-orbit is a good indicator of the robustness of design processes, the effectiveness of test programs, and the integrity of quality systems. Robust design processes are a prerequisite because no amount of testing or quality control can make up for a flawed design. Commercial manufacturers’ confidence in their processes is reflected in their success in working under firm fixed price contracts.

Figure A shows Space Systems/Loral data from the past 12 years, which tracks a steady decrease in first year component failures despite the growth in satellite size, power and complexity. Note that component failures seldom directly impact satellite operation due to system redundancies.

For 2007, Space Systems/Loral reported 99.997 percent availability for its 50+ on orbit GEO spacecraft, 12 of which were operating past their mission life requirements. Insurance records show that Space Systems/Loral delivers on average approximately 20 percent more transponder years than contracted.

Firm Fixed Price Practices
One of the most significant differentiators between typical USG procurements and commercial contracts is the establishment of a fixed cost to the customer in advance. A firm fixed price (FFP) changes the nature of a procurement and the processes that support it in fundamental ways.

Before an FFP contract is signed, there is significant communication between the customer and the supplier to develop a design concept that meets the operator's needs and is compatible with cost and schedule objectives. Schedule is often vital to support a commercial operator's business case. Once the requirements are agreed upon, the satellite is configured based on the existing product line architecture. With knowledge of the heritage building blocks that have been proven over time, the manufacturer can guide the customer toward a plan that maximizes the operator's objectives. If any technology developments are required, they are agreed upon in advance and the schedule is adjusted accordingly.

At contract signing the scope of the project is well defined with a complete set of documents including contract terms and conditions, statement of work, system specifications, mission assurance plan, and test plan. At this point the design is frozen and, whenever possible, no further changes are made.

Typically, commercial customers co-locate program staff with the manufacturer and through their continuous involvement there is real-time coordination that mitigates schedule delays and ensures that there are no surprises. Because the customer has continual insight into the status of the satellite program, it does not have to be burdened by excessive formal reporting and delays due to document approval cycles. Compliance to the contracted scope is demonstrated with approvals at specified events, and payments are made when these milestones are met. Because the profit for the commercial manufacturer is not actually achieved until the satellite performs on orbit over time, the manufacturer has significant motivation to perform flawlessly.

Currently, according to ***Federal Procurement Regulations***, FFP contracting for USG systems is allowed in cases when mission requirements are known or when a follow-on design is significantly unchanged from the previous build. On other USG satellite contracts, payment is made on a cost reimbursement basis. The focus is typically on program specific development processes and procedures, often minimizing the big picture view of how these processes impact the goal that needs to be achieved. Oftentimes the required formal reporting and delays caused by lengthy document approvals actually impede program success.

The implicit importance of schedule to commercial FFP contracts discourages the requirements creep that can plague USG procurements. All commercial contracts include provisions for contract changes, however significant redirection is rare. Since the manufacturing cycle is typically only three years, and since large satellite operators have multiple procurements in process at any given time, new requirements can always be addressed in later programs.

Hosted Payloads
Hosted payloads are an effective way for government objectives to be met on a very timely and cost effective basis. Also known as piggyback payloads, or rideshare payloads, they are garnering increased attention as a result of the same cost and schedule pressures discussed previously. USG agencies including NASA, NOAA, FAA and DoD have all recently solicited commercial operators for proposals for carrying hosted missions and payloads into space.

The ***Space Systems/Loral 1300 satellite bus*** has been shown to be a good choice for hosted payloads because of its size, high power and heat dissipation capability, as well as its standard interfaces and environments. Hosted payloads are not a new concept. Examples of hosted payloads on the 1300 platform include ***MTSAT-1R***, which was built for both the ***Japanese Civil Aviation Bureau*** (**JCAB**) and ***Japanese Meteorological Agency*** (**JMA**) and launched in 2004, and ***Optus C1*** a commercial satellite which was built for **SingTel Optus**, with an **Australian Department of Defence** hosted payload, and launched in 2003.

Built on the Space Systems/Loral 1300 satellite bus, MTSAT-1R has two payloads, one that provides aeronautical services and one for weather monitoring. MTSAT-1R combined aeronautical services with a meteorological payload. JCAB uses the satellite's L-band mobile links to provide communications and navigational services for aircraft, increasing the efficiency of aircraft flight routes, providing flexible flight profile planning, enhancing air travel safety and improving the quality of aeronautical communications.

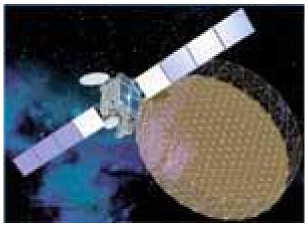
For the JMA, MTSAT-1R gathers critical weather information for users throughout the Asia-Pacific region, broadcasting cloud imagery and continuous weather data, including cloud and water vapor distributions, cloud-motion wind vector, sea surface temperature, and information on typhoons and other severe weather conditions. The **U.S. Air Force** and the **Navy Joint Typhoon Warning Center** also both use MTSAT-1R imagery to track weather patterns in the Western Pacific to Indian Ocean regions.

Optus-C1 satellite **Optus**, a leading Australian telecommunications service provider, uses ***Optus C1***'s Ku-band payload to distribute video, direct-to-home TV, and telephony and Internet connections to remote areas. For the Australian Department of Defence, the satellite's Ka-band payload provides high-data-rate broadcast coverage for video, voice and data communications. The satellite's X-band payload provides medium- to high-data-rate, voice and data communications for land and maritime applications and its UHF payload provides secure low-rate voice and data communications to mobile platforms.

More recently the U.S. Air Force contracted with **AMERICOM Government Services (AGS)** to host an experimental sensor on board a commercial spacecraft that is being built by **Orbital Sciences** and is scheduled for launch in 2010. The program, known as the ***Commercially Hosted Infrared Payload*** **(CHIRP)** ***Flight Demonstration Program***, will test a new type of infrared sensor from geosynchronous altitude. This is an example of how the commercial satellite industry can provide value to USG customers looking for affordable access to space. It represents an endorsement of commercial practices.

New Product Development
Fixed priced contracting and design closure does not mean commercial satellite systems are built with old technologies. The competitive nature of the commercial market requires state-of-the art technologies. For example, over the last decade commercial satellites have more than doubled in power capability. Other developments, such as the introduction of *Hall Effect*, or *Stationary Plasma Thrusters* (**SPTs**) for electric propulsion and the use of ***Lithium Ion*** **(Li-Ion)** batteries have become commonplace. However, in the commercial world these introductions are incremental, based on meticulous processes designed to insure success.

With insurance companies monitoring risk, it is significant to note that over the past ten years a broad range of new capabilities have been implemented on the Space Systems/Loral 1300 satellite bus with such comprehensive and thorough testing that insurers did not find it necessary to impose "first use" penalties in their premiums. SPTs are a good example. These electric thrusters replace the traditional bipropellant thrusters used for station keeping and momentum management and save several hundred kilograms of launch weight, which can be used for additional payload instead.



MBSAT-1 satellite SS/L successfully introduced the electric propulsion technology commercially on ***MBSAT***, which was built for **MBCO (Mobile Broadcasting Corporation)** of Japan. Previously these thrusters were used on multiple Russian satellite missions and adapted for SS/L use after extensive ground tests for life, power electronics interfaces, and analysis of the plume impingement effects.

Thaicom 4 is a highly complex broadband commercial satellite built by Space Systems/Loral. SPTs were also used by SS/L on ***Thaicom-4*** and ***Galaxy 28*** (**Intelsat Americas 8**), which were both launched in 2005 and by **EADS Astrium** on ***Intelsat 1002*** and the three ***Inmarsat 4*** spacecraft. To date, with nearly daily firings for stationkeeping on these seven large GEO satellites, there have been no unit failures. SPTs for station keeping and momentum management are now a standard option on the 1300 satellite bus and are regularly implemented in new satellite programs as required.

Li-Ion batteries are another mass-efficient advanced technology that has been inserted as a space-proven building block for use with the 1300 satellite bus. The same detailed process of careful qualification and extensive end-to-end ground testing was implemented before this technology was offered for use on SS/L spacecraft. The first use of Li-Ion batteries and associated power control electronics was on Thaicom-4, which provides broadband service Asia and Australia.

Because ***Li-Ion*** batteries are much smaller and lighter than traditional ***Nickel-Hydrogen*** **(NiH2)** batteries, their use on Thaicom allowed for more payload mass for the satellite. This satellite provides more than 45 gigabits per second (Gbps) data throughput capacity, which is more than 50 times the data throughput of a typical satellite built just 5 to 10 years ago. Li-Ion batteries are now being built into all of the satellites under construction at SS/L. To date, SS/L spacecraft have demonstrated 2.4 million hours of on orbit operation of Li-Ion batteries with no unit failures.

Currently all western commercial satellite manufacturers – **EADS Astrium**, **Boeing**, **Lockheed Martin**, **Orbital Sciences**, **Thales Alenia Space**, as well as **SS/L**, offer Li-ion batteries. While this technology is performing flawlessly on a number of on orbit GEO satellites, it has not yet been introduced on a USG GEO satellite.

Product Development Rigor
At most commercial satellite manufacturers, product development planning is market driven and long term. Manufacturers communicate regularly with satellite operators in order to understand their future needs and challenges and when a new product is essential to an operator's business plan, it is added by way of a carefully planned product development roadmap.

As an example, in 1999 SS/L adopted a formal ***Product Development and Qualification*** **(PDQ)** program that institutionalized a well-planned development process, thorough qualification, strict documentation requirements and pass/fail criteria. PDQ requires a consistent development approach and careful incorporation of lessons learned. It is applied to small product improvements as well as multi-year development programs for major new capabilities such as the Lithium Ion battery system.

PDQ establishes minimum standards for processes and provides planning requirements and tools for concurrent product development as well as mechanisms for tailoring the scope of the plans to the unique characteristics of each project. Integrated product teams are required so that all manufacturing, test, system integration, reliability, parts, materials and processes considerations are addressed thoroughly in the engineering and development of the product.

In many new product developments, *highly accelerated life testing* (**HALT**) is used to assess robustness. HALT stresses units thermally and mechanically well beyond qualification levels to establish the upper and lower operating limits beyond which the product ceases to meet performance requirements, and then the levels at which the product fails. HALT helps identify any latent design weaknesses so that they can be resolved during development, allowing significant robustness increases to be accomplished for a modest investment that can be amortized across a range of programs over several years.

Space Systems/Loral, like all U.S. commercial satellite manufacturers, is a Government contractor certified for classified U.S. Government programs. Space Systems/Loral received the NASA Goddard Contractor Excellence Award for its work on five Geostationary Operational Environmental Satellites (GOES). Launched between 1994 and 2001 the satellites have collectively outperformed their life expectancy by more than 55 percent, with two of the satellites still providing critical meteorological monitoring functions. These commercial product development practices are voluntarily self-imposed by spacecraft manufacturers in order to ensure low-risk insertion of new technologies into their product lines for the benefit of their customers and the future of their businesses. These practices typically meet or exceed the product development process expectations of USG customers.

Conclusion
USG agencies are coming to see that it is imperative to incorporate some of the efficiencies of the commercial satellite industry into their space assets procurement process in order to maintain national security and worldwide peacekeeping within today's ever tightening cost constraints. The timely deployment of new, reliable space assets can be ensured through the use of satellite manufacturers that have a long term culture of high quality and high reliability satellites delivered on short schedules with fixed budgets. In the future, unique, mission-driven capabilities that require multi-year developments can be segregated from the more routine capabilities. With a "best of both worlds" approach, there is the potential of finding a very attractive cost optimum for USG space system procurements.

About the author

Christopher F. Hoeber has been with Space Systems/Loral for 28 of his 33 years in the commercial satellite business. His current responsibilities as senior vice president, program management & systems engineering include customer satisfaction; program profit; schedule and performance objectives; and planning and managing SS/L's R&D and product development activities. Most recently, Mr. Hoeber was vice president of business development for SS/L, which included marketing and sales. Prior to that, he held the position of chief engineer. Throughout his career, Mr. Hoeber has served in systems test and engineering and program and functional management positions.