OPERATIONALLY RESPONSIVE SPACE-1 (ORS-1) LESSONS LEARNED

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ABSTRACT

Operationally Responsive Space-1 (ORS-1) is the first ORS Office operational satellite and an important milestone to demonstrate the capability to meet emerging and persistent warfighter needs in operationally relevant timelines. Launched in June 2011, ORS-1 was initiated at the direction of the Commander, U.S. Strategic Command and the DoD Executive Agent for Space to address a U.S. Central Command (USCENTCOM) need for enhanced battlefield awareness. The ORS Office led an assessment that produced a unique solution with proven operational utility providing timely coverage and responsive theater tasking that avoided the burden of traditional top-down procurements and provides future growth leveraging upgrades in airborne/space assets. The ORS-1 team went from the drawing board to the launch pad within 32 months and earned early combatant command acceptance in September 2011, less than 90 days after liftoff. ORS-1 is the first and only dedicated space intelligence capability for USCENTCOM, introducing Operationally Responsive Space as a new paradigm for DoD. The $224M program includes the satellite based on Goodrich's SYERS-2 payload and the proven ATK TacSat-3 bus, two mission data downlink sites, mission data processing system, and satellite command and control ground system, interfaces with the existing airborne ISR exploitation and dissemination systems, Minotaur I launch vehicle, and operations. The team doggedly adhered to a “good enough to win” approach to deliver a capability that was affordable, rapid, and risk tolerant. ORS-1 provides USCENTCOM an assured ISR capability that cannot be preempted by support to other users. It is an enabler for sustaining operations and objectives in a highly volatile region and is laying the path for future rapid reaction space systems. This paper will review the program objectives and accomplishments to date as well as the Lessons Learned already being applied to other responsive space initiatives.

INTRODUCTION

The Department of Defense officially defines Operationally Responsive Space (ORS) as “assured space power focused on timely satisfaction of Joint Force Commanders’ needs.” It contains two key elements: assurance of capabilities and timely delivery. Through robust, proven, and readily accessible means the nation will provide space effects and services within an operationally relevant timeframe prescribed by the joint commander during peace, crisis, and war. On May 11, 2007, the Deputy Secretary of Defense and Executive Agent established the ORS Office as a proactive step to adapt space capabilities to changing national security requirements and to be an agent for change across the community. Operationally Responsive Space is a new approach; rather than trying to operationalize national space utilities, this model designs military capabilities directly for the operational commander. A key attribute of the model is that the field commanders drive the demand. That demand is joint military capability to meet operational- and tactical-level needs. Rather than treating our operational- and tactical-level commanders as a lesser requirement in the overall national space plan, this business model designs a capability to meet their specific warfighting needs. Done correctly, this approach can complement and add to national space capabilities. ORS is not meant to replace the larger space program. Rather, they are complementary. Today, space power is dependent on large and expensive satellites, which, for the most part, cannot be reconstituted quickly if compromised. The concept of tactically useful satellites is not new; its roots can be traced back to experimental programs managed by the Office of Naval Research in the late 80's that were then termed Single Purpose Inexpensive Satellites, or SPINSATs.[1] However, just as the DoD has operationalized the larger space program to meet theater needs, these operationally-designed theater capabilities will also enhance our national and strategic space capabilities. Specifically, these satellites will help reduce the burden we are currently placing on our national systems and the organizations that operate them, enhance the persistence of national capabilities, assist in meeting force structure requirements mandated by current force planning constructs, and help ensure US forces are adaptable while facing an uncertain future. [2] By building systems on smaller satellites using modular components, ORS provides the ability to rapidly augment U.S. space systems. ORS can deliver capabilities in a fraction of the time it takes to build larger platforms. [3]

The successful integration of space-based capabilities into the core of U.S. national security operations has resulted in dramatically increased demand for and dependence upon space capabilities. As a result, U.S. Strategic Command (USSTRATCOM) identified needs to rapidly augment existing space capabilities when needed to expand operational capability; to rapidly reconstitute/replenish critical space capabilities to preserve operational capability; and to rapidly exploit and infuse space technological or operational innovations to increase U.S. advantage. Operationally Responsive Space (ORS) is designed to both improve the responsiveness of existing space capabilities (e.g., space, launch, and ground segments) and to develop complementary, affordable small satellite/launch vehicle combinations, and associated ground and command and control systems, that can be deployed in operationally relevant timeframes. The ORS goals are to improve robustness—provide a focused, limited capability to augment and reconstitute, with assured warfighter access and control; respond to urgent needs--deliver effects to joint warfare in response to an urgent or previously unanticipated need; reduce development/deployment time and cost--complement existing space capabilities with an element focused on increased value and timely delivery.; and capitalize on emerging/innovative capabilities--adopt new capabilities from advanced technologies and innovative operational concepts. Joint Force Commanders have three "tiers" of ORS capabilities for meeting urgent needs. Tier 1 involves employing existing, fielded space capabilities in a new and novel fashion within hours to days. Tier 1 solutions will not typically involve the design, engineering, or fabrication of new materiel items. Tier 2 involves deploying field-ready capabilities within days to weeks through rapid assembly, integration, testing, and deployment of small, low-cost satellites. Tier 3 involves developing new capabilities within a months-to-one-year timeframe. Tier 3 activities typically involve hardware and software design, engineering, fabrication, and integration. Insertion of advanced technology into Tier 3 systems must be consistent with the targeted timeframe for the solution.[4]

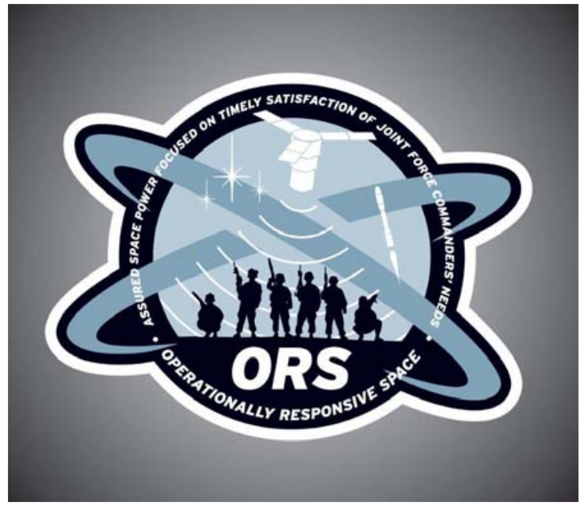

Figure 1: ORS Logo

To address the "timely satisfactions of Joint Force Commander needs", the ORS Office has created a requirements process that converts an immediate and urgent warfighter need into formal requirements and then identifies potential solutions to meet the need. This extremely rapid and thorough process was created to enable full transparency and participation across the National Security Space community. This process essentially duplicates all the key aspects of the JCIDS process - and does so in less than 30 days. In addition, one of the greatest strengths of this process is that it is not constrained to necessarily lead to an ORS solution to meet the need. This urgent needs requirements and solutions generation process begins when USSTRATCOM identifies an urgent need to the ORS Office. During the subsequent requirements and solutions development phases, teams are assembled from across the Warfighting communities. To streamline the process, the solutions development team can begin gathering data on potential solutions even before the final requirements document is delivered.

Additionally, the Joint Force Commander or other user who originally submitted the need to USSTRATCOM has multiple opportunities to provide input throughout the process. This ensures the solutions being considered will actually fit the need. To date, four urgent warfighter needs have been addressed by and it was used by the ORS-1 team to arrive at a recommended solution to the request by U.S. Central Command for enhanced battlefield awareness.[5]

PROGRAM DESCRIPTION

The satellite system, ORS-1, represents a fundamental change in the U.S. military satellite acquisition process. The ORS-1 fielding team's tireless efforts produced a unique solution to the long-standing problem faced in USCENTCOM operations; intelligence, surveillance, and reconnaissance (ISR) has suffered a lack of key battlefield awareness for leaders in the field. ORS-1 proved its operational utility almost immediately, providing timely coverage and responsive fulfillment of theater taskings. The rapid acquisition avoided the burden of traditional top-down procurements and provides for future growth by leveraging upgrades in airborne/space assets achievable in the short term. The ORS-1 team devised an ingenious risk-based technical development and test program that tailored the approach to design decisions and performance verification. ORS-1 is the first DoD satellite providing dedicated support to a single Joint Force Commander and provides an assured capability that cannot be preempted by support to other users.

The program was established during 2008 after U.S. Central Command expressed an urgent requirement for enhanced battle space awareness. Based on this request, the Commander U.S. Strategic Command directed the ORS Office to provide potential options. The evaluation process involved assembling a team from other organizations and agencies, assessing solutions from currently available systems and then reviewing the range of alternatives including the development of new capabilities. For ORS-1, the evaluation team led by the ORS Office included representatives from Air Force Space Command (AFSPC), the Space and Missiles Center (SMC), the National Reconnaissance Office (NRO), the National Geospatial Agency (NGA), United States Strategic Command (USSTRATCOM), Air Force Research Laboratory (AFRL), and United States Central Command (USCENTCOM). Once it was determined that no current solution existed to address the need for enhanced battlefield awareness, new capabilities were assessed. This was accomplished through several short-term study contracts for both satellite bus and payload designs. Factors considered included overall capability, projected schedule and cost, and technology maturity. A key consideration was a "good enough" technical solution which allowed for both reduced costs and accelerated program schedule. The projected capabilites of the potential solution although less than other available systems, was deemed adequate by the USCENTCOM operational users. Following coordination with USCENTCOM, the solution was briefed to the Commander USSTRATCOM and the DoD Executive Agent for Space at in October 2008; approval was given to proceed to Critical Design Review (CDR) at which time an assessment would be made to begin hardware build. A critical factor was the award of the initial contract to the Goodrich/ATK team by the SMC Space Development and Test Directorate (SMC/SD) within three weeks of DOD EA for Space approval.

The ORS-1 satellite is part of a larger effort by the Department of Defense to build and launch satellites faster and to put those satellites under the direct control of warfighters for faster response time in tasking and receiving information. The ORS-1 development was led by the ORS Office and executed by SMC Space Development and Test Directorate (SMC/SD). Mission partners included U.S. Strategic Command, U.S. Central Command, Air Force Space Command's 50th Space Wing, U.S. Army, U.S. Naval Research Lab, NASA Wallops Flight Facility, Goodrich Corporation and ISR Systems, ATK Spacecraft Systems and Services, L-3 Communications, Orbital Sciences Corporation (OSC), Lockheed Martin, General Dynamics, Aerospace Corporation, and TASC. [5] What makes the ORS system unique from the normal space acquisition process is that it took approximately only 32 months to develop from concept to launch and orbit, compared to traditional satellite systems, which typically take seven years or longer to develop. Three game changing approaches allowed for this success: scaling the capability for affordability, efficient acquisition, and leveraging commercial best practices.

The space vehicle features a modified version of the Senior Year Electro-Optical Reconnaissance System-2 camera built by Goodrich ISR Systems, the multi-spectral sensor used on the U-2 reconnaissance plane and deployed in theater for more than 35 years. For ORS-1, Goodrich attached a larger telescope to the SYERS-2 camera to give it adequate resolution from orbit. Goodrich also provided a ground segment for processing the data from the sensor payload to be in compatible formats with the downstream exploitation, and dissemination used for the operational SYERS sensor. The ORS-1 spacecraft bus was built by ATK Space Systems and was based on their TacSat-3 bus. It includes an integrated propulsion system as well as other critical subsystems for communications, attitude control, thermal control, command and data handling.

The ORS-1 program office worked closely with the Goodrich and its partners to ensure a viable space vehicle design derived from the proven TacSat-3 satellite along with reuse of 80% of its software. This enabled the launch vehicle interfaces and data analyses tobe preserved. ORS-1 was able to fulfill massive intelligence requirements with the existing U-2 data processing system. This enabled USCENTCOM to almost instantly exploit mission data by the existing intelligence infrastructure to Task, Process, Exploit, and Disseminate (TPED) nearly seamlessly using the same processes currently used for tactical airborne systems. ORS-1 was launched from the NASA Wallops Island facility using Minotaur I rocket.

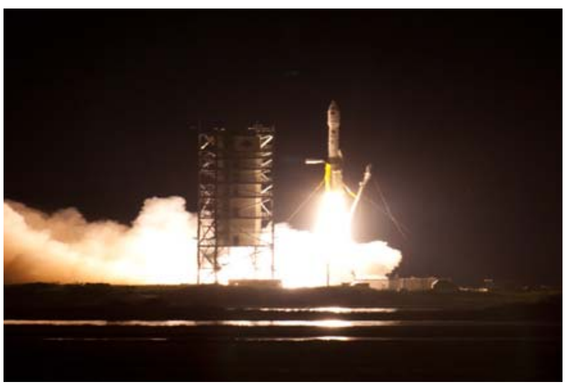

Figure 2: ORS-1 Launch from NASA Wallops

ORS-1 Payload

Goodrich used the SYERS-2 multispectral sensor with flight heritage on multiple airborne platforms as the basis for the ORS-1 sensor. This is coupled with existing interoperable ground systems, enables the nearly seamless integration of the ORS-1 data products into the battlefield picture. Adopting this proven design eliminated the need to retrain tactical forces already familiar with U-2 data products, or build a whole new ground infrastructure for such satellites. This further minimized the cost of fielding this new tactical capability. The payload concept was initiated under a contract with the Naval Research Laboratory; Goodrich developed the OASIS (Operational Airborne Sensor in Space) ISR System, a space qualified version of the Airborne Reconnaissance systems and supporting ground elements. Operationally responsive Electro-Optical (EO) imaging capability exists today and is routinely used to provide intelligence information to the tactical warfighter. This capability is provided by Goodrich Reconnaissance systems having standard interfaces to multi-mission strategic (i.e., U-2) and tactical airborne platforms. These operational systems have visible; IR and multispectral capability, and the resulting data products readily interface into existing exploitation and data dissemination infrastructures, providing timely information to theater commanders. The Goodrich approach for producing the ORS-1 payload can be visualized as pulling from their "product stream" of continually evolving airborne sensors to build ORS ISR payloads. The major effort for adapting an airborne sensor system for responsive space is associated with electronics. This adaptation was accomplished with parts and processes compatible with a short duration space missions and low power consumption for compatibility with ORS-class spacecraft buses.[6]

Space Vehicle Bus

The ORS-1 space vehicle bus was designed and fabricated by ATK Space, Beltsville, MD. Using the proven design from the TacSat-3 flight demonstration, it demonstrates modular spacecraft bus standards, interfaces, and processes to meet the goals of the ORS initiatives that seek rapid, low-cost space assets launched to support the needs of tactical warfighters. The major change for ORS-1 was the addition of a propulsion module which provides the satellite with orbit maintenance capability. In the revised design, TacSat-3 interfaces are preserved plus new interfaces are added for the propulsion subsystem. The propulsion subsystem is comprised of an Aerojet procured PROP plus and an ATK-provided propulsion control unit (PCU) and Prop deck. The subsystem provides all propulsive orbit maintenance maneuvers for the ORS-1 Mission. This adaptable, low-cost modular bus enables the tactical warfighter to rapidly deploy tactical satellites as low-cost consumables to fill critical requirements. ATK Space provided the critical design, fabrication and integration of the bus, and is provided support to Goodrich for spacecraft integration and test, launch and on orbit operations. The ATK Space design features robust power capability with 900 Watts max and the bus top deck can support 160+ kilogram payloads with an adaptable payload interface to support multiple payload configurations.

The bus provides precision pointing, power and thermal management, orbital maneuvering and payload support functionality. In addition to producing the bus, ATK also supported ORS-1 mission analysis, payload and launch vehicle integration, and space vehicle operations. The hardware includes the onboard command and data handling system, solar arrays, primary structure and interfaces to the launch vehicle and payload. ATK's innovative hexapetal bus design enables rapid integration and modular packaging of both bus and payload components - an enabling capability for future Operationally Responsive Space (ORS) missions that must meet rapid call-up requirement. The bus used for ORS-1 provides a highly-capable spacecraft that was versatile enough to support the specific mission requirements, while flexible enough to support a broad range of future ORS missions. Other innovative features of the ATK spacecraft design include the adoption of Integrated Systems Engineering Team standard interfaces, that were developed in parallel by a joint government-industry team of engineers; an agile three-axis stabilization system to enable payload sensors to collect precision data on-orbit and downlink processed information in the same orbit pass; a robust power

Figure 3: ATK Modula Bus

capability with modular power options that can be tailored for specific mission requirements; and a high-strength structure with adaptable interfaces to support a variety of sensor payloads. ATK's spacecraft bus met the ORS program goals of being operationally responsive with affordable technology and unprecedented rapid execution from design to launch. ATK built the bus in just 16 months at its Beltsville, Maryland facility and shipped it ahead of schedule to Goodrich Corporation, the prime contractor for the ORS-1 satellite. ATK demonstrated the ability to achieve remarkable milestones going from design review to production, testing and delivery. The team successfully executed on rigorous mission requirements that met the expectations of the ORS-1 program in months instead of years.

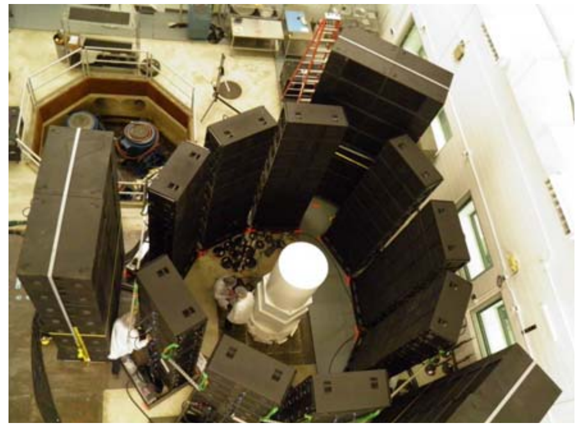

Figure 4: System Level Acoustic Testing

Integration, Test, and Launch Activities

The ORS-1 space vehicle completed final assembly and testing at the Goodrich Danbury, CT facility. Goodrich successfully completed space qualification environment

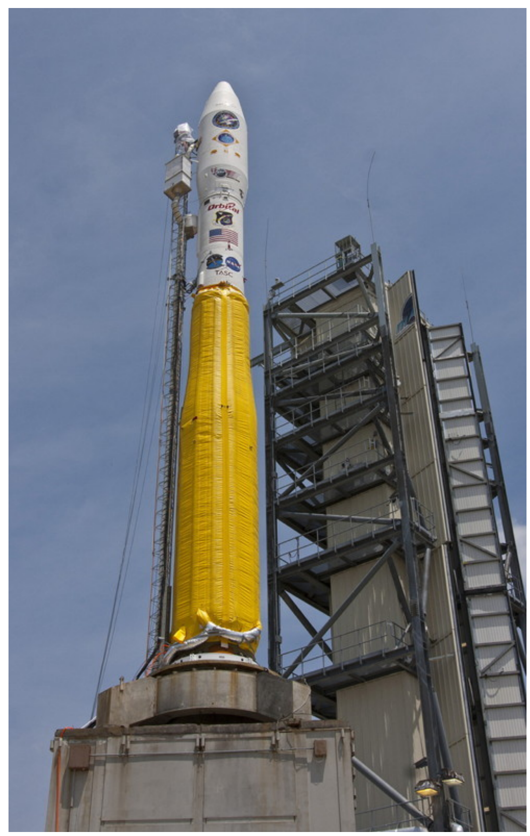

Figure 5: ORS-1 on Pad at NASA Wallops

testing including thermal vacuum testing, systems level acoustic testing, and the testing validated spacecraft performance and functionality in an environment duplicating the extreme hot and cold temperatures; successful completion of this final environmental test demonstrated the design integrity, the quality of workmanship and the satellite's readiness to withstand the rigors of launch and space. End to end testing of the ground architecture was completed to verify interoperability of the interactions between USCENTCOM PRISM, VMOC, MMSOC, GSEG, and the ground stations. The ORS-1 team encountered multiple technical issues but expertly used workarounds to maintain overall schedule and was ready to ship to the launch in late April 2011. Shipment was delayed almost six weeks due to concerns with the Minotaur I launch vehicle after anomalies with the TAURUS rockets build by Orbital Systems Corporation which had a similar design.

The ORS-1 space vehicle arrived at the NASA Wallops Island launch facility on May 20, 2011 for final testing and integration with the Minotaur I launch vehicle. Because of the concerns with the Taurus launch vehicles, minor modifications were made to the Minotaur I fairing rails and software. Overall, the activities went nearly flawlessly and represented a significant team effort by the ORS-1 program office, NASA personnel, Goodrich, ATK, and Orbital Systems Corporation. Processing of ORS-1 and the Minotaur I went extremely well and included space vehicle fueling, leak tests, installation of motorized light band, SOFTRIDE, solar panels, abbreviated functional testing and S/V software updates installed; all activities were completed by late May. The integration of Minotaur I upper stack with ORS-1 Space Vehicle was accomplished on June 4; the payload was encapsulated within a payload fairing, with two sizes available depending on the size of the spacecraft. For the ORS-1 launch the larger fairing with diameter of 1.55 meters was used.

The Minotaur I rocket used for ORS-1 is a four stage solid-fuelled expendable launch system derived from the LGM-30F Minuteman II missile which was developed in the 1960s and retired from operational service in December 1991. The Minotaur I uses the first two stages of the Minuteman, however it has an Orion-50XL as its third stage and an Orion-38 motor is used as a fourth stage. Launch Pad 0B at the Mid-Atlantic Regional Spaceport was the point of departure for the ORS-1 mission. Orbital Sciences Corporation launched the ORS-1 spacecraft via the tenth flight of a Minotaur I rocket from the Mid-Atlantic Regional Spaceport on Wallops Island. The ORS-1 satellite was launched on June 29, 2012 and placed into a 400-kilometer circular orbit at a 40 degree inclination, where it circles the globe every 90 minutes. [4]

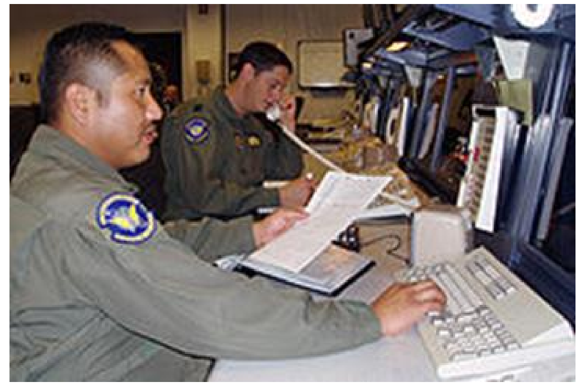

Figure 6: ORS-1 Mission Operations at SOC-11

GROUND ARCHITECTURE

ORS-1 is operated 24/7 by the 1st and 7th Space Operations Squadron (1/7 SOPS) at the 50 Space Wing's Satellite Operations Center 11 (SOC-11) located on Schriever AFB, CO 1/7 SOPS plans, schedules, and operates ORS-1 using the Virtual Mission Operations Center (VMOC), developed by the Naval Research Laboratory to produce the ORS-1 promoted schedule. and the Multi Mission Space Operations Center Ground System Architecture (MMSOC GSA). In close coordination with USCENTCOM, the ground architecture was developed for ORS-1 using existing systems to the maximum extent possible, thus reducing cost and making assimilation greatly streamlined. Focus on integrating non-developmental items and AFSPC's multi-satellite operations ground control brought trailblazing capabilities to bear for streamlined support of multiple future satellite programs. The ORS-1 ground control system used a ruggedized, off-the-shelf TWISTER downlink antenna system already employed by the Army, saving further development costs.

Ground Segment Processing (GSEG)

The GSEG was developed by the Goodrich Corporation to process the ORS-1 imagery data into standard NTIF 2.1 format, as directed by the National Geo-Spatial Agency (NGA), so that multiple organizations exploit ORS-1 mission data. It is similar to the Common Image Processor (CIP) used for the U-2 SYERS2 payload but resigned to address the unique issues associated with sending data from space versus an airborne platform. GSEG provides initial processing of ORS-1 mission data which directly downlinked from the on-board Common Data Link (CDL) to the ground station. Subsequently, intelligence analysts do exploitation of data using existing software tools.

Multi-Mission Space Operations Center (MMSOC)

The Multi-Mission Satellite Operations Center (MMSOC) Ground System Architecture (GSA) was developed by the Space and Missiles Center Space Development and Test Directorate (SMC/SD) to provide a common system to meet a broad spectrum of operational requirements. Although MMSOC GSA is structured to meet the requirements of multiple programs, mission unique changes were made to adapt for the specific ORS-1 mission requirements. MMSOC GSA consolidates satellite operations by providing an agile, flexible overarching ground segment architecture for one-of-a-kind technology demonstrations and responsive space operations. The MMSOC framework is flexible and compatible with both Research and Development, and Operations satellites, and uses a net-centric, service-oriented architecture. The MMSOC ground system architecture provides telemetry, tracking, and control through the use of open-system and COTS components. It accommodates the integration of newly developed command and control systems through an incremental development process. The MMSOC ground system architecture supports every aspect of such missions, including planning, training, mission preparation, launch and early orbit operation, normal operation, data collection and dissemination, and vehicle health and safety monitoring. Some missions end the experimental phase with a residual operational capability. [8]

The MMSOC ground system architecture has been designated as the primary satellite command and control capability for Air Force missions within the ORS Office. The Block I architecture was also used to support STPSat-2 in early 2010. MMSOC is a revolutionary approach to space operations - an operations center focused on forging a one-of-a-kind operations and acquisition team to demonstrate and field emerging space missions and satellite command and control technologies in a rapid, decisive manner. It is structured to operate a variety of satellite missions, including satellite initiatives without a program office, satellite missions of small scale (small constellations), new missions transitioning from concept toward full-scale operations and all research, development, test and evaluation satellites with operational utility remaining after test and evaluation are complete. The key to the ground system's effectiveness lies in its flexibility. The vision for MMSOC is to fly multiple missions, where an operator controlling ORS-1 with one computer while sitting next to someone who is controlling a completely different vehicle.

The fielded MMSOC GSA has institutionalized the ability to exploit emerging technologies on a significantly reduced timeline and funding profile. The flexibility and responsiveness of the architecture is the key enabler to achieve the operations concept. The common architecture leverages efficiencies in both training and maintenance, minimizing funding requirements in these areas. Likewise, transition of missions and remote backup of operations between similar Satellite Operations Centers (SOC) becomes more straightforward.

Virtual Missions Operations (VMOC) Center

The Virtual Mission Operations Center (VMOC) is a highly automated, mission planning tool which is now in operations supporting TacSat-4, a communications mission, and ORS-1, an imagery mission. VMOC is a web-based tool that allows Users to submit spacecraft task requests; VMOC then automatically creates mission plans based on spacecraft engineering models, mission constraints, and weighted User priorities. The Naval Research Laboratory VMOC concept began in 2000 with collaboration between NASA Glenn Research Center and a contracting partner. Between 2004 and 2007, the VMOC focus was on demonstrations supporting the standardization of spacecraft-to-ground interfaces needed to reduce cost, maximize user benefits, and allow the generation of the new procedures required to shape responsive space employment.[9] From its initial conception, the VMOC was designed to achieve two primary objectives of improving the speed of the mission planning process by leveraging automation tools to the maximum extent possible, and to be as persuasive and flexible as possible in its ability to quickly add new missions and capabilities through the use of open standards and shared applications. VMOC has succeeded on both accounts and is supporting worldwide users on a daily basis, providing imagery and SATCOM tasking capability and status directly to those who will be exploiting those resources, while still facilitating the critical functions of operational control and real-time status updates from ground controllers. Typically, the timelines for servicing satellite payload resource requests, which is routing electronic forms within the multi-tiered approval process, takes on the order of 30 days to request, approve, apportion, schedule, and execute. Today, with the VMOC available as a shared resource among all these stakeholders, the process is being done on a 24 hour timeline, with full capability to generate short-turnaround schedules in minutes.

VMOC performs the function of task planner, collector, and scheduler, as well as interface with the ground segment executor of the mission. The other core capability it has includes the ability to reach out to other web services to gain or update information critical to planning or scheduling functions. For the ORS-1 mission it complies with standard Application Programming Interfaces (APIs) to autonomously gather data from the Air Force Weather Center (AFWC) to determine cloud cover as part of its optimization algorithm. Another successful API is used between VMOC and a theater-planning database called PRISM (Planning Tool for Resource Integration, Synchronization, and Management). This machine-to-machine interface allows the theater to request tasking of the ORS asset using the same tool used for air breathing ISR platforms, with the added advantage of providing automated feedback on the status of requests. Notwithstanding the AFWC and PRISM interfaces, VMOC has only just begun to leverage the tremendous potential of these network enabled machine-to-machine interfaces.

VMOC is capable of handling machine-to-machine interfaces for task requests. The ORS-1 mission requires it to pull tasks from a collection management server where local users store and prioritize targets for multiple types of sensor collects. A very basic interface using standard protocols was created that allows the ORS-1 VMOC to pull tasks daily from the PRISM server. This capability greatly reduces manpower requirements that would otherwise be required to manually duplicate overhead imagery requirements in separate systems. To maximize the benefit on theater operations, ORS assets need to be directly tasked, just like any other operational asset. VMOC is a common planning, tasking, and scheduling interface that is integrated with tasking tools such as PRISM (Planning tool for Resource Integration Synchronization and Management) and with the MMSOC ground system architecture at Schriever Air Force Base. The automated interface between the tactical and mission components of the VMOC allows scalable mission planning with a "Fed-Ex" style capability that will allow users to track the status of their data requests. Using the tactical component of the VMOC as the tasking and sensor visualization tool in actual operations greatly assists in the refinement of organizational roles and responsibilities. It will provide insight into ORS availability and limitations, allowing operators to evaluate emerging requirements and apply the correct asset at the right time—without putting the platform at risk of being overtasked.[10]

As the ORS-1 mission continues, VMOC has proven the concept that a machine with the proper space vehicle capabilities/limitations, and operations CONOPS embedded into it; can greatly reduce the manpower and time requirements for scheduling satellite payloads during daily operations. The average time to produce a schedule for ORS-1 each day is about 20 minutes which includes: pulling tasking from a third party system, determining the orbital parameters for the day, developing the over lay and access requests for targets and building the commands needed by the vehicle and pushing the schedule out to the satellite C2 system. That average time is based on schedules developed from September 2011 to March 2012. The average time continues to shrink as the ORS-1 architecture becomes more stable. Currently there is one VMOC O&M person ensuring that the system runs correctly and one 1/7 Space Operation Squadron member who inputs AFSCN and other contact information and reviews the schedule on a daily basis. As a comparison it would take the average TacSat-3 planner, 4.5 to 6 hours to generate a schedule containing 7 to 8 tasks daily; significantly less than ORS-1.

Common Data Link (CDL)

The ORS-1 ground control system used a ruggedized, off-the-shelf L-3 Communications West TWISTER downlink antenna system already employed by the Army, saving further development costs. The addition of the Common Data Link to military and commercial remote sensing platforms enables real-time in-theater tasking, collaboration, collection, and dissemination by the warfighter using the existing ground infrastructure. The U.S. Army, in partnership with the ORS Office, helped design, procure, and integrate the technologies and components needed to build a space-qualified CDL for ORS-1 with design upgrades to miniaturize and space-qualify the required Common Data Link components. For more than a decade, the Common Data Link program has been the DoD standard for assured wideband communications of tactical intelligence data. Through technology insertion, this family of common hardware and software modules continues to serve on various airborne ISR platforms. These airborne assets are supported by an extensive distributed ground infrastructure for imagery-based intelligence exploitation known as the Distributed Common Ground System (DCGS). DCGS processes U.S. and allied sensor data. Information obtained by ORS-1's SYERS-2 modified sensor is transmitted to the ground via a space qualified common data link radio, similar to the kind of radio used to deliver ISR-modified data to the ground from airborne platforms like unmanned aerial vehicles and the U-2. Although the Common Data Link is employed on all airborne ISR platforms, it has not been employed on previous space-based ISR platforms to enable tactical operations.

EARLY OPERATIONS AND SUSTAINMENT

The combined ORS-1 government/contractor team moved to Shriever AFB following the June 29th launch from NASA Wallops and quickly completed early orbit checkout involving initialization of the bus, GN&C system; checkout of safe mode, payload, and fault management, and propulsion systems; and GN&C characterization. A key event was the deployment of the aperture door and subsequent checkout of the SYERS2 like payload. The team also provided procedural support as 1/7 SOPS crews gained certification and proficiency from July through October.

Figure 7: Artist's Concept of ORS-1 on Orbit

The team's intimate knowledge of ORS-1 and its capabilities directly led to the unhampered success of the 45-day on-orbit test with the transfer of Satellite Control Authority (SCA) to the 50th Space Wing in mid-September and early acceptance by USCENTCOM on September 23, 2012. The AFSPC Commander declared Full Operational Acceptance on January 3, 2012 following complete checkout of the space vehicle and ground systems. The sustainment team continues to provide on-orbit support in terms of improvements to calibration, software updates, and resolution of anomalies. On orbit performance of the ORS-1 satellite to date has been extremely positive and is providing a very valuable additional capability to USCENTCOM. It will continue to rely on its capabilities as an integral component to our ISR architecture and collection plan."

LESSONS LEARNED

"Lessons Learned" from the ORS-1 program, both strengths and weaknesses, were collected to minimize risk and increase efficiency on future ORS initiatives. This effort includes an assessment of the USCENTCOM request for enhanced battlefield awareness, examination of alternatives, requirements development, acquisition strategy, contracting activities, hardware development, program management, ground architecture, mission operations activities, and post launch activities. The Lessons Learned effort highlights many areas of the ORS-1 program - some requiring that nothing be changed but carried forward to future efforts (strengths) and others needing improvement (weaknesses). Others are very specific and narrowly focused that will enable efficiencies over time. As with most after action reviews and lessons learned efforts, the focus of the individual and team comments are naturally drawn to what needs to be fixed or how can we make this better. In light of the ORS-1 Lessons Learned comments, it is important to remember that the ORS-1 mission partners put a satellite on orbit within 32 months providing USCENTCOM with a significant capability in response to an urgent need. ORS-1 effort clearly demonstrated the value and potential of operationally responsive space to the warfighter.

The team collected a significant number of observations; some worthy of individual mention include the with focused Combatant Commander support, the ORS-1 requirement and concept refinement process worked well. Small agile teams were a key to executing at a fast pace. Although challenging, it is possible to "go fast" in the acquisition, development, and fielding of responsive space capabilities. The commitment and buy-in of senior leaders, delegation of authorities, streamlining of processes and organizational relationships, and reduction of staff bureaucracy became critical from the outset and continued throughout the life of the program.

Critical Success Factors

Multiple critical success factors were observed by the ORS-1 assessment. It is important to have leadership create and maintain a consistent vision and establish well-communicated at all tiers up and down the chain. Key stakeholders understood the acquisition goals and managed to a "good enough" mindset; leadership must empower program team to execute in a non-traditional acquisition and system integration environment. A small, cohesive team leveraged R&D experience and parlayed it for ORS-1 and the program team was adept at tailoring standards and communicating approaches to invested agencies. A major point made by the team was to avoid development, but rather explore all avenues to leverage heritage assets. Great value was derived from leveraging space and ground elements to reduce extent of the development effort; the system architecture leaned heavily on legacy capabilities. The

ORS-1 team worked to preserve the sense of urgency throughout the development and the program constantly re-evaluated schedules, approaches, and objectives to explore all acceleration and recovery options.

Major Challenges

Individuals and organizations outside of the program in many cases did not understand program goals or measures of success with the end result being that a significant time was be spent educating outside agencies and offices. Senior leadership provided top cover to minimize some of the impact, but individual team members were knowledgeable of the program objectives which also assisted. Architectural elements and processes were streamlined which caused considerable discomfort to the traditional acquisition community. Resources in assessing design risk were invested early in the program which provided substantial mitigation options. An observation by the team was that there is a need to become more effective in rapidly assessing design risk particularly with the accelerated schedule objectives.

Another important observation was the complicated relationships associated with building and integrating a federated system; individuals leading some development elements were not always empowered to implement changes necessary for optimum efficiency. Programs like ORS-1 need to create effective mechanisms to connect decision-makers with contractual authority. Another major challenge was the complex Information Assurance (IA) accreditation processes have significant program impact with lines of authority for IA decisions somewhat vague across organizational lines. IA issues became a major pacing item and approvals frequently were gained at the eleventh hour by going to higher headquarters. Working level approval authorities assumed that the program would be delayed and took very little initiative to expedite processing of IA approvals.

Mission Assurance

The non-traditional acquisition and federated nature of the ORS-1 system made the mission assurance effort complicated. Practices and entities varied depending on the acquiring organization's existing program – effort spent to tailor and align work with program posture. The traditional mission assurance programs were not suitable for the program due to data limitation and varied pedigree of various components. Despite challenges, ORS-1 was able to effectively develop ways to utilize existing mission assurance for a responsive program. There was varied response from different mission assurance entities; some groups chose not to participate. Organizations that participated were very helpful in framing the expectations of their resources and achieving positive impacts. Independent Program Assessment (IPA) by Aerospace Corporation provided invaluable strategic insight and accurately identified technical challenges and likely sources of organizational friction. There is no need to drive product risk to zero; instead focus on what can be done to enhance reliability given the constrained situation. Despite change in practices, risk management grading scale was not changed and mission risk was assessed as in traditional programs.

Testing

ORS-1 testing was tailored based on system constraints and program context. Schedule was a key driver; scope often limited to essential function/objective. The program accepted risk of pushing some tests to higher levels of assembly. No "one size fits all" solution and it is not a static process. It is recommended that programs adapt test approach based on mission and use "integration by parts" approach to architecture verification. Take small wins early, gathering verifications as elements come together. Allows tests to be done in parallel and as available; active management approach is required. Be flexible with test document timelines; many procedures were released less than 1 week before test. Reviewers repeatedly were challenged to give timely and meaningful input. Preliminary test results were sufficient to proceed to next level of test and final test reports served as crumb catchers. End item data package deliveries rarely met need dates—acceptance was based on witnessed test results and individual understanding of issues. The team continuously re-evaluated test objectives; telescope qualification—due to schedule, deferred vibration testing. The Thermal Vacuum testing during dwells ran other tests that had been deferred at lower levels.

Risk Management

A significant observation was to implement risk ownership at the IPT level. Responsive programs may lack time and resources to conduct a formal risk process. ORS-1 risk documentation was kept, but in many cases it did not keep up with the pace of the program. IPT leads owned the ORS-1 risks, recurring program tag-ups served as forums for discussing program risk, strategy, and implementing risk mitigation measures. Tests and objectives were tailored in literally real time or near real time as necessary to address certain risks. The flexibility of the test program enhanced the ability of the team to effectively mitigate and verify resolution of risks. The program schedule constraints may limit the extent to which risk mitigation measures can be implemented. As major milestones (e.g., launch) approach, the program must follow through with risk posture.

Joint Military Utility Assessment

The Joint Military Utility Assessment (JMUA) of the ORS-1 Architecture is an assessment of the military utility of the ORS-1 space vehicle and supporting architecture. The JMUA will review testing of the ORS-1 architecture and will integrate data and results from the current ORS-1 architecture testing and associated architecture. The assessment will evaluate how ORS-1 meets USCENTCOM needs and expectations, impact of ORS-1 on USCENTCOM mission effectiveness; does ORS-1 provide sufficient warfighter utility to pursue building additional copies for USCENTCOM, and what aspects of the ORS-1 architecture should be changed for future deliveries? The ORS-1 JMUA is being accomplished by the National Assessment Group and is estimated to be completed by late June 2012.

Summary

Lessons Learned for the ORS-1 program have been collected by the ORS Office, SMC/SD, AFSPC, and Aerospace Corporation. These observations are being evaluated with the end result being that a composite report is being prepared to combine findings into a single document. As with most endeavors, success was ultimately determined by individual initiative and ingenuity, and the determined will to succeed of each and every ORS-1 mission partner. Whether it was getting ORS-1 on contract within a matter of weeks, the development of "work arounds" to keep the program on schedule and funded, the experience and expertise of the many team members to overcome and adapt to technical challenges, or the aggressive and proactive program management and leadership, the ORS-1 Team successfully demonstrated the value of operationally responsive space to the warfighter.

CONCLUSIONS

ORS-1 has demonstrated that small satellites have the ability to provide affordable support in the responsive timescales associated with the operational military domain, with the result that U. S. military planners view space as the new military high ground. ORS-1 is an enabler for sustaining operations and objectives in a highly volatile region and is laying the path for future rapid reaction space systems. ORS-1 is history in the making; it is the first DoD satellite providing dedicated support to a single Joint Force Commander and provides an assured capability that cannot be preempted by support to other users. The team's phenomenal effort have been formally lauded by the CENTCOM Chief of ISR capabilities regarding impact on the operational mission: "CENTCOM is extremely pleased with ORS-1. It has met or exceeded its projected capabilities and additional capabilities and applications continue to unfold. CENTCOM will continue to rely on its capabilities as an integral component to our ISR architecture and collection plan." In summary, the ORS-1 team has achieved incredible technological feats; advancing state of the art in small spacecraft ISR systems.

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