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"Virtual Mission Operations Center: Transforming the conduct of space based operations"

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Topic 2: Networks and Networking

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Abstract

Space has been referred to as "one of the commons, along with the sea and cyberspace, that constitute the triad of capabilities on which America's global power rests."[1] The changing security landscape increases demands for the US to leverage space-based capabilities. A central challenge is providing disadvantaged users with quick-response, short-term tactical capabilities. The Operationally Responsive Space (ORS) initiative delivers timely and assured space power to Joint Force Commanders (JFC). ORS represents a new paradigm in the development, deployment, and use of space assets, and motivates the development of new capabilities that support net-centric concepts of operation (CONOPS). One of these is the Virtual Mission Operations Center (VMOC).

The VMOC is a government owned effort that provides transformational approaches to space asset apportionment, payload schedule management, and operational and tactical user access to space. The Naval Research Laboratory (NRL) manages the VMOC and it is sponsored by the Office of Naval Research (ONR) and the ORS Office. The VMOC has participated in multiple ORS related demonstrations, experiments, and military exercises and continues to evolve and develop transformational benefits to the user community. This paper describes these efforts, as well as current experimentation and operational support to ORS.

[1] Cebrowski, A. and Raymond, J. (Summer 2005). Operationally Responsive Space: A new defense business model. *Parameters*, pg. 67.

Background

Operationally Responsive Space

Space has been referred to as "one of the commons, along with the sea and cyberspace, that constitute the triad of capabilities on which America's global power rests."[2] Indeed the changing political and technological landscape continues to place increasing demands on the United States' ability to gain access to and leverage space-based capabilities and a recurring challenge continues to be providing the disadvantaged user with quick-response, short-term tactical capabilities. In 2003, the Secretary of Defense instructed the Department of Defense (DoD) to create a new business model for developing and employing space systems. In response, the Office of the Secretary of Defense's (OSD's) Office of Force Transformation[3] (OFT) initiated the ORS effort. In a collaborative endeavor that included multiple services, research laboratories and the OSD, the ORS experimentation effort aimed to develop and mature ORS capabilities and CONOPS. Building on the success of that experiment, U.S. Space Transportation Policy made ORS an explicit objective in 2005, stating that the U.S. Government shall, by 2010, demonstrate an initial capability for operationally responsive access to and use of space—providing capacity to respond to unexpected loss or degradation of selected capabilities, and/or to provide timely availability of tailored or new capabilities—to support national security requirements.

In 2006, congress requested that the DoD prepare a plan for ORS that would further define ORS capabilities. In response, the DoD delivered a *Plan for Operationally Responsive Space*[4] in April 2007 and in May 2007, a ORS Office was stood up at Kirtland Air Force Base in New Mexico. The ORS Office is responsible for integrating joint ORS capabilities. ORS is defined as "assured space power focused on timely satisfaction of JFC needs,"[5] and is intended to provide tactical and operational military decision makers access to space based assets. It represents a new paradigm in the development, deployment and use of space assets.

As the focal point for meeting these urgent and on-going JFC needs, the ORS Office relies upon three capability types, referred to as Tier-1, Tier-2 and Tier-3 capabilities. The *Plan for Operationally Responsive Space* describes these tiers as follows:

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[2] Cebrowski, A. and Raymond, J. (Summer 2005). Operationally Responsive Space: A new defense business model. *Parameters*, pg. 67.
[3] The OFT was realigned and renamed in December 2006 to the Rapid Reaction Technology Office (RRTO), reporting to the Director, Defense Research and Engineering (DDR&E), within the Office of the Under Secretary for Acquisition, Technology and Logistics (AT&L) – and is now a sponsor of various ORS initiatives.
[4] DoD Plan for Operationally Responsive Space, A report to Congressional Defense Committees. April 17, 2007. Retrieved August 21, 2007 from http://www.acq.osd.mil/nsso/ors/Plan%20for%20Operationally%20Responsive%20Space%20-%20A%20Report%20to%20Congressional%20Defense%20Committees%20-%20April%2017%202007.pdf.
[5] Ibid.

Tier-1 uses existing or on-station capabilities to provide highly responsive space effects through the employment/modification/revised application of existing, fielded space capabilities. The targeted time period for application of Tier-1 solutions is immediately-to-days from the time at which the need is established. These solutions focus on existing ground and space systems, operations, and processes. Although mission or system utilization analyses may be needed, Tier-1 solutions will not typically involve the design, engineering, or fabrication of new materiel items.

Tier-2 solutions would utilize field-ready capabilities or deploy new or additional capabilities that are field-ready. The targeted timeframe for delivering usable Tier-2 solutions is days-to-weeks from the time at which the JFC need is established. The focus of activities in Tier-2 solutions is on achieving responsive exploitation, augmentation, or reconstitution of space force enhancement or space control capabilities through rapid assembly, integration, testing, and deployment of a small, low cost satellite.

Tier-3 involves development of capabilities. In some cases, an expressed need may not be addressable through existing capabilities (Tier-1) or through the rapid deployment of field ready capabilities (Tier-2). In such events, ORS efforts must focus on the rapid development and deployment of a new capability. Once developed, Tier-3 capabilities will be responsively deployed and employed in the same way as Tier-2 assets. The goal for execution of Tier-3 approaches is months-to-one year from established need to presentation of operational capability.

Virtual Mission Operation Center

The VMOC began as a platform to incubate, mature, and transition new and relevant net-centric technologies and CONOPS via continuous operational experimentation. In support of TacSat-4 and ORS Sat-1, the VMOC is transitioning to an operational role of tasking, managing and apportioning vehicle sensors. VMOC sponsors include ONR and the OSD for the exploration elements and the ORS Office for the operational role. "The NRL has been designated program manager for development of these operational capabilities." The VMOC system has participated in several demonstrations, experiments, and military exercises that have helped to shape and mature technologies, CONOPS, tactics, techniques and procedures (TTPs) and policies related to ORS. These lessons learned are incorporated into the operational system to enhance capability, feel, and performance.

The VMOC system originally was comprised of three large components designated as tactical (formally known as *Spydr*), Space Apportionment for Effects (SAFE), and Mission. Each component provided specific capabilities and was tailored to a specific user base. The tactical component was designed to support multi-sensor access and collaboration among a diverse user community. *Spydr* was a collaborative web site that allowed non-space savvy users to task and receive data from multiple sources including ORS assets. The SAFE component provided semi-automated support to the apportionment and prioritizing process of ORS assets. The Mission component provided support for platform management, sensor access, data storage, processing, and sharing. The SAFE web site automated the space apportionment process and allowed the Joint

Space Operations Center (JSpOC) to dynamically apportion and prioritize ORS assets. The Mission VMOC was a set of systems that allowed for the command and control (C2) and data processing of ORS assets via the Air Force Satellite Control Network (AFSCN) or other ground control networks. In this architecture there could be more than one Mission VMOC allowing for the tasking and data collection of multiple assets via web services.

Multiple VMOC operational experimentation events have taken place since 2004.[6] These have largely included efforts pairing the VMOC with tactical satellites (TacSat). For example, simulated and actual TacSats have been used in multiple exercises including Terminal Fury 06 and 07 as well as Talisman Saber 07.[7] Findings from these exercises consistently point to the need for continued experimentation and development of CONOPS and TTPs. They also reveal the need for evaluation of what measures and metrics are needed to effectively evaluate an emerging capability such as ORS. Results indicate that new measures and metrics that better account for attributes such as flexibility, adaptability, transparency and increased accessibility are needed.

Table 1 below summarizes the experimentation events and associated key findings. Because these events occurred prior to the merger of apportionment, mission and tactical capabilities, the table also indicates which VMOC system (*Spydr*, General Dynamics (GD)-SAFE, or GD-Mission) was used.

Event	**Date**	**Description**	**VMOC Capabilities Evaluated**	**Findings**
Terminal Fury 05	November 2004	VMOC *Spydr* used to task simulated TacSat and to disseminate simulated products in a large-scale Pacific Command (PACOM) exercise	VMOC *Spydr*	Initial response to direct tasking via VMOC *Spydr* was positive, lessons learned included need to simulate more mature TacSat capabilities
Air Force Chief Information Office Demo	2004	Demonstration of net-centric space C2 concepts (TCP-IP based C2 of space assets)	GD-Mission	Proof of concept for internet protocol (IP) based C2 of space, successfully demonstrated numerous net-centric concepts (interoperability, mobility, etc.), success led to SAFE and Space Operations Responsiveness Demonstration (SORD)

[6] Miller, E., Medina, O., Hurley, M. (2007). Virtual mission operations center (VMOC) development and experimentation. American Institute for Aeronautics and Astronautics.
[7] Olynick, D. (2007). TacSat-2 Talisman Saber 2007 quick look report.

Event	Date	Description	VMOC Capabilities Evaluated	Findings
Terminal Fury 06	December 2005	VMOC used to task simulated TacSat, to disseminate data products, and to encourage cross-organizational collaboration in large-scale PACOM exercise	VMOC *Spydr*	Disadvantaged users are more likely to support direct tasking of TacSats; some data processing needed; need to simulate more mature ORS capabilities in order to gain accurate insight on military utility
SAFE	2006	Demonstration designed to explore JSpOC, Combined Air and Space Operations Center (CAOC) and Satellite Operations Center (SOC) C2 of space assets; and automation of the Joint Space Tasking Order (JSTO) process	GD-SA; GD-Mission	Successfully explored semi-automated C2 of space assets; highlighted need to continue developing infrastructure support (bandwidth, access, etc.) for semi-automated operations
Multi Use Ground Station (MUGS)	2006	Test to evaluate ability of authorized tactical users to directly task Low Earth Orbit (LEO) sensor payload, retrieve data, and post data on net-centric portal	GD-Mission, GD-SA	Direct tasking of the UK-DMC satellite was successful but link margin limitations prevented the retrieval of high data rate imagery in the field
Cap Archer	April 2006	Experiment to explore how VMOC can enhance collaboration among US Northern Command, Arizona Counter-Terrorism Intelligence Center, and the Arizona Civil Air Patrol	VMOC *Spydr*	Successfully demonstrated VMOC tasking of air borne sensor platform, cross-organizational information sharing and collaboration
Terminal Fury 07	December 2006	VMOC used to task simulated constellation of TacSats; retrieve data products	VMOC *Spydr*	Demonstrated the utility of ORS/VMOC concept; high level of PACOM interest and support; illustrated need to continue to explore alternative CONOPS, TTPs and policies
SORD	2007	Congressionally directed demonstration to develop ORS related intelligence, surveillance, reconnaissance (ISR) CONOPS and TTPs using Tier I asset (JRP)	GD-SA; GD-Mission; VMOC *Spydr*	Demonstration successfully illustrated possible C2 of space assets but highlighted the need to further develop alternative CONOPS and TTPs

Event	Date	Description	VMOC Capabilities Evaluated	Findings
Project Spotlight	2007	Experiment to explore how VMOC can support dissemination of automated identification system (AIS)/radar data, enhance information sharing and collaboration between the US Coast Guard Sector San Juan and the US Caribbean Maritime Operations Center	VMOC *Spydr*	VMOC successfully displayed AIS/radar data, however, this had only limited utility to users due to sensor limitations; VMOC information sharing and collaboration capabilities not fully tested
Valiant Shield	2007	VMOC used to task TacSat-2 during a large PACOM military exercise	VMOC *Spydr*	VMOC enabled geographically dispersed users to task TacSat-2; highlighted numerous CONOPS, TTPs and policy challenges associated with TacSats
Talisman Saber	2007	An Australian/US bilateral exercise, in which VMOC was used to task TacSat-2	VMOC *Spydr*	VMOC was used to task TacSat-2, however, limitations in tasking transparency and flexibility were highlighted

Table 1. VMOC Operational Experimentation Events

Lessons learned were gathered from each of the events. The three most relevant and important lessons learned regard simulation, CONOPS and TTP development and end-to-end VMOC integration. The first key lesson learned is that a simulated ORS capability is essential in order to evaluate the military suitability and effectiveness of ORS and VMOC capabilities. Second, the lack of ORS related CONOPS, TTPs and policies presents challenges to military users who seek guidance on how to use VMOC and ORS capabilities either in concert with their existing capabilities or as a stand alone capability; therefore, continued operational experimentation is needed to develop ORS CONOPS, TTPs and policies. Third, integration of an end-to-end VMOC enabled ORS capability is needed.

Beginning in 2007 the NRL, in collaboration with GD, began integrating the individual VMOC components into an overarching VMOC system that provides expanded ORS capabilities to space operators and warfighters. Collectively, the VMOC system provides an alternative approach to space C2 that has the potential to transform the traditional space tasking, processing, exploitation and dissemination (TPED) process.

This new VMOC system incorporates three distinct VMOC components: tactical, mission and apportionment – all of which were developed in support of ORS founding CONOPS.[8] Figure 1 below is a representation of this VMOC architecture.

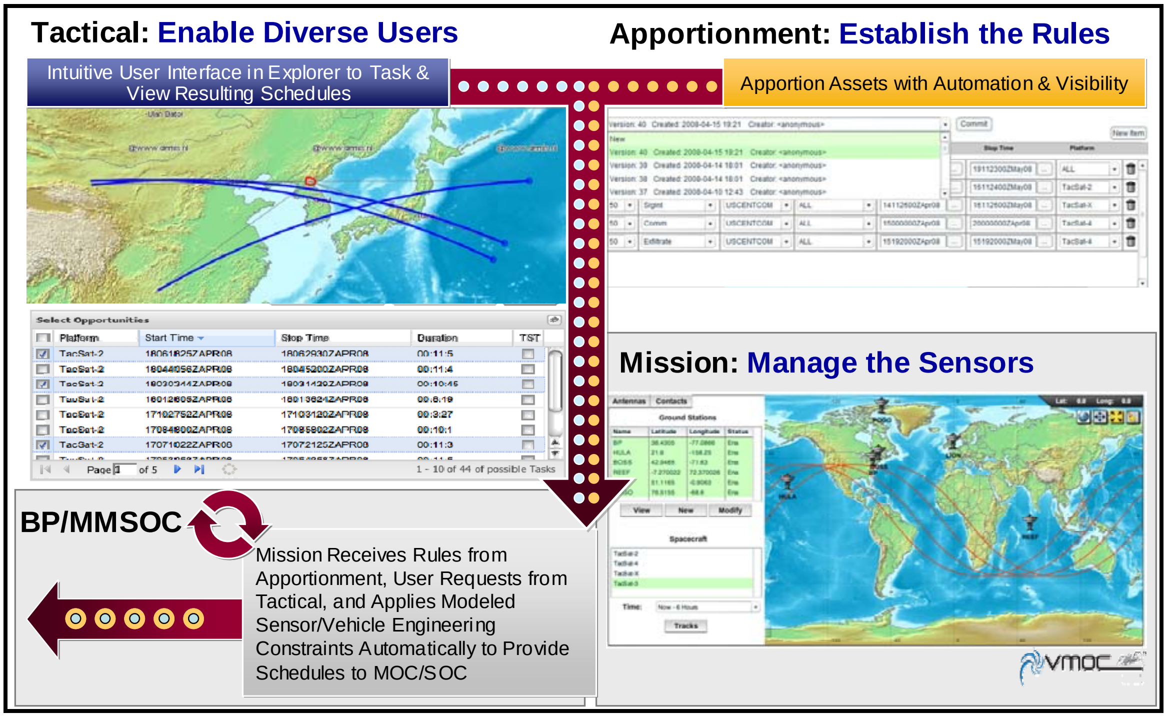

Figure 1. VMOC – Component View

The tactical component enables diverse users in a net-centric and net-enabled manner to actively participate in new space capabilities that include real-time dynamic IP-based tasking and data dissemination back to the user. User tasking is effects based, and can be conducted by literally any user at any time at any geographic location in the world. The tasking process is transparent and allows users to view their task status at all points in the process – from the original tasking request to receipt of their available data. User experience is not a limiting factor in tasking the VMOC site; in fact during many experimentation events, users with experience ranging from novice to expert were all able to task the VMOC with relative ease. The mission component of the VMOC manages the sensors in use, incorporating a data-centric / net-centric philosophy in which expanded data access and data movement yields increased access to space products. This mission component supports multi-mission management, and is therefore scaleable to accommodate multiple assets in an automated manner. Finally the apportionment component of the VMOC establishes the rules for ISR capabilities, whereby user requests are coordinated to ensure efficient allocation, data collection, processing and dissemination.

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[8] CONOPS defined in the ORS Initial CONOPS document, released 7 May 2007.

On 7 May 2008, the NRL hosted a demonstration to highlight VMOC capabilities to sponsors and members of the ORS and warfighter communities. The purpose of the event was to demonstrate the potential utility of the VMOC as an enabler of network enabled C2 capability. The specific objectives of the VMOC demonstration were to demonstrate integrated VMOC baseline capabilities, educate stakeholders on VMOC's operational value-added, demonstrate VMOC end-to-end capabilities with respect to tactical, apportionment and mission components, and to stimulate discussion for detailing and supporting ORS TPED requirements. The demonstration also sought to validate initial tactical space asset C2 CONOPS and TTPs. A series of metrics were developed collaboratively by the ORS Office and the VMOC experimentation team to facilitate evaluation of specific capabilities relevant to the ORS community. During the demonstration, activities occurred simultaneously at three distributed locations:

- NRL, VMOC Development Laboratory in Washington, DC;
- JSpOC, Vandenberg Air Force Base, CA; and
- NRL Blossom Point (BP) Test Facility, MD.

The VMOC demonstration successfully met each of the objectives and served to validate the initial CONOPS and TTPs. In the months leading to the demonstration, the VMOC team integrated all disparate VMOC systems into a unified VMOC with a single user-graphical interface and back-end data transfer. During the demonstration, all three components worked together in a seamless manner. The demonstration served as a proof of concept of network enabled C2 of tactical space assets. It validated the ability of the VMOC to manage tactical, apportionment and mission activities using a single system. It established baseline capabilities that can serve as the benchmark for comparison as VMOC capabilities mature and as a means to compare alternative tactical space C2 systems and approaches. As a result of the demonstration, the Joint ORS Office designated VMOC as the primary payload tasking and asset visibility capability for ORS.

In the fall of 2008, the VMOC program began transitioning toward an Enterprise Architecture (EA) with the aim of improving VMOC architecture in terms of modularity, flexibility, robustness and maintainability. Phase I of EA implementation is scheduled to coincide with Tactical Satellite Four (TacSat-4) operational experimentation and will be the first opportunity for operational assessment of the evolving architecture.

Current VMOC Operational Experimentation and Operational Support

VMOC has been named as an ORS baseline capability for sensor tasking and is therefore poised to be an active supporting element to operational experimentation and future operations. The VMOC experimentation effort is not intended to replace a formal joint military utility assessment (JMUA) or test and evaluation of any particular system or component; rather, the operational experimentation efforts will augment the formal JMUA of VMOC and TacSats. The VMOC operational experimentation assessment approach utilized is consistent with the DoD's practical operating guidelines for evaluation of Joint Capability Technology Demonstrations (JCTD). Several objectives for VMOC operational experimentation include:

- Facilitate the development of ORS technologies, CONOPS and TTPs;
- Evaluate the performance and value-added of VMOC as a maturing ORS capability;
- Evaluate the performance and utility of VMOC tasking, apportionment and mission capabilities; and
- Expand the ORS and VMOC community of users and create opportunities to expose new users to ORS concepts and assets; and
- Evaluate the appropriateness, functionality and usability of the evolving VMOC 2015 Architecture.

Two efforts currently being considered with the VMOC include operational experimentation with TacSat-4 and operational support to ORS Satellite 1 (ORS Sat-1) operations. Brief descriptions of each are below.

TacSat Demonstration Program

The TacSat Demonstration Program is a series of TacSat experiments being conducted in support of ORS objectives. The ORS Office has identified seven enabling elements required in order to develop and mature responsive space capabilities. Development of each of the elements, noted in the pillars below (Figure 2), contributes to an end-to-end ORS architecture. Each TacSat experiment is designed to further the ORS effort and cumulatively will facilitate the development of ORS capabilities.

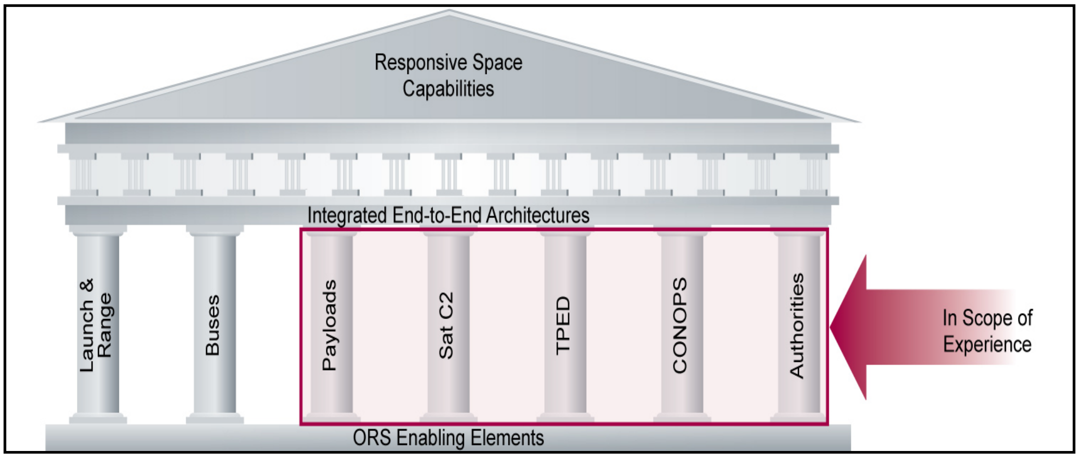

Figure 2. ORS Enabling Elements with Regard to VMOC Operational Experimentation

The TacSat experiments are rooted in the principle of operational experimentation and bring the Science and Technology (S&T), Research and Development (R&D) and operational communities together to effectively and rapidly channel promising CONOPS and new technologies into relevant capabilities. Five TacSat experiments are currently underway and are at various levels of maturity.

TacSat-1 was the first experiment in this initiative. It was delivered to the DoD within 12 months and at a cost of around $10 million.[9] TacSat-1 was developed by the Naval Research Lab for the OFT and is intended to support PACOM. The payload includes capabilities to gather low-resolution (70 meter) and infrared imagery as well as electronic intelligence (ELINT) data. Due to problems with the Space-X Falcon launch vehicle, [10] however, the launch was delayed and ultimately it was cancelled in August 2007.[11] In late 2007 it was determined that TacSat-1's payload should be updated to reflect maritime domain awareness (MDA) needs and the project was renamed to TacSat-1a. Launch is currently delayed, as issues with the launch vehicle company are resolved.

TacSat-2, developed by the Air Force Research Laboratory (AFRL) for U.S. Strategic Command, was launched December 16, 2006. TacSat-2's payload was capable of collecting higher resolution visible imagery (1 meter), and included an improved TasSat-1 ELINT data sensor. It also included a Common Data Link (CDL) X-Band radio to support tactical communications. TacSat-2 was part of a joint Advanced Concept Technology Demonstration (ACTD).[12]. During its operational experimentation phase, VMOC supported TacSat-2 operations in a major military exercise, Talisman Sabre 07. After completing its one year experimental mission, TacSat-2 ceased operations on December 21, 2007.

TacSat-3 is being developed by the AFRL with U.S. Army Space and Missile Defense Command, U.S. Special Forces, and other combatant commands. Its payload includes a hyperspectral imaging sensor for tactical targeting of hard to find targets. It also will have a limited data-exfiltration (Data X) capability. In addition, the RRTO, formerly the OFT, is sponsoring the development of a modular spacecraft bus for use by TacSat-3. Launch is expected to take place in summer 2009.

TacSat-4 is being developed by the NRL for U.S. Strategic Command. The payload includes Communications-on-the-Move (COTM), Blue Force Tracking (BFT), and Data-X capabilities. TacSat-4 will be put in a 4 hour highly elliptical orbit (HEO) that will allow it to dwell over targeted locations for one to two hours. Ultimately this orbit will enable persistent theater coverage with minimum satellites and launches supporting this low-cost class of mission. TacSat-4 will use the bus resulting from the OFT Phase 3 Bus

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[9] Government Accountability Office. (March 2006). *Space acquisition: DOD needs a department-wide strategy for pursuing low-cost, responsive tactical space capabilities*. GAO-06-449, p. 2. Note that in addition to the $10 million, around $5 million in surplus hardware was used to build TacSat-1.
[10] Malik, T. (24 March 2006). *Space X's inaugural Falcon 1 rocket lost just after launch*. Retrieved 27 December 2006, from http://www.space.com/missionlaunches/060324_spacex_failure.html.
[11] Space Today. (18 August 2007). *Report: Pentagon cancels TacSat-1 launch*. Retrieved August 2007, from http://www.spacetoday.net/Summary/3884.
[12] See http://www.acq.osd.mil/jctd/intro.htm for a description of the ACTD [now termed Joint Capability Technology Demonstrations (JCTD)] process.

Standards effort, allowing the bus standards to be refined throughout the design and testing process. Launch is planned for September 2009.

TacSat-5 is currently in the pre-design phase awaiting final decisions regarding payloads and missions.

Operational Experimentation with TacSat-4

The TacSat-3 experiment was the first TacSat mission where the payload was selected by the joint community. This process was led by Air Force Space Command (AFSPC) and consisted of white paper submissions by COCOMs and services for current needs, payload concept development, mission rankings, and General and Flag Officer Steering Group selection. The TacSat-4 experiment was also selected by the joint community. This second iteration refined the process created during TacSat-3 selection, and the process was formally documented.

TacSat-4 experiment objectives were formulated during multiple joint working group meetings. These working group meetings were held between January and May 2005 in preparation for the formal selection process meetings, which began in June and were completed with the General and Flag Officer vote in October 2005. The COCOMs, Services, and S&T communities participated in the working group meetings. As a result, the TacSat-4 mission objectives are well rooted in current user needs as well in broader ORS program objectives.

The payload selected is designed to provide the user with primarily communications capabilities. The COTM capability provides UHF legacy radio support and a Mobile User Objective System (MUOS)-like capability. The BFT capability collects existing UHF devices with tasking priority expected for underserved areas. The Data-X capability focuses on data collection from maritime buoys, which are typically remotely located on the seas and in littorals.

VMOC operational experimentation with TacSat-4 will focus on multiple objectives. Experimentation with TacSat-4 will evaluate the:

- Operational utility of TacSat-4's payloads;
- Impact of using VMOC to support TacSat-4 operations;
- Development of related TTPs, CONOPS, policies and authorities; and
- Impact of TacSat payloads (accessed via VMOC) in providing users with ORS capabilities to meet gaps in their war fighting needs:
    - COMMs, ISR, BFT, etc.,
    - Apportionment of space assets, and
    - Mission and multi-mission support.

ORS Sat-1

ORS Sat-1 is the first operational mission being conducted by the ORS Office; the Space and Missile Systems Center's Space Development and Test Wing at Kirtland Air Force Base, N.M. will manage the development and fielding of the ORS Sat-1 program. The program is designed to meet a critical ISR need for U.S. Central Command, and will use existing airborne tasking, processing, exploitation and distribution systems to carry out its mission.[13] It is expected that ORS Sat-1 will provide needed capabilities to enable the ORS Office to support critical warfighting needs which will allow customers to quickly respond to urgent space needs. Dr. Peter Wegner, Director of the ORS Office explained:

ORS-Sat 1 will fill a warfighter gap and develop and exercise many of the key ORS enablers necessary for future ORS missions, such as enhanced small satellite performance, reduced launch schedule, open command and control system architecture, and timely dissemination of information to the warfighter using existing tactical networks.

Detailed aspects of the ORS Sat-1 program will not be distributed, such as mission information, capabilities, vulnerabilities or collected data; however it can be said that the program will provide important long-term ORS capabilities to relevant users in need. The satellite is scheduled to launch in 2010.[14]

VMOC Way Ahead

Leveraging existing and planned C2 and TPED architectures allows the rapid development and integration of a new system into the JFC ISR mission areas. The ORS 2015 Ground System Enterprise (GSE) (Figure 3) focuses on an integrated approach to ISR. To minimize the impact on theater operations while maximizing space effects, ORS payloads will be directly tasked in a manner similar to any other JFC operational asset such as a U2 or Rivet Joint.

To that end, the VMOC is building a common mission planning, apportionment, and tasking interface that is integrated with the current tasking tools used by Collection/Asset Managers. The automated interface between the Tactical, Apportionment, and Mission VMOC components plays a key role in the GSE by allowing scalable multi mission planning with a "Fed-Ex" style tracking capability for user feedback from request to data availability.

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[13] Space and Missile Systems News Center. (25 October 2008). *SMC to manage ORS Sat-1 mission efforts*. Retrieved 18 January 2009 from: http://spaceflightnow.com/news/n0810/25orssat1/.

[14] Global Security. (4 December 2007). *ATK and Goodrich win contract to provide first operational ORS satellite*. Retrieved 18 January 2009, from: http://www.globalsecurity.org/space/library/news/2008/space-081204-atk01.htm.

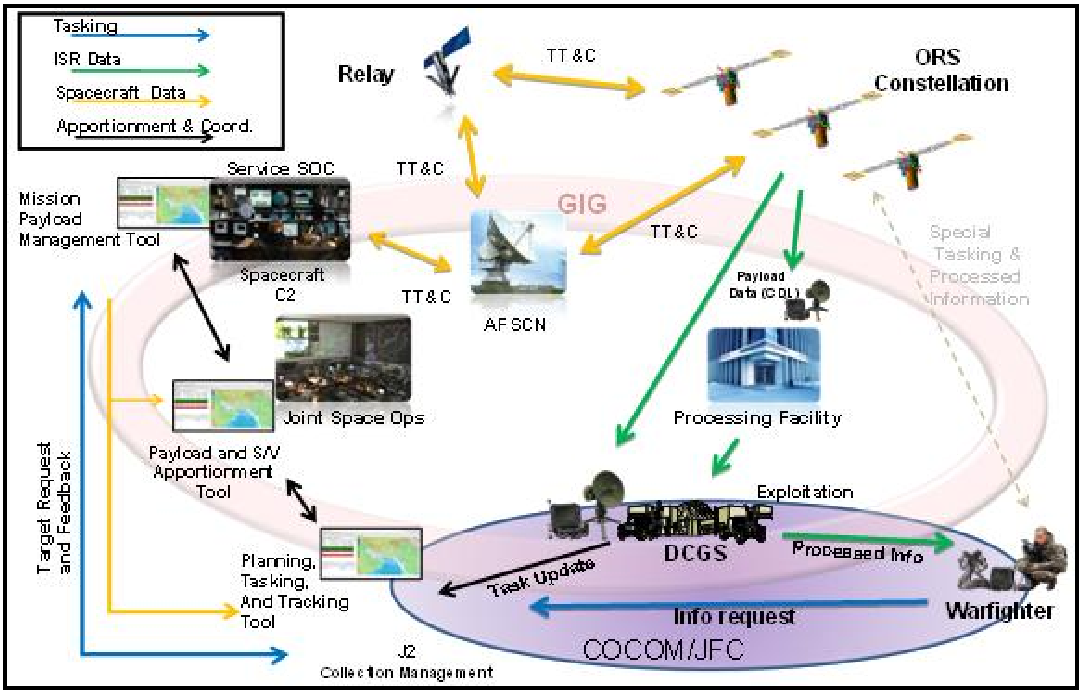

Figure 3. ORS 2015 Ground System Enterprise

Conclusion: Impact of VMOC Operational Experimentation

The VMOC's path to space operations has followed a multi-year process that emerged from a need to make space capabilities more accessible to users and to dynamically manage responsive space systems. Over time, the VMOC has matured through user experimentation and demonstrations that have reflected a core set of capabilities to support user tasking and tracking, spacecraft apportionment, and multi-mission scheduling. Operational experimentation with VMOC, an ORS baseline capability, has allowed researchers and ORS officials to expand the ORS community of users and to further investigate ORS CONOPS and TTPs. By incorporating varying platforms (each with their own unique sensors) into the experimentation effort, researchers have, and will continue to, most accurately determine how the VMOC best enables users to meet gaps in their numerous warfighting space needs, and how the VMOC can bridge the community of diverse users.

These capabilities are now currently being applied to both TacSat-4 and ORS Sat-1 for flight operations. Even more, with the launch of ORS Sat-1, the VMOC will transition from experimentation status to a fully operational program. Currently the VMOC is in the operational experimentation phase; however this current phase is providing a path for operationalizing the VMOC and is leading to a VMOC Program of Record status. VMOC is a key element of ORS's ground enterprise and will provide a scalable, dynamic, and flexible set of services to support and further the ORS vision.

Appendix 1 Acronyms

ACTD	Advanced Concept Technology Demonstration
AIS	Automated Identification System
AFRL	Air Force Research Laboratory
AFSCN	Air Force Satellite Control Network
AFSPC	Air Force Space Command
BFT	Blue Force Tracking
BP	Blossom Point
C2	Command and control
CAOC	Combined Air Operations Center
CDL	Common data link
CONOPS	Concepts of operation
COTM	Communications-on-the-move
Data-X	Data Exfiltration
DoD	Department of Defense
EA	Enterprise Architecture
ELINT	Electronic intelligence
GD	General Dynamics
GSE	Ground System Enterprise
HEO	Highly elliptical orbit
IP	Internet Protocol
ISR	Intelligence, surveillance and reconnaissance
JCTD	Joint Concept Technology Demonstration
JFC	Joint Force Commander
JMUA	Joint Military Utility Assessment
JSpOC	Joint Space Operations Center
JSTO	Joint space tasking order
LEO	Low elliptical orbit
MDA	Maritime Domain Awareness
MUOS	Mobile User Objective System
NRL	Naval Research Laboratory
OFT	Office of Force Transformation
ONR	Office of Naval Research

ORS	Operationally Responsive Space
ORS Sat-1	Operationally Responsive Space Satellite One
OSD	Office of the Secretary of Defense
R&D	Research and Development
RRTO	Rapid Response Technology Office
S&T	Science and Technology
SAFE	Space Apportionment for Effects
SOC	Space operations center or satellite operations center
SORD	Space Operations Responsiveness Demonstration
TacSat	Tactical satellite
TPED	Tasking, processing, exploitation and dissemination
TacSat-4	Tactical Satellite Four
TTPs	Tactics, techniques and procedures
VMOC	Virtual Mission Operations Center

Appendix 2 References

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