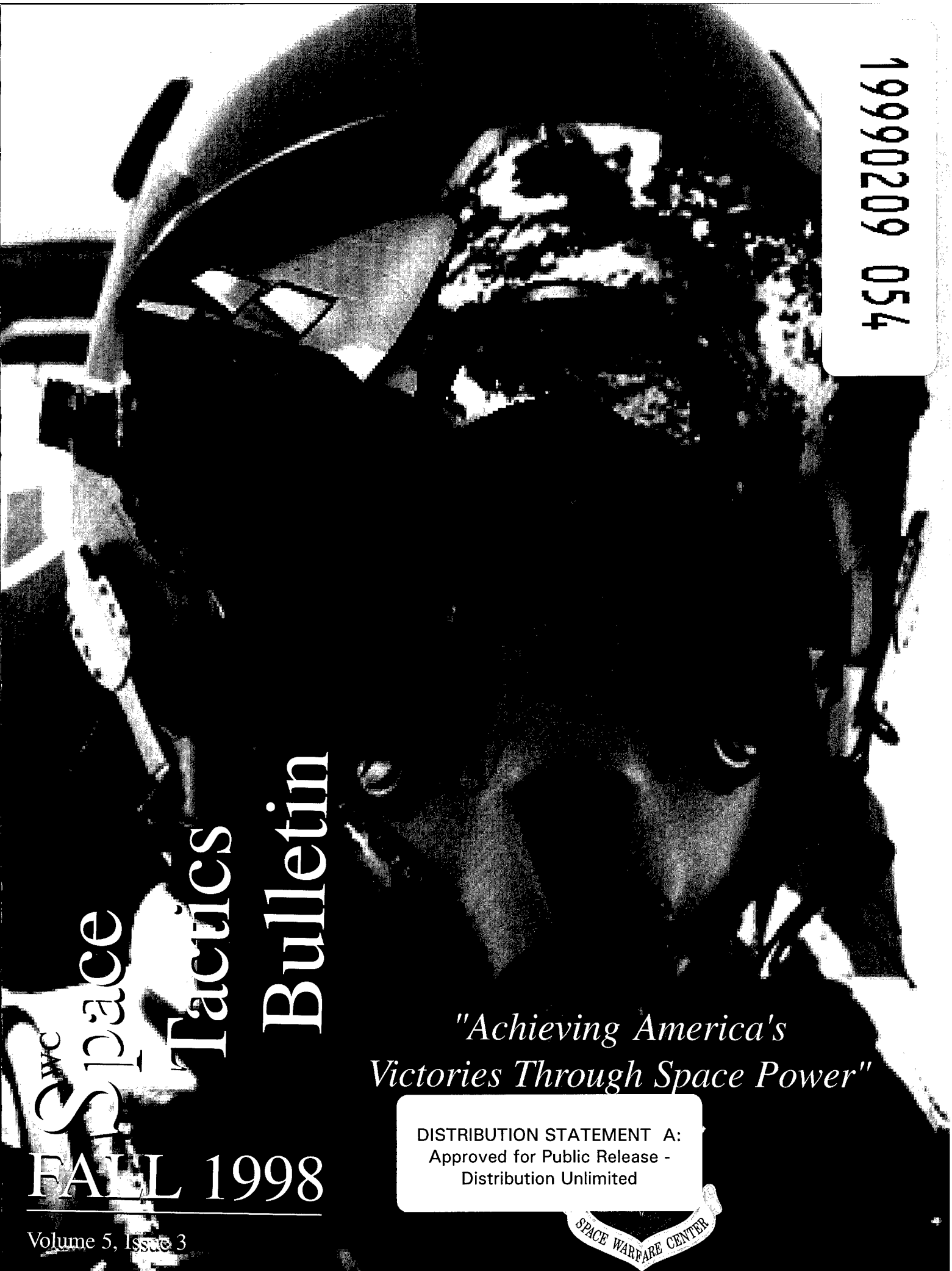

Space Tactics Bulletin

"Achieving America's Victories Through Space Power"

FALL 1998

Volume 5, Issue 3

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IN THIS ISSUE

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Mr. F. Whitten Peters
Acting Secretary of the Air Force

Gen Richard B. Myers
Commander, Air Force Space Command

Brig Gen William R. Looney III
Commander, Space Warfare Center

Ms. Bobbie Wolfe
Editor

The Space Tactics Bulletin is an official, nondirective SWC publication. Its purpose is to update warfighting staffs and units on SWC efforts to effectively employ space assets in support of operations, and provide a forum for information exchange to improve space tactics and procedures. The views and opinions expressed herein, unless otherwise specifically indicated, are those of the individual author. They do not purport to express the views of the SWC Commander, the Department of the Air Force or any other department or agency of the United States Government.

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COMMANDER'S CORNER

Welcome to the Fall 1998 Issue of the Space Tactics Bulletin (STB). We continue to receive outstanding worldwide support for this publication. The quality and diversity of the articles stands testament to the level of support our space troops are providing to different missions across the Air Force. The USAF Weapons School Space Division continues to produce excellent, tactically relevant articles that educate even the most experienced space operators.

This issue contains two articles about the use of multi-spectral imagery to enhance warfighting operations. The proliferation of commercial imaging systems and their subsequent improvements in timeliness and quality make this an ever-growing area in the intelligence communities. Imagery such as this is available to everyone. Adversaries can use commercial imagery and other products from space to enhance their own combat capabilities. The article on integrating a space-capable adversary into exercises advances the notion that the first time U.S. forces meet a space capable adversary should be during exercises, not actual combat.

AFSPC participation in exercises is increasing. The article on AFSPC exercise and wargame participation outlines the responsibilities of the new exercise branch, HQ AFSPC/DOTX. This branch will be responsible for supporting military-wide exercises and defining the AFSPC role in these exercises.

Space operators continue to impress me with their ingenuity and creativity. The article on the lunar flyby shows just how much we've improved our ability to fix complex space systems when they go wrong. The STB concludes with a FY99 HQ SWC/DOT course schedule. This branch is chartered with bringing space support to the warfighter through advanced courses. They offer some outstanding courses which will help you accomplish your mission.

Thank you for your support of this bulletin. Your past submissions have made the STB a first class publication--keep up the good work!

WILLIAM R. LOONEY III
Brigadier General, USAF
Commander, Space Warfare Center

TRANSFER OF DMSP OPERATIONS TO NOAA

Maj Mahan, HQ AFSPC/DORW, DSN 692-9876

On 5 May 94, Presidential Decision Directive NSTC-2 was issued directing the Departments of Commerce (DOC) and Defense (DoD) to converge their separate polar orbiting operational satellite programs. The goal of this directive is to merge the Polar-orbiting Operational Environmental Satellite (POES), operated by the National Oceanic and Atmospheric Administration (NOAA), and the Defense Meteorological Satellite Program (DMSP), operated by Air Force Space Command (AFSPC), into one satellite system controlled by a common command and control (C^2) segment. On 29 May 98 AFSPC and NOAA took the first step toward meeting this directive by combining operations of their separate weather C^2 systems into a single system.

According to Major General Hinson, AFSPC Director of Operations, "this merger is a force multiplier, maximizing efforts of personnel and material resources ... By giving operational control of DMSP to NOAA, we'll realize savings that can be applied to other important military space programs." A National Performance Review identified a potential savings of $1.3 billion for the DoD and DOC by combining the two programs into one. These savings won't be fully realized until DMSP and POES are merged into a single satellite system.

The new Satellite Operations Control Center (SOCC), located in Suitland, Maryland, is managed by NOAA and is responsible for the operations of both POES and DMSP. Although NOAA operates DMSP, it is still a DoD resource with the primary mission of gathering and disseminating cloud cover, water vapor content, sea ice, soil moisture, rain rate, cloud water content, land surface temperature, snow depth and ocean surface wind speed data to military planners and civil users worldwide. Since NOAA assumed DMSP operations, they have maintained the same high level of mission effectiveness, 99.9%, which was sustained by the 6th Space Operations Squadron (6 SOPS).

A significant challenge of establishing a fully converged system is determining how to transition from the current programs to a new single program. The approach selected allows each agency to fly out its existing and programmed assets while immediately creating an Integrated Program Office to develop and acquire the converged system. The first satellite in the new system, called the National Polar-orbiting Operational Environmental Satellite System (NPOESS), will be available for launch in July 2007, after NOAA and DoD have both exhausted the satellites currently in the "pipeline."

The next milestone of the convergence effort is standing up the backup Satellite Operations Center (SOC) at Schriever AFB. The 8th Space Operation Squadron (8 SOPS), an Air Force reserve unit, will maintain and operate SOC-81 as a fully functional C^2 node for DMSP and the future NPOESS. Having the reserve fulfill the backup roles gives the Air Force greater insight into DMSP operations, and provides the capability to sustain weather satellite operations should the Suitland SOCC experience a catastrophic failure. SOC-81 is scheduled to become operational in Jan' 99.

SPACE-BASED LASER (SBL)

Maj Dees, HQ AFSPC/DOMN, DSN 692-3656

Air Force Space Command is developing a concept of operations for a Space-Based Laser (SBL) system that addresses both the ballistic missile proliferation threat and the growing threat to friendly space systems.

On 14 November 1994, President Clinton signed Executive Order 12938, declaring that the proliferation of nuclear, biological and chemical weapons, along with the means of delivering such weapons constitutes an unusual and extraordinary threat to the national security, foreign policy and economy of the United States. The recent underground nuclear testing in India and Pakistan underscores the reality of this threat.

US Space Command 2020 vision not only recognizes the accelerating pace of ballistic missile proliferation worldwide, but also the increasing dependence on commercial and military space systems to our national security. Today, the United States is the preeminent military space power, but other nations are eagerly expanding their technological efforts toward developing space systems that may soon threaten our national interests and security.

With primary missions of ballistic missile defense and counterspace, an operational SBL system will help meet these future threats by applying the principles of constant global coverage, immediate response and flexibility. With its unique speed-of-light transmission of directed energy and inherent defensive countermeasure capabilities, SBL will ensure commanders retain a highly effective deterrent capability. With SBL's boost phase engagement capability, theater-class missiles with chemical or biological warheads can be destroyed over enemy territory, minimizing risk to friendly forces and reducing stress on a theater's terminal missile defense systems. SBL will operate within the Joint Force Commander's overall objectives and will complement other air and ground theater missile defense systems by expanding engagement opportunities and improving protection through a more robust, layered defense. Since SBLs will be constantly on alert, they will serve as a gap-filler early in the conflict while other defenses are deployed or generated. The SBL, as part of national missile defense architecture, will complement ground-based interceptors to provide a highly effective defense against the Intercontinental Ballistic Missile threat.

The system's large optics and low-powered tracking laser will also provide an inherent multi-mission capability that may contribute to various peacetime and wartime missions, such as:

- Near-real-time terrestrial surveillance and reconnaissance
- Space-based deterrence of air/ground attack in difficult-to-reach areas
- Rapid high resolution, broadband and hyperspectral target imagery
- Highly accurate space object tracking and imagery
- Astronomical data collection and wind sensing
- Environmental treaty monitoring (chemical agent detection)

Current plans call for proving key technologies using a single SBL Readiness Demonstrator (SBLRD) in the 2005-08 timeframe. The SBLRD is a key step in the path toward an operational system that can be combined with air, ground and naval forces as both a deterrent and a force multiplier. An SBL system will strengthen our national defense strategy through omnipresence in areas unattainable by other forces.

AIR FORCE SPACE PARTICIPATES IN EXERCISE AND WARGAMES

Lt Col Carlos Arvizu, HQ AFSPC/DOTX, DSN 692-3376

Air Force Space Command (AFSPC) has recently taken steps to enhance exercise and wargaming support among warfighters, better demonstrate space warfighting capabilities and improve the training for its space warfighters. By direction of HQ AFSPC Director of Operations, the Operations Training Division has stood up an Exercise and Wargame branch (DOTX).

DOTX's mission is to enhance AFSPC war readiness through the application of space power, improve combat support and streamline warfighting procedures by establishing MAJCOM policy and managing participation in CJCS, CINC-sponsored and other exercises and wargames. In addition, DOTX will establish a process for planning, exercising and reviewing lessons learned to help meet wartime commitments.

Some of DOTX's responsibilities include:

- Providing space support to exercises and wargames sponsored by all levels of DoD
- Helping define AFSPC objectives
- Prioritizing AFSPC participation in exercises and wargames
- Serving as HQ AFSPC's OPR for long range exercise and wargame planning
- Providing oversight for AFSPC participation in exercises and wargames
- Archiving information for future use in exercises
- Attending exercise planning conferences

Space Command has come a long way in its support to other MAJCOMs' warfighters, but there is more that can be done. Space is making great progress in the exercise arena to educate and integrate capabilities. Space Command is demonstrating space capabilities at exercises with Air Force Space Support Teams, 14th Air Force, 20th Air Force and Space Warfare Center participation. All excel at bringing expertise and "tools of the trade" to exercises. However, there are some areas that Space Command is working to improve.

One of those areas is "Lessons Learned." HQ AFSPC is working long-range planning; prioritizing exercises, ensuring execution and following up on lessons learned. The command is developing a plan to provide NAFs with a mechanism to report official shortfalls identified through exercises and ensure that the appropriate headquarters staff addresses these shortfalls. The aim is to identify requirements, prioritize and strike a balance between the NAFs' planning and exercise execution and the headquarters support in addressing shortfalls.

The plate is certainly full. Currently, AFSPC participates in and supports approximately 30 exercises and six wargames per year. Any questions about DOTX may be addressed to Lt Col Carlos Arvizu at DSN 692-3376.

SPACE PLANNING AND EMPLOYMENT

Maj Widman, HQ SWC/DOT, DSN 560-9584

"In war, nothing is achieved except by calculation.
Everything that is not soundly planned in detail, yields no result."

Napoleon 18 Sep 1806

When will the application of space technologies and capabilities truly become part of an integrated warfighting strategy? How long will we continue to rely on deployable Space Support Teams and a separate Annex N to our CONPLANS and OPLANS to fill the gap between the shooter and the force enabling support that our space assets provide? The answer is clear. We will rely on a patchwork of fixes until those responsible for the planning of military operations are masters of a Battlespace that now extends from the depths of the oceans out to geosynchronous orbit. It is why USCINCSPACE stated one of his goals is, "to integrate space at the beginning of the joint planning process, not buried in an annex." This is also the premise of a new course being considered for development at the Space Warfare Center.

The Space Planning and Employment Course (SPEC) will target planners involved in joint and component planning at the theater command level. These individuals, responsible for Deliberate and Crisis Action Planning, are key to establishing space as an essential consideration in future contingency operations. Each task identified in the operations annex of a theater OPLAN or OPORD has a space capability; limitation or threat tied closely to it. If we are to employ forces effectively, these parameters must be clearly understood by those individuals planning the campaign.

With this in mind, a primary SPEC objective is for students to "synthesize current space system capabilities with principles of warfighting doctrine to form new employment and planning considerations"--a tall order for three days of instruction. But the SPEC will take a powerfully different approach to space training.

Rather than focusing on system capabilities and limitations, the proposed SPEC will use the latest national policy, military doctrine, tactics, techniques and procedures, and mission task lists as the basis for examining the linkages between space capabilities, the shooter and a mission. Linking space to warfighting missions in this manner will lead to a better understanding of space as an enabling force. More importantly, it will highlight the need to protect friendly space assets; the need to fully exploit those assets; and the enemy's vulnerability to a fully integrated combat force.

This break with traditional systems-based space training establishes a framework for a new space-training paradigm at the Space Warfare Center. Just as we can ill-afford to "stovepipe" space operations in the planning process, advanced space training can no longer occur without a strong emphasis on warfighting principles. This new way to approach the problem recognizes that many warfighting tasks are totally, or in part, reliant on a space-based system. As we enter a new millennium, space assets will play an even larger role in military operations. As such, we must write contingency plans that integrate present and future space capabilities or we risk diminishing future combat capability.

As Yogi Berra once said, *"I've seen the future and it ain't what it use to be!"* As we move toward an integrated Air and Space Force, a new course such as the proposed SPEC will help our joint war planners see that space oriented future and plan accordingly.

If you have a requirement for such a course, or have questions or comments about HQ SWC/DOT's proposal, please call Capt Randy Olson at HQ SWC/DOT. DSN: 560-9001, olsonrw@swc.schriever.af.mil.

LUNAR FLYBY USED TO CORRECT SATELLITE ORBIT

Capt John W. Giles, 1 SLS/DOU, DSN 467-7648

On December 25th, 1997, a Proton K launch vehicle lifted off from Launch Pad 23, Area 91 of Baikonur Cosmodrome carrying a Hughes communications satellite for Asia Satellite Telecommunications Co. Ltd. (AsiaSat). The satellite was to deliver communications services to Asia and neighboring regions, but fell short of its target orbit when the Proton's fourth stage failed at the beginning of its second burn. With insufficient fuel on the satellite to correct the orbit, insurers declared it a total loss for its original purposes and turned it over to Hughes Global Services, Inc. (HGS). HGS designated the satellite HGS-1 and began work on a revenue-generating salvage mission.

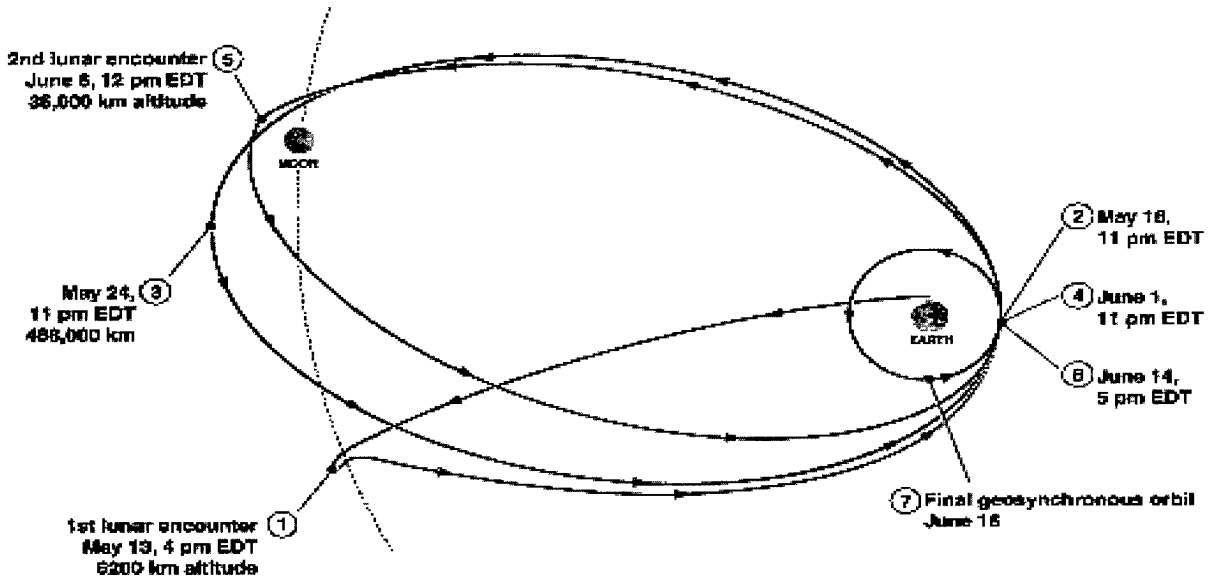
To place the satellite in a usable orbit, HGS needed to raise the orbital altitude and reduce the angle that the orbital path was inclined to the earth's equator (inclination). The salvage mission proposed by HGS hinged on the fact that less fuel is required to boost the satellite's altitude than to decrease the inclination. In fact, they could boost the apogee altitude to lunar distance using around half of the satellite fuel, while it would expend all satellite fuel to decrease the inclination to zero. The ability to reach lunar altitude meant HGS could use the moon's gravitation to change the trajectory of HGS-1. With some carefully timed course corrections after the lunar encounter, HGS-1 would return to earth's orbit at the proper altitude with nearly half its fuel remaining and low enough inclination to support some communications customers.

Beginning in May, HGS performed a series of thruster firings that sent HGS-1 to within 6,200 kilometers of the moon on May 13, 1998. The moon's gravitational field had the effect of twisting the orbit plane, and HGS-1 returned to earth on a new trajectory. After the first encounter, however, HGS determined that they could further improve the final orbit with minimal fuel expenditure by performing a second lunar flyby (approximately 36,000 kilometers from the moon) which they did on June 6, 1998. HGS-1 returned to earth orbit on its new trajectory and after a few course corrections, entered a final orbit almost identical to its original target orbit with nearly half the original fuel remaining.

Typically, the inclination of the target orbit determines which launch site is used and contributes to how much lift capability is required. Use of the moon's gravitational field to change an orbit's trajectory is one way to increase the flexibility of which launch site is selected and how much lifting capability is needed. While this type of operation could save fuel, some disadvantages are an increase in the time to reach final orbit, and higher operating expenses resulting from support required during the transfer orbit.

The information contained here was obtained from the Hughes Space and Communications Company homepage at www.hughespace.com. POC is Capt John W. Giles, 1 SLS/DOU, DSN 467-7648.

Diagram obtained from Hughes Space and Communications Company homepage (www.hughespace.com.)



HGS-1 2nd LUNAR FLYBY ORBITAL TRAJECTORIES

HYPER SPECTRAL-IMAGING COLLECTION UPON PIKES PEAK (HICUPP) STARTS DATA COLLECTION

Capt James Trimble, SWC/SB, DSN 560-9381

The Air Force Space Battlelab (SB) is now in its second year of operations and is starting to enjoy the fruits of its labor. Recently, the SB kicked off its third initiative, a Hyper-Spectral Image Collection Upon Pikes Peak (HICUPP) demonstration.

The SB's third initiative started with an initial site survey on 10 April 98. The weather challenged the team with temperatures in the teens, howling winds and snow being kicked up by the snowplow as it whipped across the windscreen. As the vehicle crawled up the 19 miles, the team was able to see why they were placing a $100,000 Hyper Spectral Image (HSI) sensor on top of Pikes Peak ... the spectacular view.

The success of the demonstration is based on exploiting that view. The team's goal is to place a HSI sensor on the top of Pike's Peak to perform a low cost, high volume collection of HSI data that can be compared to current Multi-Spectral Imaging (MSI) satellites. Past collections supporting these demonstrations have typically been performed by low altitude aircraft; e.g. 2000–20,000 feet Above Ground Level (AGL). While these experiments have been useful for studying the potential operational use of HSI collectors under the best of conditions, little work has been done to date to assess the capabilities of the technology from a space platform. The space environment represents substantial challenges for a HSI collector. The atmosphere is thicker, the spatial resolution of pixels is likely to be larger and the collection geometry is more likely to be oblique. By taking oblique angles from Pikes Peak, the SB hopes to simulate a space platform to provide new insights into HSI development requirements by comparing HICUPP data to actual MSI data.

The first day of data collection on 27 June was very different than the day of the initial site survey. The temperature was a balmy 38 F and most of the snow was gone, but the spectacular view was still there. Over

the next two weeks the HICUPP team, consisting of members from the SB, the Space Warfare Center's Analysis and Engineering (HQ SWC/AE) Division and the University of Washington at St. Louis, collected over 300 HSI scans. These scans included Colorado Springs, Schriever AFB, Peterson AFB, Ft Carson Army Post, Pueblo Munitions Depot and Mount Evans. The targets within the scans included radomes, C-130's, M-60 Abrams tanks, munitions igloos and various buildings.

Over the next few months the HSI team will be analyzing the data cubes collected from the first collect. HQ SWC/AE is currently tackling the cumbersome task of data analysis. The HSI and the MSI data taken concurrently with the initial data collect is challenging the HQ SWC/AE computer systems; however, the HICUPP team hopes this large amount of data will provide new insights on how to use the sensor for a second collect in September.

The next challenge for the HICUPP team is getting ready for the September collection. Their goal for this collection is the comparison of the data collected in Jun-Jul to the atmospheric and weather conditions of September. In addition, they hope to capture imagery of F-16 Fighting Falcons from Buckley ANG in flight.

HICUPP is an excellent example of how the SB is working hard to bring innovative and revolutionary space and logistics concepts to the warfighter. It is always looking for new ideas to explore. If you have ideas or questions on the on-going SB concepts please submit them to the AF Space Battlelab.

Mailing Address
AF Space Battlelab
730 Irwin Ave, Ste 83
Schriever AFB CO 80912-7383

Web Address
www.schriever.af.mil/swc/battlelab/

e-Mail Address
spcbtlab@swc.schriever.af.mil

Telephone
DSN 560-9392
(719) 567-9392

FAX
DSN 560-9937
(719) 567-9937

576TH FLIGHT TEST SQUADRON LAUNCHES FOUR ICBMs IN 48 DAYS

Capt Ray Staats, 576 FLTS/TEO, DSN 275-6354

The 576th Flight Test Squadron (576 FLTS) recently completed an extraordinary series of launches as part of Air Force Space Command's Force Development Evaluation (FDE) and the Air Force Operational Test and Evaluation Center's (AFOTEC) Initial Operational Test and Evaluation (IOT&E) programs. What makes this feat remarkable is that these four successful launches were completed in just a 48-day span.

Maintenance and operations crews from three task forces combined with personnel from the 576 FLTS, commanded by Col Robert E. Wood, to process and launch one Peacekeeper and three Minuteman III Intercontinental Ballistic Missiles.

The first task force, from the 90th Space Wing at F.E. Warren AFB, arrived at Vandenberg AFB in early April. After a series of orientations, 576 FLTS and task force personnel began preparing for Glory Trip 27PA, beginning with missile emplacement at Launch Facility (LF) 05. The Peacekeeper ICBM was successfully launched on 7 May.

Just days after this success the next task force arrived from Malmstrom AFB to begin preparations for

Glory Trip 167GB. 576 FLTS and 341st Space Wing personnel began work at LF-26. A smooth launch countdown on 3 June culminated in the Minuteman III first stage ignition at 1201 local time. The daytime launch, a fairly unusual event for FDE launches, drew a large crowd, with base personnel taking advantage of the rare opportunity to witness a spectacular showing of our nation's nuclear deterrent capability.

Two weeks before completing the Glory Trip 167GB mission, yet another task force arrived, this one from the 91st Space Wing at Minot AFB. 576 FLTS and the task force tackled the formidable challenge of preparing two ICBMs for a Short Time Interval Launch (STIL). Each of these two launches marked significant milestones in the continuing evolution of the ICBM force.

Joined by an AFOTEC team, 576 FLTS and task force maintenance teams emplaced the Minuteman III Guidance Replacement Program (GRP) Integrated Demonstration Flight (IDF) #1 at LF-09. GRP IDF #1 featured the new NS-50A guidance system, which will replace the 1970's vintage NS-20 system when fielding begins next year. At 0101 on 24 June the missile began its 4300-mile flight downrange to the Kwajalein Atoll.

Moments after watching a successful re-entry, the second launch countdown team took their positions to begin final preparations for the launch of Glory Trip 168GM from LF-10. This sortie was the first to be executed by the Navy's "Take Charge and Move Out" (TACAMO) platform. TACAMO replaces the Air Force EC-135 as the linchpin of USSTRATCOM's Airborne Launch Control System (ALCS). At 0545, the Launch Execute Commands were issued and the second set of RVs were enroute to the Marshall Islands in less than 5 hours. These tests marked the first use of the TACAMO platform with operational ICBMs.

While launching two ICBMs on 24 June, yet another team from the 576 FLTS was completing a two-month effort at Malmstrom AFB culminating that week in a series of eleven Simulated Electronic Launches--Minuteman (SELM).

July provides a brief but well-deserved respite following a two-month period of nearly unprecedented operations tempo--launching four ICBM sorties plus conducting a SELM in just 48 days. The squadron gears up again in August to prepare for the SIOP-99 Operational Test of the Rapid Execution and Combat Targeting (REACT) system and missile emplacement for the September launch of the second GRP IDF. Glory Trip 169GM will follow in early November and yet another task force will arrive at year's end to begin preparations for Glory Trip 170GM.

Seven ICBM SELMs at two missile wings and two REACT Operational Tests in just 12 months--business as usual for the 576th Flight Test Squadron.

WELCOME TO THE USAF WEAPONS SCHOOL SPACE DIVISION CORNER

Lt Col Gregg "Mr. Bill" Billman, WSS/CC, DSN 682-2065

Brig Gen Looney has been gracious enough to continue Maj Gen Moorhead's initiative of offering the USAFWS Space Division the opportunity to contribute to this fine publication. We wanted to take the opportunity in this issue to give a quick update on what's going on out here at Nellis, and what our sight picture looks like for the near term.

We graduated our fourth class June 13 and they have since gone on to their respective theaters, getting space into the fight. These new space weapons officers are now doing great things from Europe to Asia, and point's in-between. We are well into our fifth class--our present batch of WUGs (Weapons Officer Undergraduates) have successfully completed weapons school core and just begun their space systems phase of training (and most of them are still smiling). We are looking forward to expanding our graduate assignment base to include not only NAFs and equivalents, but also the Air Expeditionary Wings.

We continue to fine tune our academics and missions to meet the needs of fielded space weapons officers. To this end, we keep in constant touch with our graduates. In fact, just last week we participated in the first-ever NAF/CAF Space Conference sponsored by 8th Air Force at Davis-Montham AFB, AZ; a great start to what we're sure will be a continuing legacy of worthwhile conferences. Next on the list is the Space Control Conference, followed by Guardian Tiger, then the AFTTP 3-1 Conference. It's imperative to keep in touch. Our syllabus is a "living document" that is constantly evolving. Last year, we modified our missions to reflect a more theater-applications orientation, while also expanding our space control academics. This year, we are expanding our Theater Missile Defense/Warning academics and missions, and at the same time integrating more hands-on equipment training and evaluation. We continue to develop our student's AOC and SOC knowledge; the Joint Air Operations Staff Course and class visits to 14AF/SOC are now integral to our syllabus. Our close working relationships with AFSPC's Aerospace Integration Center here at Nellis, as well as the SWC, HQ AFSPC/DO and DR, USSPACE/SPJ3, USSPACE/SPJ5, and 14AF allows us to broaden our WUGs' horizons.

We think you'll find this issue's papers interesting reading. Capt "Rhett" Butler, Class 98AIS, wrote his student paper on "Integrating Space Adversary Capabilities into Exercises." It discusses using space adversaries (across the mission spectrum) much like air adversaries have been used for some time to challenge and train friendly forces. "Rhett" is now at 3AF, Mildenhall, UK doing great things for our AeroSpace force. Capt Todd Gossett, Class 98AIS, wrote his paper on "Timely Spectral Imagery for the Warfighter" and also Capt Richard Petty, Class 98AIS, wrote his paper on "Providing Effective Space Force Enhancement to the Warfighter."

See you next issue. 'Till then; check 6, 12, LEO and GEO.

Mr. Bill

INTEGRATING ADVERSARY SPACE CAPABILITIES INTO EXERCISES

Capt Rudolph E. Butler III, Space Class 98-A, USAF Weapons School

Introduction

"Today, the region of space is a military and economic center of gravity. Life on Earth is rapidly being inextricably linked to space capabilities. Because of our military strategy, economic investment and social dependence on space systems, space has become a region of vital national interest."
— General Howell Estes, USCINCSPACE, in testimony to Congress, 11 Mar 98 (2: —)

Space capabilities are increasingly being incorporated into combat operations to ensure mission success. As the USAF continues to downsize manpower and infrastructure, our ability to meet multiple overseas crises will increasingly depend on having the capability to rapidly deploy and setup in any location to conduct military operations. Space systems will play a major role in these operations. Other countries, both friendly and hostile, are incorporating space-based capabilities into their military operations as well as their society. Also, adversaries will attack our vital space assets to degrade our combat effectiveness. In future conflicts, space superiority will be as important as air superiority is to military endeavors today. Right now, space operations experts are slowly being integrated into the Numbered Air Forces (NAFs) and Air Operations Centers (AOCs). This is a positive step but it is not enough. If we truly mean to train as we fight, now is the time to standup a unit that will serve as a realistic space adversary for the AOC.

First, this paper examines the current adversary space threat focusing on how space products and services are obtained by other nations and how adversaries plan to deny the U.S. access to our space capabilities. Next, it justifies the need for a space adversary unit and proposes a concept of operations. Finally, after careful analysis, a recommendation is made of where to place this unit for maximum benefit to the USAF.

The Threat

"We are the world's most space-dependent nation thereby making us vulnerable to hostile groups or powers seeking to disrupt our access to, and use of, space."
— General Howell Estes, USCINCSPACE, AF Association Symposium, 18 Oct 96 (3: —)

Space capabilities provide the U.S. long-haul communications, navigation, weather, intelligence and ballistic missile warning. Other countries have seen our success in using space systems and are trying to access space products and services to integrate into their military operations. Some countries can't afford to purchase space products and services so they are trying to level the battlefield by denying the U.S. access to its space capabilities. The next sections discuss how other countries are gaining access to space capabilities and developing counterspace options that could become threats to successful U.S. combat operations.

Space Capabilities

Today, many countries are incorporating space capabilities into their societies. Space capabilities provide many opportunities for growth economically, politically and militarily. Normally, countries gain access to space products and services using one or more of the following methods: 1) Own and operate indigenous satellites, 2) Combine resources with other countries to own and operate satellites and 3) Purchase products and services from a commercial vendor.

Today, several countries own and operate their own satellites. Russia, China, France, Japan, Canada and India are a few examples. The majority of these satellites provide communications or overhead imagery of the Earth. These types of platforms have inherent military value to gain, maintain and pass situational awareness of the battlespace. Normally, the country with the best situational awareness and the ability to pass that awareness throughout the battlespace will win the conflict. Details of foreign reliance on space systems are published in reports that are produced and updated by U.S. Space Command's (USSPC) Combined Intelligence Center (CIC). The CIC posts these reports on the USSPC's home page on Intelink.

The cost of launching satellites and operating space systems is extremely expensive. The infrastructure required for commanding and controlling the satellite vehicle, downloading data and processing data into information is also very expensive. These costs can be reduced if several countries combine resources and work together. When this situation occurs, the countries sign agreements and form an international consortium. International consortiums are like businesses and usually develop communication satellites to provide global or regional access for the partners. Examples of communications consortiums are International Maritime Satellite (INMARSAT) and International Telecommunications Satellite (INTELSAT). The consortium partners license services and may allow other countries and even individuals access to services for a price. This allows more countries access to space capabilities. One problem this arrangement causes is the difficulty in denying a particular adversary access to space capabilities without impacting other users of the satellite. Politics and capitalism may prevent military action against consortium satellites, ground stations, or processing networks. Also, such actions may impact U.S. or allied use of the same system.

Countries that can't afford to purchase dedicated space assets can obtain space products and services from commercial vendors. There are U.S. and international businesses that have the resources to take advantage of the global nature of space. These companies are developing technologies that will provide products and services at a cost where even individuals will be able to purchase them. The main arenas for businesses are communication services and overhead imagery products.

Communications is a major arena where U.S. and international business is looking to space for profits. Global communications allows access to restricted markets. Also, it has many inherent military uses. Command, control, communications and intelligence are areas where the communications business can impact military operations. The U.S. uses commercial communications to augment its capability. If the enemy wanted to cut off communication services that the U.S. leases, it is possible they could purchase the company and shutdown our access to achieve that objective. (4: —)

Within 10 years, there will be enough imagery satellites in orbit to provide 24-hour coverage of every spot on the globe. (9: —) Within 2 years, there will be several satellites with sensors that will provide quality equal to our early National Systems. (9: —) Due to the global nature of space and legal precedence, businesses and foreign countries are not limited in where they can image. For example, the Russian SPIN-2, an overhead imagery system, takes images of sensitive and restricted areas within the continental United States and sells them. (9: —) Currently, these systems are not near real-time (within hours). However, as the space-based imagery collection industry matures, delivery times to the customer will decrease and the products will have better resolution.

To get the most useful products from overhead imagery satellites, an adversary can use the Internet to cue the overhead sensor for tasking. The Internet is emerging as a major source for intelligence. Anyone can legally access a public web site for information given a computer and a modem. Intelligence agencies can use Internet information to task space-based sensors and gain situational awareness of U.S. activities. The Space Warfare Center (SWC) emulated this process. A SWC team used a civilian computer (i.e. not ".mil" or ".gov") to access the Internet and gain information on the deployment of the 366th Air Expeditionary Wing from Mountain Home AFB, ID to Bahrain. Using the Internet and AF public affairs, the team was able to determine the deployment location 20 days in advance and the exact deployment date 4 days in advance. With this information, commercial space-based sensors were tasked to image Mountain Home, AFB and the airfield in Bahrain.

The images produced information on aircraft dispersal/protection facilities, the security perimeter and operations support facilities. An adversary could use this information to plan attacks during critical operations and hamper combat capabilities. (9: —)

Counterspace Options

Countries with limited budgets may find it is easier to invest in systems that deny space access over specific regions rather than trying to compete with U.S. and allied space capabilities. Due to U.S. reliance on space, there are several countries developing counterspace technologies for use in combat operations. Current technologies exist that can impact our space systems. For specific details, reference the Electronic Warfare Threat to Space Systems published by the National Air Intelligence Center (NAIC) and the classified annex of this paper.

How well do you know the capabilities and limitations of all U.S. satellites? Well, some of our adversaries know more details about our satellites than the majority of our operators in Air Force Space Command (AFSPC). Foreign intelligence efforts to discover information about our space systems have been relatively successful. With this information, our adversaries can target specific high-value space systems. Some of the details about the successes of foreign intelligence efforts are located in the Counterspace Threat Model published by the NAIC (Top Secret/SCI). The classified annex to this paper highlights several examples of these successes and how the information can be used against the U.S.

Adversary space capabilities and counterspace options are real threats to our combat effectiveness. To train our forces to combat these threats, exercises need to incorporate adversary space scenarios into their scripts. Unfortunately, no unit has the tasking to produce these inputs for our major exercises worldwide.

Space "Aggressors"

"Nations that observed the vital role space played in our successful operations will be motivated to find ways to deny the U.S. unimpeded access to space."

— General Ryan, Air Force Chief of Staff, AF Association Symposium, 14 Nov 97 (5: —)

People planning and executing the war inside the AOC must understand the enemy's space capabilities, limitations and threats to prepare accordingly. Today, there is no unit whose mission description includes studying and emulating an enemy's space capability during exercises. If we don't prepare for the threat, the USAF will be unable to effectively deal with an enemy targeting our space assets. In order to train as we fight, we must create a unit to realistically emulate an adversary.

The reasons for forming this unit are similar to the reasons the USAF created Red Flag. During the Korean War, U.S. pilots posted an approximate kill ratio of 10:1. In Southeast Asia, the kill ratio dropped to 2:1. As a result of this drop, the Air Force undertook an exhaustive study of all existing data on air-to-air combat encounters from World War I through Vietnam. This study led to a number of interesting conclusions. For example, American fighter pilots were hampered because they trained against similar adversaries (U.S. tactics vs U.S. tactics). U.S. pilots were unfamiliar with Soviet equipment and ignorant of how they were employed. Also, due to a lack of realistic training practices and stagnant tactics, the air-to-air skills of U.S. pilots steadily eroded. The results of this study spurred the Tactical Air Command leadership to institute dissimilar training in the early 1970s. This was the genesis of the Aggressor Squadron (now the 414th Combat Training Squadron) at Nellis AFB NV in 1972. (7: 28-30)

Today, space operations are at a similar point to where the flying Combat Air Forces (CAF) were at the end of the Vietnam War. In current exercises, the space scenarios presented are simple and have minimal

impact on AOC operations such as satellite outages and weather conditions affecting space operations. Our space experts are not prepared to face an adversary deliberately attacking U.S. space capabilities or using space capabilities against us. AOC decision-makers have assumed the U.S. will always have space superiority. The truth is the enemy has realized our dependence upon space and that makes space capabilities a center of gravity. To the pilot flying the jet, losing space assets may not seem like a big deal. However, imagine deploying into a hostile environment without effective space support. The AOC would not receive ballistic missile warning until it was too late. An adversary jamming specific communication satellites would force us to manually disseminate time sensitive information like the Air Tasking Order. As Global Positioning System (GPS) information is integrated into our latest munitions, the effectiveness of several small cheap GPS jammers arranged around high value targets could prevent direct hits. If the munitions fail to strike the target, the pilot will care because he/she has to go back into harm's way and restrike the target. These examples highlight the need to prepare for adversary space capabilities. Today, we don't prepare for these possibilities because no one is responsible for developing these realistic exercise scenarios for training. If we don't act soon, the possibilities will evolve into probabilities and that would be a disaster.

CONOPS for the Space "Aggressors"

"Since space is a growing source of national power, it will be challenged."
-- The fourth of six major themes in USSPC's Long Range Plan (6:__)

The mission of the Space Aggressor unit should be the Prepare our combat forces by providing realisitic space adversary scenarios for training while identifying and developing countertactics for emerging space threats. This mission statement identifies three distinct functions: 1) Provide realistic space adversary scenarios for training , 2) Identify emerging threats and 3) Develop countertactics for emerging space threats.

To provide realistic space adversary scenarios, you must study adversary space capabilities, limitations and employment tactics. The world is a big place with potential space adversaries spread across the globe. The space aggressors should form teams and split the globe into logical regions based on the threats and unit manning. These teams should study and become experts in a particular adversary or threat function (i.e., communications, counterspace, overhead imagery, etc.). The teams should put together scenarios that are designed to test the AOC personnel in exercises. The space aggressors should attend the planning conferences for and participate in the major exercises worldwide. They should incorporate scenarios or modify current scenarios to meet training objectives. Team members should serve as exercise controllers to assist in the execution of the scearios. They should educate the exercise participants on the space threats presented in the debriefing at the conclusion.

The second function of the space aggressors should be to identify emerging threats. Except for the Gulf War, the U.S. has been forced to react to enemy capabilities in every war it's fought. For example, in the beginning of World War II, the U.S. aircraft were inferior to the combat capability of the Japanese Zero. (1:__) A captured Zero allowed the U.S. to develop an aircraft that could take away the Japanese advantage. (1:__) The military has reacted to enemy capabilities by using technology to quickly bridge the gaps that have occurred at the beginning of conflicts. Instead of reacting to threats, the space aggressors should identify emerging threats and examine the possible effects on the battlespace. This idenfication should allow the military to take proactive measures and develop courses of action using both military and nonmilitary options to deal with emerging threats. However, even if the threat is identified, it does not guarantee the U.S will be able to prevent if from becoming a problem. A classic example is the launching of Sputnik by the Soviet Union. The U.S. knew they were developing the capability, but could not prevent them from putting the first satellite into orbit. The U.S. spent the decade of the 1960's catching up and surpassing the Soviet Union's space capabilities. In the next

war, if the U.S. is forced to react to an enemy's space capability, it may be too late to achieve victory.

The third function of the space aggressors is to develop countertactics to emerging threats. The reason the space aggressors should have this function is threat scenarios have limited exposure to space experts. The AOCs and NAF staffs have small quantities of space experts. The threat scenarios presented during exercises may only be seen by one or two space experts. The space aggressors would be the ones to trend reactions to the scenarios and present alternate solutions to the space experts for feedback. They would examine the feedback and develop ideas for countertactics. The space aggressors would have to work closely with the 17th Test Squadron (AFSPC's space test and evaluation unit) to validate successful countertactics to space threats prior to being published in Air Force Tactics, Techniques and Procedures 3-1, Volume 28: Space. The development of countertactics could transition to another unit in the future (similar to Air Combat Command's tactics process) after AFSPC creates and matures a formal tactics process.

The space aggressors will need a range of expertise to make the unit a success. Some of the specialties needed for this unit will include space operations, intelligence, communications, computers, and engineers. The unit needs liaisons or representatives from national agencies to ensure maximum exercise realism. Some other needs include a current business expert to provide insight into business and consortium operations. Internet-smart personnel are needed to manipulate the web and gain information on the latest space capabilities, limitations, and tactics used by the U.S. and other countries. The business expert and Internet- smart personnel could come from the reserves or contractors.

Home of the Space "Aggressors"

"The U.S. military must ready itself -- when challenged in space, the nation's leadership will turn to us."

— The fifth of six major themes in USSPC's Long Range Plan (6: —)

Where should the home of the space aggressors be located and who will fund their existence? There are several agencies that could incorporate this unit into their structure. The different agencies and their missions are described below.

Fourteenth Air Force (14 AF), Vandenberg AFB CA: The 14 AF is the NAF responsible for space operations and serves as the Air Force component to U.S. Space Command. The mission of 14 AF is to "ensure the readiness of assigned forces, prepare forces for deployment and employment, and exercise operational control of assigned forces."

Space Warfare Center (SWC), Schriever AFB CO: The SWC is AFSPC's center for enhancing combat capabilities using space. The mission of the SWC is to "Advance America's Space Capabilities and Employment concepts through tactics development, testing, analysis and training programs."

Air Warfare Center (AWC), Nellis AFB NV: The AWC is Air Combat Command's center to enhance America's air combat capability. The mission of the AWC is "A team of dedicated professionals conducting world class testing, training and evaluation...Improving and providing air combat capability for America's warriors."

Aerospace Command and Control Agency (AC2A), Langley AFB VA: The AC2A is the single agent for the establishment of procedures, terminology, direction and scope of Air Force Air and Space C2 activities. This agency oversees the Battlestaff Training School (BTS), which provides initial training for AOC personnel, and the Blue Flag exercises at Hurlburt Field, Florida.

Analysis

This section will use four benchmarks for agency comparison to determine the best home for the space aggressors. The first benchmark is the space aggressors need to keep abreast of the latest capabilities, limita-

tions and tactics employed by U.S. space systems. The second benchmark is the space aggressors' ability to integrate into exercises where they can effectively prepare the participants for the threats. Third, the space aggressors will require a great deal of intelligence support on threats and foreign space capabilities, limitations, and tactics. Finally, the last benchmark is to determine if any agency has taken steps toward the creation of adversary space capabilities in their organization. This last benchmark is important because experience shows it will take up to 2 years to normalize internal operations within a new unit. Integration into the major exercises may add a year to this timeline. Any agency that has taken steps towards the formation of a space aggressor unit will reduce the timeline for mission success.

Each agency will be ranked best to worst. Each rank will be given a nominal point value between 1 and 4 with 4 being the highest and 1 being the lowest. The results of the analysis are summarized in Table 1. Let's see how they compare.

Ability to Keep Abreast of Latest U.S. Capabilities, Limitations and Tactics

The SWC ranks first in this category. Their location puts them in the heart of military space. Colorado Springs is the home of U.S. Space Command, AFSPC, Cheyenne Mountain and the two space wings with the greatest tactical influence, 21st and 50th Space Wings. The SWC is the responsible agency for the development and documentation of space tactics, oversees the operational test and evaluation units for AFSPC (tactic identification and validation) and hosts the Space Battlelab.

The 14 AF ranked second. They are the space operations NAF and understand the current capabilities of systems. Unfortunately, 14 AF is separated from the majority of its forces and has played a lesser role in the tactics development process because most of the players are in Colorado Springs.

The AWC ranks third. They own the USAF Weapons School and it has incorporated a space division. They have also worked with the SWC to setup a Space Training Facility (STF) for the Red Flag and Green Flag exercises. The Weapons School and the STF have pipelines back to AFSPC to keep current on capabilities and limitations of space systems.

Finally, AC2A ranks last in this category. Their only space support comes from a few operators on staff that handle space issues.

Ability to Integrate into Exercises Where They Can Effectively Prepare the Participants

AC2A ranks first in this category. They host four Blue Flag exercises each year. These exercises prepare 8 AF, 9AF and 12 AF in the setup of AOCs for the command and control of air and space forces during joint campaign. The space aggressors should have a great impact on these exercises by preparing the AOC against adversary space capabilities. Also, the space aggressors should prepare our space employment experts since these experts are integrated into NAF staffs. Also, the AC2A oversees joint training of AOC personnel at the BTS. The space aggressors could integrate into the BTS end-of-course exercise to expose a joint community to the space threat.

The AWC ranks second. The AWC hosts the Red Flag, Green Flag and the Weapons School's Mission Employment exercises. These exercises are an excellent opportunity to integrate air and space. The flying CAF would get more exposure to space and a taste of adversary capabilities. The reason for a lower ranking than AC2A is the exercises hosted by the AWC are designed for the "Tactical" level of war. Space doesn't play a major role at this level, yet, so adversary space won't have a great effect on these exercises.

The SWC ranks third. The SWC supports some of the major exercises held worldwide. The SWC's biggest drawback is they can only participate in exercises to which they are invited.

The 14 AF ranked the lowest. 14 AF doesn't participate in all the major exercises. As the space operations NAF, their focus should be how they can best integrate space into combat operations during the exercise rather than how to emulate an adversary's space employment.

Intelligence Support

The SWC ranks first in this category. Colorado Springs is home to the Combined Intelligence Center operated by U.S. Space Command. This center specializes in space intelligence and could easily support the space aggressors at the SWC. Also, the SWC has an intelligence division that can provide continual support to the space aggressors in their preparation of scenarios and research of foreign space capabilities, limitations and tactics.

The AWC ranks second. Red Flag has dedicated intelligence support to study adversary air capabilities, limitations and tactics. This support could be broadened to support the space aggressors during their development of scenarios.

14 AF ranks third. As a NAF, the headquarters staff is designed to have minimum manning to support the mission. The 14 AF intelligence staff is focused on current space operations and their impacts. Their ability to support the study of adversary space capabilities, limitations and tactics is not as robust as the SWC or the AWC.

AC2A ranks last. Their intelligence staff at Hurlburt Field is small. ASC2A is reorganizing and redefining its role in the future and that places many additional burdens on a strained intelligence staff.

Steps Toward the Creation of Adversary Space Capabilities

AC2A ranks first in this category. Blue Flag is the current pioneer in integrating adversary space into exercises. During Blue Flag '98-1, the adversary jammed the primary communications system for disseminating theater missile warning. During this period, the adversary launched 2 SCUDs against friendly territory that went unobserved by the forward-deployed forces until it was too late. This scenario enlightened the leadership on their dependence on space. (8: —)

The SWC ranks second. They have started an effort called the Aggressor Space Applications Project (ASAP). This 3-6 person team is designed to demonstrate to commanders the emerging threat from satellite imagery and open-source information. They are the team who tracked the deployment of the 366th Air Expeditionary Wing to Bahrain through open sources, Internet and commercial satellite imagery. Also, other SWC individuals have provided realistic space adversary inputs into exercise scripts. (9: —)

The AWC ranks third because they are training our future space employment experts, Weapons School graduates, for theater operations. The school's syllabus includes 28 hours on foreign space capabilities.

Fourteenth Air Force ranks last. Though they could possibly convert the Air Force Space Support Teams into an aggressor squadron, the conversion would not happen until around fiscal year 2003, which is too late.

Table 1 summarizes the rankings of the different agencies. Ideally, the unit should receive the best support and have an impact on the preparation for combat operations. Looking at Table 1, the SWC ranked first in two categories. Everywhere the SWC isn't ranked first, the AC2A ranks best. AC2A ranks last where the SWC ranks the highest. An organization that takes advantage of this situation best meets Air Force needs.

Table 1. *A comparison of four agencies to serve as home to space aggressors*

	14 AF	SWC	AWC	AC2A
Ability to Keep Abreast of Latest Capabilities and Tactics	3	4	2	1
Integrate Into Exercises Where They Can Effectively Prepare the Participants	1	2	3	4
Intelligence Support	2	4	3	1
Steps Toward the Creation of Adversary Space Capabilities	1	3	2	4
TOTAL	**7**	**13**	**10**	**10**

4=ranked first, 3=ranked second, 2=ranked third and 1=ranked last

Recommendation

Based on the previous analysis the USAF should place the space aggressors at the SWC with a detachment at Hurlburt Field to support AC2A's Blue Flag and BTS exercises. This solution allows the space aggressors' access to the latest space information, while simultaneously having a permanent presence at Hurlburt Field to support the Blue Flag and BTS exercises.

The space aggressors unit should maximize its opportunities to interface with the rest of the USAF. The detachment at AC2A should support the Blue Flag and BTS exercises. The main unit at the SWC should deploy teams to other major exercises worldwide to bring space adversary scenarios to the theaters. There are many side benefits to this situation. The space aggressors bridge the gap between AFSPC and ACC to gain benefits from both commands to improve combat capability. The creation of this unit needs to happen as soon as practical.

When building a unit, it takes time for the initial cadre to figure out how to accomplish the mission. As stated earlier, it will take about 2 years to normalize internal operations within a squadron. With the space aggressors, this timeline should be extended because most major exercises begin planning at least a year in advance. The space aggressors should immediately integrate into Blue Flag exercises and slowly integrate themselves into the other major exercises. Eventually, they would become regular members of exercise planning conferences and exercise controllers. The delay in the activation of this unit will result in longer timelines to integrate them into exercises.

Conclusion

As an emerging member of the CAF, AFSPC should prepare for the day when they will own and operate (combatant command of) weapons that are available for tactical operations. Today, AFSPC needs to study the threats to our space systems and capabilities. AFSPC is learning to speak the language of tactical combat operations and formation of the space aggressors would be another step in that process. In the beginning of this paper, General Estes was quoted as saying, "Life on Earth is rapidly being inextricably linked to space capabilities."(2: —) Both General Ryan and Estes recognize future adversaries will attack that vital space link. If successful, the adversary will reduce U.S. influence and capability to respond to situations worldwide. The U.S.

needs to prepare for attack against space capabilities. The USAF conducts operations everyday and prepares for operations by exercising our capabilities and learning from our mistakes. Now is the time to designate a unit to integrate adversary space capabilities into exercises. Many people ask, "What does space bring to the fight?" The answer to that is simple, let the space aggressors show you by taking it away.

Postlude

Other issues to consider when dealing with the formation of a space aggressor unit are the integration of space and information warfare, the creation of a single agency responsible for all dissimilar combat training, and the development of a tactics process for AFSPC.

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TIMELY SPECTRAL IMAGERY FOR THE WARFIGHTER

Captain Todd W. Gossett, SPACE CLASS 98AIS

Introduction

One of a commander's primary tasks is to gain and maintain information superiority, with the objective of achieving faster and more effective command and control of assigned forces than the adversary. [1:32]

Napoleon said, "A general never knows anything with certainty." This maxim is as true today as it was in Napoleon's age. However, where Napoleon employed spies to observe and report back on enemy positions, the modern warrior can take advantage of a myriad of technological innovations to give him situational awareness of the adversary. Whether we eavesdrop on enemy radio communications or take pictures of enemy positions and facilities with overhead platforms, gathering information about an adversary is crucial to understanding an enemy's capabilities and intentions. Further, the quicker a commander can gather and process information, the better able he is to make decisions more rapidly than the enemy--to get within the enemy's observe-orient-decide-act loop (OODA-loop). [1:32]

One method to gain situational awareness on an adversary is imagery. The Combat Air Forces rely on imagery intelligence to accomplish several functions: analysis, targeting, battle damage assessment (BDA), combat assessment and mission planning. The two primary types of imagery we use to observe an adversary are panchromatic (the visible band of energy) and spectral (using several bands of energy, in the ultraviolet through infrared bands of energy). We can use high-resolution panchromatic imagery to get details of a limited

area or target--it acts as our "eyes" in this respect. Spectral imagery can give us more information about a scene to include material composition of objects--almost acting as our "noses." While high-resolution panchromatic imagery gives us very small scenes of an area, spectral imagery offers broader area images, giving us a bigger view, and therefore better awareness, of the battlefield.

Certainly panchromatic imagery is very useful in supporting military operations and has been for years. But recently, we in the military have started to take notice of the wealth of information spectral imagery can provide us and are striving to find more ways to use it and better ways to get it. Some of the applications we use spectral imagery for are broad area coverage, perspective scene generation, counter-camouflage detection, area delimitation, terrain categorization, change detection, cueing higher-resolution systems, targeting, and battle damage assessment.

The Problem

As a military, we recognize the value of having spectral imagery as an additional source of intelligence on our adversaries. Currently, we get most of our spectral imagery from the U.S. LANDSAT civil satellite system and French SPOT commercial satellite system. While we've been able to exploit spectral imagery for many military applications, we can't obtain spectral imagery fast enough to meet time-critical military information needs. For example, let's say intelligence personnel in the Air Operations Center (AOC) combat operations division are trying to find the location of an enemy maneuver unit that they suspect is carrying short-range ballistic missiles with chemical warheads. Attempts to find the unit with panchromatic imagery systems are fruitless. Intelligence personnel are aware that the broad area overviews that spectral imagery provides can pinpoint the location of the unit and possibly verify the presence of chemical weapons. Battle managers in the AOC are ready to give the word to an on-call interdiction flight of two B-1's armed with CBU-87 Combined Effects Munitions to attack the unit. However, the spectral imagery intel ordered through higher headquarters from a commercial imagery company won't arrive for two or three days. The enemy unit successfully evades our forces and positions itself to launch an attack across our lines. This is not an acceptable situation. The problem here is that there is no near-real-time spectral imagery available to warfighters that is tactically tasked and responsive enough to meet time-critical needs in our tactical or operational-level military operations.

Possible Solutions

The good news is that military planners recognize this dilemma and want to do something about it. One near-term solution for the lack of responsive spectral imagery is the Air Force's upcoming Warfighter-1 satellite, a program designed to evaluate the utility of having a hyperspectral imagery system directly tasked by theater commanders. [25:1-1] Another solution to getting spectral imagery quicker is to receive it directly from the satellite into the theater. The Air Force's Eagle Vision system is currently demonstrating this capability in USAFE. Other near-term solutions include putting spectral sensors on unmanned aerial vehicles (UAVs) or manned aircraft.

Approach

This paper will first discuss the basics of spectral imagery, then describe the current state of spectral imagery use in our operations. Next, the paper will discuss the characteristics of each of the previously mentioned alternative solutions. The paper will first discuss the Warfighter-1 solution to include its capabilities, limitations and its ability to meet warfighter needs. Next, it will discuss the Air Force's Eagle Vision program to include its characteristics, capabilities and limitations. The paper will then look at the last solution, putting spectral sensors on UAVs and manned aircraft. It will also briefly look at an architecture these systems should comply with. Finally, it will analyze all these programs and provide a recommendation for obtaining a timely

spectral imagery capability within the next three years.

Background

What is Spectral Imagery?

Before we talk about spectral imagery, let's first discuss what type of energy we are recording. Electromagnetic energy interacts with objects in several different ways.
Energy can be scattered after hitting an object, absorbed by an object (to be later emitted), refracted upon passing through an object, and reflected by an object. The energy we record in imagery is reflected and emitted (after being absorbed) (Figure 1).

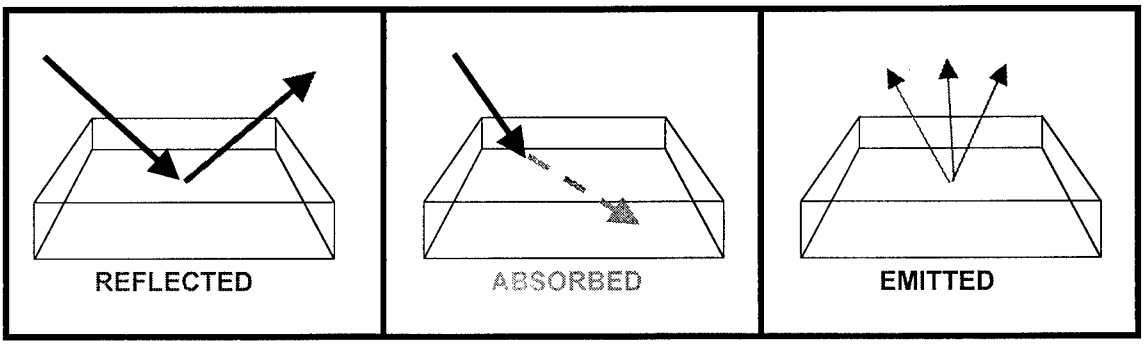

Figure 1. Types of Electromagnetic Energy Recorded in Imagery [22:4]

Most of the imagery that we deal with day-to-day in the military is panchromatic imagery--usually displayed as black and white photographs. This type of imagery uses energy recorded in the visible band of the electromagnetic spectrum. We can derive useful military information from analyzing imagery recorded from the visible band. Analysts can determine target locations, troop movements, battle damage assessment, etc. from visible band imagery, but they aren't getting all the information available about an object. In fact, only two percent of electromagnetic energy is from the visible band. [28:4] Spectral imagery records energy from other bands to get even more information about an object. Table 1 highlights some of the differences between spectral and panchromatic imagery.

Table 1. Comparison of Panchromatic and Spectral Imagery v(28:5)

Panchromatic	Spectral
Single Band	Separate bands
Black and white images	Multicolored images
Fewer interpretive features	More interpretive features
General identification and analysis	Detailed identification and analysis

For spectral imagery, we record energy emitted in the ultraviolet through longwave infrared portions of the electromagnetic spectrum, to include the visible band (Figure 2).

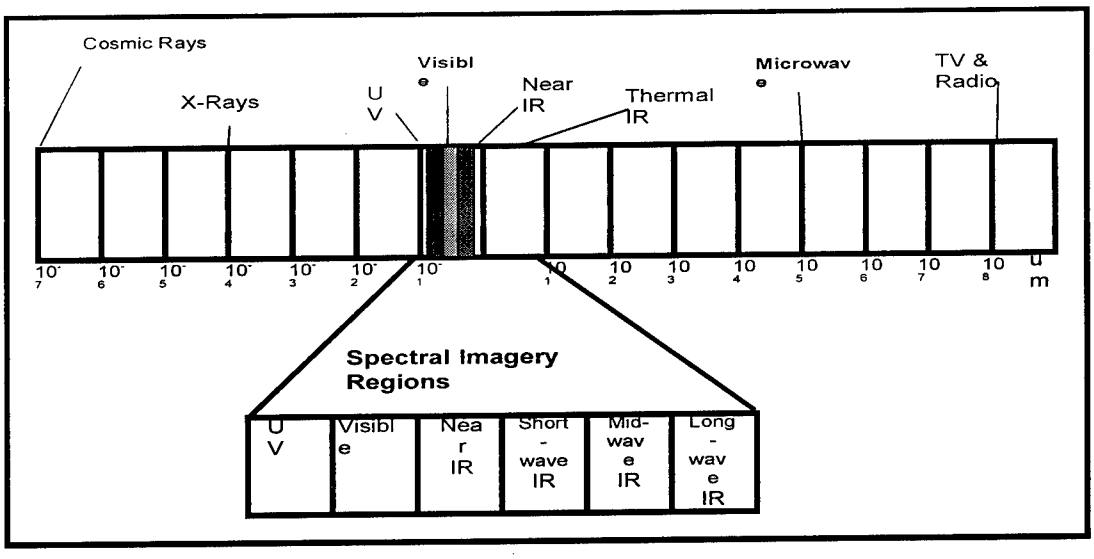

Figure 2. Spectral Imagery Bands in the Electromagnetic Spectrum [22:4]

While we cannot see energy from the ultraviolet or any of the infrared bands with the human eye, spectral sensors can record energy emitted and reflected in these bands. So what does this do for us? Spectral sensors record the level of reflectance a material has in each of these bands. Because different materials have varying reflectance levels in each band, we can determine unique spectral signatures for them. For example, green camouflage netting may appear the same as green vegetation (i.e. same reflectance) in the visible band, but have different levels of reflectance in the IR bands. These signatures can be recorded and placed in a database for use when analyzing spectral imagery. So how is this applied when viewing spectral imagery?

Using a spectral sensor, we can record data from a scene with both green camouflage and green vegetation in two or more bands simultaneously and then place that data on a single image. While the camouflage and vegetation would appear nearly indistinguishable in a panchromatic image (visible band only), the camouflage would stand out from the vegetation on a spectral image (multiple bands). By employing false color on images, we can distinguish different materials present in an image from each other. See Tab A for an example of what this looks like.

The most common type of spectral imagery we use today is multispectral imagery (MSI). MSI records two or more bands on an image. Both LANDSAT and SPOT are MSI systems. Another type of spectral imagery, hyperspectral imagery (HSI), can discern and record hundreds of smaller and narrower bands, thus giving it a better ability to differentiate materials in a scene. Many applications that can't be accomplished using MSI can be accomplished with HSI. For example, we could use HSI to detect chemical or biological weapons or conduct battle damage assessment of underground structures. [21:—] While there currently aren't any HSI sensors in space, there will be several in a few years. Both commercial and military space communities are developing HSI satellites.

Spectral Imagery in Military Operations--The Current State of Affairs

While the military has used spectral imagery for several years, the Gulf War highlighted just how useful it can be. During Desert Shield/Desert Storm, we used SPOT and LANDSAT MSI for several applications. We used MSI's broad area overview characteristics to update our old Persian Gulf area maps. We used its ability to discern different materials for target detection. We combined MSI with digital terrain elevation data (DTED) to make three-dimensional (3-D) scenes for aircrew mission rehearsal. We used MSI of the Kuwaiti oil fires to find the best routes in and around the smoke for aircrew mission planning. The list of uses in the Gulf goes on

and on. Table 2 highlights some of spectral imagery's military applications.

Table 2. Spectral Imagery Applications

APPLICATION	USES/EXAMPLES
Broad area coverage Gives overall snapshot of battlefield SPOT provides 60 km x 60 km scenes, LANDSAT provides 185 x 185 km scenes	In Desert Shield/Desert Storm, Defense Mapping Agency used SPOT imagery to update 4000 maps of the Gulf (13:9)
Perspective scene generation Spectral imagery, combined with digital terrain elevation data, gives 3D view of an area	Aircrews in the Desert Shield/Desert Storm used perspective scene generation to rehearse missions and become familiar with ingress/egress views (3:20)
Counter-camouflage detection Spectral imagery can differentiate camouflage material from surrounding vegetation/soil	Intelligence elements can determine location & presence of targets hidden by enemy camouflage
Area delimitation Spectral imagery can differentiate soil types, soil water content, types of vegetation in an area	By examing soil water content, planners can determine if heavy vehicles can traverse an area
Terrain categorization Spectral imagery can reveal terrain features	Planners used LANDSAT imagery of Sarejevo to determine drop zones for humanitarian relief (ops 917:--)
Targeting Spectral imagery can help detect targets Spectral imagery can help reduce collateral damage	During Desert Storm, MSI of the Al Qaim fertilizer plant in Iraq revealed air defense sites on its perimeter, making it a potential target (17:-) Planners used SPOT imagery in the Gulf to locate mosques, hospitals, schools and residential areas. Weapons are employed to minimize collateral damage in these areas (15:19)
Battle Damage Assesment	SPOT imagery of bridges on the Tigris River taken on 19 Feb 91 and 10 Mar 91 showed intelligence personnel extent of damage to bridges (19:92)

Since the Gulf War, we in the military have recognized spectral imagery's value to our operations and are using spectral imagery more than ever. In fact, over the past few years, each of the services has established organizations to educate their personnel on the benefits and uses of spectral imagery, and to obtain and exploit spectral imagery for their use. The intelligence community's lead imagery organization, the National Imagery Mapping Agency (NIMA), has established points of contact for spectral imagery and is exploring alternatives to better provide it to the U.S. national security community. [18:—]

Now that we've seen that spectral imagery can be used in a variety of military applications and that the services are using it more than ever, let's take a look at how this imagery actually gets to the warfighter.

The imagery we use can either be new images taken for a specific request or images archived from previous purchases. Theater echelons can use archived imagery for applications such as updating maps or terrain characterization. Using archived imagery for these applications is suitable because features such as terrain and roads don't change that often. When using spectral imagery for applications such as BDA or to image enemy

forces' current positions, we need very recent imagery. Let's take a look at what is involved to get new spectral imagery.

When a theater echelon needs spectral imagery, it just doesn't go to the SPOT or LANDSAT vendor to buy the imagery; it has to use a specified chain to obtain it. Each service has established organizations to help theater components obtain imagery. Army Space Command and Naval Space Command have set up cells to provide spectral imagery to their respective components. For the Air Force, our point of contact for obtaining spectral imagery is the 480th Intelligence Group at Langley AFB, VA.

If the 480th doesn't have the imagery you need already archived or if you need new imagery, it will to go to NIMA to get it. If NIMA doesn't have it (or if you need new imagery), it has to order it from the vendor. [22:18] Your request for imagery may get up through the chain and to a vendor quickly. However, because of the revisit rates of civil and commercial spectral imagery satellite systems, the vendor might not be able to meet your request for several days or even weeks. LANDSAT's revisit rate is up to 16 days on-nadir. On-nadir is defined as taking an image directly below the spacecraft. Because LANDSAT can't slew its camera, it takes on-nadir shots only. SPOT can slew its camera, giving it a 2-6 day revisit rate off-nadir. SPOT can image on-nadir every 26 days. [28:7]

Once the vendor collects your imagery, it will give it to NIMA, who will pass it via the 480 IG back to you. As you can see, this collection and dissemination process is not responsive enough to meet time-critical needs of the military commander.

As mentioned earlier, military planners have seen the benefits of having timely spectral imagery available to the warfighter. Let's now discuss a few programs that could help solve the problem of no near-real-time spectral imagery available to the warfighter.

Possible Solutions

Warfighter-1

Warfighter-1 is a project under the Integrated Space Technology Demonstration Program (ISTD), a program designed to reduce the amount of time it takes to provide cutting edge technologies to the warfighter. [8:1] Currently scheduled for launch in fiscal year (FY) 2000, the Warfighter-1 satellite will employ a space-based hyperspectral sensor to provide imagery to support several warfighter applications. Among these applications are target detection/classification/identification, terrain characterization, battle damage assessment, and nuclear, biological and chemical material detection. [8:1]

Ok, you say we already are doing most, if not all, of the above applications using SPOT and LANDSAT imagery. So what does Warfighter-1 give us? First, Warfighter-1 will provide hyperspectral imagery. Second, the system will be geared toward providing timely spectral imagery to the warfighter. Let's take a closer look at each of these attributes.

Warfighter-1's hyperspectral sensor will be capable of imaging in 280 spectral bands with 8-meter resolution. [25:1-2] What does 8-meter resolution mean? If you placed two objects side-by-side, Warfighter-1 would be able to image them as two separate and distinct objects only if they were 8 meters or more from each other. By comparison, LANDSAT images in 7 spectral bands with 30-meter resolution. SPOT images in 3 bands with 20-meter resolution. Warfighter-1's enhanced spectral and spatial characteristics will give us a better capability to distinguish different materials as well as discern visual characteristics of objects in an image. This means that Warfighter-1's sensor can do a better job of detecting/identifying targets, classifying terrain, conducting battle damage assessment and detecting nuclear, biological and chemical weapons/activities. The sensor will also image in 5 km X 20 km scenes, giving it a broad area coverage capability. Now let's take a look at how it will provide imagery to the warfighter.

One of the program's goals is to show that spectral imagery can be used in time-critical or tactical situations. To decrease the time it takes to get imagery to the warfighter, this system transmits imagery directly

to a mobile ground station mounted on a High Mobility Multipurpose Wheeled Vehicle (HMMWV). To reduce the time it takes to task the satellite, that same mobile ground station will have the capability to uplink imaging commands to Warfighter-1. [26:4] Current plans call for the Warfighter-1 mobile ground station to task, image, & downlink a hyperspectral image in a single 10-minute satellite pass. After the satellite downlinks the image to the mobile ground station, system operators will process and disseminate images within three hours. [26:2]

Another way Warfighter-1 will be more responsive to tactical needs is that it will be able to image a particular target or area more often than LANDSAT and SPOT. Warfighter-1's 470 km sun-synchronous orbit will allow it to revisit a target for imaging every 2 to 3 days, compared to up to16 days for LANDSAT and up to 26 days for SPOT.

Warfighter-1 is a joint DoD/commercial program. The commercial partner, Orbimage, will build and operate the satellite from a fixed CONUS ground station. The government team, comprised of the Air Force's Space Warfare Center, Phillips Lab, and various other DoD participants, will evaluate the tactical utility of the system. [8:1] To evaluate user utility, the government team will conduct demonstrations at exercises in Germany, South Korea, Saudi Arabia and CONUS over a 1-3 year time period in which they will evaluate the effectiveness of system end-to-end operations. [26:2] The team will evaluate mission planning, scheduling and tasking, image collection and processing, product generation, and exploitation and dissemination. While these demonstrations won't be fully integrated with in-place operations, they will demonstrate how such a system can be integrated into a theater's collection management and imagery dissemination processes. [25:1-5, 1-6]

While this system's intended purpose is to evaluate hyperspectral technologies and tactical user utility of spectral imagery system, operational use of the system is a possibility after the demonstration period is over. The design life for the system is three years, but the goal is for the satellite to remain operational for five years. [25:7] This would leave two years of operations after the system evaluation is complete for Warfighter-1 to provide imagery to theater warfighters. An arrangement or contract with Orbimage would need to be in place to get imagery in additional years, but it may prove worthwhile to let theater users "wring the system out."

Now that we've looked at Warfighter-1, let's look at another program fielded to accomplish a similar goal, to get spectral imagery from space to the warfighter quickly: Eagle Vision.

Eagle Vision

One of the lessons the Air Force learned from Desert Storm was that commercial spectral imagery could not get to theater quick enough to meet timelines for mission planning. [9:—] To help improve this deficiency, the Air Force developed the Eagle Vision system.

The system, housed in a 20-foot shelter, receives spectral imagery directly from the imaging satellites then processes that imagery into formats required by users. [16:—] The entire system, including the shelter and 18 transit cases can be transported in two C-130s. [9:—] Originally capable of receiving SPOT imagery only, the system was recently upgraded to receive imagery from LANDSAT and Canada's RADARSAT, a synthetic aperture radar satellite. [16:—] To see how Eagle Vision expedites the receipt of spectral imagery to theater, we'll now take a look at the process from imagery request to receipt by the warfighter.

Eagle Vision can request an imaging event, then later receive the image. The system can also passively receive what the satellite is imaging. Let's say a theater echelon needs imagery of an area. After the request makes it through the collection management process to Eagle Vision, Eagle Vision operators will contact SPOT at least five days prior to the imaging event to request the shot. Operators can contact SPOT fewer than five days in advance for critical or emergency requests. SPOT operators will then process the request and deconflict with other potential customers for that imaging event. Once the satellite is in position and takes the requested image, it will downlink it to any station capable of receiving it (including Eagle Vision) near-real-time. In a passive mode, Eagle Vision operators would not contact SPOT to request an image, but monitor the images that come down as the satellite passes overhead, hoping for one that will meet their needs. This is possible because

Eagle Vision can receive whatever imagery SPOT downlinks, even if it is intended for other customers. [4:—]

Once the shelter receives the imagery, analysts process the imagery into a format required by the user. Eagle Vision can process simple scenes in about an hour, while more elaborate processing such as combining MSI with digital terrain elevation data to make 3-D scenes takes up to 18 hours. Eagle Vision then disseminates the imagery to the user via hard copy, fiber optic transmission or by writing the imagery file to a CD-ROM. [16:—]

The Air Force developed Eagle Vision as a demonstration under the DoD's Foreign Comparative Test (FCT) program. Under this program, the services test and evaluate nondevelopmental military equipment made by our allies to determine if it satisfies warfighter requirements or addresses mission area shortcomings. In the case of Eagle Vision, the system finished testing in 1995 and is currently demonstrating its capabilities around the world. An Air Force decision on procuring several units is pending. [2:—]

We've looked at two alternative solutions to providing timely spectral imagery, both from space-based sensors. However, space isn't the only place we can put a spectral sensor. Now let's take a look at the third alternative solution, spectral sensors on airborne platforms.

Manned Aircraft and Unmanned Aerial Vehicles (UAVs)

Manned aircraft and UAVs offer a potential for providing timely spectral imagery to the warfighter. In this section we'll look at airborne spectral imaging capabilities that could be implemented in the near future. First, let's take a look at manned aircraft. The DoD has one manned system capable of providing near-real-time imagery for the warfighter, the U-2R/S with the Senior Year Electro-optical Reconnaissance System (SYERS) payload. [11:—] While this sensor is not multispectral capable, a future upgrade to SYERS called the Multi-spectral Electro-Optical Reconnaissance Sensor will give it this capability. [20:—] The upgraded sensor, which is projected to fly in FY98, will have "high spatial resolution in six different spectral bands in order to enhance the U-2's detection and discrimination of targets." [12:—] Capable of imaging more than 100,000 square miles during a single 10-hour mission, the U-2 and SYERS payload downlinks imagery to the Contingency Airborne Reconnaissance System (CARS). [27:—] CARS, a 27-shelter deployable system, processes and disseminates the U-2 imagery to users.

While manned airborne platforms can provide the warfighter with imagery, there always exists the risk of putting an airman in harm's way when accomplishing one of these missions. For this reason, DoD planners are trying to move more and more functions to UAVs. While there are no current operational DoD UAVs carrying spectral sensors, plans for spectral payloads are in the works.

In 1997, the Joint Requirements Oversight Council's (JROC) UAV Special Studies Group worked with the services and operational CINCs to develop a list of potential payloads for UAVs. The group suggested using the U-2's Senior Year multispectral payload on the new Global Hawk UAV. [7:—]

The Global Hawk, currently undergoing testing, will be capable of loitering 24 hours over an area 3000 nm from its home base (40 hours at closer ranges) and at altitude of up to 65,000 ft, imaging a 40,000 square mile area during a single mission. [10:—] The current plans are for Global Hawk to carry synthetic aperture radar, electro-optical and infrared sensors. After taking an image, Global Hawk will downlink imagery line of sight to a ground station or transmit the imagery to a ground station via satellite communications relay. In both instances, Global Hawk will be able to provide near-real-time imagery to the theater. [24:—] Adding a multispectral sensor to this architecture would provide the warfighter an additional source to meet his time-critical spectral imagery needs.

While the Senior Year multispectral payload/Global Hawk combination is a JROC recommendation for future technology investment, it is a program that could be implemented in the near-term given enough funding. A final procurement decision on Global Hawk is due at the end of FY00. An operational multispectral sensor on Global Hawk could follow shortly thereafter.

Distributed Common Ground Station

While not a spectral sensor, it is worthy to mention here the architecture our solution should be compliant with. That architecture is the Distributed Common Ground Station (DCGS). Scheduled to begin operations in late 1998, the DCGS is a deployable system for receiving, processing, storing, and disseminating imagery to support Combat Air Forces and Unified Command users. [5:ES-1] It is important that our solution fit in with this architecture and not be "stovepiped." "Stovepiped" systems tend to use unique architectures that make information sharing difficult. Since we want to provide spectral imagery to a variety of users quickly, it is important that our solution meet the common standards DCGS can provide. This will prevent the user from having to accomplish time-consuming processing or converting after receiving the imagery.

We've looked at Warfighter-1, Eagle Vision, and airborne multispectral sensors, as well as the architecture our solution should comply with. Now let's compare and contrast these systems to determine which ones are best suited to meeting time-critical spectral imagery needs of the warfighter.

Analysis of Alternatives

To determine which solution will meet the problem of no near-real-time spectral imagery available to the warfighter, we'll look at the capabilities and limitations of the possible solutions concentrating on their ability to provide imagery to the warfighter in a timely manner. In order to analyze this timeliness issue, each solution will be looked at for three elements: rapid tasking by the theater, processing and disseminating imagery to users in a timely manner, and availability.

Tasking

One key element to getting imagery quickly is for the theater to have tasking authority over the imaging system. If a theater commander can task a system, it will be more responsive to his needs and therefore able to react and provide imagery faster. Let's now look at Warfighter-1 with this in mind.

One of the objectives of the program is to demonstrate the utility of a theater-tasked space system. [25:1-1] The Air Force is planning to give the HMMWV mobile ground system satellite tasking capabilities. If the program is successful in this, it will give the theater commander the capability to quickly task the system for imagery requirements.

Now let's look at Eagle Vision. Unlike Warfighter-1, the theater commander cannot task the spectral imaging satellites Eagle Vision uses, SPOT and LANDSAT. These two systems are in the commercial/civil sector and the theater commander can only request images from these systems. The theater has to compete with the other customers of these systems for imaging time.

Let's now look at the last solution, airborne systems. Both the U-2 and Global Hawk with the Senior Year multispectral payload will be theater resources. The theater commander will therefore have the ability to rapidly task these systems to meet his time critical imagery needs.

Processing and Dissemination

Another key element in getting timely imagery is the ability of system operators to quickly receive, process, and distribute imagery to users. Let's look first at Warfighter-1's capabilities in this area.

One of Warfighter-1's objectives is to demonstrate its ability to process and disseminate the imagery to theater users quickly using the mobile ground station. [25:1-1] The satellite will downlink imagery near-real-time as it is imaging an area. After the ground station processes and formats the imagery, operators will then disseminate the imagery out to the warfighter. The entire process from tasking of the satellite to imagery dissemination will take about three hours, good enough to meet most time-critical imagery requirements of a

theater commander.

Like Warfighter-1, Eagle Vision can receive imagery directly from satellites into the theater, process it, then disseminate it very quickly. Eagle Vision is currently able to process and disseminate imagery to users in between 1 to 18 hours, depending on the amount of processing required. [14:—] As with Warfighter-1, these timelines could meet most of the time critical imagery needs of the theater commander.

Both U-2 and Global Hawk will downlink imagery directly to a ground station or relay imagery to a ground station via a communications satellite, both methods being near-real-time. Analysts at the ground stations will rapidly process and disseminate the imagery to theater users in a matter of a few hours. Like Warfigher-1 and Eagle Vision, U-2 and Global Hawk spectral imagery processing and dissemination will get imagery to users quickly to meet time-critical needs.

Availability

The last element in providing timely spectral imagery to the warfighter is the sensor's availability for use. For the satellites, availability is a function of how often a satellite is over an area—the revisit rate. Warfighter-1's revisit rate is three days. This means that if a commander wanted to task Warfighter-1 to image an enemy airfield for BDA after a strike, he might have to wait up to three days until he get could get imagery of that airfield. In this circumstance, Warfighter-1 might not be able to meet the commander's needs. One way to improve on this is to increase the satellite constellation size. However, because Warfighter-1 is a technology demonstration, the Air Force is planning only one satellite.

Let's now take a look at Eagle Vision. Like Warfighter-1, a limitation to Eagle Vision is the revisit rates of the satellites it uses. With a two-satellite constellation, (LANDSAT 7 will be launched in the summer of 1998, bringing constellation strength to two satellites), LANDSAT's revisit rate over a target is every 8 days--on-nadir only. Using the three functional SPOT satellites, Eagle Vision could receive on-nadir shots of a target approximately every 8 days. [28:7] If the theater can use SPOT's off-nadir shots of a target, the news is a bit better. Its off-nadir revisit rate with three satellites ranges from twice a day to once every two days. Like Warfighter-1, the revisit rates of LANDSAT and SPOT could prevent Eagle Vision from providing timely imagery to theater users.

Finally, let's look at the airborne system's availability. Airborne sensors have an advantage over satellites in that they can loiter over an area and take images as long as their fuel holds out. If a theater commander desires continuous coverage over an area, he can launch another airborne sensor to provide overlapping coverage before the previously on-station platform returns to base.

However, enemy air defenses such as surface-to-air-missiles (SAMs) or anti-aircraft artillery (AAA) can threaten airborne platforms. Putting a U-2 over a heavily defended area could result in the loss of both the airman and the aircraft. While putting Global Hawk in the same situation would prevent putting an airman's life at risk, losing a valuable platform like Global Hawk could hamper a theater's intelligence gathering capability. Both the U-2 and Global Hawk would most likely fly over an area only after the U.S. achieves air superiority and conducts a successful suppression of enemy air defenses (SEAD) campaign. And even then, previously undetected or mobile SAM and AAA threats might be able to shoot these platforms.

Airborne platforms will be available to meet the theater commander's timely spectral imagery needs when not threatened by enemy air defenses. However, presence of air defenses could severely hamper their availability for use in providing timely imagery.

As we've discussed in this section, Warfighter-1, Eagle Vision, and airborne platforms all have unique capabilities as well as limitations to solving the problem of providing near-real-time imagery to the warfighter.

Table 3 summarizes these capabilities and limitations with regards to the three elements we just discussed.

Table 3. Comparison of Capabilities and Limitations of Solutions

	WARFIGHTER-1	EAGLE VISION	U2/GLOBAL HAWK
TASKING	+	-	+
PROCESSING & DISSEMINATION	+	+	+
AVAILABILITY	-	-	-

+ capability -limitation

As you can see in the table, none of the systems we've looked at is a 100% solution to the problem. With this in mind, let's now look at which solution will best serve warfighter's timely spectral imagery needs.

Recommendation

"You can take the example of [retired Chief of Staff] General Fogleman's vision to 'find, fix, target, track, and engage anything of significance on the face of the earth' as we enter the next decade...Some of that you will do from airborne platforms, some of it from space platforms, and some of it will migrate from one to the other. Some of it will always be best done with a ***combination of air and space****." Gen John Jumper, USAF 27 Oct 97*

To come up with a recommendation to solve the problem of providing near-real-time imagery to the warfighter, this paper compared the capabilities and limitations of the alternative solutions. As discussed above, none of the alternatives alone can solve the problem of providing near-real-time spectral imagery to the warfighter--each has limitations that will prevent them from being an effective sole source of timely spectral imagery for the warfighter. However, the capabilities of one alternative can complement the limitations of another. Based on this analysis, the best solution is using all three systems in a planned, integrated architecture.

Direct tasking of a spectral sensor by the theater commander makes it more responsive to his needs and therefore able to react to provide imagery faster. While Eagle Vision can provide a wealth of spectral imagery for the theater, the mere fact that the theater commander can't task SPOT or LANDSAT might hinder their ability to provide imagery when the commander needs it. He can, however, task Warfighter-1, U-2, and Global Hawk to support his needs and re-task them as needed to ensure they meet his emerging or changing requirements.

Also, because there will likely be gaps in satellite coverage with Warfighter-1 or when using Eagle Vision, a theater commander would likely need to use a U-2 or Global Hawk to get timely spectral imagery when no satellites are overhead. However, let's say the desired imagery is of an area deep in enemy territory and the U.S. has not yet established air superiority. The U-2 or Global Hawk may not be able to obtain the desired imagery because of adversary air defenses. The theater commander might have to use Warfighter-1 or one of the SPOT or LANDSAT satellites via Eagle Vision to get the desired imagery.

To effectively manage these systems, the theater commander needs a central element to accomplish sensor tasking as well as imagery processing and dissemination--the DCGS. The U-2's CARS and the Global Hawk's ground station are already migrating to the DCGS architecture. To ensure effective management of spectral sensors, Warfighter-1 and Eagle Vision should migrate to this architecture as well. This will effectively give the theater a single point of contact for obtaining timely spectral imagery.

One can envision a spectral imagery collection manager at the DCGS taking requests from subordinate units, prioritizing those requests, tasking the appropriate sensor, receiving and processing the imagery into a common format, then disseminating it to the requestor, all within a few hours.

Conclusion

As we've discussed, spectral imagery has proven itself an indispensable tool for use in military operations. We learned especially how useful this imagery is during the Gulf War. While we enjoyed the benefits of spectral imagery, we also realized that obtaining it took too long to satisfy some of our military requirements. While the current method of obtaining imagery, new or archived, through NIMA is adequate for some of our imagery needs, it can't give our commanders the situational awareness needed to make decisions in time-critical situations such as targeting and BDA.

The good news is that there are some efforts underway to demonstrate and operationalize a timely DoD spectral imagery capability. The bad news is that a long-term robust timely spectral imagery capability is years away. In fact, long-range planners foresee a constellation of DoD spectral imagery satellites in the 2013-2018 time frame. However, we can take advantage of the Warfighter-1 and Eagle Vision demonstrations and use them in conjunction with the emerging spectral imagery capabilities of the U-2 and possibly Global Hawk. Integrating all these capabilities into the DCGS architecture, we will be able to satisfy many of our time-critical spectral imagery needs within the next few years.

Our goal with spectral imagery, as well as any other information of value regarding our adversaries, is to help our commanders make sound decisions to prosecute the campaign. And the quicker we can get our commanders that information, the better able they are to make rapid decisions. An integrated spectral imagery architecture will do its part in helping our commanders get an edge on our adversaries—to get inside that OODA loop and defeat him on our own terms at a time and place of our choosing.

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PROVIDING EFFECTIVE SPACE FORCE ENHANCEMENT TO THE WARFIGHTER

Captain Richard W. Petty, Space CLASS 98 AIS

Introduction

A serious situation has developed in Magatona; the top generals just assassinated the democratically elected president. Immediately after, the generals stated their intent was to invade and overthrow neighboring Verbatimo, a very close U.S. ally. Magatona is marshalling troops along the border and the U.S. intelligence community estimates they will invade Verbatimo in approximately 30 days. The Joint Force Air Component Commander (JFACC) has tasked you to plan an integrated air and space campaign to achieve three objectives: 1) maintain air and space superiority throughout the entire conflict; 2) prevent the Magatona military from crossing the border; and 3) restore pre-hostility regional borders.

Being an operator, you understand how to plan an air campaign, but are not sure of how to plan and execute space forces. Wouldn't it be great to have a single point of contact for you to call? Fourteenth Air Force (14 AF) is the Numbered Air Force (NAF) responsible for the command and control of all Air Force space assets. It became operational on 1 Jul 93 and was designed to be the single point of contact to provide space force enhancement worldwide...anywhere, anytime!

Unfortunately, the level of in-theater space force enhancement you can expect to receive from 14 AF is limited due to manning, experience shortages and organizational deficiencies causing continuity problems and limited support to deployed forces. Fourteenth Air Force has developed a solution to fix these shortcomings. The problem is that budgetary constraints will delay implementation for another two years (8:-). This makes planning difficult for you and the JFACC!

To attack this problem, a review of some of the background is needed. This review will show that despite making great strides since its activation, 14 AF continues to experience difficulty when supporting warfighters. Fortunately, 14 AF understood this and created a detailed plan to solve their manning, experience and organizational problems. This paper will take an in-depth look at their plan and the negative impact the two-year timeline will have on the Combat Air Forces (CAF). Most importantly, this paper offers a three-phased ap-

proach, which if implemented, will bridge the two-year gap and provide the necessary manning, expertise and continuity well into the future.

Attempts to Provide Space Force Enhancement to the Warfighter

Major Commands

In the early 1980s, space was a sheltered community because Strategic Air Command (SAC) and Air Force Systems Command (AFSC) owned and operated these systems. SAC focused on fighting the cold war, whereas Systems Command focused on the acquisition and operation of space systems.

In the mid 1980s to the early 1990s, Headquarters Air Force Space Command (HQ AFSPC) attempted to fill the role of space warfighter. They were limited in their abilities because their primary focus, like AFSC, was the acquisition of new systems. Additionally, their focus was strategic, like SAC, versus the operational level of warfare. The space community needed an "eye opening" experience and it came with Desert Storm. During Operation Desert Storm, military planners realized the force enhancement value space brings to the fight. Thus, the roles and contributions of space forces changed from "nice to have" to "must have" during every phase of conflict. Yes, space played an important role, but its overall effectiveness was less than what it could have been. What was the problem? Tailored support was not available to theater commanders and there was no central "belly button" for space forces tasking. This resulted in limited integration of space into air operations planning. The result--HQ AFSPC realized the increased importance of space force enhancement and the need for a space NAF. Thus, today you have the 14 AF located at Vandenberg AFB. However, standing up a space NAF did not solve all the problems.

Numbered Air Force

Fourteenth Air Force experienced difficulty providing space force enhancement to the warfighter from the get-go because of three factors that have contributed to the manning, expertise and organizational deficiencies.

First, since its inception in 1993, 14 AF has played primarily an administrative role. HQ AFSPC did not fully understand the role the NAF would play. What they created was another command echelon rather than a true warfighting NAF.

Second, much of the space system expertise resides at 14 AF subordinate units. Therefore, many external agencies go VFR-direct to the space units bypassing the NAF entirely. Who can blame them? For example, in September 1997, the 6th Space Operations Squadron (SOPS) received a direct tasking from Air Force Weather Agency (AFWA) to provide Defense Meteorological Satellite Program coverage for Hurricane Fran as it hit the east coast of the United States. Time was critical, they needed the information from the "horses mouth," and got it!

The third factor is the relationship between 14 AF subordinate units and users of space products and deployed forces. Space squadrons had established relationships long before the 14 AF stood up, but unfortunately, many of these relationships went undocumented. This caused difficulty for 14 AF as it tried to get its "hands" around its responsibilities. These contributing factors have compounded and negatively affected the support provided to warfighters worldwide. There is a reason for this.

In the past, space squadrons provided warfighters information of various types and formats. This was done without centralized command and control or standardized procedures to ensure accurate, timely, and pertinent space information was received by the warfighter in theater (10:3). Previously, this was not an issue because space was not a highly tasked resource. However, since Operation Desert Storm, the requests for space force enhancement have grown. The reason for this, according to Maj Gen Perryman, 14 AF/CC, is "Air Force

space technology ... makes our troops safer and more effective, and there's no more efficient means for collecting and disseminating information about navigation, communication, intelligence, weather, and missile warning" (5:1).

Through the years, several organizations have attempted to provide space force enhancement to the warfighter. They have consistently missed their goal for one reason or another. Will this trend continue or will one of these organizations step-up to the challenge? Fortunately for the warfighter, 14 AF decided to tackle this problem.

Fourteenth Air Force Solution

Understanding that space was coming up short, 14 AF performed a top-down review to address its command and control problems. The 14 AF/CC chartered teams to identify solutions and develop a roadmap to improve space force enhancement provided to the flying CAF. Two major areas of focus were maximizing Global Positioning System (GPS) utility for the warfighter and developing a Space Tasking Order, similar to the Air Tasking Order (ATO). The Space Tasking Order serves as the mechanism for the 14 AF/CC to task his forces as the ATO tasks air assets for the JFACC (10:1-4). Additionally, 14 AF personnel went TDY to various locations around the world to learn how other NAFs set up and operate their air operation centers (AOCs), and what level of space support was needed to enhance their operations. After compiling all the findings, 14 AF grouped the results, identified several deficiencies, and determined some underlying causes.

The most critical issue was 14 AF's organizational structure. It was not set up to handle warfighter requests (6:-). Other limitations included the lack of a forward space presence in deployed locations and the lack of permanent-party space employment experts in theater. Fortunately, the United States Air Force Weapons School, Space Division, is presently filling the need for space employment experts. Activated on 1 July 1996, the division graduates 16 space weapons officers each year who receive assignments to combat NAFs and other CAF organizations to roll space capabilities into air operations. Moreover, Space Division instructors bring space to deployed locations by performing 120-day rotations. Presently, there is one permanent slot in Joint Task Force – Southwest Asia, manned 240 out of 365 days by Space Division instructors.

Finally, a 14 AF white paper, "Command and Control of AFSPACE Forces," addressed the organizational issue and lack of a forward space presence in deployed locations. It documented the need to stand up the 614th Space Operations Group (SOG). This group, when operational and fully manned, will serve as the equivalent of the theater AOC and will accomplish parallel planning and operational functions for the 14 AF/CC (4:-). This is a critical factor, because experience has shown that parallel operations are more effective, achieve results faster, and are less costly than serial operations (1:49).

Fourteenth Air Force's organizational structure will set up in accordance with joint practice and AF Instruction 38-101. The 14 AF peacetime structure shown in Figure 1 is equivalent to similar NAFs: it includes an A-1, A-2, A-3/5, A-4, and an A-6 section. The three squadrons depicted will fall directly under the guidance of the 614 SOG/CC who, in-turn, will work directly for the 14 AF/CC (4:11-12).

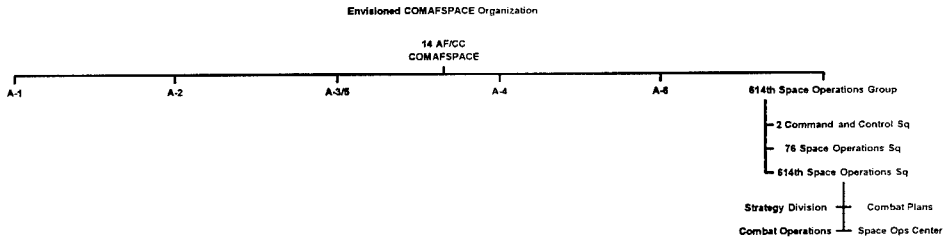

Figure 1. 14th Air Force's Proposed Organization

The purpose of the operations group is to consolidate command and control of all Air Force space

forces. The 2nd Command and Control Squadron is responsible for planning, assessing, and developing execution orders for passive surveillance missions. The 76th SOPS is responsible for the support relationship between the 14 AF/CC and JFACCs worldwide. The 614th SOPS has four divisions. Strategy, Combat Plans, and Combat Operations are similar to an AOC organization and the fourth division is the SOC (4:16).

The following is a brief description of each division to show how 14 AF is attempting to parallel AOC operations to provide space force enhancement desperately needed in theater.

Strategy Division

The Strategy Division will translate the supported CINC's campaign objectives and 14 AF/CC guidance into an executable strategy to guide Space Tasking Order development, directly supporting the ATO planning cycle. Additional focus areas include long-range planning, integration of space operations, and serving as space liaisons between USCINCSPACE (combatant command of all space forces) and component planners (4:17).

Combat Plans

Combat Plans Division will serve as the Space Tasking Order production team. They will plan near-term space operations in parallel with the space forecast provided by the Strategy Division to ensure the Space Tasking Order supports JFACC, USCINCSPACE and 14 AF/CC objectives. Additionally, this team will generate special instructions (SPINS), when appropriate, and disseminate the Space Tasking Order to all subordinates and to the AOC's Combat Plans and Strategy Divisions via the Global Command and Control System (GCCS) (4-17).

Combat Operations

Combat Operations is responsible for Space Tasking Order execution and providing direct support to forward-deployed JFACCs and Air and Space Expeditionary Task Force Commanders. Similar to Combat Operations in the AOC, this division will provide modifications to the tasking order to accommodate operational dynamics. Their most critical responsibility is the final verification of the Space Tasking Order. In close coordination with the AOC, they ensure the Space Tasking Order supports the commander's objectives (4:18).

Strategy, Combat Plans and Combat Operations will fill in the holes for the warfighter; however, they will not be fully manned until Fiscal Year (FY) 2000 and will still be in their infancy until around 2005.

Space Operations Center

The last division, the 614 SOC is a 24-hour focal point similar to a wing command post. The SOC, when fully integrated with the other divisions will correlate all information and oversee resource allocation necessary to support the JFACC, to include planning and execution expertise not located in theater. They are presently the single focal point within 14 AF for Air Force space assets and are working hard to establish direct liaison relationships with all theaters to improve space force enhancement efforts (4:19)

To provide centralized direction to subordinate units and improve situational awareness for the warfighter, the 614 SOG will provide the products listed in Table 1 (4:20)

Table 1. Situational Awareness Space Products

Product Name	What is it?	When is it distributed?
COMAFSPACE Operations Forecast	Reflects current maintenance status, exercise schedules, and resources available	Every 30 days
Master Space Operations Plan	Details COMAFSPACE guidance, forecast, commander's intent, and strategy	Weekly
Standing Order	Documents day-to-day tasking for subordinate space units	As Needed
Space Tasking Order	A mechanism to task space assets if request is outside Standing Order	As needed, however, units should receive it 24 hours prior to mission execution

In a nutshell, the 14 AF plan for four divisions (Combat Operations, Combat Plans, Strategy, and the SOC) provides the foundation to overcome the limitations presently impacting space force enhancement to the warfighter. It will also provide a forward space presence in deployed locations via the products listed in Table 1. These products will keep the warfighter abreast of any changes or degradation to space systems and will be immediately available on GCCS. Additionally, having a 24-hour space operations center should correct many of the lack of support problems experienced by warfighters requesting space products today. A good plan, but it's two years away!

Problem

Why is two years unsatisfactory? Today, space force enhancement support to theaters is limited because of manning, expertise limitations and 14 AF organizational deficiencies. If nothing is done to bridge the gap, space support to the CAF will be less than 100 percent.

Two years is too long to wait for optimum support to the warfighter. Warfighters rely on space assets and one promising way to deliver optimal space force enhancement is by implementing the following three-phase approach to expedite the two-year timeline for standing up the 614 SOG.

Three-Phase Approach

Phase I

This phase will begin with the identification of Subject Matter Experts (SMEs) at the wing or squadron level for each space system. The role of the SMEs will be to answer calls forwarded by the SOC from deployed forces. This direct access to space SMEs will improve the level of force enhancement provided to warfighters today. The goal should be something akin to field all questions within an hour of receipt. This is the kind of support warfighters need!

Operators identified as SMEs should be mission-ready (certified operators) and come from Tactics, Training, or Evaluation Sections. Typically, operators working in these sections have the best understanding of the capabilities and limitations of their system. The unit commanders would select their SMEs. The wing would forward the names to the SOC. The SOC will reference this list when fielding questions/requests from the field. For example, if someone has a GPS question, the SOC would forward the request to the on-duty SME

at 2 SOPS. Using SMEs will take the pressure off the SOC that, today, is ill equipped to handle technical questions. If units change personnel, it would be incumbent upon the unit to get new SMEs identified and notify the SOC of changes. Phase I temporarily fixes the organizational structure needed to field incoming support requests and accounts for the absence of a forward space presence in deployed locations. This phase buys 14 AF time to implement Phase II, which is using augmentees to stand up the 614 SOG in times of crisis.

Phase II

Phase II addresses the same issues as Phase I; however, Phase II is another step toward a more permanent fix. During this phase, 14 AF will use augmentees from subordinate units and other agencies to man the 614th during a crisis. This concept was borrowed from the 9th and 12th Air Forces. These flying NAFs stand up their AOCs when the JFACC orders sustained air operations. They bring in augmentees from several disciplines (space support teams, pilots, navigators, electronic warfare officers, communications and national intelligence agencies) to augment their staff. In addition, they use reserve or national guard personnel to augment the AOC staff during long deployments.

Personnel selected for augmentation duties in combat NAFs are experts in their primary duties or mission design series (MDS) and have received specialized training such as Joint Doctrine Air Campaign (JDAC), Joint Air Operations Staff Course (JAOSC), and other training directed by the NAFs. To reinforce previous training, personnel participate in Red Flag, Blue Flag, and other major exercises that bring the entire team together to exercise as a unit. Fourteenth Air Force could use a similar augmentee philosophy for manning the 614th during a crisis (2:-).

Augmentees would come from the 21st and 50th Space Wings. Using SMEs previously identified in Phase I, would put 14 AF ahead of the game. Additionally, for long deployments, 14 AF could use mission-ready reserve personnel from the 7th and 8th SOPS located at Schriever (formerly Falcon) AFB to augment their team. Another pool of expertise the 14 AF could tap into is the Space Warfare Center. These personnel can bring space, CAF, and joint expertise to the 614th. Though not considered primary players, their input would be invaluable in steering the 614th in the right direction, because improving space force enhancement is something they do every day.

However, who could 14 AF use to help stand up the 614th while awaiting the arrival of 21st and 50th Space Wing augmentation personnel? The answer is the 14 AF staff and instructors from the 381st Training Group also at Vandenberg AFB. Is this feasible? Colonel Mark Lilevjen, 381st Deputy Group Commander stated "it could be done and our instructors would provide the expertise needed to stand-up the 614th in time of need" (9:-). What this buys 14 AF is time. Personnel could be in place within an hour of tasking and begin working with unit and theater warfighters.

Identification of augmentee personnel is the first step, but how will 14 AF train them and maintain their currency? Personnel selected should attend JAOSC to learn the CAF language and the workings of a Joint AOC. They should also attend the Space Applications Advanced Course (SAAC) to bridge the gap between their system and the rest of the space systems, because space operators have a tendency to 'stovepipe.' To maintain currency, 14 AF could hold semiannual training in conjunction with exercises like the Mission Employment Phase held at the United States Air Force Weapons School every six months.

The first two phases will bridge the gap and provide space force enhancement for the next two years. What happens after that? As previously stated, the 614 SOG will have the manning necessary to sustain daily operations, but where is the continuity to prevent 14 AF from having the same problem with providing 24-hour space force enhancement? The answer is Phase III.

Phase III

Phase III calls for the creation of a full-time reserve or national guard unit at Vandenberg AFB. Operators in this unit would work within the 614th structure to provide continuity for years to come. They would be mission ready in a particular space system and maintain a high level of proficiency. This unit would play an enormous role in normalizing space for the 21st Century. If adopted, it would take the unit approximately 12-18 months to become fully operational (realize it will take time to find experienced personnel, get them up to speed in a particular space system, and relocate them to Vandenberg AFB).

Recommendation

A review of the entire three-phase approach is instructional. It is important to note that not everything will be corrected overnight. Implementation of Phase I can occur immediately. The identification of SMEs followed by some procedural training should not take more than a week. By implementing this phase, 14 AF will ensure the deployed warfighter receives timely and accurate information and alleviate unnecessary delays. Additionally, the tasking process is clearer because the SMEs will make the decision on whether or not filling the request is possible.

Phase II carries this effort forward, but also provides the manpower and expertise (augmentees) needed to stand up the 614 SOG during a crisis. The warfighter will have the single point of contact needed to roll space into air operations.

Finally, Phase III provides the continuity, with reserve or national guard, to ensure previous efforts are not repeated. With the three phases implemented, the warfighter will have the space force enhancement he needs and wants...in a timely and accurate fashion!

Conclusion

Since its inception, 14 AF has fought an uphill battle when trying to provide space force enhancement for flying CAF operations. The 14 AF/CC recognized the shortfalls of his unit and took corrective measures. The fix he identified, however, is dependent upon manning and expertise that will not be available until FY 2000. It is possible to overcome this two-year gap and provide much-needed continuity by implementing the three-phased alternative offered in this paper. This approach will alleviate the problems (manning, experience shortages and organizational deficiencies) experienced by warfighters when requesting space support.

Recall the opening scenario where Magatona was threatening to invade Verbatimo? The JFACC tasked you to plan an integrated air and space campaign that would achieve three objectives: maintain air and space superiority and stop Magatona from crossing the border now and in the future. Given the magnitude of the task, you were like a "deer in the headlights" wondering how to execute space forces and restore pre-hostility borders. Unfortunately, 14 AF was limited in the help it could provide because it did not have the manning, expertise, or organizational structure to help you.

On the other hand, consider how much better it would be if 14 AF had implemented the three-phase approach and you had the 614 SOG at your disposal. The 14 AF would be able to provide you with the expertise needed to effectively execute space forces. As you stand in front of the JFACC, he nods, and says "it's about time air and space worked together" and adopts your fully integrated air and space plan, thanks to that reachback from the 614 SOG!

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WHAT IS THE AEROSPACE INTEGRATION CENTER?

Lt Col Trest, AIC Director, DSN 682-6630

Officers from many nations are moving throughout the room. There is talk of suppression of enemy air defense (SEAD) missions, combat air patrols (CAP), surveillance with unmanned aerial vehicles (UAVs), Airborne Warning and Control Systems (AWACS) and Rivet Joint (RJ) orbits, and high and low strike options. Fliers from the various nations are gathered, making air campaign plans, taking into account multi-national, multi-service aircraft and discussing whether the Tornado or F-16 is best suited to counter threats such as F-4s and MIGs. Approach routes are planned taking into account surface-to-air missiles (SAM) that must be avoided, suppressed, or destroyed. Who and how can re-targeting against mobile targets such as SCUD transporter erector launchers (TELs) be accomplished? Aircrews and intelligence personnel are searching databases for the latest imagery. Others are discussing Air Defense System Integrator (ADSI) and Multi-source Tactical System (MSTS) capabilities, procedures, call signs, and frequencies. Is this the scene at a combined air operations center (CAOC) supporting operations in Bosnia-Herzegovina, Southwest Asia, or Korea? No, it's the Red Flag Building at Nellis Air Force Base, NV. Specifically, it's in the Space Warfare Center's Aerospace Integration Center (AIC).

What is the AIC? Simply put, the AIC mission is to integrate space assets and support into Red FLAG, Green FLAG, and the USAF Weapons School final Mission Employment (ME) phase. The AIC works with the Air Warfare Center (AWC) at Nellis and their operational test and evaluation (OT&E) units to test new or modified equipment, tactics, techniques, and procedures. USAF personnel from aviation, space, intelligence, and communications specialties man the AIC. Contractors support the display, processing, and communications equipment. These capable people expose and train aircrews and others on the systems providing three basic functions. First are tools for calculating satellite overflight times used in exploiting overhead capabilities or evading collection threats. The second type provide imagery used for surveillance, targeting, and route planning. The third category provides situational awareness displays for showing air and ground threats, relaying information and imagery to decision-makers or strike aircraft, and in-flight route tracking and mission adjustment. Let's look at each of the three areas and see how the AIC is able to integrate space into day-to-day battle plans and air operations.

The AIC has much of the same equipment found in an AOC or aircraft supporting AOC operations. For the FLAGS, the AIC is integral from planning to execution. Systems capable of calculating satellite orbits help determine the best time to strike with Global Positioning System (GPS) guided weapons, when to time air strikes to take advantage of overhead imagery for intelligence preparation of the battlefield (IPB), or

calculating best opportunities to collect bomb assessment (BDA). Ground radars and missile launches can be modeled, if needed. Enemy satllites can be taken into account in planning to avoid detection or exploitation by intelligence collection capable satellites. Typically, aircrews come to the AIC for target imagery or to gain a sense of what they will face out on the Nellis Range. Archived images from spacecraft and aircraft are available via internet connections, on-site storage, or live feeds from the UAVs being broadcast over the Global Broadcast System (GBS). Images can be captured and printed or transmitted as needs dictate and aircraft capabilities allow. After a crewmember has their target folder, they might want to step over the MSTS and "fly" their mission. This system allows the pilot or weapons system officer to rehearse their mission by pulling up maps of their planned route. Imagery draped over Digital Terrain Elevation Data 9DTED) gives the appearance of flying through the valleys and over the peaks they will see out on the Nellis Range. Even threats such as an SA-2 they will see are displayed showing the threat ring, or basket, they must avoid. Actual electronic emitters can be displayed as radar, aircraft, or other assets intercept their signal. When the aircrew steps on the airplane and flies their mission, they continue to receive information from the AIC. The ADSI or MSTS takes live inputs from tactical broadcast networks, radars on the Nellis Range, ad the AWACS or other aircraft capable of sending data directly or through data links. Displayed iformation on the systems gives a complete air and ground threat picture. The AIC also relays information by radio or improved data modems (IDM) to the AWACS and strike aircraft. This process helps all players keep a common, complete picture throughout the fog of the air battle. During planning, execution, and post-battle assessment, the AIC ensures aircrews get exposure to systems, tactics, and procedures they will see in single-service, multi-service, or multi-national operations.

Among the main equipment and systems available at AIC are:

SMAT – Satellite and Missile Analysis Tool
UNEST – a Unix-based National satellite exploitation tool
OMEGA – Operational Model to Exploit GPS (Global Positioning System) Accuracy
MET – Multi-Image Exploitation Tool
5D – Demand Driven Direct Digital Dissemination
SIPRNET – Secure Internet Protocol Routing Network
GBS – Global Broadcast System
MSTS – Multi-source Tactical System (with Combat Track II)
ADSI – Air Defense System Integration
TRE (SUCCESS radio) – Tactical Receive Element
STRED – Standard TRE Display
IDM – Improved Data Modem
CIS AA – Combat Intelligence System with Automatic Association
CTAP Tutorials – Contingency Theater Automated Planning System

If you want experience before showing up for duty at a CAOC or AOC, the AIC can help. If you want to know more about air operations, or AOC equipment and system employment, the AIC is a place where as a space warfare officer, intelligence officer, or aircrew member you can go to get needed hands-on experience with machines and communications capabilities you will encounter in any AOC. For more information call the AIC Director, Lt Col Trest, at DSN 682-6630.

USAF WEAPONS SCHOOL SPACE DIVISION INSTRUCTOR CADRE

NAME	TITLE	AREAS OF RESPONSIBILITY	DSN 682-x	EMAIL
FRONT OFFICE				
Lt Col Gregory "Mr. Bill" Billman	Commander	Space Policy Space Doctrine Weapons Officer Training	x-2065	wss@nellis.af.mil
Maj Jeffrey "Massa" Gruner	Operations Officer	Communications Systems Joint Operations Planning Weapons Officer Training	x-5184	jeffrey.gruner@nellis.af.mil
Maj Frank "Forrest" Gallagher	Assistant Operations Officer, Support Div	Communications SIGINT Theater Missile Defense	x-3336	frank.gallagher@nellis.af.mil
Maj Christopher "Scout" Kinnan	Assistant Operations Officer	GPS Accuracy Prediction Theater Missile Defense	x-3336	christopher.kinnan@nellis.af.mil
TSgt Emma Duren	Information Security Specialist	Admin & Security	x-5365	emma.duren@nellis.af.mil
MISSIONS FLIGHT				
Maj Donald "Gouda" Ridolfi	Missions Flight Commander	Theater Missile Defense	x-6719	donald.ridolfi@nellis.af.mil
Capt Nathan "Chili" Lindsay	Instructor	SIGINT MASINT	x-7106	jim.lindsay@nellis.af.mil
Capt Billy "Sensei" Starkey	Instructor	Space Control	x-7106	billy.starkey@nellis.af.mil
ACADEMICS FLIGHT				
Capt Bruce "Squirrel" Rayno	Academic Flight Commander	IMINT Remote Sensing	x-5360	bruce.rayno@nellis.af.mil
Capt Alan "Rebel" Rebholtz	Instructor/Scheduler	Space Control	x-6962	alan.rebholtz.nellis.af.mil
STUDENTS FLIGHT				
Maj Michael "Coyote" Smith	Student Flight Commander	GPS/NAVWAR Space Control	x-3138	michael.smith.@nellis.af.mil
ATTACHED INSTRUCTORS				
Maj (Sel) Joanna "Nuts" Sobieski	Assistant Operations Officer Support Division	IMINT	x-6820	joanna.sobieski@nellis.af.mil
Maj Robert "Ratdog" Wasserman	Assistant Operations Officer, Support Division	Theater Missile Defense Operations Planning Tactical Comm Systems Tactical Comm Networks	x-8792	robert.wasserman@nellis.af.mil

NOTES:

1. Effective 30 Sep 98 Maj David "Muff" Wilsey will be assigned to HQ USAF/XOOO, Pentagon, Washington DC
2. USAF Weapons School-Space Division Internet address: www.nellis.af.mil/usafws/default.
3. USAF Weapons School SIPRNET address: wws@nellis.af.smil.mil

USAF WEAPONS SCHOOL-SPACE DIVISION PAPERS

To access unclassified papers via Internet: http://wwwmil.nellis.af.mil usafws/spacesp.htm
To access classified papers via SIPRNET: http://204.20.176.135/weapons_school/index.htm
Web Page OPR: Cindy McKinney, DSN 682-6625

PAPER TITLE & SYNOPSIS	CLASS	AUTHOR/ ADVISOR	CLASS
Atmospheric Scintillation and UHF Satellite Communications	U	Ackerman Jeffcoat	96B
SYNOPSIS: This paper analyzes UHF satellite communications problems, specifically examing Atmospheric Scintillation of UHF communication and proposing solutions.			
Theater Warning	SCI	DeGeer Jeffcoat	96B
SYNOPSIS: Instructional Text **NOTE: DETERMINED "NO DISTRO" DUE TO BEING INSTRUCTIONAL TEXT**			
Communications Fundamentals	U	Gallagher Jeffcoat	96B
SYNOPSIS: Instructional Text			
Annex N, Space Operations for Dummies	S	Gruner Jeffcoat	96B
SYNOPSIS: This paper analyzes the components that define good OPLAN Annex N, Space Operations, and how to effectively improve one if it's not effectively defined and documented.			
Signal Intelligence Fundamentals	SCI	Kuwashima Jeffcoat	96B
SYNOPSIS: Instructional Text **NOTE: DETERMINED "NO DISTRO" DUE TO BEING INSTRUCTIONAL TEXT**			
Integrating Space into the Fight	U	Perales Jeffcoat	96B
SYNOPSIS: This paper analyzes how Space Division graduates will attempt to accomplish the immediate task of fully integrating today's space capabilities into current combat operations. **PUBLISHED: USAF Weapons Review, Summer 1997; Space Tactics Bulletin, Jan 1998**			
Defense Meteorological Satellite Program (DMSP)	U	Rayno Jeffcoat	96B
SYNOPSIS: Instructional Text **NOTE: DETERMINED "NO DISTRO" DUE TO BEING INSTRUCTIONAL TEST**			
Why the USAF Weapons School needs a Space Division	U	Smith Jeffcoat	96B
SYNOPSIS: Examination of what space will bring to the battlefields of the 21st century, not only in force enchancement roles, but in force application as well. **NOTE: NO HARD COPY OR SOFT COPY OF PAPER ON FILE DUE TO CLASSIFICATION**			

Imagery Dissemination	SCI	Sobieski Jeffcoat	96B

SYNOPSIS: Text on Imagery Intelligence product dissemination.
NOTE: DETERMINED "NO DISTRO" DUE TO BEING INSTRUCTIONAL TEXT

Space Support to a Theater Air Operations Center	U	Wasserman Jeffcoat	96B

SYNOPSIS: This paper examines how information from space assets support theater operations with a particular focus on operations at the AOC level. It also examines space support provided by Space Weapons Officers assigned to the AOCs.

Global Positioning System Error Analysis	U	Wilsey Jeffcoat	96B

SYNOPSIS: This paper performs an analysis of the errors inherent in Global Positioning System satellite signals and presents GPS mission planning techniques which should be used to ensure combat operations are performed at times of optimum GPS accuracy.

Using the JOPES Process to get Space Support	?	Echiverri	97A

SYNOPSIS:
NOTE: NO HARDCOPY OR SOFTCOPY OF PAPER ON FILE

Use of Foreign Communications Satellites for Combat Operations	S	Hanak	97A

SYNOPSIS:

14th Air Force Space Operations Center: Reachback Support For The Space Weapons Officer	U	Jefferson	97A

SYNOPSIS: This paper is about 24-hour Space support to the warfighter or the Space Weapons Officer's primary reachback tool. That is, where the Space Weapons Officer can get current space status, intelligence on space related threats, Air Force Space Support Team (AFSST) support, Crisis Action Planning support, and assistance in developing or updating their Operations Plan's Annex-N. It discusses the background of the 14th Air Force's Space Operations Center (14 AF SOC); what it is, what it isn't, and most importantly, its current capabilities and limitations.

Navigation Warfare	?	Konnath	97A

SYNOPSIS:
NOTE: NO HARDCOPY OR SOFTCOPY OF PAPER ON FILE

Theater Support Operations Cell (TSOC): A Space Situational Awareness Tool	U	Pletcher	97A

SYNOPSIS: In modern combat, information can determine the outcome of a conflict. To be useful in conflict, there must be a system to bridge the gap between the information produced by our space systems and the operational or tactical commander. Without this interface, data is of very little value. This "bridge" for space systems is the Theater Support Operations Cell (TSOC). The purpose of this paper is to provide background on the TSOC system, highlight its capabilities and limitations, and its ability to provide timely, tactically relevant space derived information to operational and tactical commanders.
NOTE: DETERMINED "NO DISTRO"

Space Weapons Officer Responsibilities In The Theater	U	Prestgard	97A

SYNOPSIS: The intent of this paper is to provide an initial roadmap for the Space Weapons Officers once they arrive in their Area of Responsibility (AOR). Space Weapons Officers are a new breed of animal and no one knows exactly what their roles and responsibilities are. The role and responsibilities of the Space Weapons Officer will be fulfilled by applying our "Patch" knowledge in the different theaters. However, based on the capabilities of our space systems and the Air Force's role in the different theaters, we can

assume the Space Weapons Officer will integrate space assets in support of their AOR's combat role, in particular, how space can support putting bombs on target on time.

Gimme Some Space! (Or Overcoming Obstacles To Integrating Space Into CAF Operations)	U	Ridolfi	97A

SYNOPSIS: In these times of shrinking budgets, force drawdowns and doing more with less, the Air Force faces ever increasing challenges to combat capability. The Quadrennial Defense Review (QDR) results announced on 19 May 97 called for even further reductions in manpower and infrastructure. One way to overcome these challenges is to integrate space into Combat Air Forces (CAF) operations. This integration would make CAF operations more effective, efficient and save lives and equipment. There are many challenges to integrating space. This paper identifies present obstacles to integrating space into CAF operations and recommends solutions. How to integrate space is up to the units involved, but this discussion will help identify and overcome some of the things that can impede progress toward that goal.
NOTE: DETERMINED "NO DISTRO"

How to Prepare for the Next Solar Maximum	U	Bishop Gruner	97B

SYNOPSIS:
NOTE: DETERMINED "NO DISTRO"

The Hunt for Red Missiles: Detecting, Tracking, and Destroying Theater Ballistic Missiles Before Launch	U	Cross Perales	97B

SYNOPSIS: Desert Storm revealed a significant weakness in the US's ability to eliminate the Theater Ballistic Missile (TBM) threat. The solution to this problem is the detection and destruction of the TBM and it's associated equipment before launch. This paper describes one means of pre-launch detection of TBM through the use of the Unattended Measurement and Signature Intelligence (MASINT) Sensor (UMS), which can be tuned to detect a particular vehicles acoustic frequency. The paper further describes the UMS employment process and compares the capabilities and limitations of both airborne and spaceborne collection platforms used to relay UMS data to decision makers and strike aircraft.
PUBLISHED: Space Tactics Bulletin, Summer 1998 (proposed)

Use of Conventional Ballistic Missiles in Theater Operations	U	Griswold Wasserman	97B

SYNOPSIS: There is a growing trend for nations to protect their high value assets such as command and control facilities and weapons of mass destruction by using buried hardended structures. A large number of these Hardended Deeply Buried Targets (HDBTs) are impervious to attack except by nuclear means. This paper presents as a solution the use of conventional ballistic missiles to defeat these HDBTs. It goes on to explain the employment process and the capabilities and limitations of this weapon system.

Dominant Battlefield Awareness: The Commercial Key to Tactical Warfighter Success	U	Kinnan Gruner	97B

SYNOPSIS: No formal plan exists to augment our space communication systems during contingency or wartime operations. The assumption is that the government will be able to contract for all the bandwidth it needs. There are problems with such ad hoc planning and contracting schemes. This paper addresses these SATCOM problems and suggests an alternative solution — to structure, prioritize, and negotiate standard contracts, in a manner similar to the CRAF, prior to conflict.

Custom Product Network – Closing the Gap Between National Imaging Systems and the Needs of the Warfighter	SCI ?? Needs Class RVW	Lindsay	97B

SYNOPSIS: This paper describes the Custom Product Network (CPNet), an imagery dissemination tool developed by the National Reconnaissance Office and the National Imaging and Mapping Agency, which can enable tactical users to receive soft copy images in near real-time. It advocates the use of near real-time imagery obtained through CPNet by mission planners to improve the effectiveness of tactical military operations.

Joint Planning for the Extended Tether Program — Using Space Assets to Solve the Line-Of-Sight Constraints of Near-Real-time Aerial Reconnaissance | S | Starkey | 97B

SYNOPSIS: This paper advocates and explains the use of the Extended Tether Program (ETP) as a capability that merges the U-2 reconnaissance system with pre-existing space systems to create a more secure, versatile, and deployable aerial collection resource. When properly integrated with other collection resources available to theater commanders through inclusion in joint operational planning, ETP can fill a critical gap in providing superior battlespace awareness to the warfighter.
PUBLISHED: USAF Weapons Review, Classified Edition, Summer 1998

Composite Space Wing – Improving Space Warfighting | U | Vidmar
Perales | 97B

SYNOPSIS: Currently, to accomplish their various missions, all the services depend heavily on space systems to provide force enhancement for their assets in theater. This paper proposes one option for how the Air Force can best provide tactical space support in order to satisfy theater warfighting requirements for space force enhancement today, and space force application in the future. That option being the formation of a Composite Space Wing to manage responsive launch and direct control of satellites to provide flexible and near real-time support to the warfighter.

A Comparison of Current Orbital analysis Tools and the Needs of the Space Weapons Officer | U | Zeitler
Smith | 97B

SYNOPSIS: Space Weapons Officers lack two essential tools in the field; a high fidelity instructional aid and a standardized planning tool necessary to make space a more integral part of the Joint Air Operations Center. This paper is a basic study tying orbital prediction and instructional display tools to theater combat requirements. It discusses some of the orbital analysis tools currently available as well as analyzing the results of a survey to determine the "concept tool" that Space Weapons Officers really want and need.

Integrating Adversary Space Capabilities Into Exercises | U
W/SCI Anx | Bulter
Wilsey | 98A

SYNOPSIS: This paper examines the current adversary space threat focusing on how space products and services are obtained by other nations and how adversaries plan to deny the U.S. access to our space capabilities. It justifies the need for a space adversary unit and proposes a concept of operations. Finally, after careful analysis, a recommendation is made of where to place this unit for maximum benefit to the USAF.
PUBLISHED: Submitted to USAF Weapons Review – proposed to submit to STB

What Planners Need to Know about GPS Jamming | S | Colon
Wasserman | 98A

SYNOPSIS: This paper is a brief look at navigation warfare (NAVWAR) and basic concepts that a planner needs to know about GPS in order to be as effective as possible in employing GPS-guided weapons. The trend in the military is towards more and more GPS-guided weapons. Potential adversaries recognize the importance of GPS to our military operations and may seek to deny our access to the GPS signal in a future conflict. Planners must know what weapons are currently using/will use GPS and how to mission plan for these weapons in a GPS jamming environment. This paper provides the basic information a mission planner needs to begin understanding what he needs to do to employ GPS munitions effectively.

UHF SATCOM as an Alternative to the Improved Data Modem (IDM) for the F-16 Block 50 HARM Targeting System. | S | Dant
Gruner | 98A

SYNOPSIS: Improved enemy integrated air defenses systems (IADS) are a serious threat to US airpower. Potential enemies are investing in IADS at a pace that exceeds US platforms, doctrines and planning. The suppression of enemy air defense (SEAD) is absolutely critical to the effective use of air and space power to win our nations wars. Two primary players in SEAD are the Block 50 Viper and the Rivet Joint. The IDM is the primary communication method for the Rivet Joint and Viper in the SEAD role. There are numerous limitations to the connectivity. This paper offers UHF SATCOM as a possible alternative solution/backup to IDM and provides supporting evidence for SATCOM as a viable and tactically relevant possibility.
BEST PAPER CLASS 98A
PUBLISHED: Submitted to USAF Weapons Review

Timely Spectral Imagery for the Warfighter | U | Gossett
Gruner | 98A

SYNOPSIS: During the Gulf War, the military used spectral imagery from commercial and civil imaging satellites on an unprecedented level. Our military used spectral imagery for several applications including targeting and battle damage assessment (BDA). However, normal methods of obtaining this imagery weren't timely enough to meet all the theater's spectral imagery needs. While the military has made strides towards developing timely spectral imagery systems, it will be several years before we have a robust DoD spectral imagery capability. In the meantime, there are two demonstration systems and an emerging operational capability that could deliver timely spectral imagery to the warfighter. The paper discusses these options and makes a recommendation for ensuring we have a timely spectral imagery capability within the next few years.
PUBLISHED: Proposed to submit to STB

Effect Of Weather On Space Based Theater Missile Defense (TMD)	S	Lutton Ridolfi	98A

SYNOPSIS: The military lacks a broad awareness of and effective means to account for the impact of weather on space based warning systems. The paper reviews critical background information to include the history of TMD, the science behind weathers effect on space based sensors, and the pillars of TMD. With the foundation established, an analysis of the current situation leads to a recommendation for theater commanders to overcome this limitation.
PUBLISHED: Submitted to Space Battle Lab

Providing Space Force Enhancement for the Warfighter	U	Petty Ridolfi	98A

SYNOPSIS: 14th Air Force has set itself up to be the focal point for all Air Force space assets. However, their present organizational structure is not set up to handle theater space requests. To correct this deficiency, 14th Air Force created the 614th Space Operations Group and the 614th Space Operations Squadron that will provide centralized command and control for all space tasking. Unfortunately, this organization will not be fully manned or operational until Fiscal Year 2000 due to budgetary constraints. This paper presents a three phased solution to overcome this limitation and allow 14th Air Force to provide optimal space force enhancement to the warfighter today.
PUBLISHED: Proposed to submit to STB

Tactical Employment of Space Control	U	Rebholz Rayno	98A

SYNOPSIS: This paper explains and advocates how to command, control, and execute future space control operations in a tactical manner. It presents the definition of space control and shows its current command and control structure. It then advocates and justifies an alternative command and control architecture for future space control operations. This paper does not cover the areas of legal considerations, blue space forces deconfliction, exploitation, end-state considerations, tasking orders or retaliation. These issues are all beyond the limited scope of this paper.

The Space Weapons Officer and the Air Expeditionary Force	U	Sterns Lindsey	98A

SYNOPSIS: Military operations previously conducted in the air, on land, and from the sea are evolving into space. As such, the evolving concept of the AEF needs a mechanism for direct space support to their operations to capitalize on current and future space capabilities. Currently however, AEFs do not have personnel with space expertise directly integrated into their operations. This paper delineates the merits of having a Space Weapons Officer (SWO) dedicated to AEF operations. It presents a brief sketch of AEF operations and analyzes how space assets and SWOs can impact and enhance AEF operations.
PUBLISHED: Submitted AEF Battle Lab

USAFWS GRADUATE TRACKER

GRADUATE	CURRENT UNIT	CURRENT BASE	JOB TITLE	DSN
Ackerman, Mitchell D. "Cliffy" Maj	HQ AFSOC/DOXS	Hurlburt Field, FL	Ch, Space Sys Ops	579-5932
Billman, Gregory M. "Mr Bill" Lt Col	USAFWS/WSS	Nellis AFB, NV	Commander	682-2065
Bishop, David A. "Flex" Maj	607 COS/TMD	Osan AB, Korea	Space Ops Officer	(315) 784-1520
Butler III, Rudolph E. "Rhett" Capt	3 AF	Mildenhall AB, GB	Space Wpns & Tactics Off	
Colon, Miguel J. "Shark" Capt	32 AOS	Ramstein AB, GE	Space Wpns & Tactics Off	(314) 480-7328
Dant, Daniel A. "Sphynx" Capt	76 SOPS	Schriever AFB, CO	Space Wpns & Tactics Off	560-9518
DeGeer, Diane "Laika" Capt	SWC	Schriever AFB, CO	Space Wpns & Tactics Off	
Echiverri, Kathy N. "Yoda" Maj	HQ USAFE/XPXS	Ramstein AB, GE	Dep Ch, Long Range Strat	(314) 480-7328
Gallagher, Frank P. "Forrest" Maj	USAFWS/WSS	Nellis AFB, NV	Ass't Ops Officer	682-8792
Gossett, Todd W. "BS" Capt	14 AF	Vandenberg AFB, CA	Space Wpns & Tactics Off	275-6250
Griswold, James W. "Bohdi" Capt	5 AF/DOX	Yokota, Japan	Space Ops Officer	(315) 225-4007
Gruner, Jeffrey S. "Massa" Maj	USAFWS/WSS	Nellis AFB, NV	Operations Officer	682-5184
Hanak, David W. "Alf" Maj	609 IWS/DOX	Shaw AFB, SC *Riyadh	Space Warfare Planner Space Wpns & Tactics Off	965-2670 *(318) 435-7567
Jeffcoat, Thomas M. "Top" Lt Col	USAFWS/DCOA	Nellis AFB, NV	Deputy Commandant	682-5777
Jefferson, Vince B. "Dodger"	HQ 16 AF/DOXP	Aviano AB, Italy	Chief, Space Operations	(314) 632-8433
Kinnan, Christopher J. "Scout" Maj	USAFWS/WSS	Nellis AFB, NV	Ass't Ops Officer	682-6962
Konnath, Anne M. "Konan" Capt	HQ 8AF/DOXZ	Barksdale AFB, LA	Chief, Space Ops & Plans	781-4237
Kuwashima, Gary R. "Rastro" Maj	HQ SAF/AQS	Pentagon, DC	PEM, Space Based Laser	225-9640
Lindsay, Nathan J. "Chili" Capt	USAFWS/WSS	Nellis AFB, NV	Ass't Missions Flight Cmdr	682-7106
Lutton, Michael J. "Lips" Capt	Projected: 32 AOS	Ramstein AB, GE	Space Wpns & Tactics Off	(314) 480-7328
Perales, Michael H. "Ham" Maj	HQ AF/XOOC	Pentagon, DC	Chief, Space Ops and Strat	227-8996
Petty, Richard W. "Pit-Stop" Capt	76 SOPS	Schriever AFB, CO	Space Wpns & Tactics Off	560-9518
Pletcher, Brian S. "OT" Maj	ACSC	Maxwell AFB, AL	ACSC Resident Student	
Prestgard, Greg A. "Presto" Maj	612 CPS/DOXP	Davis-Monthan, AZ	Chief, Space Tactics & Ops	228-5124
Rayno, Bruce "Squirrel" Capt	USAFWS/WSS	Nellis AFB, NV	Academics Flt Cmdr	682-5360
Rebholz, Alan F. "Rebel" Capt	USAFWS/WSS	Nellis AFB, NV	Instructor, Academics Flt	682-6962
Ridolfi, Donald H. "Gouda" Maj	USAFWS/WSS	Nellis AFB, NV	Missions Flight Cmdr	682-6571
Smith, M.V. "Coyote" Maj	USAFWS/WSS	Nellis AFB, NV	Student Flight Cmdr	682-5538
Sobieski, Joanna "Nuts" Maj	USAFWS/WSP	Nellis AFB, NV	Ass't Ops Officer	682-4759

Starkey, Billy L.B. "Sensei" Capt	USAFWS/WSS	Nellis AFB, NV	Instructor, Missions Flt	682-6719
Sterns, Peter B. "Howie" Capt	Cope Thunder	Elmendorf AFB, AK	Space Wpns & Tactics Off	317-377-4655
Van Hook, Richard B. "Dick-B" Capt	613 AOS/DOJX	Andersen AFB, Guam	Space Warfare Planning	(315) 366-1053
Vidmar, Mark K. "Villian" Maj	14AF/DOXE	Vandenberg AFB, CA	Space Wpns Instructor	276-2919
Wasserman, Robert A. "Ratdog" Maj	USAFWS/WSP	Nellis AFB, NV	Ass't Ops Officer	682-4718
Wilsey, David G. "Muff" Maj	USAFWS/WSS	Nellis AFB, NV	Ass't Ops Officer	682-6962
Zeitler, Catherine M. "Xena" Capt	32 AOS/AOW	Ramstein AB, GE	Chief, Space & Info Ops	(314) 480-7290

STUDENTS

Balts, Keith W. "Weed" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538
Brost, Todd M. "Q" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538
Flores, Peter J "Fester" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538
Pulliam, G. Russell, "Popeye" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538
Rawson, Holly B. "Gooey" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538
Rhodes, Kevin M. "Gordo" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538
Schaupp, Reagan E. "Blinky" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538
Sleeth, Denette L. "Styx" Capt	USAFWS/WS	Nellis AFB, NV	Weapons Under-Graduate	682-5538

FY99 COURSE SCHEDULE

SAAC (SPACE APPLICATIONS ADVANCED COURSE)

DATES	DATES	LOCATION	LOCAL POC
1 Dec 98	18 Dec 98	Schriever AFB	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610
9 Mar 99	26 Mar 99	Schriever AFB	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610
13 Apr 99	30 Apr 99	Schriever AFB	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610

DATES	DATES	LOCATION	LOCAL POC
11 May 99	28 May 99	Schriever AFB	SWC/DOTR (719)567-9640/8610

			DSN 560-9640/8610
20 Jul 99	6 Aug 99	Schriever AFB	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610
17 Aug 99	3 Sep 99	Schriever AFB	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610

CSAWC (COMMANDER'S SPACE APPLICATIONS FOR THE WARFIGHTER COURSE)

DATES	DATES	LOCATION	LOCAL POC
20 Jan 99	20 Jan 99	AFSOC, Hurlburt Fld	
27 Jan 99	27 Jan 99	AFMC, Wright-Patterson	
Mar 99 (Pending)	Mar 99 (Pending)	AMC/ANG, Scott	
Jun 99 (Pending)	Jun 99 (Pending)	PACAF, Hickam	
Aug 99 (Pending)	Aug 99 (Pending)	ACC/AFRC, Langley	
Sep 99 (Pending)	Sep 99 (Pending)	USAFE, Ramstein	

SWISC (SPACE WEAPONS INSTRUCTOR SPIN-UP COURSE)

DATES	DATES	LOCATION	LOCAL POC
1 Dec 98	18 Dec 98	Schriever AFB	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610
8 Jun 99	25 Jun 99	Schriever AFB	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610

GE 98 (GLOBAL ENGAGEMENT 98)

DATES	DATES	LOCATION	LOCAL POC
7 Oct 98	9 Oct 98	BETAC	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610
26 Oct 98	28 Oct 98	BETAC	SWC/DOTR (719)567-9640/8610 DSN 560-9640/8610