HANDBOOK

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OPERATING in a DENIED, DEGRADED, and DISRUPTED SPACE OPERATIONAL ENVIRONMENT

LESSONS AND BEST PRACTICES

Operating in a Denied, Degraded, and Disrupted Space Operational Environment

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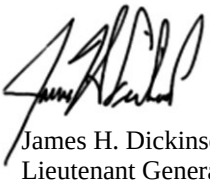
Foreword

This Center for Army Lessons Learned (CALL) handbook is a collaboratively produced effort providing the Warfighter with techniques and strategies to successfully operate in a denied, degraded, and disrupted space operational environment (D3SOE). It provides information derived from lessons learned and best practices on how to effectively integrate space capabilities into mission planning, training, and mitigation strategies for operating in a D3SOE. The space domain is a vital component of the emerging concept of the multi-domain battle and the Warfighter is reliant on the capabilities it provides to be successful in executing operations.

We must leverage space capabilities in preparation for current conflicts. Today's adversaries are aware of the U.S. military's use of space-enabled equipment and will try to disrupt those assets. The space domain is critically important to Joint/Coalition forces and it takes an integrated team effort to succeed and remain ahead of our potential adversaries. The target audience for this publication is not confined to the Army space cadre whom deliver our critical space-enabled capabilities to the U.S. Army and Joint community. It includes all Warfighters: Sailors, Marines, Airmen, Coast Guard, Soldiers, and Department of Defense Civilian employees. All of us working together as a Department of Defense team will operate in a D3SOE setting against near-peer opponents in current and future conflicts.

The Army depends upon space capabilities to enable and enhance land warfare; virtually every Army and Joint operation benefits from these capabilities. The use of space domain assets increases the effectiveness of our combat forces. We can communicate, navigate, target, find, fix, and finish the enemy; anticipate weather and its impact on operations; and protect our forces based on information available from the space domain.

Lessons and best practices in this handbook help train and prepare our Soldiers and leaders to continue to successfully operate from remote, globally deployed locations to protect the Army and Joint force, and protect critical assets around the globe. Integrating space domain capabilities into mission planning and training will prepare and enable our forces to successfully fight and win future conflicts in a D3SOE while protecting our Homeland, our Warfighters, and our way of life.



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Commanding

Operating in a Denied, Degraded, and Disrupted Space Operational Environment

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Introduction

Recall for a moment the devastating impacts improvised explosive devices (IED) had on U.S. military operations throughout OPERATION ENDURING FREEDOM (OEF) and OPERATION IRAQI FREEDOM (OIF). This weapon, varied and plentiful, was the enemy's lethal weapon of choice. It caught the U.S. Army ill-equipped and untrained to operate within an IED operational environment (OE), IEDs were the number one casualty-producing weapon employed against U.S. troops. It significantly restricted the U.S. military's freedom of movement and it required the U.S. to invest many tens of billions of dollars in countermeasures (counter-IED). The IED was arguably the enemy's "king of battle" during OEF and OIF. The harsh reality was that the U.S. Army's training readiness was insufficient at the onset of these operations to provide a high level of force protection and to operate in an IED OE.

"We have got to recondition ourselves to a different type of war, since 9/11, we've been doing counterinsurgency and counterterrorism against relatively lightly armed and low-tech foes, but "there are many other types of war, and the one that is perhaps most difficult and challenging — and a very real possibility — is a larger war against a near-peer or a much more capable state adversary… in very rugged, urban, complex terrain. In that environment…if you're stationary, you'll die. Your logistics lines and your lines of communications are going to be under intense stress, (and) the electromagnetic spectrum is going to be at least degraded if not completely disrupted…and yet you're still going to have to fight and you still have to win."

– GEN Mark A. Milley, Chief of Staff of the Army

Breaking Defense
"Let Leaders Off The Electronic Leash: CSA Milley "
Sydney J, Freedberg Jr., 5 May 2017

Now imagine "OPERATION NEXT WAR (ONW)" against a near-peer threat (e.g., China or Russia). It is both predicted and likely any one of these near-peer threat's "king of battle," or at least one of the major arrows in its quiver, will be the electromagnetic spectrum (EMS). The EMS has been referred to as the "spinal cord of the modern Army," and the Army which best operates and maneuvers within, and protects and weaponizes the EMS, will have the combat advantage. A sobering thought is that the threat's offensive operations within the EMS has the potential to create the

same devastating impacts on U.S. combat formations in ONW as IEDs had in OEF and OIF. The space-based equities within the EMS, specifically, the U.S. military's protection and reliance on the Global Positioning System (GPS); satellite communications (SATCOM); space-based intelligence, surveillance, and reconnaissance (ISR) capabilities; and associated frequencies are of major concern. The U.S. Army's current training readiness is not optimized today to operate and win in a denied, degraded, and disrupted space operational environment (D3SOE). The D3SOE is a composite of the conditions, circumstances, and influences which affect the employment of space effects and capabilities. A D3SOE is applicable to both the EMS and physical assets and impact to either may seriously test the limits of adaptability for all warfighting functions. Examples include signal jamming, signal spoofing, physically or virtually disabling or destroying space assets such as ground control stations and satellites, and disabling or deceiving user equipment.

Operating effectively in the space domain is a top Department of Defense (DOD) priority. The U.S. Army, evolving from a space-enabled to a space-dependent force, is the largest user of space-based capabilities within the DOD. Space-based capabilities are enablers in planning, preparation, and effective execution across the full range of military operations. They are a critical component of an agile, responsive, and tailorable force capable of responding to any mission, anywhere, and at any time.

This handbook supports the Army Space Training Strategy (ASTS) which addresses key aspects of space training and education for Soldiers and leaders at every echelon. Space education and training, fostered in the institution, must be applied and reinforced in the operational training domain. The Army must train as it expects to fight against a near-peer, ensuring the Army is a decisive force of action, trained and ready to prevent, shape, and win future conflicts. Operational training in contested space operational environments progressively moves Soldiers and units from exposure to competence to confidence in leveraging space-enabled capabilities. Army leaders and Soldiers will be able to initiate and maintain access to space capabilities and mitigate attempts to deny, degrade, and disrupt that access, as well as continue to execute combat operations when space-enabled capabilities are not available.

This product also reinforces the ASTS objective to improve the Army's understanding and use of space capabilities, products, force enhancements and protection to enable unified land operations, especially in contested space operational environments.

The ASTS key tasks/lines of effort include the following:

Institutional. Increase space knowledge across the force by incorporating it into institutional training.

Operational. Train units at home station and combat training centers (CTCs) on how to exploit space capabilities and respond in a D3SOE.

Personnel Development. Continue to train Army space cadre (See Appendix A, Space Cadre).

"Clearly, freedom to operate in space is not guaranteed. In fact, space is now a warfighting domain, similar to the more familiar air, land, and maritime domains our men and women are fighting in today."

Joint testimony submitted to the Senate Armed Services Subcommittee on Strategic Forces

Source: "Top Air Force Officials: Space is now a Warfighting Domain, Space Policy Online, Marcia S. Smith, 17 May 2017.

The importance of the space domain as one of the key components of multi-domain battle (MDB) (along with the air, land, maritime, and cyberspace domains) cannot be understated. Potential adversaries, and near-peer threats will seek to disrupt our space capabilities. Much of the equipment units rely on are space-enabled. For instance, there are more than 2,500 pieces of space-enabled equipment in a Stryker brigade combat team (SBCT). Lessons and best practices in this product provide "a way" to employ mitigation techniques and strategies to help overcome D3SOE challenges and reduce risks to Soldier and unit mission accomplishment. Units must train in a setting at home station and combat training center (CTC) rotations in conditions replicating what they will experience in combat. Incorporating space-enabled capabilities through all operational environments, including a D3SOE, meets the Army vision to provide training experiences which better reflect the complex operational challenges troops will face in future conflicts.

Endnotes

1. Electronic Spinal Cord of the Modern Military, from the Breaking Defense magazine article, January 12, 2017, by Mr. Sydney J. Freedberg Jr. titled, "Cyber/EW, Aviation, Air Defense, Artillery: CSA Milley's Priorities."

Chapter 1

U.S. Army Reliance on Space-Enabled Capabilities

Today's Army is trained to operate with countless devices and weapons systems which either require or are enabled by space-based assets. These include, but are not limited to, various precision-guided munitions (PGM); communications systems; navigation systems; intelligence, surveillance, and reconnaissance (ISR) assets; and battle-tracking devices. The U.S. Army has become accustomed to fighting with almost uninterrupted, or assured, access to these space-enabled capabilities ever since they became available. The Army first started seeing these capabilities at the tactical level in relatively large numbers during OPERATION DESERT STORM with PGMs and satellite communications (SATCOM) capabilities, etc. Since then, these space-enabled capabilities have increased significantly. The U.S. Army's adversaries have not tried to deny or disrupt our access to space in any large manner. They have observed, learned, and planned for the U.S. Army's heavy reliance on space-enabled devices and associated assured access. At the same time, Army Soldiers and leaders continue to expect access to space-enabled capabilities and many assume they will always be available.

> *"The Army divested much of its EW capabilities, given the fight in which it has been engaged for the last 16 years.*
>
> *Now we're finding that those capabilities did not go away on our threat — enemy, adversaries — at the near-peer level."*
>
> – MG Bo Dyess, Acting Director of the Army Capabilities Integration Center at TRADOC.
>
> "Electronic Warfare Emerging in Army Arsenal"
> Mark Pomerleau, 18 May 2017
>
> https://www.c4isrnet.com/c2-comms/2017/05/18/electronic-warfare-emerging-in-army-arsenal/

U.S. adversaries have numerous capabilities designed to deny assured access to space-enabled capabilities. They are developing, improving, training, and – in some cases – executing in battle, their own systems which may affect our assured access to space. In many instances, the technology and sophistication is not difficult to acquire and operate even by non-peer or non-state actors. For example, the Global Positioning System (GPS) signal is relatively weak and easily jammed by basic equipment which can be inexpensively acquired worldwide. More sophisticated equipment can try to manipulate (spoof) the GPS's positioning, navigation, and timing (PNT) signals to confuse and disrupt U.S. forces which are using GPS-

enabled devices. These are generally terrestrial effects but our adversaries can also attack our assets in the space domain. Although This requires more sophisticated equipment and training, access to the space domain is also currently available to near-peer adversaries and other state actors.

> *"The common thread running through the paper is the challenge posed by Russia's jammers and other electronic warfare tools."*
>
> *An enemy equipped with these "could effectively neutralize a GPS system from 50 miles away using one-fifth the power of a tactical radio," the report estimates, so "we should assume that GPS will be either unavailable or unreliable for the duration of the conflict if the [brigade] faces a near-peer threat or sophisticated non-state actors."*
>
> – Wesley Morgan, "U.S. Army Unprepared to Deal with Russia in Europe", Politico, 2 Sep 2017

There are natural and manmade factors which also affect the Army's access to space-enabled capabilities and the electromagnetic spectrum (EMS). The EMS and access to space capabilities can be affected by both terrestrial and space weather, terrain and vegetation, unintentional EMS interference, space debris, etc. See Appendix E for a graphic on factors that can create a denied, degraded, and disrupted space operational environment (D3SOE).

Senior Army leaders understand the threat posed by our adversaries and the various environmental conditions of the operational environment (OE) which may challenge our assured access to space. Thus, the Army is emphasizing the need to train in complex conditions like a D3SOE at both home-station training and at the combat training centers (CTCs).

The Army is developing training and combat solutions across the doctrine, organization, training, materiel, leadership and education, personnel, facilities and policy (DOTMLPF-P) construct to enable unit training and warfighting capability. In the meantime, commanders must train their units to fight with the equipment and training enablers on hand. Some training enablers include, but are not limited to, graphic training aids (GTA), space subject matter experts at the division staff, Soldiers with a 3Y Skill Identifier, and electronic warfare personnel in the unit. Soldiers must be trained to better understand the capabilities and limitations of their equipment with respect to operating in a D3SOE. Simple measures, like encrypting the PSN-13 Defense Advanced Global Positioning System Receiver (DAGR) are quite effective at helping to defeat and deter enemy jamming and spoofing attacks. Another is to establish mission command, and communication procedures such as antenna displacement, and manual battle tracking in the command post which reduces its electronic footprint. Of course, like any combat capability, we must plan and execute training

with these conditions in mind to achieve success in accomplishing the mission.

> *"There isn't a single aspect of our space architecture that isn't at risk."*
>
> Lt Gen David Buck, Commander 14th Air Force, "Why the Next Pearl Harbor Could Happen in Space"
>
> Newsweek, 6 May 2016

Chapter 2

Planning Considerations for a Denied, Degraded, and Disrupted Space Operational Environment

"The Army's newly formed Rapid Capabilities Office (RCO) underscores the pressing need to address threats [into mission planning, training, and operations] to Army and Joint networks [from near-peer adversaries], both cyber-attack (hacking) and electronic warfare (jamming), in particular against the GPS [Global Positioning System] signal on which U.S. forces rely… In [eastern] Ukraine and Crimea, Russian [new generation warfare] capabilities transformed RCO focus: mainly electronic warfare; Position Navigation and Timing [PNT], and cyber.

Focusing on Russia, one finds that it presents many problems for the U.S. Army, from its missile-deflecting main battle tanks to cluster munitions to tactical nuclear weapons. But the greatest threats lie in cyberspace and electromagnetic spectrum. Russia's hacker corps brought Estonia to a standstill in 2007…Russia's electronic warfare corps didn't disband after the Cold War – as the U.S. Army's did – and can by turns paralyze Ukrainian military communications and triangulate their sources for artillery bombardment.

So what's the single worst thing Russian cyber and electronic warfare (EW) can do? Both of them can go after the Global Positioning System. So can anti-satellite weapons, but it's easier to jam the signal or hack the software than to shoot down the satellites. Without GPS, U.S. troops don't know precisely where they are and the most precision weapons go blind. Without GPS, modern radios and communications networks don't know precisely what time it is, so senders and receivers go out of synch, potentially rendering them deaf and dumb. No wonder, then, that the military is looking intently for other ways to get…Position, Navigation and Timing.

We built a network that allowed us to maneuver and have good operational awareness…Now this network may become a vulnerability in itself. More than just defend against cyber/EW attack, the Army needs to learn to take the battle to the enemy in the cyber and electromagnetic domains just as it does on land. The ultimate goal is what evolving Army doctrine calls multi-domain battle, with simultaneous and mutually supporting actions on land, at sea, and in the air, space, cyberspace, and electromagnetic spectrum."

Source. "Red Electrons: Army Rapid Capabilities Office Fights Russian GPS Jamming, Cyber, and EW," Sydney J. Freedberg Jr, 22 Nov 2016, http://breakingdefense.com/; based on author's dialogue with (former) Deputy Commander of U.S. Army Europe, Major General Walter Piatt.

Space-enabled capabilities are quickly becoming enemy targets. Space enables extended operational ranges and increases operational tempo (OPTEMPO) and units must be ready to operate in a Disrupted Space Operational Environment (D3SOE). To do this effectively, units must heed the lessons and best practices identified below.

Lessons/best practices

- **Prepare**. Train in normal and contested space operational environments, with and without the use of space-enabled assets.
- **Recognize**. Know what a D3SOE looks like (Recognize Electromagnetic Interference [EMI]) Task 150-MC-5903.
- **React**. Take all appropriate steps to mitigate the effects of a D3SOE (React to EMI) Task 150-MC-5902.
- **Report**. Inform interested parties of suspected EMI to maintain situational awareness at all levels.

The following planning/execution/procedural considerations are applicable to multiple warfighting functions. They provide mitigation techniques along with lessons and best practices which battle staffs and Soldiers can use when planning and executing operations in a D3SOE.

Mission Command/Movement and Maneuver

- Prepare for manual (versus automatic) population of the common operational picture (COP). For example, Command Post of the Future (CPOF) may be required.
- Use an analog map board to track movement and maneuver.
- Ensure unit primary, alternate, contingency, and emergency (PACE) plan is current and thoroughly rehearsed.
- Use a map and compass when GPS-enabled devices are unavailable and/or inoperable.
- Increase the use of the Inertial Navigation Systems (INS).
- Ensure proper employment and increase use of graphic control measures such as boundaries and phase lines.
- During pre-combat checks in an unjammed environment, establish Defense Advanced Global Positioning System Receiver (DAGR) “jammer finder” baseline signal strength reading.

Satellite Communications (SATCOM)

- Ensure the unit PACE plan is current and thoroughly rehearsed (see detailed PACE information in Chapter 6).
- Use line-of-sight (LOS) communications in lieu of satellite communications (SATCOM).
- Prioritize communications traffic.
- Transfer data/information manually or verbally.
- Master control stations (MCS) need to transmit timing at regular intervals to keep timing synchronized.
- Practice configuring and receiving timing via non-automated methods; for example, those other than the automated "boot" file.
- Use LOS unmanned aircraft system (UAS) data links to conduct retransmission operations, especially when fewer ISR platforms are available.
- Retransmission sites require additional security measures; for example, using an infantry squad for security decreases available combat power.
- Deploying alternate command posts may require additional personnel and equipment.

Intelligence

- Use LOS UAS.
- Request repurposing of fixed- and rotary-wing assets.
- Repurpose assets to function as scouts.
    - Repurposing combat power may change force ratios.
    - It may require additional forces to achieve an appropriate force ratio throughout the operation.

Fires

- Increase use of the fires brigade/battalion-level survey teams.
- Increase use of laser-guided munitions. This requires laser-compatible rounds, laser designators, and communications.
- Plan for increased use of conventional munitions. This adds logistical tail.

- Use a DAGR with GPS lock-acquired signal from outside the D3SOE.
- Increase use of GPS/INS weapons (i.e., Army Tactical Missile System [ATACMS]).
- Use consequence management considerations for potential increased collateral damage issues.

Sustainment

- Change to the push versus the pull philosophy for logistics support.
- Use manual procedures and hard documents to track and request equipment and parts.
- Use conventional airdrop versus Joint Precision Airdrop System (JPADS).

All planners, regardless of warfighting function, should integrate D3SOE concerns into mission planning.

Chapter 3

Training Event Observations:

Home Station, Combat Training Centers (CTCs), and Command Post Exercises (CPXs)

For more than three years, the United States Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) has provided denied, degraded, and disrupted space operational environment (D3SOE) training support throughout Training and Doctrine Command (TRADOC) schools and courses. This includes space operations training support to combat training center (CTC) events (National Training Center [NTC], Joint Readiness Training Center [JRTC], Joint Multinational Readiness Center [JMRC], Mission Command Training Program [MCTP]); Army Service Component Command (ASCC)-level exercises; and home-station training (HST) events. HST support includes preparatory space operations training (classroom, hands-on, and live-effects training) at home-station locations leading up to each CTC training event. Requested training can include classroom instruction and/or live effects for individual and operator, unit live situational training exercise (STX)/field training exercise (FTX) integration, and all echelons of staff training. CTC support includes refresher training for a rotational training unit (RTU) and observer-coach/trainer (OC/T) support to the CTC Operations Group. USASMDC/ARSTRAT currently funds all temporary duty (TDY) costs when going to unit HST and CTC events.

Some USASMDC/ARSTRAT key observations and trends have become largely predictable as combat units continue the challenging transition from more than 16 years of counterinsurgency (COIN) operations, when the U.S. military operated with virtually uncontested space supremacy, to preparing for a war when adversaries are expected to aggressively challenge the U.S. military's space advantages.

The following key observations and trends reflect training and readiness from individual operators of space-enabled systems through brigade (BDE) and below collective training (STX lanes, FTXs, CPXs) and collective staff operations at division, corps, and ASCC command posts.

Section I: Division and Above-Echelon Observations, Fiscal Year 16-17

USASMDC/ARSTRAT provides academic and hands-on D3SOE training to the Army's battalions (BNs) and BDEs at home station and at the Army's maneuver CTCs (NTC, JRTC, and JMRC). USASMDC/ARSTRAT also supports the Army's MCTP for division, corps, and ASCC headquarters with D3SOE instruction, reach-back, and OC/T support in preparation for and during their Warfighter exercise (WFX) and ASCC command post exercises.

> *"In light of the current threat, training for degraded conditions should be considered critical. Opponents in future conflicts will continue to seek asymmetrical means to offset the US technological reliance on PNT [positioning, navigation, and timing] and the network…The unit should be able to shoot-move-communicate under degraded, less than optimal, conditions. Being able to fight under degraded conditions is an extremely perishable skill and should be trained as a regular part of annual cyclic training and certifications."*
>
> "Degraded Operations Whitepaper," Headquarters, United States Army Field Artillery School (USAFAS), page 8, 12 Oct 2016.

Academic instruction on D3SOE considerations may be requested by the training audience to be included in the MCTP-hosted mission command training (MCT) event. Reach-back support to D3SOE planning and operations is coordinated through the division Space Support Elements (SSEs) and is available as staffs develop their plans and annexes for the WFX. Additional support can also be requested for D3SOE planning and operations during home-station CPXs or other workups to the capstone exercises. Finally, USASMDC/ARSTRAT provides OC/T augmentation focused on D3SOE to MCTP Operations Groups Alpha and Delta, division, corps, and the ASCC headquarters.

D3SOE instruction during the unit's MCT is requested through the hosting MCTP Operations Group (A or D), while reach-back and home-station support can be requested through the USASMDC/ARSTRAT G-3-7 Army Space Training Integration Branch – commercial: 719-554-1924/1923 (DSN 692).

"A good staff reports what happened. A better staff reports what happened and gives analysis. The best staffs report what happened, give analysis and provide recommendations."

Division commander, during a recent Warfighter final after action review

The top D3SOE-related observations noted during FY 16 and FY 17 MCTP Warfighters and ASCC exercises include but are not limited to the following:

Observation #1: Units are developing and employing innovative techniques to identify and target enemy D3SOE systems.

Discussion. During the planning process, half of the divisions in FY 17 WFXs developed leaflets for distribution to internally displaced persons (IDP) requesting their help in identifying and reporting threat jammers. In these WFXs, the divisions conducted the necessary research, analysis, and coordination to develop and "distribute" these handbills and then exploit the information gathered (see Figure 3-1).

Recommendations. The space denial threat varies from large and immobile strategic systems to truck or small man-portable jammers to easily disguisable and distributed systems and networks. Many will be difficult to detect. Any means which can gather information on these systems should be employed for analysis, order of battle identification, and targeting.

References. Field Manual (FM) 3-14, *Army Space Operations*, Chapters 4, 5, and 8, 28 Nov 2017; Army Warfighting Challenge #7, Conduct Space and Cyber Electromagnetic Operations and Maintain Communications**.**

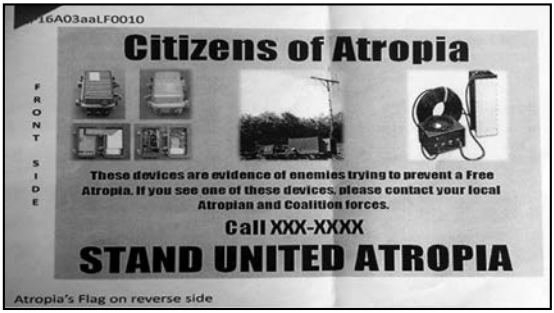

Figure 3-1. Flyer identifying threat systems for reporting by IDPs.

Observation #2: Space and D3SOE awareness and training are generally lacking across the staff.

Discussion. D3SOE is a condition of the modern battlefield, yet its effects are often not understood, identified, nor recognized and responses and reactions are not addressed across the warfighting functions outside the SSE. This is evident in unit operations orders (OPORDs), annexes, and fragmentary orders (FRAGORDs) which do not address or synchronize D3SOE considerations. Integration of space considerations is gradually improving across the force but only about a third of the units observed through FY16-17 had adequate Space Operations annexes (Annex N) which did more than just excerpt from doctrinal field manuals; and only half of those units with useful Space Operations annexes adequately addressed space considerations in other staff annexes such as Annex B (Intelligence); Annex C, Appendix 12 (Cyberspace and Electromagnetic Activities [CEMA]); Annex D (Fires); or Annex H (Signal).

Recommendations. Staffs must be educated and trained to integrate D3SOE considerations into planning and operations. At the division, corps, and ASCC levels, introductory D3SOE staff instruction during the unit's MCT is vital and should be requested through the hosting MCTP Operations Group (A or D).

References. FM 3-14, *Army Space Operations*, Chapters 4, 5, and 8, Change 1, 28 Nov 2017; Army Warfighting Challenge #7, Conduct Space and Cyber Electromagnetic Operations and Maintain Communications.

Observation #3: Units which received D3SOE MCT in preparation for WFX effectively applied recommendations, lessons learned, and best practices thereby improving operational execution.

Discussion. Annex N included more applicable and detailed space considerations. This improved staff integration and synchronization/ execution of OPORDs, annexes, FRAGORDs, battle drills, and operations. SSEs and Army Space Support Teams (ARSSTs) contributed to more boards, bureaus, cells, centers, and working groups; directly influenced operations (collection plans, high-payoff target list [HPTL], fires); and were able to provide valuable and innovative products and ideas. D3SOE considerations were also included as the commander's critical information requirements (CCIR) "wake-up" criteria for the commanding general (CG). For example, CCIR #6 Loss of any critical strategic asset: (terminal high-altitude area defense [THAAD]/strategic – strat lift/satellite [Global Positioning System (GPS) or communications]).

Recommendations. Staffs must integrate D3SOE considerations into planning and operations. Unit SSEs must be integrated into the military decisionmaking process (MDMP) and all staff planning efforts. At the division, corps, and ASCC levels, introductory D3SOE staff instruction during the unit's MCT is vital with tangible results for those units receiving it and should be requested through the hosting MCTP Operations Group (A or D).

References. FM 3-14, *Army Space Operations*, Chapters 4, 5, and 8, Change 1, 28 Nov 2017; Army Warfighting Challenge #7, Conduct Space and Cyber Electromagnetic Operations and Maintain Communications.

Observation #4: Although integration of D3SOE in planning is gradually improving across the force, integration of space operations in current operations (CUOPS) and future operations (FUOPS) is lagging.

Discussion. Integration of space and D3SOE is lacking due to a number of factors inhibiting information sharing. Typically space estimates are not maintained and space considerations are not briefed at the daily updates (commander update briefing [CUB]/battle update briefing [BUB] or during CUOPS "seven minute drills." Space integration is also severely hindered by lack of web portal pages, access to Command Post of the Future (CPOF) systems, or other collaborative tools including commercial systems such as Ventrilo or Adobe Connect. Additionally, the physical location of the SSE in unit command posts (separated from main staff or in limited access sensitive compartmented information facilities [SCIFs]) has often hindered productivity and information sharing with the rest of the staff. CUOPS processes and procedures often lack functional D3SOE battle drills, communications contingency (primary, alternate, contingency, emergency [PACE]) plans, or detailed SSE standard operating procedures (SOPs).

Recommendations. Space operations personnel (SSEs and ARSSTs) must be equipped and trained to contribute to CUOPS and FUOPS. As with any other staff section, SSEs must maintain running estimates to include such information as satellite statuses, terrestrial weather impacts, space weather impacts, enemy and friendly space activity, and status of space support requests (SSRs). SSEs and/or ARSSTs should be required to brief relevant space information – at least by exception – during drills, updates, and assessments. They should be equipped with the appropriate communications, web portal access systems, and collaboration tools to enable real-time information sharing. Space operations need to be considered across all planning horizons (plans, FUOPS, and CUOPS), and

across all warfighting functions. Units must ensure SOPs and battle drills address a D3SOE (electromagnetic interference [EMI] of GPS; satellite communications [SATCOM]; and space-based intelligence, surveillance, and reconnaissance [ISR] systems). See Appendix D, Sample Division-level EMI Battle Drill, for more information.

References. FM 3-14, *Army Space Operations*, Chapters 5 and 7, Change 1, 28 Nov 2017; Army Warfighting Challenge #7, Conduct Space and Cyber Electromagnetic Operations and Maintain Communications.

Observation #5: Distributed Common Ground System – Army, Space Variant (DCGS-A/Space) employment is underutilized and connectivity remains a challenge at the division level.

Discussion. SSE abilities to produce space analysis products with assigned systems varies greatly, and directly affects SSE effectiveness. Unit modified tables of organization and equipment (MTOEs) authorize SSEs a DCGS-A, LIN A35329, nomenclature Workstation Portable Multifunction: AN/TYQ-93(V). DCGS-A/Space enables SSEs to produce space analysis products and conduct space-specific analyses (e.g., GPS Interference and Navigation Tool [GIANT], access to space-enabled databases such as web-based IR data for operators and warfighters [WIDOW]). When properly networked and employed on secure Internet protocol router network (SIPRnet), the DCGS-A/Space is highly effective in supporting planning and operations across the warfighting functions. DCGS-A/Space systems fielded to division SSEs and ARSSTs often are not permitted access to the unit's networks despite on-hand authorization to operate (ATO) documentation, resulting in inoperable and non-networked systems, and SSEs and ARSST being incapable of providing effective space support.

Recommendation. To best support planning and operations with space analyses across all warfighting functions and all planning horizons in a complex training and operational environment, units must deploy their DCGS-A/Space systems and ensure space professionals are thoroughly trained on its use. This must be addressed during the exercise planning events cycle (initial, middle, and final event planning) in preparation for exercises or prior to real-world deployment (i.e., in operational plans and orders).

References. FM 3-14, *Army Space Operations*, Chapters 7 and 8, Change 1, 28 Nov 2017; Army Warfighting Challenge #7, Conduct Space and Cyber Electromagnetic Operations and Maintain Communications.

Observation #6: D3SOE modeling and simulations in WFXs is limited.

Discussion. Current modeling and simulation effects of D3SOE lack detail and depth within the WFX/Warfighter Simulation (WARSIM) confederation and do not accurately replicate threat capabilities or friendly intelligence collection and analysis capabilities. This may lead to "negative training" based on overly simplified or inaccurate workarounds and misrepresentation of space-enabled capabilities. Also, unit SSEs are not able to fully exploit their space analysis systems and processes due to an immature space simulation "backbone" which is incapable of providing detailed data for realistic analysis and does not interface (automated, system-to-system) with the SSE/ARSST's DCGS-A/Space. Simulation of space operations is limited and although workarounds for some space-based effects, events, and capabilities do exist for WFX, they lack the fidelity to accurately replicate effects and make substantial contributions to operations.

Recommendations. "Fight the fight, not the simulation." Units should "train as they fight" to the maximum extent possible. Information should be gathered, analysis conducted, plans developed, and operations undertaken as if no simulation limitations exist. Units should know the current WFX workarounds (available on the MCTP-N [network] portal homepage), and work within them, but not limit their efforts and operations based solely on these workarounds. Where workarounds exist, they will be employed, as much as can be supported by the exercise design. Where workarounds do not exist, procedures may be developed during the planning event cycle or ad-hoc during the exercise. Space operations personnel (SSEs, ARSSTs, etc.) must master their craft and educate their commanders and staffs on the actual capabilities and limitations of space so that while workarounds continue to be developed and refined, staffs will already be familiar with actual space capabilities and limitations. Employment of a D3SOE in training will only continue to increase and will help commands reach an objective-T (trained) rating.

References. FM 3-14, *Army Space Operations*, Chapters 4 and 5, Change 1, 28 Nov 2017; MCTP Rules and Work-Arounds Manual, Jan 2017; Headquarters, Department of the Army G3/5/7, *Leader's Guide to Objective Assessment of Training Proficiency*, 15 Mar 2017; Army Warfighting Challenge #7, Conduct Space and Cyber Electromagnetic Operations and Maintain Communications.

Observation #7: Units are unaware of how to request space and D3SOE training, further hindering staff efforts to understand and incorporate space into planning and operations products.

Discussion. USASMDC/ARSTRAT provides both academic and hands-on D3SOE training for individual Soldiers and units in preparation for rotations at the CTCs and ASCC exercises. The USASMDC/ARSTRAT G-3-7 Army Space Training Integration (ASTI) Branch provides tailored introductory D3SOE staff academic training (30 minutes, one hour, or more) by request during unit MCT at Fort Leavenworth, KS, or at home station, reach-back support, home-station SME support, OC/T support in preparation for and during WFX, and ASCC command post exercises.

Recommendations. Academic D3SOE training during MCT is requested by the unit through MCTP while developing its MCT schedule. This is coordinated with USASMDC/ARSTRAT G-3-7. Reach-back and home-station support is requested directly from the USASMDC/ARSTRAT G-3-7 ASTI Branch (MCTP Team). SSEs should conduct their own internal HST and can coordinate through USASMDC/ARSTRAT G37 or U.S. Army Space and Missile Defense School and Doctrine Center for additional training support.

References. Army Warfighting Challenge #7, Conduct Space and Cyber Electromagnetic Operations and Maintain Communications.

Section II: Maneuver CTC Training Team Observations

USASMDC/ARSTRAT G-3-7 training, readiness, and exercise (TREX) ASTI Branch deploys its maneuver CTC training team to support employment of a D3SOE and to provide SME support during rotations at the maneuver CTCs (NTC, JRTC, and JMRC). Optimally, these brigade combat teams (BCTs) request and receive D3SOE training prior to their CTC rotations. This initial training instills fundamental training to staffs and subordinate units on D3SOE fundamentals. This best prepares the BCT to function in a D3SOE during their CTC events and potential deployments.

USASMDC/ARSTRAT's Maneuver CTC Team augments and supports the Operations Group Plans Teams. The team advises and assists planners for scenario development and employs multiple training devices to replicate a contested GPS environment. Each CTC Team member is a certified OC/T and focuses on training BCT leadership and staff to prepare for, recognize, react to, and report the effects of a D3SOE in the training environment.

Observation #1: NCOs did not report indications of enemy GPS jamming.

Discussion. In a competitive environment at NTC, an unmanned aerial system (UAS) platoon operating independently, experienced effects from enemy GPS EMI operations. An OC/T approached the platoon leader and several noncommissioned officers (NCOs) and inquired as to whether or not they suspected any enemy jamming of their systems. The NCO looked on the Joint Capabilities Release (JCR) screen, which did not indicate anything unusual, and said "no." The platoon leader indicated he suspected the enemy jammed their frequency modulation (FM) communications the previous day but nothing for GPS. They both stated they do not know how to detect such an environment unless their Shadow system is unable to operate.

The OC/T showed the NCO the Defense Advanced GPS Receiver (DAGR), which supported their JCR, and highlighted the jamming environment detected banner on the main screen. The NCO was surprised that the DAGR provided this function and that the platoon may be getting jammed. The platoon leader stated he had no SOP for reporting a suspected jammed environment unless he was unable to employ the Shadow because of jamming. Despite heavy coaching from the OC/T, the NCO was reluctant to report this to his higher headquarters and was unfamiliar with the Joint Spectrum Interference Resolution (JSIR) process. Recognizing and reporting such events are particularly critical for such a GPS-dependent asset as the Shadow, especially as the BDE had a limited number to employ.

Recommendation. Develop and implement SOPs, TTPs, and battle drills for preparing for, recognizing, reacting, and reporting a D3SOE. The UAS platoon (and by extension the brigade) must understand these procedures down to the squad/section leader level. SOPs should include spot reports sent from the user to the tactical operations center (TOC); TOC distribution to S-2, S-6, and the electronic warfare officer (EWO); S-2/S-6/EWO responsibilities for troubleshooting and submitting JSIR-O reports.

References. FM 6-99, *U.S. Army Report and Message Formats*, Aug 2013; and Chairman, Joint Chiefs of Staff Manual (CJCSM) 3320.02D (Joint Spectrum Interference Resolution Procedures), 3 Jun 2013.

Observation #2: Task organization and employment of BCT electronic warfare (EW) personnel as EW teams did not successfully support combined arms maneuver.

Discussion. The RTU was augmented with EW equipment from Digital Receiver Technologies (DRT). The equipment enabled the unit to task-organize their BN EW NCOs into three individual teams capable of conducting electronic warfare support (ES) and electronic attack (EA). The teams were held at the BDE level for tasking in support of operations. The RTU employed the systems twice during the rotation: once in support of seizing an urban objective and once in support of a deliberate defense. The RTU did not conduct EA against enemy forces throughout the rotation. The RTU conducted limited ES operations with little success due to a lack of tactical communications capabilities in the teams. The staff did not integrate or synchronize the team's capabilities with the RTU information collection plan or targeting cycle.

Recommendations. RTUs seeking to employ tactical EW teams must develop concepts for employment prior to arrival at NTC and educate their staffs on the capabilities these teams bring to the BCT formation. Synchronize EW capabilities with the information collection plan to answer priority intelligence requirements (PIR). Plan EA in conjunction with the unit targeting cycle to provide affects against enemy forces in support of maneuver.

Reference. Army Warfighting Challenge (AWFC) #7 (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications).

Observation #3: There was no standardized reporting criteria for EMI across the BDE.

Discussion. One of the BNs reported to the BDE TOC that they experienced GPS jamming for the past 30 minutes. The BDE EW section received the report but failed to gather any pertinent details about the situation such as where was the jamming experienced and on what system and what troubleshooting has been done. This information would help the EW section determine likely locations for jammer for targeting purposes. There was no clear battle drill for the BDE staff to execute in the event of a report of jamming.

Recommendation. Establish and rehearse battle drills at all levels for responding to EMI. The staff can execute targeting concurrently with operator troubleshooting to save time. Report EMI events to the next higher level as soon as possible. Establish, publish, and rehearse using a standardized EMI report or adopt and use a JSIR (CJCSM 3320.02C and D) or Meaconing, Intrusion, Jamming, and Interface (MIJI) report. Pertinent information includes:

- What system is experiencing EMI?
- Where is it located?
- When did the EMI start?
- How long has it been happening?
- What is the impact to the mission?
- What frequency is affected?

Reference. AWFC #7 (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications).

Observation #4: The unit recognized GPS denial but did not report it to higher headquarters.

Discussion. Due to high winds, many of the remote terminal units for the SATCOM systems were not in operation, limiting traffic to lower tactical Internet (TI). As a result, the BDE S-2 section was forced to use couriers to send and receive information from the BNs. During one of these courier missions, the convoy was disoriented while traveling through the central corridor at night and took longer than usual to arrive at its final destination. This incident was reported to OC/Ts the next day but not to the unit's headquarters.

Recommendation. As jamming becomes more prevalent in the operating environment, units and staffs must ensure rapid and accurate reporting of EMI regardless of the suspected source. Jamming could be an indicator of enemy operations.

Reference. AWFC #7 (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications).

Observation #5: GPS receivers on unmanned aircraft systems (UAS) were not encrypted.

Discussion. The GPS receiver on the Shadow UAS did not have cryptographic(s) (crypto) loaded. As a result, it entered into a contested GPS environment and was forced to return to base when it lost the GPS signal. The BDE lost a critical ISR asset.

Recommendation. Ensure UAS and all ISR platforms are properly configured for entering a GPS-denied environment. Conduct analysis of threat jammers to determine likely placement locations. Integrate placement locations into the information collection plan.

Reference. AWFC #7 (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications).

Observation #6: The BDE staff did not have a good understanding of threat capabilities for contested electromagnetic environments.

Discussion. The BDE staff did not fully appreciate the contested environment and subsequently reacted slowly to a GPS denial event. The Shadow UAS was forced to return to base after it lost the GPS signal. The battle captain asked the OC/T if they jam GPS at the NTC. The OC/T responded by asking if the OPFOR had GPS jamming capability (which they did). The GPS signal was jammed the two previous nights but UAS were grounded due to high winds so effects were not immediately felt. The battle captain did not know how susceptible the GPS signal is to jamming. The S-2 section recognized the GPS receiver on the Shadow was not loaded with crypto, and thus, might be affected by jamming. However, no analysis of the threat capability was performed during MDMP.

Recommendation. Staffs must account for a contested GPS environment when conducting MDMP. EWOs and S-2s analyze the threat and incorporate into course of action (COA) development and COA analysis so the BDE can be more proactive in countering the threat and targeting the threat jammers. Understanding threat system capabilities (ranges, power levels, frequencies, etc.) will help in targeting while providing options for mission execution.

Reference. AWFC #7 (Conduct Space and Cyber-Electromagnetic Operations and Maintain Communications).

Observation #7: The BCT EW section was not integratedinto planning and operations.

Discussion. The BCT EW section operated independently from the rest of the BCT staff. The section was not adequately resourced with computers and network connectivity to reach back to division for EW products, coordination, or external assets. The BCT EW section failed to contact an Air Force EW asset when it checked in because it did not have the architecture to establish communications while the BCT main jumped locations. As a result, the external asset returned to base without providing any support. The BCT EW section did not integrate well into the BCT staff. The staff sections, specifically the S-2 and S-3, did not understand the threat in terms of the electromagnetic spectrum nor did it understand how to employ organic or external EW assets. The EW section did not participate in the MDMP with the rest of the staff and as a result, the effects were not synchronized with operations. The S-2 did not understand the threat in the spectrum and therefore did not account for threat jamming.

Recommendations. EW sections actively participate in all steps of the MDMP, advising staff primaries on both threat and friendly EW capabilities and vulnerabilities. The COAs should account for threat actions in the spectrum against the BCT and the BCT should target threat assets to ensure freedom of maneuver and mission command. Friendly EW should be rehearsed and synchronized with every operation.

Reference. AWFC #7 (Conduct Space, Cyberspace, Electronic Warfare, and Communications Operations).

Observation #8: Tactical employment of ground-based EW systems in support of BCT operations was successful utilizing task-organized BCT EW personnel.

Discussion

Background

The BCT EW technician submitted a Rapid Equipping Force (REF) request to receive EW equipment in preparation for a future deployment. DRT provided a suite of systems that could be employed tactically at NTC. The systems supplied included EW support sensors as well as EA equipment. The BCT EW technician coordinated with the Operations Group EW technician and the installation G-6 spectrum management office to acquire

clearance to operate the systems. The BCT EW staff acquired a military mine-resistant ambush protected [MRAP] all-terrain vehicle (MATV) and two high-mobility multipurpose wheeled vehicles (HMMWVs) to mount the equipment. The MATV contained an ES sensor as well as the EA equipment. Each HMMWV contained one ES sensor for targeting and geolocation of enemy emitters. The equipment was installed on the vehicles during reception, staging, onward movement, and integration (RSOI). Operators were trained on the equipment during installation in RSOI.

Task Organization

The BCT task-organized its EW personnel at home station into three teams. The ES sensor teams consisted of two personnel each: one 29E staff sergeant (SSG) and one 29E sergeant (SGT). The third team consisted of one 290A CW2 chief warrant officer, one 29E SSG, and two 29E SGTs operating the EA system. The BCT EW staff consisted of one functional area (FA) 29 captain (CPT), one 29E sergeant first class (SFC), and one 29E SSG. The CPT was the BDE EWO responsible for planning and integration of EW into the BCT planning process. The SFC supported EW current operations within the BCT tactical command post. The SSG supported EW current operations within the main command post. Each BN had a 29E SSG or SGT to conduct EW planning and integration. The BN EW NCOs also held the responsibility of tracking and maintaining counter radio-controlled improved explosive device electronic warfare (CREW) equipment within their respective BNs. The brigade engineer battalion (BEB) EW NCO was given the responsibility for oversight of counter-radio controlled improvised explosive device (RCIED) operations and CREW management across the BCT. The personnel demonstrated the task organization had no impact on their ability to synchronize aerial- and ground-based EA, as 14 requests for aerial support were submitted during the rotation and ground EA was planned for each phase. CREW systems were maintained and tracked with no significant degradation to reporting.

Tactical Employment

The system was successfully employed during the rotation in support of BCT operations. The EW teams were included in BCT planning, and high-payoff targets were established for EW during BCT targeting meetings. The BCT EW staff were able to differentiate appropriate targets for aerial EW assets versus targets for ground-based EW. This led to successful integration of live ground and air EW assets during the rotation. The ground

EW system was employed to support the close fight while the air platform supported the deep fight. During the Phase I battle, the BCT commander directed placement and jamming triggers for the system which were not well understood or optimized to support operations. The EA system was placed in a rear echelon position of a defense in depth, while the ES sensors were at the forward line of troops (FLOT) with the cavalry squadron. The system was task-organized to the light infantry task force for Phase II. The system was emplaced overlooking the urban objective for the task force and was employed immediately upon emplacement. Targets and triggers were developed by the BCT EW staff and presented to the commander for approval. The system was utilized a second time for another urban objective in a similar manner. The team was task-organized with an armor task force during Phase III. That task force was the trail element in the BCT maneuver for the phase and the team was placed in the rear of its formation. The team followed the task force toward the objective and assumed a position in order to conduct EA in support of the task force. The task force had been rendered combat ineffective by the time the team was in place and the system was not utilized as the NTC initiated suspension of battlefield effects.

Recommendation. The successful task organization of BCT EW manning to support employment of ground-based EW systems demonstrates manning is robust enough to field a system while also planning and operationally supporting the BCT and subordinate BN staffs. Further use of this or similar task-organization models will serve to validate this observation. System fielding and integration at the BCT level will also drive specialization within the EW career field between the officer, warrant officer, and NCO cohorts. This will allow for a more clear separation of duties and responsibilities and a more efficient EW staff. Continued fielding of ground-based EW systems to BCTs will facilitate the discovery and integration of tactics, techniques, and procedures (TTPs) for future system employment. Planning and integration should begin at home station prior to employment at a CTC or other large-scale exercise in order to validate these TTPs. This will drive shared understanding across the BCT formation about the capabilities a ground-based EW system brings to BCT operations.

References. Army Warfighting Challenge #7 (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications). This observation has implications for the following Army Warfighting Challenges:

AWFC #1 Develop Situational Understanding. Ground-based EW sensors enable development of situational understanding of the electromagnetic environment. It gives near-real-time situational awareness of friendly and enemy use of the EMS.

AWFC #8 Enhance Training. Ground-based EW systems used during CTC rotations improve and evolve the integrated training environment. EW Soldier and leader proficiency and readiness will increase, resulting in improved outcomes and return on investment.

AWFC #13 Conduct Wide-Area Security. Ground-based EW enables reconnaissance and surveillance to perform security operations and allows for dissemination of actionable combat information for the commander.

AWFC #15 Conduct Joint Combined Arms Maneuver. Integration of ground EW into training strategies supports proficiency in combined arms maneuver operations by allowing the BCT commander the ability to seize and retain the initiative in the EMS in order to maintain freedom of maneuver during offensive operations.

AWFC #17 Integrate Fires. Ground-based EW synchronizes with other elements of fires, in order to mass effects on targets at the decisive point. Ground-based EW has the capability to engage targets on the commander's high payoff target list or dynamic targets of opportunity.

AWFC #18 Deliver Fires. Ground-based EW gives another organic form of fires in its EA capability to the BCT commander. EA can potentially affect targets beyond the range of traditional artillery or disrupt targets that the commander does not wish to engage kinetically.

AWFC #19 Exercise Mission Command. Ground-based EW provides situational awareness of the EMS, enabling mission command. It can detect threats to friendly mission command systems in the EMS and assist in defeating those threats before they are able to disrupt the exercise of mission command.

Section III: Home Station Training Observations

The USASMDC/ARSTRAT G37 ASTI HST team is the USASMDC/ARSTRAT lead for home station D3SOE training across the Army. The team offers flexible training options in order to prepare units for CTC rotations and operational deployments. Training can consist of an eight-hour classroom instruction (focus is on DAGRs/SATCOM EMI) and unit leadership specific blocks of instruction addressing SOPs, staff sections, training methodologies, etc. Additionally, USASMDC/ARSTRAT can integrate D3SOE into field training/STX lanes with a live D3SOE. This requires approximately 90 days of advanced notice to USASMDC/ARSTRAT to facilitate USSTRATCOM coordination for jamming approval authorizations.

HST team objective: To improve understanding and use of space capabilities, products, force enhancements, and protection enabling unified land operations, especially in contested operational environments.

Observation #1: The BDE, BN, and company (CO) leadership and staff are rarely available or attend home-station training.

Discussion. During FY 17, company grade officers made up 13 percent of HST participants (a decrease of 2.4 percent from FY 16) and field grade officers made up 1.9 percent (an increase of 0.7 percent from FY 16). Most depart training upon completion of the threat brief (first presentation).

Recommendation. Training and operations would be more beneficial if leadership and staff at BDE and below would attend the training to understand the importance of preparing to fight in a D3SOE. Additionally, they are the key personnel to facilitate their training events and will learn how to request D3SOE training enablers.

References. Unit training schedules/SOPs and AWFC #7 (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications).

Observation #2: Units trained in FY 17 attended HST training with unencrypted DAGRs.

Discussion. As a whole, S-6 Soldiers are unaware of the DAGR encryption process. A large majority of units trained are unaware DAGRs only need to be filled with crypto once per calendar year. DAGRs will not require another fill unless the holdup battery (HUB) is depleted or replaced, DAGR

is zeroized, or software is upgraded. If filled correctly, DAGR will not require another fill until the following calendar year. Units are often unaware of the need to encrypt their DAGRs; therefore, communications security (COMSEC) custodians and/or S-6 Soldiers are not aware of the number of fill cables they have on-hand per their MTOE. Most units are missing fill cables for their DAGRs with a count of usually one per BN. The exception is with the field artillery BNs, which usually have multiple fill cables.

Recommendation. S-6 and COMSEC custodians need to develop comprehensive SOPs that include DAGR encryption. Additionally, units need to conduct training to ensure all Soldiers are aware of the encryption equipment and processes. Units should consider making this a portion of their pre-combat checks and inspections (PCCs/PCIs). All Soldiers should read the preventative services publication PS Magazine, The Preventive Maintenance Monthly, Issue 761, April 2016, Pages 48-51. https://www.logsa.army.mil/psmag/archives/PS2016/761/761-49-51.pdf

References. PS Magazine, The Preventive Maintenance Monthly, Issue 761, April 2016, Pages 48-51; "Defense Advanced GPS Receiver (DAGR) Satellite SignalsNavigation Set," Change 1, Jun 2005 (supersedes March 01, 2005); AWFC #7, (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications).

Observation #3: Confusion between the DAGR communication security (COMSEC) and radio COMSEC drives restrictive COMSEC plans.

Discussion. COMSEC custodians and staff often allow units to only fill the DAGRs with the monthly DAGR COMSEC key versus all three DAGR COMSEC keys which enable encryption for one calendar year. This drives restrictive COMSEC plans at all levels.

Recommendation. COMSEC custodians as well as all communication Soldiers need to follow and adhere to COMSEC regulations to better understand the difference between SATCOM and DAGR COMSEC. All Soldiers should read PS Magazine, The Preventive Maintenance Monthly, Issue 761, April 2016, Pages 48-51. https://www.logsa.army.mil/psmag/archives/PS2016/761/761-49-51.pdf

Note. This provides very valuable information and links concerning proper DAGR COMSEC encryption (see Appendix I).

References. PS Magazine, The Preventive Maintenance Monthly, Issue 761, April 2016, Pages 48-51. https://www.logsa.army.mil/psmag/archives/PS2016/761/761-49-51.pdf.; "Defense Advanced GPS Receiver (DAGR) Satellite Signals Navigation Set," Change 1, June 01, 2005 (supersedes March 01, 2005); AWFC #7, (Conduct Space and Cyber Electromagnetic Operations and Maintain Communications).

Chapter 4

Considerations in the Military Decisionmaking Process (MDMP) Plans

A unit's MDMP consists of a well-defined series of steps ensuring collaborative and parallel planning which continually shares information concerning future operations with subordinate and adjacent units, supporting and supported units, and unified action partners through planning meetings, warning orders, and other means. Necessary throughout this process is the need to continually assess and plan defensively for anticipated enemy actions against the U.S. Army's use of space as well as the U.S. Army's offensive intent to deny, degrade, and disrupt the enemy's use of space. For example, lethal and non-lethal means to deny the enemy use of any combination of commercial, organic, or third-party satellite communication [SATCOM]; space-based positioning, navigation, and timing [PNT]; and space-based intelligence, surveillance, and reconnaissance [ISR]; and its plans to employ lethal and non-lethal countermeasures against the enemy's counter-space capabilities [the lethal destruction of enemy jammers]).

These denied, degraded, and disrupted space operational environment (D3SOE) considerations throughout MDMP should be both offensive and defensive in their approaches. Through a series of space estimates, the resulting plans and orders should reflect the cumulative considerations and assessments of U.S. and enemy uses of space and D3SOE. The culminating result of these space estimates is an Annex N (Space) to the operations plan (OPLAN) and/or operations order (OPORD) as well as appropriate space and D3SOE discussions, considerations, and tasks throughout other annexes.

Primary tools for assessing each step throughout the MDMP include running estimates, after action reviews, and the assessment plan. Running estimates provide information, assessments, conclusions, and recommendations from the perspective of each warfighting function (WfF). Running estimates help to refine the common operational picture (COP) and supplement it with information not readily displayed. An extension or subset of the COP is the "Space COP" which when developed and presented to the commander, provides insights into and predictions of how space operations and the full array of all available space capabilities, products, services, and effects may or will impact operations. See Army Doctrine Publication (ADP) 5-0, *The Operations Process*, for more information.

In the space estimate and the Annex N (Space Operations), the staff informs the commander of space and D3SOE-related conditions, assessments,

and recommendations through a series of space estimates as they relate to each WfF. The "space estimate," and afterwards the "space running estimate," provides input into course of action (COA) analysis and forms the development of space and D3SOE-related commander's information requirements in Annex N (Space) to the OPLAN/OPORD and the full integration of all space and D3SOE-related consideration throughout other appropriate annexes. See Field Manual (FM) 3-14, *Army Space Operations*.

Commander's D3SOE-related information requirements

Resulting from a unit's MDMP and continually evolving and changing combat situation, the staff informs the commander of space and D3SOE-related conditions, assessments, and recommendations. Serving to support both commander's critical information requirements (CCIR) and essential elements of friendly information (EEFI), staffs will propose and recommend a series of information requirements addressing space and D3SOE considerations and predicted impacts on operations. The following are generic examples of what some of these information requirements may be:

CCIR

- **Priority intelligence requirements (PIR).** Examples of space- and D3SOE- related PIR may include but not be limited to:
    - How will enemy forces attempt to degrade or destroy our command and control (C2), mission command capabilities?
    - What is the enemy's electronic attack (EA) order of battle (OB) (including type, quantity, capabilities, limitations, disposition/location, tactics, intent of jammers, etc.)?
- **Friendly Force Information Requirements (FFIR).** Examples of space- and D3SOE- related FFIR may include but not be limited to:
    - Report any electromagnetic interference (EMI)/enemy jamming of communications, unmanned aircraft system (UAS) platforms, or Global Positioning System (GPS).
    - Report loss of critical Mission Command Systems (Warfighter Information Network-Tactical [WIN-T], Joint Battle Command-Platform [JBC-P], SATCOM segments, and PNT/GPS).
    - Report loss of critical intelligence collection UAS systems (Shadow, Gray Eagle).

EEFI. Examples of space- and D3SOE- related EEFI may include but not be limited to:

- What are the tasking, processing, exploitation and dissemination (TPED)/timelines associated with electronic warfare support (ES) to target threat jammers?
- How effective are threat jammers against U.S. space-enabled capabilities, systems, and munitions?
- What are the SATCOM signals of interest (SOI) associated with UAS operations?

D3SOE considerations in other annexes

Every OPLAN and OPORD includes a standardized list of supporting annexes and many of these are likely to address which space-based or space-enabled capabilities support the mission areas addressed in each annex. It is imperative that each appropriate annex address how a space capability plan is to be used; how the unit will continue to operate when its space-based/space-enabled capabilities are denied, degraded, or disrupted; and in some cases how the enemy does or intends to both use space and employ jammers against U.S. Army forces. Some of the annexes, in addition to Annex N (Space), which can be expected to require some discussion of space and D3SOE, include but are not limited to:

- Annex B (Intelligence)
- Annex C (Operations.
- Appendix 12 (Cyberspace and Electromagnetic Activities [CEMA]) with tabs for Offensive Cyberspace Operations (OCO), Defensive Cyberspace Operations (DCO), EA, Electronic Protect (EP), and ES
- Annex D (Fires)
- Annex H (Signal) with Appendices for DCO and Spectrum Management Operations (SMO)
- Annex J (Inform and Influence Activities) with Appendices for Public Affairs (PA), Military Deception (MILDEC), Military Information Support to Operations (MISO), and Soldier and Leader Engagement
- Annex L (Information Collection.
- Annex N (Space)
- Annex P (Information Operations [IO]) with Appendix for Electronic Warfare

Chapter 5

Considerations in Future Operations (FUOPS)

This chapter discusses the denied, degraded, and disrupted space operational environment (D3SOE)-related considerations staff sections should address throughout a unit's battle rhythm. These are boards, working groups, and planning teams as well as an Air Tasking Order (ATO) cycle within its FUOPS planning horizon. Formal FUOPS planning is typically conducted at echelons at or above division headquarters levels and is therefore the focus of this chapter.

Throughout these processes, the current and predicted status and availability of all space capabilities, services, products, and effects – both friendly and enemy – to include counter-space tactics employed and targeting options planned on both sides of the battle will shape and impact each warfighting function and must be assessed and planned during each phase of the operation. The means by which the status of space effects is tracked and assessed throughout the battle is largely contained within the space estimate. From a space running estimate, maintained by the organic Space Support Element (SSE), plans and tactics for the protection of U.S. space capabilities as well as plans for U.S. countermeasures (both counter-space and counter-EA), are provided.[1]

> *"The Fires Warfighting Function is the engine of the staff"*
>
> LTG (Retired) Thomas G. Miller, Mission Command Training Program (MCTP), Senior Mentor to Eighth U.S. Army (EUSA) Commanded by LTG Vandal, during Exercise Ulchi Freedom Guardian 2016 (UFG16), 30 Aug 2016.

Space Running Estimate.[2] The space running estimate is a continually evolving and updated collection of textual and graphical assessments regarding the current and predicted status of how space is working, or not working, for both friendly and enemy forces. This includes new facts and assumptions as the situation changes and the operation proceeds. From these new facts and assumptions, conclusions, and recommendations are generated for the commander in terms of how space capabilities influence and impact operations.

The G3 SSE develops and maintains the space running estimate.[3] For echelons below division, units may rely on the higher command's SSE to provide the space running estimate. This describes how space influences and impacts operations across each warfighting function (WfF) at echelons of brigade and below.

The space running estimate is not solely a standalone staff estimate but rather a series of estimates which support, and are integrated into, the staff estimates of other staff elements and WfFs.

In addition to the content suggested in Field Manual (FM) 6-0, *Commander and Staff Organization and Operations,* Chapter 8, and FM 3-14, *Space Operations*, Chapter 8, examples of information tracked and provided within the space running estimate may include but not be limited to:

- Type, quantity, status/intentions (actively jammer or not), tactics, and known or suspected locations of threat Global Positioning System, (GPS) and satellite communications (SATCOM) jammers. This information supports the S-2/G-2's ability to develop and maintain, the enemy electronic order of battle (EEOB) which sets the conditions for the development, refinement, and assessment of the information collection plan[4] and the development of lethal and non-lethal targeting options for the commander.
- Ongoing or anticipated areas impacted by threat GPS and SATCOM jammers and the corresponding effects on GPS-enabled (e.g., friendly force tracking [FFT] devices, radios, unmanned aircraft systems [UASs], GPS-aided precision guided munitions [PGM], target acquisition systems, etc.) and SATCOM or SATCOM-enabled systems (e.g., Warfighter Information Network –Tactical [WIN-T], Joint Battle Command Platform [JBC-P], Command Post of the Future [CPOF], Force XXI Battle Command, Brigade-and-Below [FBCB2], U.S. Marine Corps Joint Capabilities Release [JCR], etc.). This information (e.g., what specific systems are denied, degraded or disrupted, and where throughout the battlefield) supports the unit's ability to perform information collection, target development, targeting, movement and maneuver, battle damage assessment (BDA), and mission command.
- Ongoing or predicted impacts of solar and terrestrial weather effects on GPS; SATCOM; space-based intelligence, surveillance, and reconnaissance (ISR); and missile warning systems, platforms, and architectures.
- Predicted overflights of enemy satellites by type/sensor and associated tasking, processing, exploitation, and dissemination (TPED) over friendly area of operations (AO). This information is provided to the staff using satellite reconnaissance advanced notice (SATRAN) reports.
- Predicted periods when GPS is degraded and its subsequent impacts on GPS guidance accuracies and employment times/locations of GPS-aided munitions. This information is assessed using positional dilution

of precision (PDOP) values[5] in charts and graphs, and directly supports the fires WfF by assessing what munitions (PGMs vice conventional munitions) should be employed at specific times and locations.

- Assessments on the adversary's reliance on space (organic, commercial, or third-party) such as SATCOM; space-based ISR; space-based Global Navigation Satellite System (GNSS) (e.g., GPS and/or GLONASS[6] and/or other GNSS constellations); space-based environmental monitoring, etc.
- Availability and status of U.S. capabilities to attack the enemy's GPS and SATCOM jammers and the U.S. Army's use of space-based capabilities.
- BDA from lethal and non-lethal attacks against threat use of space. This information supports follow-on requirements for target reengagement options for the commander, as well as, ongoing staff assessment efforts.

Examples of how portions of the space running estimate may support other WfFs and their respective staff estimates include but are not be limited to:

- **G-2/S-2's Intelligence Estimate** for space intelligence, threat electronic OB (type, quantity, capabilities, limitations, disposition/location, tactics, intent of jammers), information collection issues, current and predicted enemy actions against U.S. space capabilities (e.g., threat jamming operations), ongoing impacts (manmade or naturally occurring) on GPS and SATCOM-enabled information collection and/or joint and national ISR platforms.
- **G-2/S-2's Weather Estimate/Staff Weather Officer (SWO)** for space and or terrestrial weather and its impacts on operations, especially those relying on space enablers such as space-based ISR, missile warning (MW), SATCOM, or GPS.
- **G-3/S-3's Operations Estimate.** As the staff proponent for several information related capabilities (IRC) to include, but not limited to cyberspace, electronic warfare (EW)[7], space, and cyberspace electromagnetic activities (CEMA), the S-3/G-3 maintains cyberspace effects (including offensive and defensive cyberspace operations [OCO] and [DCO]) and electronic warfare (inclusive of the EW components of electronic attack (EA), electronic protection (EP) and electronic warfare support (ES) estimates. The S-3/G-3 addresses threat activities designed to deny, degrade, or disrupt space-enabled mission command systems (e.g., attacks against U.S. use of GPS and SATCOM system's support to CPOF, Blue Force Tracking [BFT], etc.).

- **G-3/S-3's Protection Estimate/Air and Missile Defense Cell** for missile warning, overhead persistent infrared (OPIR) information, and how degradation of any of these space-enabled capabilities influence or impact protection efforts.
- **G-3/S-3's Fires Estimate.** Use of GPS-aided munitions, employment of UASs for reconnaissance and surveillance and/or attack missions, employment of GPS-enabled field artillery firing platforms, and space impacts on GPS-enabled target acquisition systems. This estimate supports input to the attack guidance matrix and or the target synchronization matrix[8].
- **G-6/S-6's Signal Estimate** including SATCOM and GPS and how degradation of any of these capabilities influences or impacts mission command efforts, D3SOE effects and equities as they pertain to spectrum management operations (SMO), navigational warfare (NAVWAR)[9] considerations, space equities represented within the Joint Restricted Frequency List (JRFL), and the status/trends noted from Joint Spectrum Interference Resolution (JSIR) reporting.

> *"Both the space estimate and space input to IPB process are systematic, continuous methods of analyzing and documenting factors affecting space capabilities that affect the operational environment."*
>
> FM 3-14, *Army Space Operations*, Change 1, 28 Nov 2017

Boards, Working Groups, and Planning Teams. Space and space-related considerations should be thought about throughout most of a unit's battle rhythm events, especially when the focus area of the meeting involves reliance on space-enabled capabilities. Within division and above headquarters, the SSE will support several WGs, especially the following:

- Information operations working group (IOWG)
- CEMA WG
- Targeting WG or board

For all boards, working groups, planning teams, staff planning, and staff estimates efforts, there should be a synchronized working relationship between all WfFs and IRC enablers[10] (e.g., EW, cyberspace operations, space operations, military deception [MILDEC], military information support to operations [MISO], etc.) to ensure all space-related offensive and defensive operations are addressed, assessed, and included in all phases of operations.

Endnotes

1. Countermeasures – That form of military science that, by the employment of devices and/or techniques, has as its objective the impairment of the operational effectiveness of enemy activity. ADRP 1-02, *Military Terms and Symbols,* 2 Feb 2015.

2. Running Estimate – The continuous assessment of the current situation used to determine if the current operation is proceeding according to the commander's intent and if planned future operations are supportable (ADP 5-0, *The Operations Process*, 17 May 2012).

3. FM 3-14, *Army Space Operations,* Change 1, 28 Nov 2017.

4. ATP 2-01, *Plan Requirements and Assess Collection,* 19 Aug 2014.

5. PDOP is a value assessment on the quality of the physical geometry of the GPS satellites which correlates to the amount of accuracy provided, where PDOP of "1" is best and "10" is the worst.

6. Globalnaya Navigazionnaya Sputnikovaya Sistema, or Global Navigation Satellite System. GLONASS is Russia's version of GPS and is currently fully operationally with 24 navigational satellites in orbit.

7. FM 3-12, *Cyberspace and Electronic Warfare Operations,* 11 Apr 2017.

8. ATP 3-60, *Targeting,* May 2015.

9. NAVWAR – Deliberate defensive and offensive action to assure friendly use and prevent adversary use of positioning, navigation, and timing (PNT) information through coordinated space, cyberspace, and electronic warfare capabilities. Joint Publication 3-14, *Joint Space Operations,* 23 May 2013.

10. FM 3-13, *Information Operations,* 6 Dec 2016. *An information-related capability* (IRC) is a tool, technique, or activity employed within a dimension of the information environment that can be used to create effects and operationally desirable conditions (JP 1-02).

Chapter 6

Considerations in Current Operations (CUOPS)

The staffs in charge of executing current operations typically track current operations and upcoming operations out to 24 hours. They rely on their tactical standard operating procedures (TACSOPS) to guide operations and the accomplishment of tasks. Some of these SOP items include both primary, alternate, contingency, emergency (PACE) plans and battle drills. Both PACE plans and battle drills should include steps, processes, tasks, and considerations associated with operating in a contested space environment. The following provides definitions and guidance on the development of PACE plans and battle drills which specifically address or consider denied, degraded, and disrupted space operational environment (D3SOE).

PACE Plans

PACE plans establish standardized, predictable, and repeatable solutions to tactical situations in response to enemy actions and or environmental effects that negatively impact a unit's capabilities. PACE plans provide Warfighters contingency steps, processes, and techniques ensuring forces are able to continue operations as combat situations change, degrade, or become denied.

PACE is defined as:

- **Primary.** This is the routine, primary, and most effective system, capability, or technique employed by a combat unit.
- **Alternate.** This is another common method of accomplishing the task with minimal to no other impact. May be used along with "primary" means under normal circumstances to assure readiness, redundancy, and task accomplishment.
- **Contingency.** This method will not be as fast, easy, inexpensive, or convenient as the first two methods but is capable of accomplishing the task in an acceptable time frame. However, it does involve a level of delay, risk, and negative impact on the operation.
- **Emergency.** This is the method of last resort and typically has significant risks, delays, costs, or negative impacts.

PACE plans are unit-specific and must be developed by their respective WfF, staff element, or functional area subject matter experts (SME). PACE plans must reflect the training, equipment status, and the operational environment for each specific unit. If the unit cannot execute the full PACE plan directed by its higher command, it must inform the issuing headquarters with an assessment of shortfalls, gaps, and possible mitigation strategies.

Some unit PACE plans, especially with regard to operating in D3SOE conditions, may include but are not limited to:

- **Communications**. The U.S. Army relies heavily on satellite communications (SATCOM) as the primary means to move large volumes of data securely and over great distances; however, when select SATCOM systems are denied, degraded, or disrupted, then alternate SATCOM systems such as other line of sight (LOS) systems, hard wire/land-line, and manual methods (e.g., runners) should be employed.

> *"If you ain't talkin', you're just camping."*
>
> 3rd Infantry Division After Action Report,
> OPERATION IRAQI FREEDOM, 2003

- **Friendly Force Tracking (FFT).** Units should consider and train on how to maintain situational understanding of units using SATCOM/ beyond line-of- sight (BLOS), LOS communications, and analog methods of unit location and status tracking.
- **Battle Damage Assessment (BDA).** A unit's ability to conduct BDA often times relies on unmanned aircraft system (UAS) and national intelligence, surveillance, and reconnaissance (ISR) systems (national technical means [NTM]) to collect post-strike information. Units should consider other means such as manned aircraft, ground forces, and multiple communication means to report data back to higher headquarters. An "emergency" method for BDA might be pre-positioned cross-forward line of troops (FLOT) friendly forces, equipped with high-frequency radios, to observe a deliberate strike and report back to higher headquarters.
- **Precision Engagement (PE).** In a D3SOE, the fires should be prepared to support and employ multiple types of munitions providing the greatest accuracies available. Commanders and staffs should have PACE plans to achieve "the best precision" under other-than-optimal tactical conditions.
- **Target Acquisition.** Primary target acquisition often involves the use of UASs, NTM, radars, laser designation systems, and forward observers using SATCOM reporting means. In a D3SOE, commanders and staffs should develop PACE plans about how best to detect, geo-locate, and report targets.

- **Information Collection.** Many information collection and Joint ISR assets rely on Global Positioning System (GPS), SATCOM, and NTM capabilities. As GPS, SATCOM, and NTM systems become denied, degraded, or disrupted, commanders and staffs should develop PACE plans on how best to develop and execute their information collection plans to support the commander's priority intelligence requirements (PIR) in support of decision points (DP) and high-value target lists (HVTL)/high-payoff target lists (HPTL).
- **Manned, Unmanned-Teaming (MUM-T).** MUM-T relies in part on both GPS and SATCOM for data sharing, platform tracking, target acquisition, and mission command. As GPS and/or SATCOM systems become denied, degraded, or disrupted, commanders and staffs should develop PACE plans on how best to continue flights, operations, target acquisition, reconnaissance and surveillance, and mission command.
- **Total Asset Visibility (TAV).** Many Army sustainment units primarily rely upon both GPS and SATCOM systems to conduct mission command and share logistical information between units. As GPS or SATCOM systems become denied, degraded, or disrupted, commanders and staffs should develop PACE plans on how best to continually share logistical information by means other than SATCOM thus using other means such as alternate SATCOM systems, LOS radios, or runners.
- **Overhead-Persistent Infrared (OPIR)/Missile Warning (MW).** Force protection requirements against near-peer forces who are likely to employ a wide variety and large quantity of ballistic missiles will require U.S. Army forces to develop PACE plans to detect missile launches and static infrared (IR) activity, warn downrange forces, and characterize and geo-locate each IR detection when GPS, SATCOM, space-based ISR sensors, and select warning systems and architectures are denied, degraded, or disrupted.

Battle Drills

Battle drills provide both individuals and collective staffs with standardized actions (sequencing or concurrent processes, steps, and tasks) that need to be accomplished in response to common battlefield occurrences. Battle drills are developed, rehearsed, and refined for rapid reaction situations such as those which CUOPS staffs respond to.

Some unit battle drills for staffs, especially with regard to steps and tasks associated with operating in D3SOE conditions, may include but are not limited to:

- **GPS electromagnetic interference (EMI).** See Appendix D for an example GPS EMI battle drill.
- **SATCOM EMI.** The SATCOM EMI battle drill differs distinctly from the GPS EMI battle drill because its impacts are different and it requires access to and collaboration with a different set of reach-back and supporting organizations to fault-isolate, characterize, and respond to EMI with SATCOM systems.
- **UAS anomalies.** There are a wide variety of reasons why unit UASs may experience problems or anomalies in how they are performing. The UAS battle drills should address and account for the UAS platform's reliance on GPS (for positioning and navigation) and or SATCOM (for its command and communications/C2 data link). If and when it is determined that GPS and/or SATCOM capabilities are at fault, this battle drill should direct the staff to the separate and more detailed GPS or SATCOM EMI battle drills for further fault isolation, problem solving, and steps necessary to ensure continuity of UAS operations.
- **Personnel Recovery (PR)/Downed Aircraft/Combat Search and Rescue (CSAR).** A unit's PR battle drill may be one of the more complex battle drills. They typically involve all staff sections and warfighting functions and include many capabilities that are space-enabled. This battle drill should address how to accomplish each space-enabled task when the various space-enabled capabilities are denied, degraded, or disrupted.
- **OPIR/High Energy/Missile Warning/Static-IR Event.** Space-based sensors provide commanders much of their capability to detect, characterize, and track various IR events throughout the battlefield. Subsequently, SATCOM systems provide means to disseminate much of this data throughout the force. These battle drills should address how IR events are detected and disseminated when SATCOM and space-based ISR capabilities are denied, degraded, or disrupted.
- **Time-Sensitive Targeting (TST) (especially for threat EA/jamming assets).** A unit's TST battle drill addresses the full spectrum of enemy targets, which by their nature are mobile and require dedicated intelligence, targeting, and fire support to attack. As an example, a commander's targeting guidance may include the rapid targeting of small mobile GPS jammers. If so, this battle drill should include all requisite capabilities to rapidly find, fix, and finish these enemy assets.

- **Degraded NTM/NTM anomalies.** This battle drill is typically developed for corps and above level staffs and addresses how select NTM assets support missions and operations and the steps necessary to assess and mitigate the effects when NTM assets are denied, degraded, or disrupted.

In summary, all units must prepare, document, train for, and refine how to continue operations when enemy forces deliberately employ means to deny, degrade, and disrupt U.S. space capabilities. PACE plans provide a means to continue operations while "hoping for the best and preparing for the worst." Battle drills provide staffs the means to follow set procedures ensuring the rapid and efficient execution of required tasks to ensure combat operations continue with the least negative impact resulting from any and all combat variables to include D3SOE conditions.

Chapter 7

Army Space Operations Integration and Space Support Augmentation

This chapter provides an overview of how staff elements should integrate space operational considerations to better plan and execute operations in a denied, degraded, and disrupted space operational environment (D3SOE).

Space Support Elements (SSEs) are organic to the G-3 sections of Army divisions, corps, and Army Service component command (ASCC) headquarters and serve as critical "touch points" for space and space-related requirements, capabilities, predictions, and effects. Although SSE composition varies between echelons (see Appendix C), each composition provides direct support to all staff elements, warfighting functions (WfFs), and planning horizons in support of the commander's objectives and scheme of maneuver. Space augmentation, typically from an Army Space Support Team (ARSST), may also support these headquarters providing increased space-related analysis, operations, and planning support.

At echelons below division, where Functional Area 40 (Space Operations) officers or SSEs are not assigned, battalion and brigade staffs receive support from their higher command's SSE in the form of space estimates and other space-based planning products. Requests for space support from the SSE follow unit standard operating procedures, such as request for information (RFI) or space support request (SSR) procedures.

Much of the space support provided to the staff is contained within the unit's basic operations order (OPORD) and its annexes and is also derived from the space estimate which continually monitors and assesses factors impacting the unit's ability to maintain assured access to space capabilities, services, and effects while denying the same to the enemy.

Examples of space support provided by the SSE may include but are not limited to:

G-2/S-2

- Enemy space order of battle (e.g., type, quantity, and tactics of Global Positioning System [GPS] and satellite communications [SATCOM] jammers; space-based capabilities used including organic, third party/allies, or commercial; and space-related signals of interest). This information is baselined in the OPORD's Annex B (Intelligence) or Annex N (Space Operations) and is continuously updated as part of the space running estimate.

- Current and predicted GPS and SATCOM jamming effectiveness; denied, degraded, and disrupted areas; and related impacts on intelligence systems and operations (e.g., UASs and space-enabled intelligence, surveillance, and reconnaissance [ISR]; ability to conduct battle damage assessment [BDA]; etc.).
- Support to the development and updating of priority intelligence requirements (PIR) and subsequent information collection plans, especially as they relate to the enemy's space order of battle (how they are using space) and their employment of jammers (locations of jammers and their associated tactics, techniques, and procedures [TTPs] for electronically attacking the U.S. Army's use of space).
- Support to the development of intelligence-related primary, alternate, contingency, and emergency (PACE) plans and battle drills which involve the use of space-enabled capabilities.
- Support to the staff weather officer (SWO) with assessments of natural impacts on space operations including solar weather effects on ultra-high frequencies (UHF) SATCOM, GPS, and high-frequency (HF) communications, and terrestrial weather effects on SATCOM and space-based ISR, and overhead persistent infrared (OPIR)/missile warning/environmental monitoring, etc.
- Development of additional imagery – imagery/geospatial intelligence (IMINT/GEOINT) requirements and request of processes that may, in part or fully, be satisfied by new space-based sensors, collection methodologies, post-processing techniques or specialized reach-back organizations, databases, analysis, and production centers.
- Development of measures of effectiveness (MOEs)/measures of performance (MOPs) for lethal and non-lethal BDA of attacks against enemy space capabilities.

G-3/S-3

- Assessment of current and predicted impacts of space-based and space-enabled capabilities (e.g., OPIR, friendly force tracking (FFT) systems, missile detection/missile warning, personal locator beacons/combat search and rescue (CSAR) radios support to personnel recovery/hostage recovery [PR/HR]) and resulting impacts on operations.
- Development of PACE plans, mitigating strategies, and battle drills to respond to disruption of U.S. Army access to the electromagnetic spectrum (EMS) and space-related frequencies (GPS, SATCOM, and radars).

- Support from the electronic warfare officer (EWO)/electronic warfare element (EWE)/cyberspace electromagnetic activities (CEMA) chief.
- Support the development of the Joint Restricted Frequency List (JRFL), especially for critical space-related frequencies (e.g., GPS and SATCOM).
- Coordinate tasks and processes to rapidly recognize, characterize, report, and react to electromagnetic interference (EMI), especially that directed against GPS and SATCOM frequencies used by U.S. Army forces.

Fires

- Support development of lethal and non-lethal targeting options against enemy space capabilities such as enemy jammers, ground control stations, satellite segments, or associated frequencies.
- Assess impacts of D3SOE on GPS-dependent target acquisition, designation, and guidance systems.
- Support the development of PACE plans and battle drills which support target development and targeting.

Air and Missile Defense (AMD)

- Support the development of PACE plans and battle drills supporting missile detection and missile warning (MD/MW) architectures, especially as they relate to space-based capabilities (OPIR sensors, SATCOM dissemination architectures, etc.).
- Assess impacts of D3SOE on MD/MW architectures.
- Information operations (IO).
- Support SATCOM integration into cyberspace operations (e.g., SATCOM portion of the Department of Defense Information Network [DODIN]).
- Support military deception (MILDEC), operations security (OPSEC), and IO, with predictive analysis of enemy space-based ISR collection utilizing Satellite Reconnaissance Advanced Notice (SATRAN) predictions.

G-4/S-4

- Assess impacts of D3SOE on SATCOM architectures that support total asset visibility (TAV). For example, the use of the SATCOM-based Combat Service Support-Very Small Aperture Terminal (CSS-VSAT).
- Development of PACE plans related to space-enabled FFT and logistics-related communications.

G-5

- Integrate D3SOE considerations and mitigating strategies into the military decisionmaking process (MDMP).
- Assist with the development of requesting available specialized space and space-related effects to support the commander's objectives and scheme of maneuver.

G-6/S-6

- Development and continual assessments on the operational status of those satellites and satellite architectures supporting unit operations, especially GPS and SATCOM.
- Development of assessments and predictions regarding D3SOE impacts on space-based frequencies, especially GPS and SATCOM.
- Development of PACE plans and battle drills addressing impacts of D3SOE including all sources causing degradation such as enemy activities, natural phenomenon (space weather, terrestrial weather, impacts of terrain/urban masking on GPS and SATCOM, etc.), satellite anomalies, and navigation warfare (NAVWAR) considerations.

Appendix A

Army Space Cadre

The Army Space Cadre is a force of Soldiers and Civilians who have documented training and experience on the space domain. The Space Cadre was originally comprised only of Functional Area 40 (FA 40) Space Operations Officers but expanded in 2007 to other military occupational specialties and areas of concentration (AOCs) and Department of the Army Civilians who perform duties in one of the five space mission categories as defined in JP 3-14, *Space Operations*, and FM 3-14, *Army Space Operations*. There are currently more than 4,000 personnel identified as Army Space Cadre in all three components throughout the Army. These Army Space Cadre are key training assets to operate effectively in a denied, degraded, and disrupted space operational environment (D3SOE).

FA 40 Space Operations Officers

FA 40s form the core of the Army Space Cadre and serve in operational positions supporting the Army and joint, interagency, intergovernmental, and multinational (JIIM) organizations.

FA 40s serving in operational positions deliver space capabilities to the Warfighter. They are trained to comprehend, enable, and improve how the operating force uses space capabilities and to know the space-based products they require and produce. FA 40s are also trained to understand the reliance of military units on space assets and the effects when those capabilities are denied, degraded, or disrupted; and know how to prevent, mitigate, or work through and continue operations under such conditions.

Nominating Billets for "Space Cadre" Designation (Remarks Code 65)

Units/organizations can nominate billets (other than FA 40) meeting the screening criteria outlined in the following material for Space Cadre designation following the procedures outlined in Military Personnel (MILPER) message 11-336, Nominating Billets for Space Cadre Designation. The nomination must be signed by the first general officer (GO) or senior executive service (SES) equivalent in the chain of command and forwarded to the Army Space Personnel Development Office (ASPDO). If there is no GO or SES in the chain of command, then ASPDO will accept a nomination signed by a colonel-level commander.

While the coding is pending, ASPDO considers the positions as approved Space Cadre billets and Soldiers assigned to the positions are eligible to attend space-related professional development courses. They will qualify for the Space Badge, once they meet the criteria, and be awarded Skill Identifier/Additional Skill Identifier (SI/ASI) 3Y, Army Space Cadre, and personnel development skill identifier (PDSI) S1A, Unit Space Trainer.

Screening criteria. A validated billet which requires assigned personnel to perform duties in one or more of the five space operations mission categories (Space Situational Awareness, Battle Management Command and Control, Space Control, Space Support to Operations, and Space Service Support).

Army Space Cadre Qualification and Recognition

There are three Space Cadre qualification levels corresponding to the criteria for award of the three levels of the Space Badge to Soldiers.

The criteria and procedures for awarding the Space Badge, SI/ASI 3Y, and PDSI S1A, and attending certain space-related professional development courses are outlined in procedural guides posted on the Army Space Knowledge Management Site (ASKMS). ASKMS can be accessed using the following link (select your CAC email certificate when prompted): https://army.deps.mil/army/sites/ASKMS/SitePages/Home.aspx.

Points of Contact

The ASPDO points of contact are listed in ASKMS.

Appendix B

Space Operations Tasks

This appendix outlines some of the key Space Operations Tasks available in Army Doctrine Reference Publication (ADRP) 1-03, Army Universal Task List (AUTL), and on the Army Training Network (ATN).

AUTL

ART 5.1.1.7: Integrate Space Capabilities

ART 5.6: Integrate Space Operations, including subtasks:

- ART 5.6.1: Provide Space Force Enhancement (SFE)
- ART 5.6.2: Provide Space Control (SC)
- ART 5.6.3: Provide Army Space Support
- ART 5.6.4: Provide Space Situational Awareness (SSA)

ART 6.6.5: Coordinate Army Space Capabilities

ATN (https://atn.army.mil/) login required

Search the following ATN Tasks for "*Space Operations*" or "Electromagnetic Interference"

Integrate Space Capabilities (40-6-5003) – Individual

Synchronize Space Operations (40-6-5004) – Collectiv.

Provide Space and Technical Operations Support (40-6-5009) –Collective

Conduct Navigation Warfare (NAVWAR) Operations (40-6-5010) - Individual

Enable Space-based Communications (40-6-5011) – Individual

React to Electromagnetic Interference (EMI) (113-641-3008) – Individual

React to Satellite Communications (SATCOM) EMI (113-SI7E-0018) – Individual

Plan Space Operations (129-040-1040) – Individua.

Recognize EMI (129-800-9000) – Individual

Respond to Electromagnetic Interference (129-800-9001) – Individual

React to Wideband Satellite EMI (11-CW-8050) – Collective

React to Electromagnetic Interference (150-MC-5902) – Individual

Recognize EMI (150-MC-5903) – Individual

Integrate Space Operations (150-290-0014) – Individua.

Provide Theater Ballistic Missile Warning Support (40-TS-2151) – Collective

Appendix C

Space Manning and Augmentation

This appendix outlines the Space Operations personnel assigned to the Space Support Elements (SSEs) at division, corps, and Army Service Component Command (ASCC) levels, and outlines available Space Force augmentation.

Organic Division Space Support

(Field Manual [FM] 3-14, *Army Space Operations*)

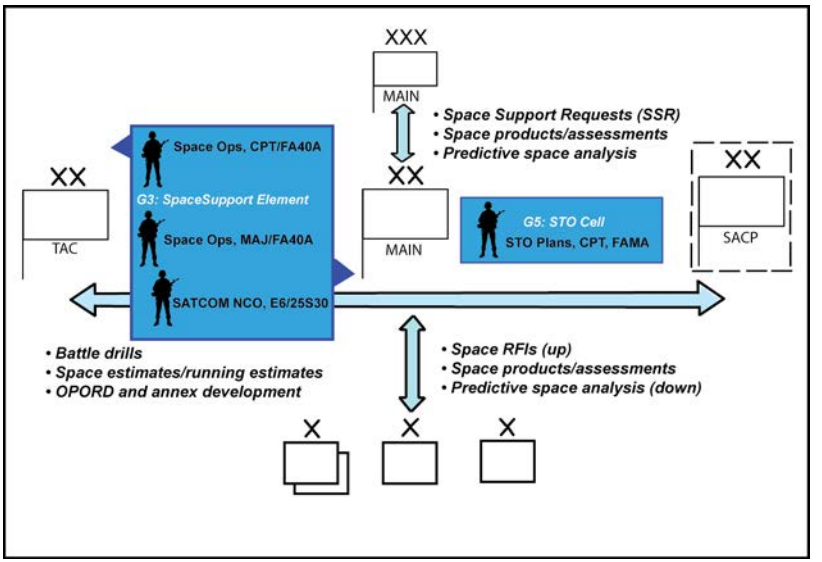

Figure C-1. Organic division space support.

Division is the lowest level where Space Operations personnel are authorized by modified table of organization and equipment (MTOE):

- MTOE authorizes 1 x O-4, 1 x O-3, and 1 x E-6 to the G3 (Space Support Element), and 1 x O-3 to the G5 (Special Technical Operations (STO) Cell).
- MTOE provides Space (and special technical operations [STO]) support across all warfighting functions/staff elements and through all planning horizons (plans, future and current operations [FUOPS and CUOPS]).

- MTOE provides space support to subordinate units and links to higher space support channels.
- Space operations personnel ay be located at tactical, main, or support area command post (SACP) (if employed).
- Actual assignment and location are determined by the commander.

Organic Corps Space Support

(FM 3-14, *Army Space Operations*)

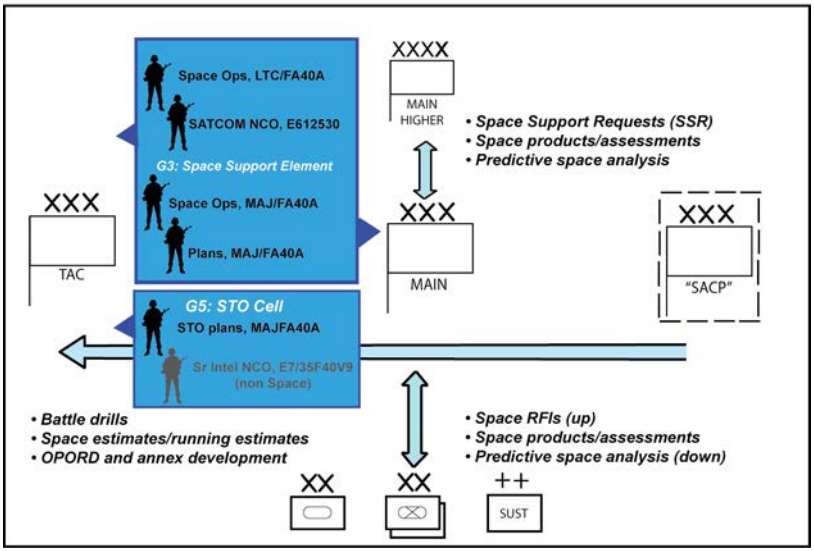

Figure C-2. Organic corps space support.

Corps Space Operations personnel as authorized by MTOE are depicted as follows:

- MTOE authorizes 1 x O-5, 2 x O-4, and 1 x E-6 to the TAC and Main CPs in the G3 (Space Support Element), and 1 x O-4 and 1 x E-7 to the tactical (TAC) FUOPS G5 (STO cell).
- MTOE provides Space (and STO) support across all warfighting functions/staff elements and through all planning horizons (plans, FUOPS, CUOPS).
- MTOE provides space support to subordinate units and links to higher/lower space support channels.

- Space operations personnel may be located at TAC, Main, or SACP (if employed).
- Actual assignment and location are determined by the commander.

Organic Army Service Component Command Space Support

(FM 3-14, *Army Space Operations*)

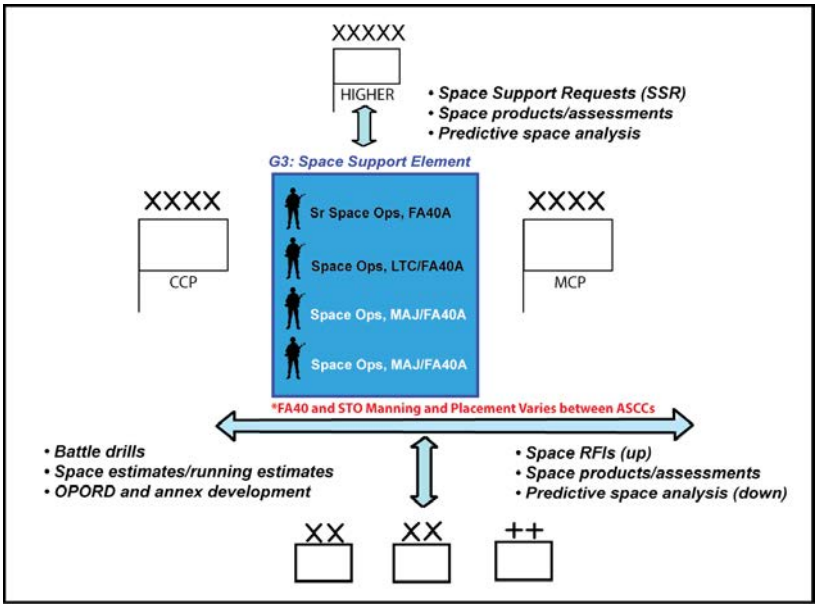

Figure C-3. Organic Army Service Component Command Space Support.

ASCC Space Operations personnel as authorized by MTOE are depicted as follows:

- MTOE authorizations vary significantly between ASCCs but generally include 1 x O-6/O-5 and 1 x O-5/O-4 at the main command post (MCP), and 1 x O-5/O-4 at the contingency command post (CCP).
- Unlike at the corps and division, the STO chief is not an FA. 40-designated position.

- MTOE provides Space support across all warfighting functions/ staff elements and through all planning horizons (plans, FUOPS, CUOPS), to subordinate units and to the theater director space forces (DIRSPACEFOR), or "DS4" at the Combined Air Operations Center/ Joint Air Operations Center (CAOC/JAOC).
- Space Operations personnel may be located at MCP or the CCP.
- Actual assignment and location are determined by the commander.

Space Support Augmentation

(FM 3-14, *Army Space Operations*)

Organic Space Support Elements may need augmentation to sustain extended operations. Depicted below are doctrinal organizations that may be requested from United States Army Space and Missile Defense/Army Forces Strategic Command (USASMDC/ARSTRAT) 1st Space Brigade.

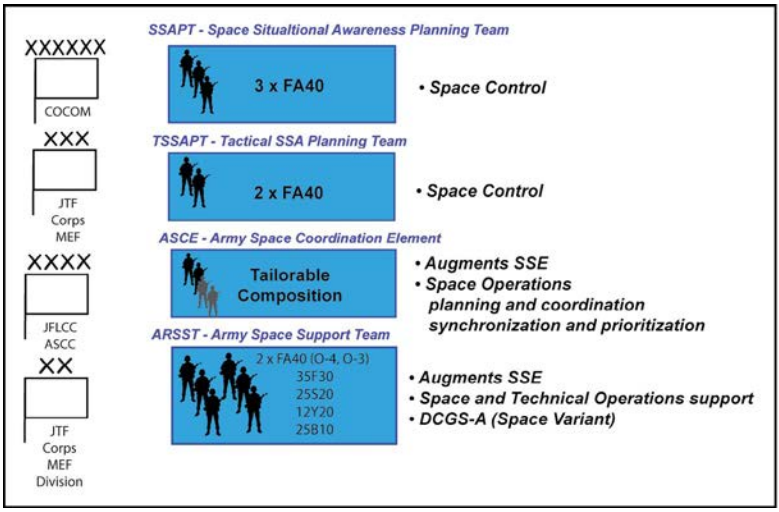

Figure C-4. Space support augmentation.

These Space augmentation forces provide space situational awareness (SSA), Space Force Enhancement (SFE), or Space Control (SC), and will

be attached, operational control or tactical control, and provide direct or general support to the gaining command:

- Space Situational Awareness Planning Teams (SSAPTs) support corps commander-level headquarters, augmenting the Joint Space Control Coordination Element, and provide space and space control planning and coordination.
- Tactical Space Situational Awareness Planning Teams (TSSAPTs) support tactical level headquarters, Joint task force, corps, and Marine Expeditionary Force (MEF) with planning, requesting, and coordinating space control capabilities.
- Army Space Coordination Element (ASCE) and pronounced "AS-KEY," supports Joint Force Land Component Commander (JFLCC)/ ASCC headquarters with planning, synchronizing, coordinating, and prioritizing space operations.
- Army Space Support Teams (ARSSTs) support Joint Task Forces (JTFs), corps, divisions, and MEFs.

Appendix D

Sample Division-level Electromagnetic Interference (EMI) Battle Drill

This appendix depicts "a way" that a division staff may address Global Positioning System (GPS) EMI. As with all battle drills, this should be tailored to the unit and must be thoroughly rehearsed.

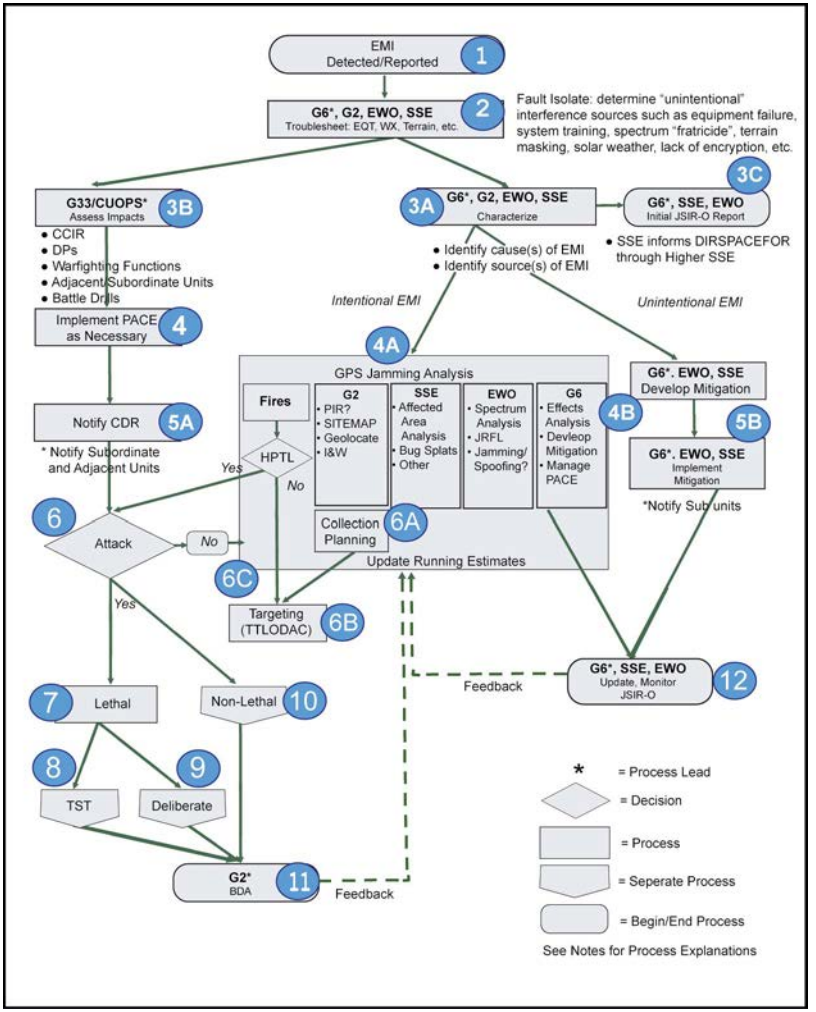

Figure D-1. Possible division-level EMI battle drill.

Division-level EMI Battle Drill Process Notes

1. BEGIN EVENT: EMI may be detected by the headquarters or reported by higher/lower/adjacent units.

2. Operational Planning Team (OPT) including G-6, G-2, electronic warfare officer (EWO), space support element (SSE), and system subject matter expert troubleshoots the event to rule out "unintentional" interference such as equipment failure, spectrum "fratricide," terrain masking, solar weather, lack of encryption, lack of training, etc.

3. Concurrently:

    a) OPT continues analysis to characterize causes and sources of EMI.

    b) G-3-3 assesses impact of EMI on commander's critical information requirements (CCIR) (Who needs to know?); decision points (DPs) (How does it affect upcoming DP/ conditions checks?); Warfighting functions (effects on capabilities); adjacent units; other battle drills, (effects/ modifications on other battle drills, [e.g., how is isolated person battle drill affected by disrupted GPS?], etc.)

    c) G-6 submits initial JSIR-O and sends a copy to the higher HQ; SSE informs higher SSE and director of space forces/combat operations division space (DIRSPACEFOR/CODSPACE).

4. G-3-3 directs implementation of primary, alternate, contingency, emergency (PACE) plans. Concurrently:

    a) OPT conducts detailed jamming analysis (staff should have more detailed processes).

    b) Fires assess against high-payoff target list (HPTL); if YES recommends attack to G-3-3 (Step 6).

    c) G-2 assesses against priority intelligence requirements, templates against enemy order of battle situation template, geolocates, and conducts spatial and temporal analysis to determine indications and warnings.

    d) SSE identifies affected area(s) ("Bug Splats") and conducts other space assessments.

e) EWO conducts spectrum analysis, compares against Joint Restricted Frequency List (JRFL), and identifies if possible jamming or spoofing or both.

f) All continuously update running estimates.

g) G-6 assesses effects on communications systems and determines/develops mitigation tactics, techniques, and procedures (TTP) for both intentional/unintentional EMI and manages implementation of PACE Plan.

5. Concurrently:

a) G-3-3 notifies commander in accordance with CCIR (including impact on operations) and informs subordinate and adjacent units.

b) G-6 implements mitigation TTPs and notifies subordinate units about intermittent continuous wave (ICW) EWO and SSE.

6. G-3-3/CUOPS (current operations) determines if attack is required in accordance with commander's guidance and HPTL:

a) G-2 conducts collection planning: priority, location, asset capability, asset availability, etc.

b) Fires develop targeting information: target, trigger, location, observer, delivery system, attack guidance, and communications (TTLODAC).

c) If NO, continue analysis/assessment.

d) If YES, lethal attack – Step 7 OR

e) If YES, non-lethal attack – Step 10.

7. In a lethal attack, develop target for attack with lethal means and determine if target is to be engaged as time-sensitive or deliberate target.

a) If time-sensitive targeting – Step 8.

b) If deliberate targeting – Step 9.

8. Time-sensitive targeting (separate battle drill).

9. Deliberate targeting (separate battle drill).

10. Non-lethal targeting (separate process).
11. G-2 collects battle damage assessments from attacks and feeds back to analysis/update running estimates.
12. G-6 updates Joint Spectrum Interference Resolution-Online (JSIR-O), monitors status of JSIR-O, and feeds information back to analysis/running estimate.

Appendix E

Denied, Degraded, and Disrupted Space Operational Environment (D3SOE) Contributing Factors

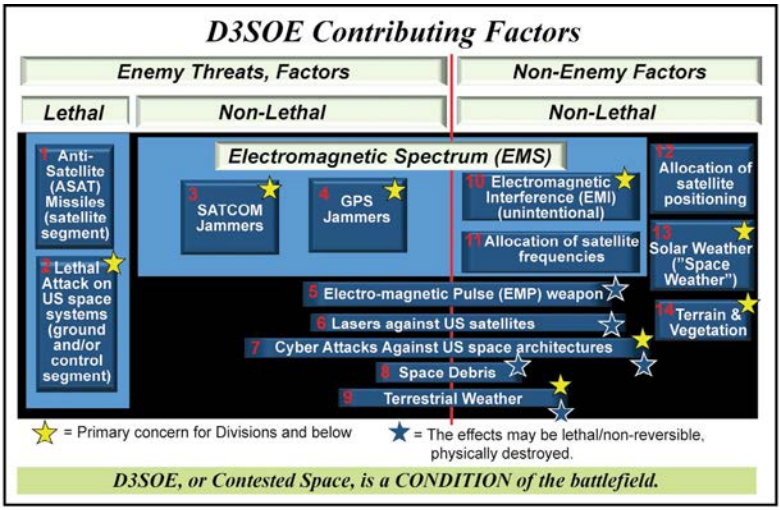

Figure E-1. D3SOE contributing factors.

Figure E-1 depicts the 14 major factors which may deny, degrade, or disrupt U.S. Army forces from fully accessing all available space capabilities, services, and effects. It is important to note that denial, degradation, or disruption of any specific space capability may not have anything to do with intentional enemy actions against U.S. forces. In other cases, the denial of a specific space capability may be directly the result of deliberate enemy counter-space efforts.

Appendix F

Space Fundamentals

This appendix discusses space fundamentals and provides insight into how space-enabled military and commercial equipment and devices can be affected in a space environment. In a denied, degraded, and disrupted space operational environment (D3SOE), space-enabled capabilities may not initially perform as expected. When mitigation techniques and strategies to retain capabilities are not apparently successful, operators may become frustrated with their equipment. This can create vulnerabilities to operations when personnel either attempt to create a "work-around" to avoid the symptoms experienced or simply abandon their equipment for something they believe is more reliable, resulting in operators working in a non-secure environment.

> The adversary only needs to make you lose confidence in your equipment to be effective.

Earth Orbits and Common Military Missions

Figure F-1 describes the various earth orbits and their relationships to common military missions.

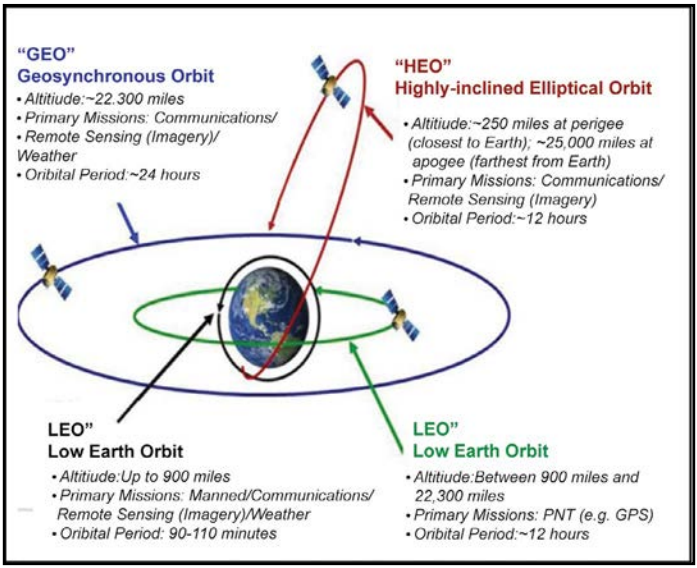

Figure F-1. Earth orbits and common military missions.

Space Environment

The sun constantly emits charged particles and solar radiation (energy). It creates ever-present ionospheric disturbances ("space weather"). Geomagnetic storms severely disturb the ionosphere.

Impacts

The Global Positioning System (GPS):

- The ionosphere is the largest source of error in GPS positioning and navigation (with errors in excess of 100 feet), and loss of lock.
- Signal must pass from satellite through a charged ionosphere to a receiver, affecting signal propagation and timing which affects accuracy.
- Impacts on GPS systems can occur any time of day or night, but increased effects are seen at night.

Satellite Operations: (communications, television/radio, national defense, meteorology, and more)

- **Radiation exposure (interaction of charged particles and radiation):** satellite orientation problems, damage to electronic devices and other hardware
- **Geomagnetic storms:** satellite charging with electrostatic discharge, vehicle failure, signal propagation is delayed or completely lost

Power Transmission:

- Geomagnetic storms create electric current in the magnetosphere and ionosphere which compresses and disturbs the earth's magnetic field.
- Disturbed conditions create additional currents in conductors on the ground (e.g., overhead transmission lines) and can cause voltage instability and damage to unshielded power system components.
- **Atmospheric Perturbations:** atmospheric heating increases drag on satellites flying in lower orbits.

The following three figures illustrate space environment impacts, and the electromagnetic spectrum.

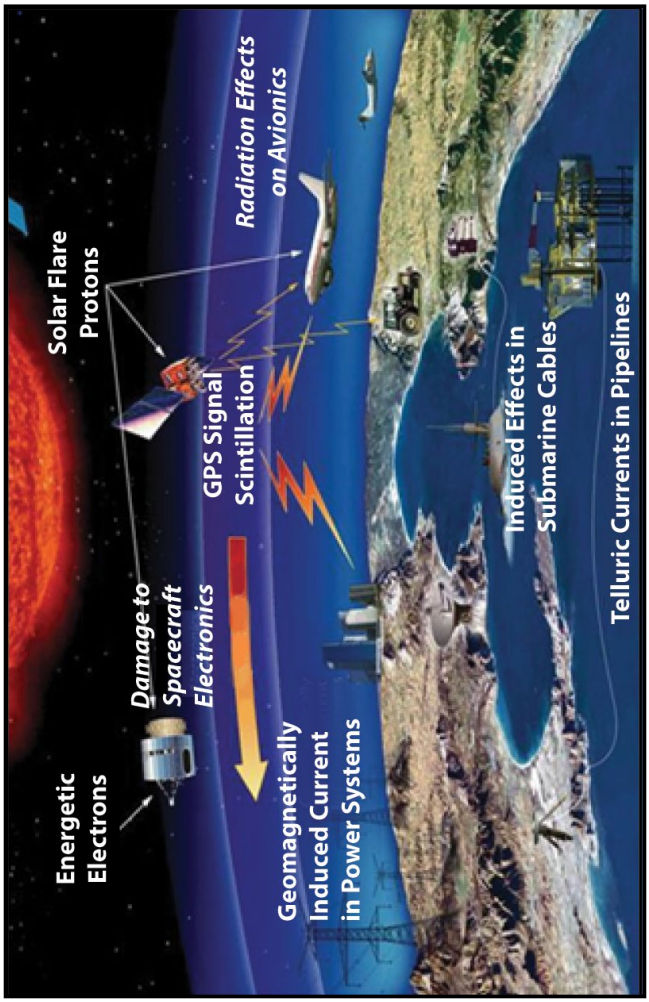

Figure F-2. Space environment effects.

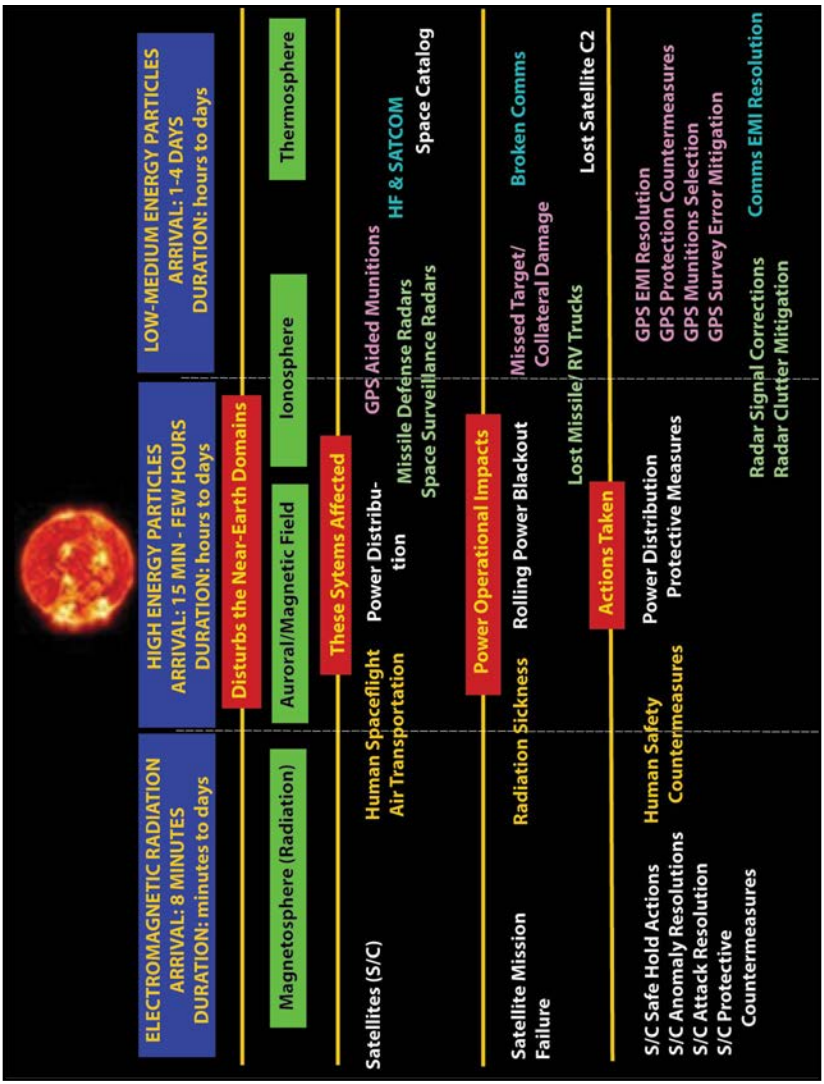

Figure F-3. Space environment impacts.

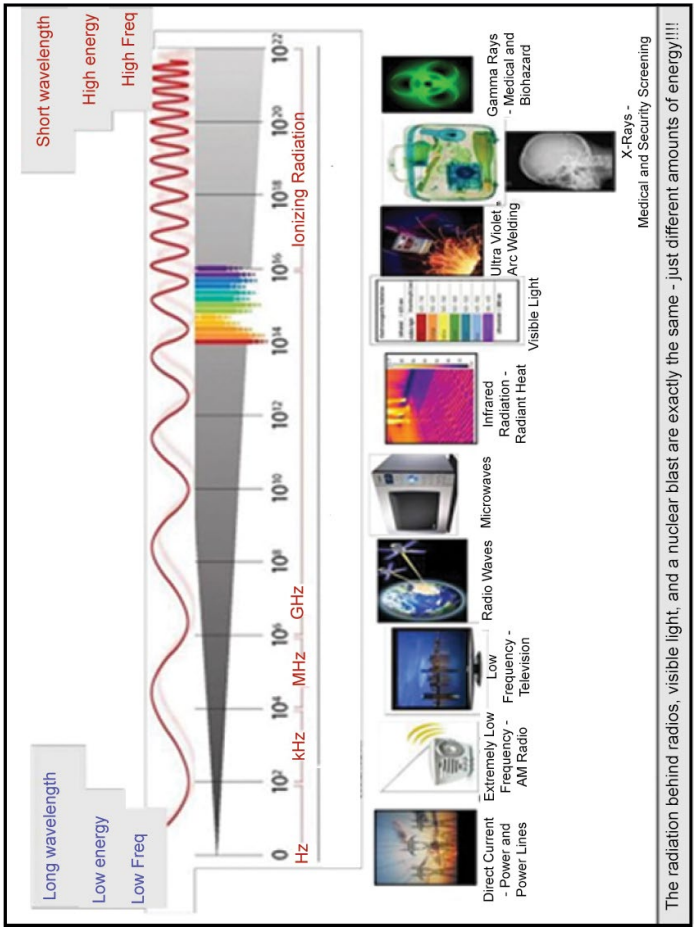

Figure F-4. Electromagnetic spectrum.

Satellite Communications:

- Communications satellites relay and amplify signals through the use of a transponder between a transmitter and a receiver.
- Communications satellites are used for television, telephone, radio, Internet, and military applications.
- The signal traveling from the ground to the satellite is referred to as the uplink (see Figure F-5).
- The signal traveling from the satellite to the ground is referred to as the downlink (see Figure F-5).

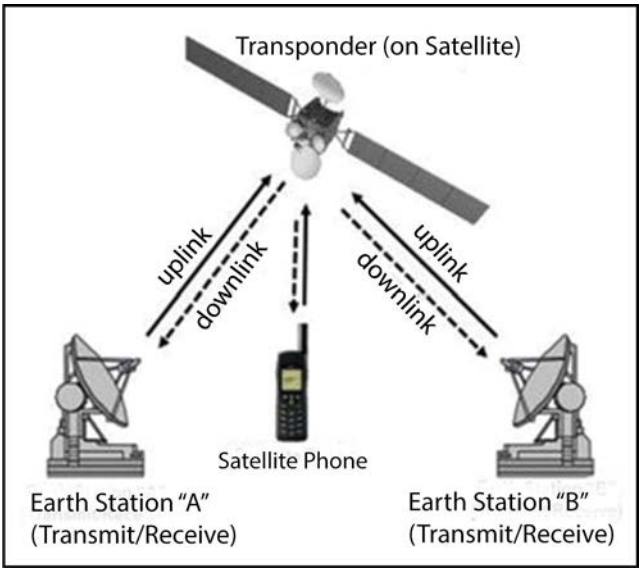

Figure F-5. Signal travel path.

- The uplink is sufficiently narrow in width to ensure it is received by the desired satellite and not an adjacent satellite (see Figure F-6).

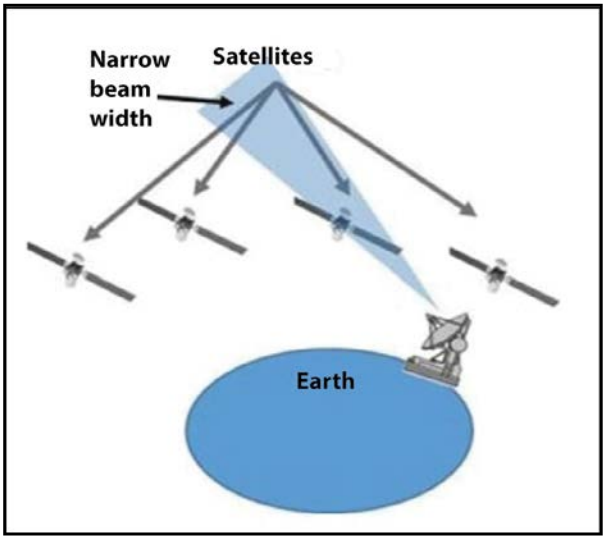

Figure F-6. Narrow beam width.

- The downlink signal creates a “footprint” on the earth’s surface; the transmitting and receiving stations can “see” the satellite if there are no obstructions, and can obtain access to the satellite if one is designated as an authorized user.
- All satellite communications currently in use operate within a range of frequencies called “bands.”
- **Ultra-High Frequency (UHF) Narrowband Communications**
    - Frequency range: 300 megahertz (MHz) to three gigahertz (GHz)
    - Includes Mobile User Objective System (MUOS) and UHF follow on (UFO)
    - More susceptible to ionospheric disturbances (“space weather”)
    - Least jam resistant
- **Super High Frequency (SHF) Wideband Communications**
    - Frequency range: 3 GHz to 30 GHz
    - Includes Wideband Global Satellite (WGS) communications (SATCOM) and Defense Satellite Communications System (DSCS) as well as most commercial/civilian SATCOM systems
    - Less susceptible to space weather effects
    - More jam resistant
- **Extremely High Frequency (EHF) Protected Communications:**
    - Frequency range: 30 GHz to 300 GHz
    - Includes advanced EHF (AEHF) and Military Strategic and Tactical Relay (MILSTAR)
    - Most susceptible to terrestrial weather
    - Most jam resistant

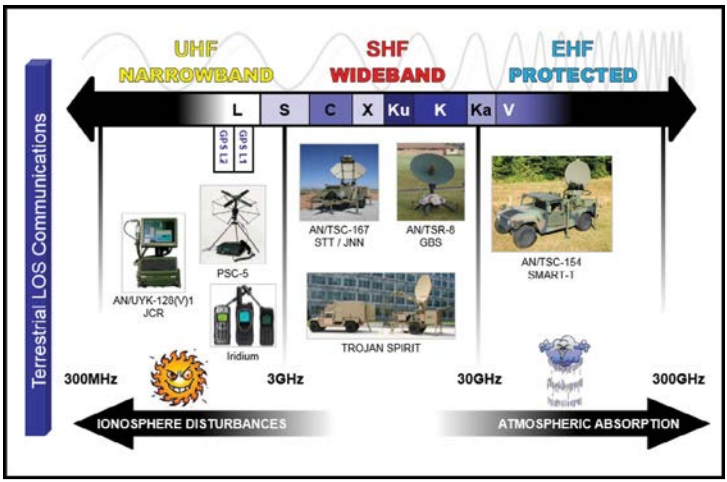

Figure F-7. Terrestrial line-of-sight (LOS) communications.

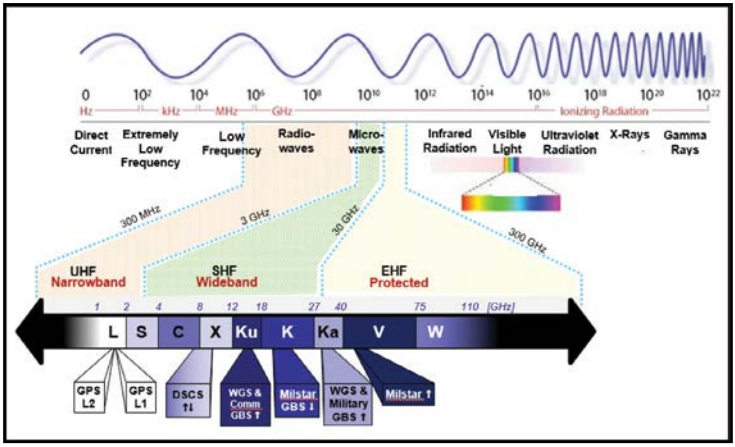

Figure F-8. SATCOM systems use of the Electromagnetic Interference (EMI) spectrum.

Table F-1. Basic communication band specifications.

Name	Frequency range	System usage
HF	3-30 MHz	HF communications
VHF	30-300 MHz	SINCGARS, weather, FAA {PRC-117f/psc-5/ prc-148]
UHF	300m-1 GHz	LOS RADIOS, UFO, MUOS, [PRC-117f/psc-5/PRC-1]
L	1-2 GHz	LOS RADIOS FFT, Iridium, INMARSAT, THURAYA, [GPS/JBC-P (FBCB2)]
S	2-4 GHz	Commercial TROPO commercial
C	4-8 GHz	TROPO commercial
X	8-12 GHz	DCSC, WGS, [WIN-T]
Ku	12-18 GHz	Commercial
K	18-27 GHz	MILSTAR, AEHF, UFO/E/EE, IBS, WGS, GBS, (downlink)
Ka	27-40 GHz	WGS, GBS (uplink)
Q and A	40-75 GHz	MILSTAR, AEHF, UFO/E/EE, IBS (uplink) [SMART-T/SCAMP]

Table F-2. Communications capabilities, limitations, and vulnerabilities.

ULTRA HIGH FREQUENCY (UHF) - NARROWBAND COMMUNICATIONS		
Capabilities	**Limitations**	**Vulnerabilities**
GEO orbit: 1/3 earth coverage Mobile terminals Easy signal acquisition All terrestrial weather Foliage penetration	Older legacy equipment = degradation Channels limited Narrow bandwidth Access limitations	Easily jammed Space weather – Ionospheric disturbances
SUPER HIGH FREQUENCY (UHF) - NARROWBAND COMMUNICATIONS		
Capabilities	**Limitations**	**Vulnerabilities**
GEO orbit: 1/3 earth coverage High data rates and through put "Sweet spot" More channels Footprint tightly focused (protection)	Large antennas High antenna Footprint slightly focused (access) More expensive Limited mobility	Jamming* *SHF is more resistant than UHF, but less resistant than EHF, to jamming
EXTREMELY HIGH FREQUENCY (EHF) - PROTECTED COMMUNICATIONS		
Capabilities	**Limitations**	**Vulnerabilities**
Various orbits Extensive bandwidth Cross banding on satellite Uncrowded spectrum jam resistant (MILSTAR)	Expensive Data rates Highest antenna Accuracy	Terrestrial weather (rain/snow) - atmospheric disturbances

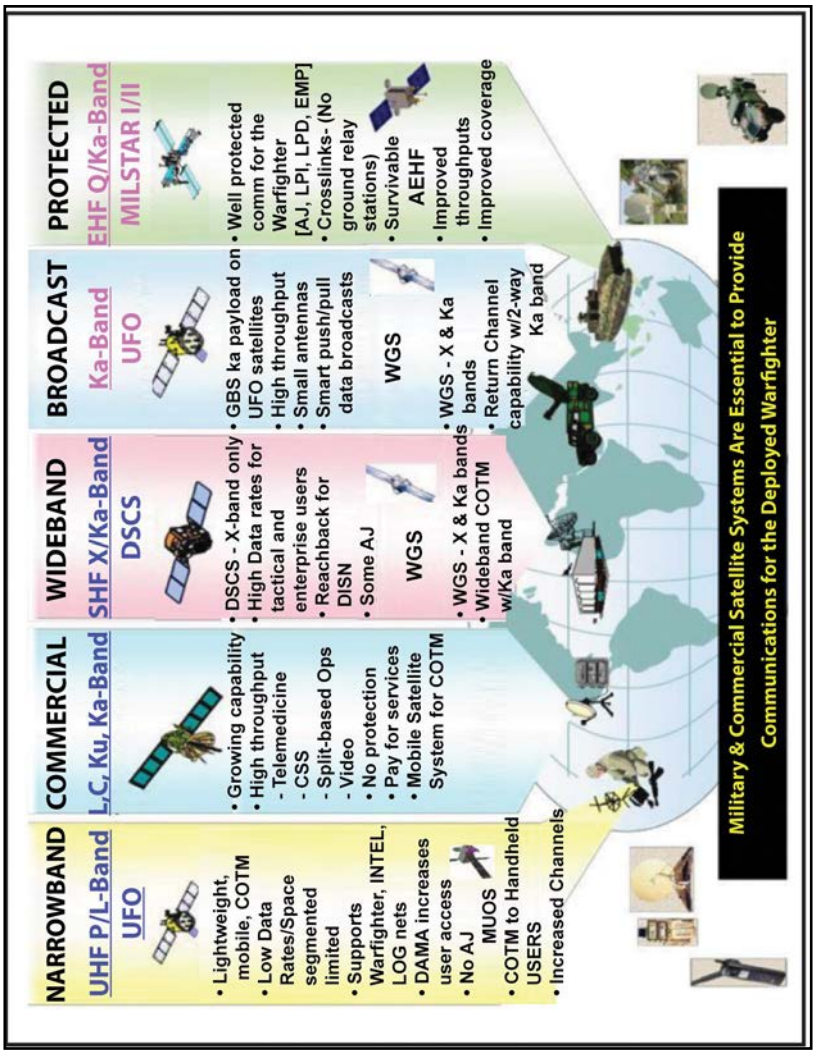

Figure F-9. Military and commercial satellite systems provide communications for the Warfighter.

EMI

- EMI occurs when a device's performance is disturbed or interrupted by electromagnetic radiation/conduction. It can affect virtually anything with some form of electrical current passing through it.
- Natural or artificial in origin, unintentional or intentional (most is unintentional).
- GPS-enabled receivers are highly susceptible to EMI. Signal is very weak when it arrives at the receiver.
- EMI can vary greatly, change rapidly, and affect similar systems differently.

How to recognize EMI:

- First indications of possible EMI often appear as equipment malfunctions, user reports of communications loss (partial or complete), or a reduction in bandwidth (i.e.,, a "slow" network).
- Certain devices provide a visual indication of EMI.

Lessons/best practices:

- Troubleshoot the device to ensure it is operating properly.
- Ensure nothing obstructs the receiver's view of the satellites.
- Plan for increased solar activity, which has the potential to affect communications in the UHF portion of the spectrum.
- Adverse terrestrial weather may impact communications in the EHF portion of the spectrum.
- All suspected EMI must be reported. Submit reports in accordance with local unit SOP.
- Classify report in accordance with system-specific security classification guide.

GPS Positioning, Navigation, and Timing (PNT)

Missions: Position, navigation, timing, and nuclear detonation detection.

Characteristics:

- Always available globally ("24/7").
- Signal is not usually affected by terrestrial weather conditions.

- Continually broadcasts specially coded satellite signals that can be processed in a GPS receiver enabling the receiver to compute position, velocity, time, and crypto-loaded military receivers to receive the secure encrypted PNT signal.
- Uses Common grid (WGS-84) as a base reference (Datum).

. Enables:

- Positioning information (Defense Advanced Global Positioning System Receiver [DAGR])
- Navigational information (Joint Battle Command-Platform [JBC-P]/ JBC-Log)
- Network synchronization and timing (non-secure and secure Internet protocol router [NIPR/SIPR]/SATCOM)
- GPS-aided munitions – Joint Direct Attack Munition/Army Tactical Missile System (JDAM/ATACM/Excalibur)
- Timing for intelligence, surveillance, and reconnaissance (ISR) missions (e.g., timestamp of overhead imagery collection product)
- Unmanned aircraft systems (UAS)

. Limitations:

- It needs an unobstructed view to a minimum of four satellites.
- Multi-path interference causes timing errors resulting in accuracy errors.
- Satellite proximity to each other affects accuracy; the closer together the satellites are in view, the worse the accuracy.
- Multiple datum and grid references available can result in positioning and navigational accuracy errors.
- Operates in “L Band” (L1: 1575 MHz; L2: 1227 MHz) within the UHF frequency range at a very low signal strength – susceptible to ionospheric disturbances and easily jammed.

How GPS Works

Figure F-10 illustrates how a receiver (such as a DAGR) uses signals from four or more satellites to calculate its position in 3-dimensiona. trilateration.

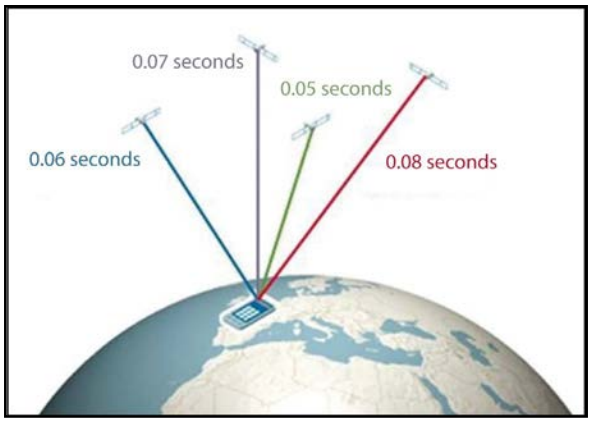

Figure F-10. Process of trilateration.

- Each GPS satellite is continually sending out weak radio signals with its position and the exact time.
- On earth, the receiver such as a DAGR, compares the time the signal was sent with the time it was received.
- After correcting for errors, the receiver uses the signals from four or more satellites to calculate its position in 3-dimensional trilateration.

Multi-Path Interference

Figure F-11 portrays how reflected signals causes timing errors with the following list of interferences.

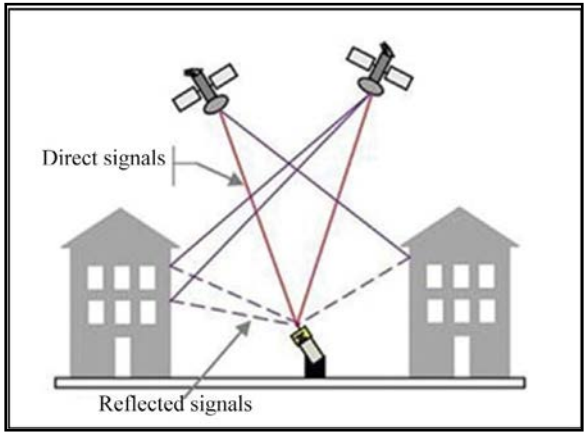

Figure F-11. Multi-path interference.

- Caused by GPS signals reflecting off of surfaces near the GPS receiver that can either interfere with, or be mistaken for, the “true” signal that follows a direct path from the satellite to the receiver.
- Common sources of multi-path interference include rock outcroppings, bases of valleys, buildings, and vehicles.
- The reflected signal is delayed in arriving at the receiver (longer path) causing timing errors.
- One nano-second (one-billionth of a second) of timing error equals one foot of error; one second of timing error equals 189,394 error miles.

Joint Friendly Force Tracking (JFFT) Generic Data Processing

- GPS continuously transmits signals to GPS-enabled JFFT devices.
- JFFT devices either actively or passively uplink their precise location information (PLI) to an overhead communications satellite.
- Most handheld JFFT devices only transmit to the overhead asset.
- Most vehicle dismounted JFFT devices may both transmit and receive data with the communications satellite.
- In select situations, a brevity code or text message may be added to the message uplinked to the communications satellite.
- The communications satellite downlinks the data to a ground station that transmits the data to the Mission Management Center (MMC) or Blue Force Tracking (BFT) Global Network (BGN) via the Global Information Grid (GIG).
- The MMC processes the data and disseminates the JFFT information to various command and control display systems where the JFFT icon is displayed.

Display systems include:

- Command Post of the Future (CPOF)
- Maneuver Control System-Light (MCS-L)
- Battle Command Sustainment Support System (BCS3)
- JBC-Platform (JBC-P) terminals
- **Note:** The JFFT device must be registered with the MMC and BGN or the data is not disseminated.

- JFFT data dissemination is determined by the Data Owner Guidance (DOG) which is pre-coordinated between the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) MMC and the user.

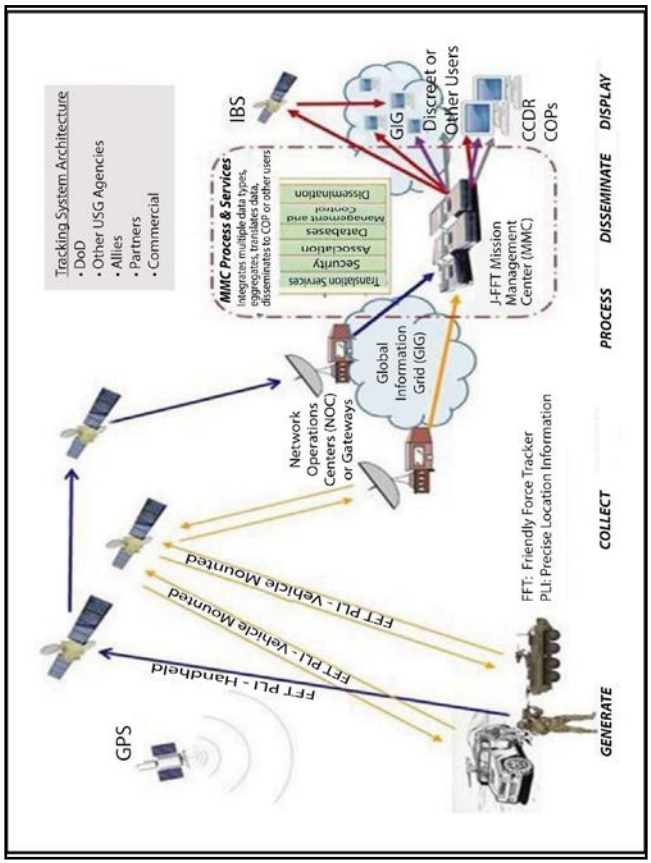

Figure F-12. JFFT generic data architecture process.

JFFT Technical Details

- JFFT devices use both GPS and SATCOM:
  - GPS provides position data.
  - Communications satellites relay data to the MMC for processing and dissemination.

- SATCOM frequencies:
  - Uplink: L-Band (UHF) [1-2 GHz]
  - Downlink: S-Band (UHF) [2-4 GHz]
- GPS:
  - L1 (UHF): 1575 MHz
  - L2 (UHF): 1227 MHz
- EMI can impact GPS signals and SATCOM signals and therefore impact JFFT devices.
- All suspected EMI must be reported. Follow your unit SOP to report all suspected EMI.

Some JFFT devices are illustrated in Figures F-13 and F-14.

Figure F-13. JBC-P LOG.

Figure F-14. AN/UYK-128(V)1 - JBC-P.

ISR

- ISR provides improved situational and battlespace awareness to commanders, staffs, operational units, and individual operators often using space capabilities such as GPS and SATCOM.
- The Army executes ISR through the operations and intelligence processes and through information collection.

Think of it in reverse order…

- **First, we conduct a** *reconnaissance*
- **Then, we** *surveil (***observe***)*
- **Finally, we collect and produce** *intelligence*

Overhead Persistent Infrared (OPIR)

What is OPIR?

- Near continuous coverage of broad or specific areas on the surface of the earth
- Sensors detect high-energy events – think missile launches
- OPIR is not imagery but can be used in conjunction with it
- Examples include Space-based Infrared System (SBIRS) satellites in geosynchronous earth orbit (GEO) and highly elliptical orbit (HEO) to provide global OPIR capabilities

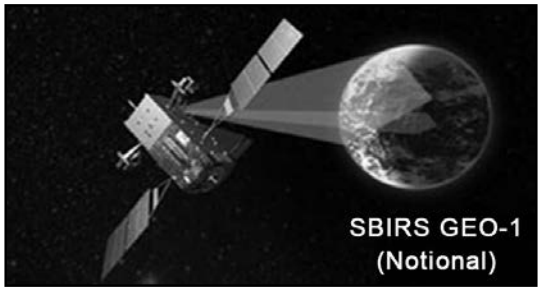

Figure F-15. Notional SBIRS GEO-1.

How does OPIR assist the Warfighter?

- Mission planning
- Surveillance of named areas of interest (NAIs), targets, etc., for trend analysis and event correlation
- Weather
- Operations
- OPIR "watch boxes" – focused surveillance areas
- Missile warning/defense
- Post-mission assessment (e.g.,, battle damage assessment [BDA])

Imagery:

- Imagery is collected via “remote sensing.”
- Imagery from government-owned systems has limited release.
- Imagery from commercially-owned systems is more easily released to civilian and coalition partners.
- Enhanced View Web Hosting Service provides personnel with a .”mil” email address for direct access to commercial imagery at no cost.

Types of imagery:

- **Electro-optical (EO):** Collects what it “sees” in daylight; limited by cloud coverage/smoke
- **Infrared (IR):** Collects indications of IR (heat) and is best done at night when the surrounding area is cooler; limited by high clouds
- **Synthetic aperture radar (SAR):** Collects energy (radar) the satellite payload transmits and “pings” off the target to create an image, (very granular images); can collect anytime of the day or night and in all weather conditions

Figure F-16. SAR image.

Imagery Collection Formats/Processing Technique

- **Panchromatic** (gray scale): very sharp image, "crisp"

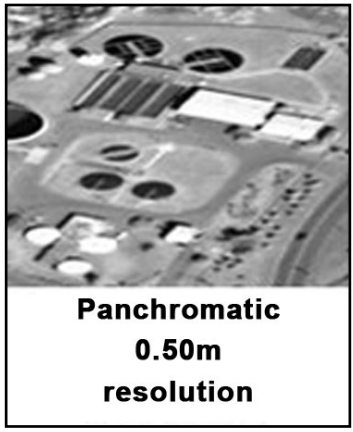

Figure F-17. Panchromatic image.

- **Multispectral** (color): image resolution not as sharp and can distinguish what objects are based on multispectral signatures (e.g., pine tree from a maple tree)

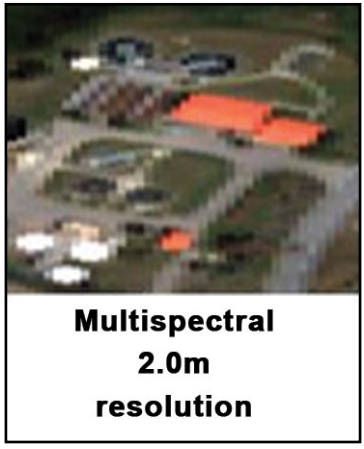

Figure F-18. Multispectral image.

- **Pan-sharpened**: The image is easier to interpret by overlaying a multispectral image over its matching panchromatic image.

Figure F-19. Pan-sharpened image.

Military Applications for Imagery

- **Operational Planning:**
  - Terrain analysis
  - Helicopter landing zones (HLZs)
  - Intelligence
  - Change detection
  - Choke point identification
- **Counternarcotic Support:**
  - Crop analysis
  - Pattern of life
- **Disaster Response:**
  - Short-wave infrared (SWIR)/long-wave infrared (LWIR) aids in firefighting
  - Change detection

Appendix G

Sample Report Formats

Report Formats

All suspected electromagnetic interference must be reported. Unit standing operating procedures (SOPs) will dictate in what format the information is to be reported to the tactical operations center (TOC).

Examples:

- Tactical unit submits a spot report (SPOTREP or SPOT report) to the tactical operations center (TOC).
- TOC submits to battalion/brigade (BN/BDE) S-6, S-2, and electronic warfare for troubleshooting and intelligence request for information (RFI) process.
- S-6 notifies theater/regional satellite communications (SATCOM) support facility within 10 minutes of receiving the report.
- S-2 or S-6 submits a Joint Spectrum Interference Resolution - Online (JSIR-O) report.

Remember to follow your unit SOPs when selecting the reporting format you will use.

Sample report formats included in this appendix:

- SPOT report
- Joint Spectrum Interference Resolution (JSIR) report
- Meaconing, Intrusion, Jamming, and Interference (MIJI) report

Refer to Field Manual (FM) 6-99, *U.S. Army Report and Message Formats,* Aug 2013, for additional Army reporting formats.

Refer to Chairman Joint Chiefs of Staff Memorandum (CJCSM) 3320.02D, *Joint Spectrum Interference Resolution (JSIR) Procedures,* 3 Jun 2013, for additional information on JSIR procedures.

SPOT Report

General Instructions. Use to report intelligence or status regarding events that could have an immediate and significant effect on current and future operations. This is the initial means for reporting troops in contact and event information. References: FM 3-20, FM 3-90.5, and FM 3-90.5, and FM 3-90.6.

Line 1 –Date and Time _____

(Date time group – DTG)

Line 2 –Unit _____

(Unit making report)

Line 3 –Size _____

(Size of detected element)

Line 4 –Activity _____

(Detected element activity at DTG of report)

Line 5 –Location _____

(UTM or grid coordinate with MGRS [Military Grid Reference System] grid zone designator of detected element activity or event)

Line 6 –Unit _____

(Detected element unit, organization, or facility)

Line 7 –Time _____

(DTG of observation)

Line 8 –Equipment _____

(Equipment of observed element)

Line 9 –Assessment _____

(Apparent reason or purpose of observed activity)

Line 10 –Narrative _____

(Free text for additional information required for report clarification)

Line 11 –Authentication _____

(Report authentication)

UTM: Universal Transverse Mercator

Joint Spectrum Interference Resolution (JSIR) Format

Classification* (TS/S/C/U – when filled in)

WHEN STARTED, ZULU* _____

(Format must be a valid date in the spreadsheet "date format" [e.g., 1/1/2020, not 012233ZJAN10])

AFFECTED SYSTEM* _____

AFFECTED FREQ MHz** _____

(Format must be numeric [e.g., 1234.234 no. M1234.234])

CHANNEL** _____

LOCATION OF AFFECTED RECEIVER* _____

COUNTRY OF AFFECTED RECEIVER _____

DESCRIPTION OF EMI EVENT _____

(Include what is sounds like, actions taken so far, suspected cause, and other comments)

VICTIM POC NAME _____

VICTIM UNIT _____

COCOM/SERVICE/AGENCY _____

* Required item

** At least one of these items is required

Preferred method of submission is online via JSIR-Online (JSIR-O), http://intelshare.intelink.sgov.gov/sites/jsir/default.aspx

See CJCSM 3320.02C and D for additional information. Submit report in accordance with local unit SOP. Classify report in accordance with system specific security classification guide.

CLASSIFICATION * (TS/S/C/U – when filled in)

EMI: electromagnetic interference

COCOM: combatant commander

POC: point of contact

TS/S/C/U: top secret/secret/classified/unclassified

Meaconing, Intrusion, Jamming, and Interference (MIJI) Report

General Instructions: Use to share MIJI incidents in a timely manner, and to provide for joint exchange of tactical MIJI information, including electro-optic interference.

LINE 1 –DATE AND TIME _____

(DTG)

LINE 2 –UNIT _____

(Unit making report)

LINE 3 –INTERFERENCE _____

(Strength and characteristics)

LINE 4 –LOCATION _____

(UTM or six-digit grid coordinate with MGRS grid zone designator of incident)

LINE 5 –ON TIME _____

(Start DTG)

LINE 6 –OFF TIME _____

(End DTG)

LINE 7 –EFFECTS _____

(Operations or equipment affected)

LINE 8 –FREQUENCY _____

(Frequency or affected frequency range)

LINE 9 –NARRATIVE _____

(Free text for additional information required for report clarification)

LINE 10 –AUTHENTICATION _____

(Report authentication)

DTG: Date-time group

MGRS: Military Grid Reference System

UTM: Universal Transverse Mercator

Appendix H

Institutional Education and Training Opportunities

The Army Space Cadre

The Army Space Cadre is a force of Soldiers and Civilians who have documented training and experience in the Space domain. These personnel can receive the following skill identifiers:

Army Space Cadre ASI 3Y "Army Space Cadre," and PDSI S1A "Unit Space Trainer"

Army Space Cadre (ASI 3Y)

ASI 3Y identifies Soldiers who have the required education necessary to enable them to be used as members of the Space Cadre in support of Army operations and planning.

To qualify, Soldiers must meet one of the following criteria:

- Successful completion of the U.S. Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT) 80-hour Army Space Cadre Basic Course (ASCBC)
- Successful completion of the National Security Space Institute (NSSI) Space 200, NSSI Space 300, or Advanced Space Operations School (ASOpS) Space Operations Course (80-hour resident course)
- Successful completion of the Space Activities portion (specifically courses A537 and A543) of the Command and General Staff Course at Fort Leavenworth, Kansas
- Successful completion of other 80-hour space-related resident courses approved by the ASI 3Y proponent

Unit Space Trainer (PDSI S1A)

Identifies Soldiers who have the training background necessary to enable them to be used as organizational trainers in support of the Army Space Training Strategy.

To qualify, Soldiers must meet the following criteria:

- Complete the Army Space Cadre Basic Course (ASCBC) or higher-level residential space professional development course (such as Space 200)
- Compete the Foundation Instructor Facilitator Course or equivalent
- Complete at least eight hours of Tactical Space Training as determined by the USASMDC/ARSTRAT G37 TREX, Army Space Training Integration (ASTI) branch

Available Space Education

The following courses are available and can be scheduled via the Army Training Requirements and Resource System (ATRRS). Additional courses are available through the USASMDC/ARSTRAT Space and Missile Defense School and Doctrine Center.

Army Space Cadre Basic Course (ASCBC)

ASCBC, a two-phase course, provides a fundamental understanding of space concepts and capabilities for members of the Army Space Cadre as well as other Warfighters. This course teaches the following topics. Space Cadre Overview, USASMDC/ARSTRAT Command, U.S. Space History, Orbital Mechanics, U.S. Space Policy, Space Organizations, Electromagnetic Spectrum, Space Environmental Impacts, Spacecraft Systems, Space Lift, Satellite Operations, Space Acquisitions, Satellite Command and Control (C2), Space Surveillance Network (SSN), Satellite Communications (SATCOM), Global Positioning System (GPS), Weather Satellites, Military Application of Space-based Imagery, and Overhead Persistent Infrared (OPIR). Students will have a fundamental understanding of the capabilities, limitations, and vulnerabilities of the space-based assets available for operations, and provide a basic understanding of how those assets are critical to the planning, preparation, and effective execution of unified land operations.

ASCBC is in ATRRS, School Code 129, Course Number 2G-SI/ASI3Y/043-ASI3Y (MC), and is offered in residence at Colorado Springs, CO, and through mobile training teams (MTTs).

ASCBC Phases I and II fulfill the education requirements for the Basic Space Badge, Level 1 Civilian Space Professional certification, ASI/SI 3Y (Space Cadre), and PDSI S1A (Unit Space Trainer).

SATCOM Electromagnetic Interference (EMI) Fundamentals

SATCOM EMI Fundamentals provides fundamental training on satellite EMI and related topics for personnel working in the area of diagnosing issues with intentional and unintentional interference with on-orbit satellite systems. Instruction includes foundations of orbital predictions, radio frequency propagation, Army and Air Force systems, signal characteristics, space environment, principles of geolocation, threat emitters, and space law. Prerequisite for follow-on courses. Army Mobile Integrated Ground Suite System operator initial qualification training, Army Space Integrated Ground Suite System operator initial qualification training, and a planner's course for deployment and employment of both systems.

SATCOM EMI Fundamentals is in ATRRS, School Code 129, Course Number 2G-F208/102-F133.

Note: This course does not satisfy the education requirements for the Basic Space Badge, Level 1 Civilian Space Professional certification, or the Personnel Development Skill Identifier S1A.

Army Space Control Fundamentals (ASCF)

ASCF provides Soldiers, Civilians, and contractor personnel entering the Space Control mission area with the foundational knowledge required to understand Army Space Control, how it fits in the Department of Defense enterprise, and how it provides support to the Warfighter. This course also introduces the concepts of the radio frequency spectrum, satellite EMI, orbital predictions, radio frequency propagation, Army and Air Force systems, signal characteristics, space environment, principles of geolocation, threat emitters, and space law.

ASCF is in ATRRS, School Code 129, Course Number 2F-F213/233-F27.

Note: This course does not satisfy the education requirements for the Basic Space Badge, Level 1 Civilian Space Professional certification, or the Personnel Development Skill Identifier S1A.

To review all available Army Space related courses search School Code 129 in ATRRS.Common access card required:

https://www.atrrs.army.mil/atrrs2.aspx

National Space Security Institute (NSSI) and Advanced Space Operations School (ASOpS)

In addition to Army specific courses as related to Space Operations, the U.S. Air Force Space Command offers multiple courses through the National Space Security Institute (NSSI) and ASOpS.

Introduction to Space – Distance Learning

The Introduction to Space course is a dynamic web-based familiarization course for all branches of service and government agencies. The course is for new space support personnel or those within the space community with little exposure to Space Operations. The course is designed to provide a foundational understanding of the space mission areas and organizations and covers a wide range of topics from Space History to Future Systems.

Introduction to Space (DL) is in ATRRS, School Code 129A, Course Number 2G-F120/043-F40 (DL).

Note: This course does not satisfy the education requirements for the Basic Space Badge, Level 1 Civilian Space Professional certification, or the Personnel Development Skill Identifier S1A.

Space Operations Course (SOC)

The SOC is a two-week course designed to provide a foundation of space knowledge for new space support personnel, acquirers, engineers, or those with little space operations exposure. It introduces the areas of doctrine, orbital dynamics, space environment, space law, physical science aspects of space systems, force applications, and other related subjects that enhance the understanding of the operational aspects of space.

SOC is in ATRRS, School Code 129A, Course Number 2G-F117/043-F36.

Note: This course does not satisfy the education requirements for the Basic Space Badge, Level 1 Civilian Space Professional certification, or the Personnel Development Skill Identifier S1A.

Space 200

Space 200 prepares students for intermediate-level leadership roles within the military space community. The course investigates two major areas. Space Systems Development and Space Power. The course focus is space applications and employment in operational and tactical theaters. It provides an understanding of the design, development, and acquisition of space systems; explores space asset capabilities, limitations and vulnerabilities; and explores the impact of space mission areas, and competing space and counter-space capabilities on Joint and coalition forces.

Space 200 is in ATRRS, School Code 129A, Course Number 2G-F118/043-F37.

Space 200 fulfills the education requirements for the Basic Space Badge, Level 1 Civilian Space Professional certification, the ASI/SI 3Y (Space Cadre), and the PDSI S1A (Unit Space Trainer).

To view more NSSI and ASOpS information of available courses search School Code 129A in ATRRS. Common access card required: https://www.atrrs.army.mil/atrrs2.aspx

USASMDC/ARSTRAT Space and Missile Defense School and Doctrine Center

This provides Army space; denied, degraded, and disrupted space operational environment (D3SOE); and space domain institutional instruction to the U.S. Army Training and Doctrine Command Centers of Excellence (CoEs) through common core courses and military occupational specialty/branch specific instruction. Specific detailed space training and advanced blocks of instruction are available upon coordination.

Appendix I

Defense Advanced Global Positioning System Receiver (DAGR) Encryption

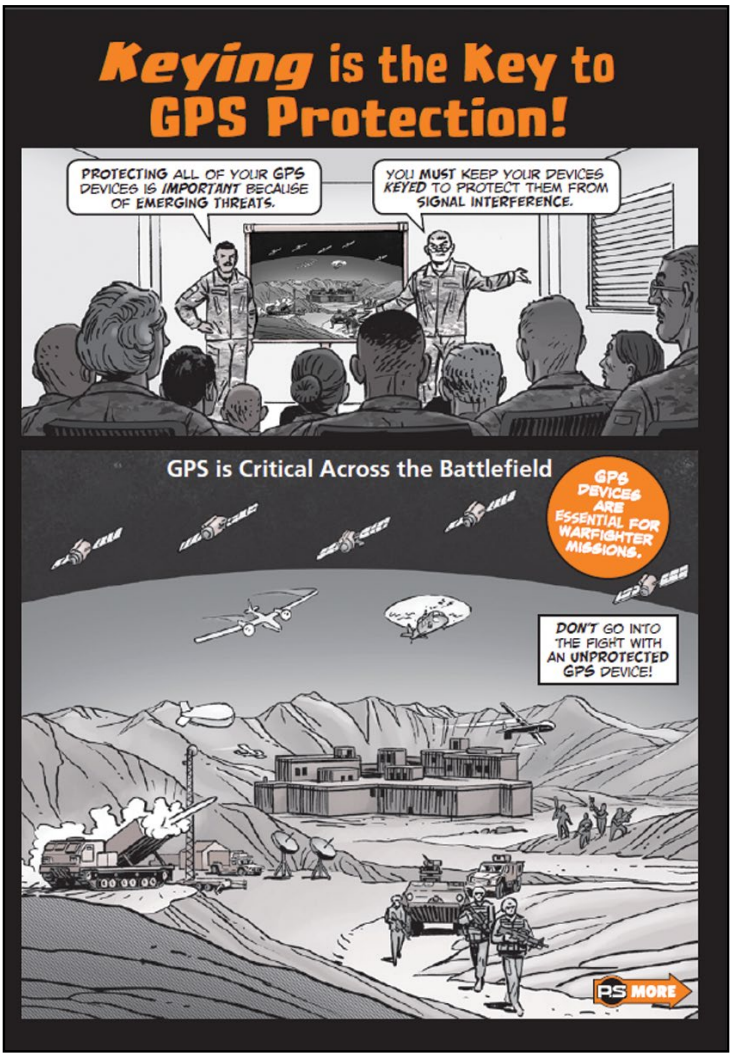

Figure I-1. PS Magazine, The Preventive Maintenance Monthly, Issue 761, Apr 2016, Pages 48-51. https://www.logsa.army.mil/psmag/archives/PS2016/761/761-49-51.pdf.

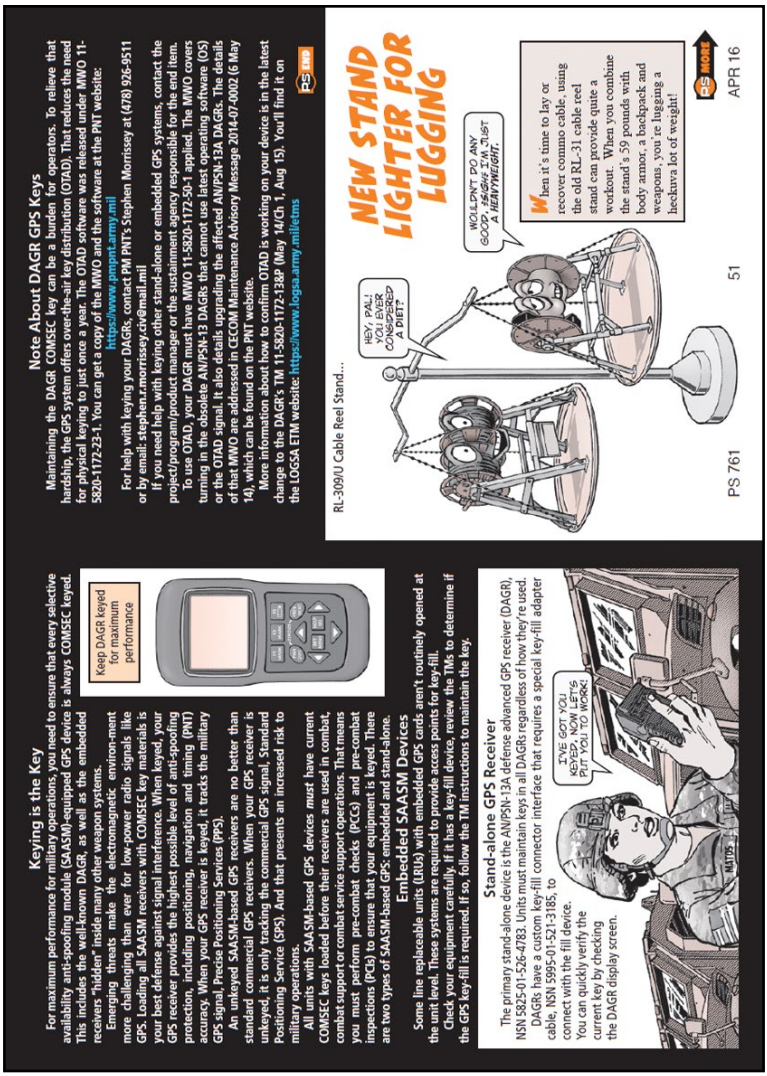

Figure I-2. PS Magazine, The Preventive Maintenance Monthly, Issue 761, Apr 2016, Pages 48-51. https://www.logsa.army.mil/psmag/archives/PS2016/761/761-49-51.pdf.

Appendix J

Acronyms

ADRP	Army Doctrine Reference Publication
AEHF	advanced extremely high frequency
AMD	air and missile defense
AO	area of operations
AOC	area of concentration
ARSST	Army Space Support Team
ARSTRAT	Army Forces Strategic Command
ASCBC	Army Space Cadre Basic Course
ASCC	Army Service Component Command
ASCE	Army Space Coordination Element
ASCF	Army Space control fundamentals
ASI	additional skill identifier
ASKMS	Army Space Knowledge Management Site
ASOpS	Advanced Space Operations School
ASOS	air support operations squadron
ASPDO	Army Space Personnel Development Office
ATACM	Army Tactical Missile System
ATN	Army Training Network
ATO	air tasking order
ATO	authorization to operate
ATRRS	Army Training Requirements and Resource System
AUTL	Army Universal Task List
AWFC	Army Warfighting Challenge
BCS3	Battle Command Sustainment Support System
BCT	brigade combat team
BDA	battle damage assessment
BDE	brigade
BEB	brigade engineer battalion
BFT	blue force tracking

BGN	Blue Force Tracking Global Network
BLOS	beyond line-of-sight
BN	battalion
BUB	battle update brief
C2	command and control
CCIR	commander's critical information requirements
CCP	contingency command post
CEMA	cyberspace electromagnetic activities
CG	commanding general
CJCSM	Chairman of the Joint Chiefs of Staff Manual
COA	course of action
COCOM	combatant command
CODSPACE	combat operations division space
CoE	center of excellence
COIN	counterinsurgency
COMSEC	communications security
COP	common operational picture
CPOF	Command Post of the Future
CPX	command post exercise
CREW	counter RCIED electronic warfare
CSAR	combat search and rescue
CSS	combat service support
CTC	combat training center
CUB	commander's update briefing
CUOPS	current operations
D3SOE	denied, degraded, and disrupted space operational environment
DAGR	Defense Advanced Global Positioning System Receiver
DCGS	Distributed Common Ground System
DCO	defensive cyberspace operations
DIRSPACEFOR	Director of Space Forces
DODIN	Department of Defense Information Network

DOTMLPF	doctrine, organization, training, materiel, leadership and education, personnel, facilities and policy
DRT	digital receiver technologies
DSCS	Defense Satellite Communications System
DTG	date-time group
EA	electronic attack
EEFI	essential elements of friendly information
EEOB	enemy electronic order of battle
EHF	extremely high frequency
EMI	electromagnetic interference
EMS	electromagnetic spectrum
EO	electro-optical
EP	electronic protection
ES	electronic warfare support
EW	electronic warfare
EWE	electronic warfare element
EWO	electronic warfare officer
FA	functional area
FARG	focus area review group
FBCB2	Force XXI Battle Command, Brigade-and-Below
FFIR	friendly force information requirements
FFT	friendly force tracker
FLOT	forward line of own troops
FM	frequency modulation
FRAGORD	fragmentary order
FTX	field training exercise
FUOPS	future operations
GEO	geosynchronous earth orbit
GEOINT	geospatial intelligence
GHz	gigahertz
GIANT	GPS interference and navigation tool
GIG	global information grid

GLONASS	Globalnaya Navigazionnaya Sputnikovaya Sistema, or Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GO	general officer
GPS	Global Positioning System
GTA	graphic training aid
HEO	highly elliptical orbit
HF	high frequency
HLZ	helicopter landing zone
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HPTL	high-payoff target list
HR	hostage recovery
HST	home station training
HVTL	high-value target list
ICW	intermittent continuous wave
IDP	internally displaced person
IMINT	imagery intelligence
INS	Inertial Navigation System
IO	information operations
IOWG	information operations working group
IR	infrared
IRC	information-related capabilities
ISR	intelligence, surveillance, and reconnaissance
JBC-L	Joint Battle Command-Logistics
JBC-P	Joint Battle Command-Platform
JDAM	Joint Direct Attack Munition
JFFT	Joint Friendly Force Tracking
JFLCC	Joint Forces Land Component Command
JIIM	Joint, Interagency, Intergovernmental, and Multinational
JMRC	Joint Multinational Readiness Center
JPADS	Joint Precision Airdrop Delivery System
JRFL	Joint Restricted Frequency List

JRTC	Joint Readiness Training Center
JSIR	Joint Spectrum Interference Resolution
JSIR-O	Joint Spectrum Interference Resolution-Online
JTF	Joint Task Force
LOS	line-of-sight
LWIR	long-wave infrared
MATV	Mine-Resistant Ambush Protected [MRAP] All-Terrain Vehicle
MCP	main command post
MCS	master control station
MCT	mission command training
MCTP	Mission Command Training Program
MDMP	military decision making process
MGRS	Military Grid Reference System
MHz	megahertz
MIJI	meaconing, intrusion, jamming, and interference
MILDEC	military deception
MILPER	military personnel
MILSTAR	military strategic and tactical relay
MISO	military information support to operations
MMC	Mission Management Center
MOE	measure of effectiveness
MOP	measure of performance
MTOE	Modified Table of Organization and Equipment
MTT	mobile training team
MUM-T	manned, unmanned-teaming
MUOS	mobile user objective system
MW	missile warning
NAI	named area of interest
NAVWAR	navigational warfare
NCO	noncommissioned officer
NIPR	Non-Secure Internet Protocol Router
NSSI	National Space Security Institute

NTC	National Training Center
NTM	national technical means
OB	order of battle
OC/T	observer coach/trainer
OCO	offensive cyberspace operations
OE	operational environment
OPIR	overhead persistent infrared
OPLAN	operations plan
OPORD	operations order
OPSEC	operations security
OPT	operational planning team
OPTEMPO	operating/operations tempo
PA	public affairs
PACE	primary, alternate, contingency, and emergency
PCC	pre-combat checks
PCI	pre-combat inspections
PDOP	positional dilution of precision
PDSI	personnel development skill identifier
PGM	precision-guided munition
PIR	priority intelligence requirements
PLI	precise location information
PNT	positioning, navigation, and timing
POC	point of contact
PR	personnel recovery
PS	preventive service
RCIED	radio-controlled improvised explosive device
RCO	Rapid Capabilities Office
RFI	radio frequency interference
RSOI	reception, staging, onward movement, and integration
RTU	rotational training unit
S/G-2	Staff/General Staff (Intelligence)
S/G-3	Staff/General Staff (Operations)

S/G-4	Staff/General Staff (Logistics)
S/G-6	Staff/General Staff (Signal)
SACP	support area command post
SAR	synthetic aperture radar
SATCOM	satellite communications
SATRAN	satellite reconnaissance advanced notice
SBIRS	Space-based Infrared System
SC	space control
SCIF	sensitive compartmented information facility
SES	senior executive service
SFE	space force enhancement
SIPRnet	secure Internet protocol router network
SLO	space liaison officer
SMO	spectrum management operations
SOC	Space Operations Course
SOP	standard operating procedure
SOPS	space operations squadron
SSA	space situational awareness
SSAPT	space situational awareness planning team
SSE	Space Support Element
SSN	Space Surveillance Network
SSR	space support request
STO	special technical operations
STX	situational training exercise
SWIR	short-wave infrared
SWO	staff weather officer
TAC	tactical command post
TACSOP	tactical standard operating procedures
TAV	total asset visibility
TDY	temporary duty
THAAD	theater high altitude area defense
TI	tactical Internet
TOC	tactical operations center

TPED	tasking, processing, exploitation, and dissemination
TRADOC	U.S. Army Training and Doctrine Command
TREX	training, readiness, and exercise
TTLODAC	target, trigger, location, observer, delivery system, attack guidance, communications
TTP	tactics, techniques, and procedures
UAS	unmanned aircraft system
UAS	user application software
UAV	unmanned aerial vehicle
UFO	ultra-high frequency follow-on
UHF	ultra-high frequency
USASMDC/ ARSTRAT	U.S. Army Space and Missile Defense/Army Forces Strategic Command
UTM	Universal Transverse Mercator
VSAT	very small aperture terminal
WARSIM	Warfighter simulation
WfF	warfighting function
WFX	Warfighter exercise
WGS	wideband global satellite communications
WIDOW	web-based IR data for operators and Warfighters
WIN-T	Warfighter Information Network-Tactical

Appendix K

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CAL plans and programs leadership instruction, doctrine, and research. CAL integrates and synchronizes the Professional Military Education Systems and Civilian Education System. Find CAL products at http://usacac.army.mil/cac2/cal.

Combat Studies Institute (CSI)

CSI is a military history think tank that produces timely and relevant military history and contemporary operational history. Find CSI products at http://usacac.army.mil/cac2/csi/csipubs.asp.

Combined Arms Doctrine Directorate (CADD)

CADD develops, writes, and updates Army doctrine at the corps and division level. Find the doctrinal publications at either the Army Publishing Directorate (APD) at http://www.apd.army.mil or the Central Army Registry (formerly known as the Reimer Digital Library) at http://www.adtdl.army.mil.

Foreign Military Studies Office (FMSO)

FMSO is a research and analysis center on Fort Leavenworth under the TRADOC G-2. FMSO manages and conducts analytical programs focused on emerging and asymmetric threats, regional military and security developments, and other issues that define evolving operational environments around the world. Find FMSO products at http://fmso.leavenworth.army.mil.

Military Review (MR)

MR is a revered journal that provides a forum for original thought and debate on the art and science of land warfare and other issues of current interest to the U.S. Army and the Department of Defense. Find MR at http://usacac.army.mil/cac2/militaryreview.

TRADOC Intelligence Support Activity (TRISA)

TRISA is a field agency of the TRADOC G-2 and a tenant organization on Fort Leavenworth. TRISA is responsible for the development of intelligence products to support the policy-making, training, combat development, models, and simulations arenas.

Capability Development Integration Directorate (CDID)

CDID conducts analysis, experimentation, and integration to identify future requirements and manage current capabilities that enable the Army, as part of the Joint Force, to exercise Mission Command and to operationalize the Human Dimension. Find CDID at http://usacac.army.mil/organizations/mccoe/cdid.

Joint Center for International Security Force Assistance (JCISFA)

JCISFA's mission is to capture and analyze security force assistance (SFA) lessons from contemporary operations to advise combatant commands and military departments on appropriate doctrine; practices; and proven tactics, techniques, and procedures (TTP) to prepare for and conduct SFA missions efficiently. JCISFA was created to institutionalize SFA across DOD and serve as the DOD SFA Center of Excellence. Find JCISFA at https://jcisfa.jcs.mil/Public/Index.aspx.

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