AIR LAND SEA BULLETIN




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Purpose: The ALSA Center publishes the ALSB two times a year. ALSA is a multi-Service Department of Defense field agency sponsored by the US Army Training and Doctrine Command (TRADOC), Marine Corps Combat Development Command (MCCDC), Navy Warfare Development Command (NWDC), and Curtis E. LeMay Center for Doctrine Development and Education (LeMay Center). The ALSB is a vehicle to "spread the word" on recent developments in warfighting concepts, issues, and Service interoperability. The intent is to provide a cross-Service flow of information among readers around the globe. This periodical is governed by Army Regulation 25-30.

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Submissions: Get published—ALSA solicits articles and readers' comments. Contributions of less than 5,000 words or less are ideal. Submit contributions, double-spaced in MS Word. Include the author's name, title, complete unit address, telephone number, and email address. Graphics can appear in an article, but a **separate computer file for each graphic and photograph (photos must be 300 dpi) must be provided.** Send email submissions to alsadirector@us.af.mil. The ALSA Center reserves the right to edit content to meet space limitations and conform to the ALSB style and format.

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FEATURE ARTICLES

IN HOUSE

Top: Unnamed tactical air control party Airmen from the 227th Air Support Operations Squadron, New Jersey Air National Guard (NJANG), conduct Fast-Rope Insertion Extraction System training on April 21st, 2015 using a UH-60 Black Hawk helicopter from the 1-150th Assault Helicopter Battalion, NJANG, at Joint Base McGuire-Dix-Lakehurst, NJ. (Photo by Master Sgt Mark C. Olsen)

Left: Unidentified members of an E-8C, Joint Surveillance Target Attack Radar System aircraft's weapons section participate in an exercise in the Korean Peninsula area July 29, 2016. (Photo by Tech Sgt Rey Ramon)

Right: An Atlas V rocket carrying the Global Positioning System II-7 satellite for the US Air Force launches August 1, 2014, from Cape Canaveral's Space Launch Complex-41, Florida. (Courtesy photo/United Launch Alliance)

DIRECTOR'S COMMENTS

The Air Land Sea Application Center (ALSA) team meets the needs of the warfighter by providing timely, relevant, and compelling doctrine.

We welcome Lt Col Gage Evert, United States Air Force (USAF); and LTC Mike Wiser, MAJ Steve Padilla, and MAJ Kate Ogletree, United States Army (USA) to the multi-Service team. Also, we say farewell to LTC Randy Wiesner, USA, who retired after 25 years of service; and MAJ Shawn Herrick, USA, who relocated to accept a branch chief position with the Defense Intelligence Agency. They were fantastic teammates and are missed.

This Air Land Sea Bulletin (ALSB) is an open forum offering a wide mix of lessons learned, current status, and future considerations for warfighters. It contains a variety of articles that provide thought-provoking viewpoints and showcase the ingenuity and flexibility of United States (US) Service men and women.

The first article is "Assured Access to Space: An Examination of the Space Domain as a Tool for National Power", by LTC Gregory Sharpe and MAJ Kenneth Rich, USA. This article discusses the importance of space access to facilitate using US instruments of national power.

The second article, "Countering the UAS Threat (a Joint Perspective)", is by Lt Col Jeffrey Lamport, USAF, and COL Anthony Scotto, USA (retired). This article explores the threats posed by unmanned aerial systems, the abundance of new technology, and ways to mitigate the effectiveness of adversarial systems while on the battlefield.

The third article is, "Improving Link 16 Efficiency and Providing Advanced Engagement Options for Anti-Access/Area Denial Operations", by Dr. Earl W. Burress, Jr. (Ph.D.); Mr. George Dick; and Mr. Steven McDougall. Their article discusses the outcome of a joint test conducted to improve the resilience in links used during the roll back of anti-access and area denial operations.

The fourth article is "Reviving JAAT Capabilities with Existing Joint Doctrine", by Majors Justin Banez, Joel Bier, David Gunter, Steve Joca, John Ryan, Gregory Stack, USAF; and Maj Jeffrey Robb, US Marine Corps. The authors provide analyses on current doctrine and joint air attack teams resulting from participating in an ALSA-led joint working group.

The fifth article is "The Army and Air Force Need USAF 13L Officers, Joint Fires Integrators" by SMSgt Eric Muller, USAF, the superintendent/joint terminal attack controller for the 274th Air Support Operations Squadron (Air National Guard). He calls for a renewed emphasis on 13L specialists to integrate joint fires due to a lack of training based on the recent operational environment.

The final article is "True Impacts of Space Weather to a Ground Force", by By LTC Gregory Sharpe, USA (retired) and MAJ Kenneth Rich (USA), who are former staff members at the Command and General Staff College; Fort Leavenworth, Missouri. Their article describes the impacts of space weather and space events on terrestrial operations. It indicates ground forces, and the systems they rely on, are becoming more and more space dependent.

We invite you to seize opportunities to represent your Service and share your ideas, not only by being published in future ALSBs, but by participating in joint working groups, also. As we tackle the challenges ahead, your ideas matter now more than ever. Your unique perspective can spark innovation on current and future tactics, techniques, and procedures.

To help shape the discussion and be part of the solution, go to www.alsa.mil and provide inputs through the "Contact Us" link. Thank you for reading.

MICHAEL E. KENSICK, Colonel, USAF
Director

ASSURED ACCESS TO SPACE: AN EXAMINATION OF THE SPACE DOMAIN AS A TOOL FOR NATIONAL POWER

Unidentified workers encapsulate the a Global Positioning System IIF satellite inside a payload fairing at a processing facility before it was launched aboard an Atlas V rocket February 5, 2016, at Cape Canaveral Air Force Station, Florida. (Courtesy photo/United Launch Alliance)

by MAJ Kenneth C. Rich, PhD and LTC(R) Gregory K. Sharpe

"It is increasingly clear that Space is becoming critically important to how the United States employs several key instruments of national power."[1]

—COL Frank Todd

Assured access to space is critical to promoting and protecting vital United States (US) national interests.

The spectacle of limitless space is mesmerizing. When contemplating the space domain, most envision the National Aeronautics and Space Administration (NASA) through the lens of science fiction, exploring the far reaches of outer space for the benefit of mankind. Still others view the space domain through an operational lens and envision the multiple systems which enable our joint force to achieve an asymmetric advantage on the battlefield. Few, however, view the space domain through a strategic lens and recognize the direct link between assured access to space, vital national interests, and instruments of national power.

Assured access to space is critical to promoting and protecting vital United States (US) national interests. Moreover, space-based capabilities are directly linked to each instrument of national power. The diplomatic, information, military, and economic (DIME) instruments of power are all enabled in some way by assured access to space. Numerous challenges, however, are threatening US military and civil space operations and have serious implications for our national security. The stark reality is that the US is dealing with a growing number of foreign entities that either possess, or are actively developing, the ability to degrade, disrupt, and destroy our space-based capabilities. Moreover, many foreign entities are attempting to develop space-based capabilities on their own, which could lead to less dependence on US capabilities or strengthen their power relative to ours. While space is recognized as a vital enabler of the joint force, research regarding space as a tool within each of the instruments of national power is scarce. Therefore, this paper uses case studies to illustrate the positive and negative effects of specific space domain issues on the four instruments of national power.

NATIONAL POWER

Although the concept of "power" is the foundation of most political analyses, it continues to remain a highly contested concept with a wide variety of usage and definitions.[2] One view is that national power can be defined as the set of available means that can be leveraged towards national objectives that support the "pursuit of four enduring national interests: security, prosperity, values, and international order."[3]

Another view is that national power can be defined "simply as the capacity of a country to pursue strategic goals through purposeful action."[4] Two distinct dimensions of capacity emerge from this latter view: external and internal. The external dimension relates to a nation's capacity to use its economic, political, and military strength to influence the global security environment. Additionally, the internal dimension relates to a nation's capacity to produce superior technologies through efficiently transforming available resources into knowledge that promotes "purposeful action."[5] Consequently, both dimensions should be viewed as a requisite for defining national power.

Scholars have challenged the "elements of national power" approach of exercising national power, arguing that the "relational power" approach better defines power as a multidimensional construct as opposed to power as a one-dimensional possession of nations.[6] The majority of extant scholarly literature focuses on a relational construct of "power as a means, the strength or capacity that provides the ability to influence the behavior of other actors in accordance with one's own objectives."[7] Basically, a nation exercises power in order to have influence within the international security environment. More specifically, power can be viewed as the ability to get someone else to do something they would not otherwise do. This influence can be accomplished either by positive means (e.g., carrots) or negative means (e.g., sticks).

> ... a nation exercises power in order to have influence within the international security environment.

Since definitions of power vary widely, a simple model to describe power might be more useful. This model can be described as three distinct approaches to power: resources and capabilities, conversion, and outcomes."[8] The first approach can be envisioned as "power-in-being"[9] and has the resources and capabilities available to be used towards achieving a nation's interests. Power-in-being is, essentially, the natural resources, population, technology, and economic capabilities available for promoting national interests. Consequently, nations can be thought of as "capability containers". [10]

These capabilities, however, must go through a process of conversion (the second approach) to serve as instruments utilized to achieve desired outcomes. The third approach, outcomes, is what decision-makers value the most. Power is viewed not as resources and capabilities, or "converted" power-in-being, but as an outcome meeting the desired ends for which the exercise of power was initiated to begin with.[11] While the three approaches are viable ways to view power, translating the first two into the third is what really matters.

Resources converted into capabilities that will achieve the desired outcome can be conceptualized as instruments of national power composed of "tools" derived from the elements of power. Elements of power fall into two distinct categories: natural and social. Natural elements of power refer to a nation's geography, natural resources, and population. Social elements (economic, political, military, psychological, and informational) are concerned with the ways a nation's population organizes and alters its environment.[12] Instruments of power are distinctly different than the elements of power, however, in that the former is a subcomponent of the latter. Instruments of national power can be viewed as the "ways" resources are used and derived from elements of power. For example, a "show of force" is a "way" within the military instrument of national power and derived from the military element. Instruments of national power are how nations achieve power in outcomes. It is through using various tools within the instruments of national power you can apply power to create a desired outcome.

INSTRUMENTS OF NATIONAL POWER

The first international relations scholar to define the instruments of national power was Edward Carr who, in his seminal work of 1939, stated, "Political power in the international sphere may be divided, for purpose of discussion, into three categories: (a) military power, (b) economic power, (c) power over opinion. ... But power is an indivisible whole; one instrument cannot exist for long in the absence of the other."[13] The idea of instruments of national power, however, is only a generalization and terminology is not widely agreed upon. Additionally, depending on circumstance, these named instruments are "merely quick jumping off points on the way to discussing the concrete capabilities—or 'tools'—of the departments and agencies that house the instruments."[14] Moreover, a nation's power cannot be assumed to be absolute, and is only relevant in relation to other state and non-state actors in the international security environment. Therefore, the question is: how do nations exercise power?

... space has become critical to how the US utilizes the tools available within each of the instruments of national power.

There are numerous means for exercising national power and multiple ways in which to categorize them. A prevalent view for classifying the means of influence in the international security environment includes the following categories.[15]

- **Diplomatic.** Diplomacy is the principal instrument for engaging with other states and foreign groups to advance US values, interests, and objectives, and to solicit foreign support for US military operations.
- **Informational.** Information remains an important instrument of national power and a strategic resource critical to national security.
- **Military.** The US employs the military instrument of national power at home and abroad in support of its national security goals
- **Economic.** A strong US economy with free access to global markets and resources is a fundamental engine of the general welfare, the enabler of a strong national defense.

SPACE POWER

According to Joint Publication 3-14, Space Operations, space power is defined in as "the total strength of a nation's capabilities to conduct and influence activities to, in, through, and from space to achieve its objectives."[16] This definition conveys that space has become critical to how the US utilizes the tools available within each of the instruments of national power.

As the National Security Space Strategy states, "space is vital to US national security and our ability to understand emerging threats, project power globally, conduct operations, support diplomatic efforts, and enable global economic viability."[17] Therefore, assuring free and open access to space has become a vital national interest. Moreover, a nation's space power includes not only a nation's military space capabilities, but it's civil and commercial systems which also contribute, significantly, towards achieving national objectives. For example, military, civil, and commercial partnerships in environmental monitoring and communications are critical to the nation's space capabilities and its ability to achieve national objectives.[18] With regard to this focus on national objectives of the entirety of a nation's space capabilities, a more complete definition of space power would be: "the pursuit of national objectives through the medium of space and the use of space capabilities."[19] However, the US is not alone in the recognition of space as a vital national interest. As international actors continue to pursue their space and counterspace capabilities, the US will continue to encounter opportunities and challenges within the space environment.

Military and civilian US space operations are facing the stark reality that a growing number of nations are developing—or currently possess—the ability to disrupt, degrade, and destroy our space capabilities; thereby thwarting our ability to safeguard our assured access to space.[20] Therefore, if the US is to continue to remain the global leader in space, space power must be effectively utilized as a tool within each of the instruments of national power to address these challenges and achieve the desired outcomes. Achieving desired outcomes, however, will be difficult due to the increasingly congested, contested, and competitive nature of the space environment.

Achieving desired outcomes that support national objectives is the main purpose of a nation's space power. Space power, therefore, can be thought of as a "tool" available within each of the four instruments of national power to achieve national objectives. Space power definitions, while varying widely, all have a common focus; that is, "to use space and deny its use to enemies."[21] Consequently, securing space assets, controlling the medium of space, and deterring the hostile use of space capabilities, are essential to national space power.[22]

... a growing number of nations are developing—or currently possess—the ability to disrupt, degrade, and destroy our space capabilities ...

Space has, fundamentally, changed over the last several decades; however, becoming an increasingly

A United Launch Alliance (ULA) Delta IV rocket carrying the AFSPC-6 mission lifts off from Space Launch Complex-37, Cape Canaveral Air Force Station, Florida, August 19, 2016. (Courtesy photo/United Launch Alliance) congested, contested, and competitive domain. The rate of increase in the amount of space objects is staggering; more than 1,100 active satellites and 22,000 pieces of man-made debris are currently being tracked.[23] Additionally, NASA estimates that there "likely several hundreds of thousands of additional pieces of debris too small to track with current sensors yet still capable of damaging satellites in orbit."[24] Combining a growing global competition in space with more than 60 space-faring nations, and an increasing number of potential adversaries utilizing a wide range of counterspace capabilities, it is clear that access to, and the protection of, the new global commons of space is essential to national security.

SPACE POWER EVENTS EXPRESSED AS A TOOL WITHIN DIME

The DIME instruments of power are all enabled in some way by assured access to space.

Assured access to space is vital to promoting and protecting vital US national interests. The DIME instruments of power are all enabled in some way by assured access to space. Moreover, space-based capabilities are directly linked to, and can be used by, each instrument of national power as a tool to achieve national policy objectives.

DIPLOMATIC

Diplomatic tools are used to influence international situations to achieve national interests. Space capabilities enable diplomatic interactions and the application of other diplomatic tools. Satellite communications allow for ambassadors to quickly collaborate and build coalitions or consensus on an issue of national policy. Remote sensing images can inform the diplomats of other nations' actions which better enables signaling by the Department of State in private talks or in public forums such as the United Nations (UN) National Security Council meetings. However, space power not only enables other diplomatic tools, but can be a diplomatic tool itself.

On December 12, 2012, North Korea launched the Kwangmyongsong-3 satellite into orbit. With this

A United Launch Alliance, Delta IV rocket carrying AFSPC-6 mission lifts off from Space Launch Complex-37, Cape Canaveral Air Force Station, Florida on August 19, 2016. (Courtesy photo/United Launch Alliance) key international event, North Korea joined the elite club of 11 other countries capable of space launch with their own launch vehicles.[25] North Korea showcased its space launch program and, consequently, increased its international prestige and taunted the rest of the international community. North Korea used this satellite launch as a diplomatic tool to illustrate its strength and the inherent weakness of UN resolutions that are not backed by the military instrument of national power.

North Korea incurred the wrath of the international community by testing a nuclear weapon, on October 9, 2006, resulting in international condemnation and the UN unanimously passing resolution 1718. This resolution stated that North Korea must "not conduct any further nuclear tests or launch of a ballistic missile."[26] Three years later, North Korea tested another nuclear device. The UN Security Council acted unanimously, once again, passing resolution 1874 using the same language as before. Both resolutions invoked Chapter VII of the UN Charter, but neither allowed for military force as an enforcement mechanism.

In the beginning of April 2012, North Korea announced it would launch a satellite in late April 2012 to celebrate the centennial birth date of Kim Il Sung. This prompted diplomatic posturing in the media and international policy forums between the US and North Korea. The US' stance was that this launch was a violation of previous UN resolutions and agreements made in the six-nation talks. The central complicating factor is that space launch capability roughly translates into intercontinental ballistic missile launch capability; and, therefore, of particular concern to the US, Japan, and South Korea. The US began to apply political pressure to stop the North Korean launch.

North Korea's response was that the launch was legal according to the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, otherwise known as the Outer Space Treaty.[27] Article I of this treaty declares that space is free to access for any state. Therefore, according to Article I, North Korea could legally launch a satellite.

This is one example of using space power as a tool of diplomacy in the international community. The US used diplomatic tools to try to stop the launch. The North Koreans used the successful launch as a tool to boost their international prestige and power. The open source debate illustrated the importance of space lift capabilities, the dual-use nature of rockets and the lack of enforcement mechanisms inherent in the international community's main diplomatic tool—the UN Security Council.

Another event occurred when, on April 29, 2014, Dmitry Rogozin, Russia's deputy prime minister, tweeted: "After analyzing the sanctions against our space industry, I suggest to the USA [United States of America] to bring their astronauts to the International Space Station using a trampoline."[28] In the late 1980s, when communism was collapsing, the US diplomats made a strategic decision with regard to the superb Russian rocket engine capability. In an effort to keep the Russians from complete collapse and keep the rocket engines from falling into nefarious party hands, "President Bush and, after him, President Clinton urged US aerospace executives to look for Russian rocket business partnerships that made sense."[29] In the ensuing decades, the US aerospace industry became reliant on the Russian-built rocket engines. At the beginning of 2014, when this comment was made, the majority of lift capability certified to launch the nations' national security satellites used Russian rocket engines.[30] The decision to stop most research on rocket engines made diplomatic and economic sense until Russia, once again, emerged as a player on the international stage.

Launch Complex 40 on Cape Canaveral Air Force Station, Florida on March 4, 2016. (Courtesy photo/SpaceX)

This scenario is one example of space being used as diplomatic and economic means to help mitigate the economic challenges of another government. However, it also illustrates the diplomatic power one country, which is a sole supplier, can exert over another. Since this comment was made, Congress and the aerospace industry scrambled to reduce the impact of a possible embargo. The commercial space industry stepped up to certify their engines and launch capabilities. Congress took steps to ensure the US no longer buys Russian rocket engines by attempting to codify their intent, in law, with an import ban.

Like the diplomatic tools, the informational tools are heavily reliant on space-based capabilities.

Space power can be an effective soft-power tool. Space capabilities can enable and compliment other diplomatic tools. Space-lift capability enables a country to maintain a presence in the new global commons. Additionally, the technical and economic implications of being a space-faring nation increase the international prestige and negotiating power.

INFORMATIONAL

Informational power is displayed when a government communicates its intent, desires, and views to various audiences and obtains information used to make key decisions. The dual nature of informational power makes it difficult to point to specific entities that exercise the information tools. National media, diplomats, and intelligence agencies all use informational tools. Diplomatic démarches inform rogue or wayward governments and entities of a government's displeasure with their actions. Public policy statements declare a nation's intentions. Like the diplomatic tools, the informational tools are heavily reliant on space-based capabilities. Remote sensing and space based signals intelligence inform decision makers around the world. Media sources receive stories and publish information globally using satellite communications either directly or indirectly. Space power can be used in the information realm to highlight a nation's power and achievements.

On September 24, 2014 the world media was awash with reports that India had become the first Asian nation to reach Mars, and the first to achieve this milestone on their first try.[31] Although India has a space program almost as old as that of the United States, it is little known on the world stage. The Indians have accomplished several key space faring milestones. They first launched a rocket in 1963. In 2008, they sent a deep space probe to the moon. They are also one of the few commercial space launch providers. The media coverage of the Indian Mars Orbiter Mission overshadowed NASA's Mars Atmosphere and Volatile Evolution spacecraft, which reached Mars two days earlier. This information campaign illustrated India's space prowess, and increased interest in the Indian Space program can increase their soft power as other regional countries vie to develop and launch satellites with the Indian Space Agency. The perception of a reliable and prestigious launch capability can translate into an increased price or negotiating position for commercial launch contracts.[32] It also illustrates, to India's neighbors, its long-range rocket ability; thereby increasing deterrence.

The International Space Station (ISS) is among the greatest international cooperative endeavors in the history of engineering, science, and technology.[33] Launched on October 31, 2000, the international space station is a premiere example of international cooperation for the betterment of mankind and increasing the body of human knowledge. The principle contributors are the US, Russia, the European Space Agency, Japan, and Canada. Additionally, the space station has been visited by astronauts from 14 different countries.[34] While scientists and academics have a tendency to work together across geopolitical lines, governments do not. The international space station is one such joint governmental venture and illustrates an example of collaboration. The research conducted on the space station directly translates into earthly rewards. Advances in neurosurgery inspired by the ISS robotic arm, water purification systems modeled after the ISS water system, and tele-ultrasound technology developed to diagnose astronaut issues are a few examples that have enriched our lives on earth. A message that could be leveraged from this venture, by participating countries, is that they have proven how flexible and cooperative they can be.

Because there is no one organization at the governmental level responsible to the informational instrument of national power, there is no one illustrative example of how space power has been used as a tool of informational national power. Information about a nation's space program can increase its soft power, driving other nations to conduct business with them. Information sharing, like the US Strategic Command sharing the catalog of space objects with the international community, can increase the positive image others have of a country. However, space capabilities can be used to withhold information. Libya, Iran, and Ethiopia have electronically jammed satellite media to keep the international community in the dark on internal issues.[35] Iran jammed Thuraya satellite based phones, the British Broadcasting Corporation and the Voice of America during protests in Tehran in 2009. They attempted to control information flow out of the country, exemplifying the suppression of information as a way to exert informational power.

Information about a nation's space program can increase its soft power, driving other nations to conduct business with them.

MILITARY

The most visible and easily translatable instrument of national power is military. It is often the only instrument with a standing, professional planning staff to synchronize its use. Additionally, it is often provided resources more than other tools. Other world powers have grown to appreciate how space enabled the US military is and are developing capabilities to negate the asymmetric advantage it offers. Space-based positioning, navigation and timing enables, forces to know where they are in relation to each other, reported enemies, and their surroundings. It offers precision in munitions placement, decreasing collateral damage. Remote sensing yields strategic warning in denied airspaces. Multispectral data enables worldwide weather prediction and allows for predictive reaction to natural disasters, such as typhoons.

On January 11, 2007, China destroyed the FY-1C polar orbiting weather satellite with a kinetic kill vehicle resulting in over 2,000 pieces of trackable debris left in orbit. In October 2006, President George W. Bush published a National Space Policy (NSP) that contained a strongly worded message to other space nations that the US would take actions to preserve its space capabilities.[36] President Bush's policy was meant to illustrate the US' resolve in preserving our access and capabilities in space, but was taken as a challenge to other space powers. The tone of the NSP was distinctly more adversarial than in years past. President Dwight D. Eisenhower used an NSP to create NASA and split military use and developments of space from commercial and scientific exploration for the benefit of all mankind. President John F. Kennedy used an NSP to commit the US to landing on the moon.

... the US answered China's ASAT test by destroying USA-193 from a sea-based Aegis cruiser floating in the Pacific Ocean.

The January 2007 Chinese Anti-Satellite (ASAT) test was a military response to President Bush's NSP. The Chinese military showed its capability of shooting down low-earth-orbit satellites from a mobile launch system. It ushered in a new age of space and "marked the end of an era characterized by a lack of friction between space-faring nations and a general acceptance of norms governing the common use of space."[37] The show of force illustrated Chinese strength and the US' inability to actually enforce the tone of the 2006 NSP. The Chinese government was quick to point out that this was not militarization of space, an outcome they had been trying to avoid through international policy such as the Prevention of an Arms Race in Outer Space Treaty. There is doubt within the international community, expressed in numerous articles, if the Chinese Government knew about and blessed the military action of testing the ASAT weapon. However, the result was indisputable.

In late January 2008, satellite USA-193 (as designated by the International Launch Registry) malfunctioned within weeks after launching. The hydrazine on board presented a health risk to whatever nation the satellite might hit when deorbiting. Since the responsibility to clean up and rebuild any structure destroyed after a satellite launch falls on the launching country. In accordance with the Outer Space Treaty of 1967, the US took preventative action. On February 14, 2008, the US answered China's ASAT test by destroying USA-193 from a sea-based Aegis cruiser floating in the Pacific Ocean. This ASAT not only destroyed the satellite but created much less debris, which would rapidly deorbit. The answering show of force demonstrated to the Chinese that their low-earth-orbit systems were also vulnerable and the US ASAT capability was equally as hard to target preemptively. The precision and planning in which it was conducted also allowed the US to claim high moral ground by not creating a significant amount of long-term orbiting space debris.

Military use of space is prevalent and the most easily recognized of the tools illustrating space power. The recent success of the global, power-projecting US military relies on a space backbone. Every space-faring nation recognizes it. Also, Space power has been used to illustrate the fragile nature of space capability and the need to keep the global commons of outer space demilitarized.

ECONOMIC

The economic instrument of national power aims to shape international activity through government spending and monetary policy. Trade

Pictured are the Mobile User Objective System (MUOS) receivers located at Naval Computer and Telecommunications Area Master Station Pacific, Wahiawa, Hawaii. The MUOS is a next-generation, narrowband tactical satellite communications system intended to significantly improve ground communications for US forces. This photo was taken November 3, 2008. (Photo by Seaman John Ciccarelli, US Navy)

alliances promote US interest abroad, while trade sanctions and tariffs protect US interests at home. Debt forgiveness can enable an emerging country to rise out of poverty and, subsequently, be indebted via allegiance vs. money. Space power can also be used to help or hinder economic growth and, therefore, national power. The previous example of US policy to buy Russian rocket engines enabled Russia to keep its aerospace industry more solvent. Economic involvement with space can be a tool used by the government to further its goals.

Satellite communication (SATCOM) is a premium commodity for a global power. It is a prerequisite for a force projection based military, enables diplomats to rapidly communicate, promotes information sharing globally and speeds processing international commerce. Military satellite communication systems are expensive and over requested. Introducing partnerships into procuring and using military SATCOM can benefit all countries involved. International partners investing in the new Wideband Global Satellite Communications System enabled the US military to procure and launch a special satellite. At the cost of limited, reduced access to the whole network, the military gained this satellite with more capability than the entire, older Defense Satellite Communications System constellation. Increasing partner capacity fits with the national military strategy38 and saves money for the fiscally constrained military in the process.

On September 29, 2013 the SpaceX Falcon 9 launch vehicle successfully launched a satellite into orbit. Commercial space organizations have been a part of the US space program since the 1962. The Communications Satellite Act of 1962 allowed the US Government to participate as a private corporation and led to the development of international maritime satellite and the International Telecommunications Satellite Organization. Recent

> ... the military gained this satellite with more capability than the entire, older Defense Satellite Communications System constellation.

advances in commercial remote sensing led to innovative new tools that are indispensable to modern life. It would be hard to imagine navigation in a new city without a Google map to rely on. Additionally, commercial remote sensing has enabled the Government to more effectively and rapidly react to natural disasters. The Commercial Remote Sensing Space Policy encourages the commercial sector to develop new technologies to meet the needs of national agencies, increasing soft power of technical dominance and increasing the overall gross domestic product. Access to certified, commercial launch platforms can assist the Government in overcoming a Russian rocket engine embargo, as previously illustrated.

While commercial capabilities have been explored extensively to increase our Government's capability, the use of US commercial space capability as a tool to improve other countries' institutions is still nascent. Encouraging easy access to US commercial vendors for developing satellites or launch systems can target partners with whom the US wants to develop closer ties. Without giving away national secrets or endangering our own military capability, commercial companies can expand the US' global reach by developing dual-use communications systems; new, remote sensing capability; and other scientific ventures that more closely tie our economy with potential partners or adversaries. As a result of the economic interdependence, the US can achieve deterrence and stability.

CONCLUSION

National power is difficult to define and even harder to translate into a means to lead to national policy goals. The majority of extant, scholarly literature argues that a nation exercises power in order to have influence within the international security environment. Nations exercise their power by converting resources into capabilities that will achieve the desired outcomes. The instruments of national power (i.e., diplomatic, informational, military, and economic) can be viewed as the "ways" resources are used and derived from natural or social elements of power. The instruments are applied using "tools" that enable a government to focus the elements of power within one of the four instruments. Space power is one tool that is available within each of the instruments of national power, to pursue national objectives through space and space capabilities.

Space power is a unique source of power available to a few countries in the international security environment. The preceding discussion illustrated how space and space power can be used as tools in each of the instruments of national power, in order to achieve national policy objectives. An area of further research would be to develop an overarching framework for applying these tools in a nonthreatening way to achieve policy aims without ceasing a new arms race or militarizing the new global commons. While understanding space power is available, knowing how to apply it in a manner capable of influencing another nation or instigate, within another country, a change in behavior would be better.

This article was originally published in "Through the Joint, Interagency, and Multinational Lens: Perspectives on the Operational Environment" Volume 1 (Fort Leavenworth: US Army Command and General Staff College Press, 2015).

END NOTES

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COUNTERING THE UAS THREAT (A JOINT PERSPECTIVE)

Unidentified Soldiers from 3rd Brigade Combat Team, 82nd Airborne Division, Unmanned Aircraft Systems Platoon prepare to start the RQ7-B Shadow unmanned aircraft at Fort AP Hill, Virginia, October 26, 2016. (Photo by Sgt. Steven Galimore, US Army)

By Lt Col Jeffrey Lamport, USAF and COL(R) Anthony Scotto, USA

BACKGROUND

As technology advances and the United States (US) military touts the advantages of drone warfare, other countries, terrorist organizations, and criminals will continue to develop and procure low-cost unmanned aerial vehicles (UAVs). Often, these small, complex systems are equipped with cameras, laser designators, radio frequency (RF) collection devices, or weapons to provide battlefield intelligence and engage friendly forces. The size and composite materials used in UAV production make them inherently difficult to defeat with traditional force protection measures and short-range air defense (SHORAD) systems.

The battlefield is not the only area susceptible to the effects of unmanned aircraft system (UAS) operators.

One of the most significant uses of unmanned systems on the battlefield is occurring in Ukraine, where Ukrainians and Russian-backed separatists are operating UAVs in relatively large numbers. They are, reportedly, operating more than a dozen variants (including fixed- and rotary-wing configurations, functioning at different altitudes, with various sensor packages) designed to complement each other's capabilities.

The battlefield is not the only area susceptible to the effects of unmanned aircraft system (UAS) operators. The nation's capital, nuclear facilities, correctional facilities, borders, and sporting venues are among targets already "attacked" with this rapidly proliferating technology. Terrorists leverage UAVs to interrupt our daily routine, while criminals defeat traditional security devices (e.g., fences, or walls) and "no-fly" zones to scout low-risk routes for illegal alien and drug transport across US borders and contraband deliveries to prisoners. While these are not traditional military missions, Department of Defense (DOD) specialized equipment and personnel may be tasked to support civil agencies in the defense support to civil authorities construct.

For nearly three decades, the US Army and unified action partners conducted ground and air operations in a virtually uncontested airspace environment. Therefore, developing and fielding dedicated SHORAD systems declined and passive air defense skills atrophied across the force. Continued UAS technology development, UAS fielding acceleration, and "bad actor" successes around the world clearly demonstrate that the US is faced with a viable air threat. Leaders, at all levels, cannot be lulled into a false sense of security because of the small size of these UAVs. They are as effective as, if not more effective than, traditional manned aircraft (or even stealth aircraft) in reconnaissance, surveillance, and target acquisition precision attack, and indirect fire support. Troops must assume they are being watched and targeted and take appropriate action to minimize the impact of UAV operations to their mission.

WHAT LEADERS AND SUBORDINATES NEED TO KNOW

- UAVs can create serious problems for maneuvering or static forces. Their size, composite construction, small radar and electromagnetic signatures, and quiet operation make them difficult to detect and track. Their low-cost, lethality, and widespread proliferation make them an air threat the US military can no longer ignore. The following are some factors contributing to the counter-unmanned aircraft system (C-UAS) challenge.

- Small, slow, and low profiles provide significant challenges to traditional air defenses.

- Conventional systems often filter out their tracks to avoid confusion with clutter, large birds, and aerostats.

- Systems optimized for this threat often forfeit effectiveness against other target sets (e.g., manned aircraft, cruise missiles, rockets and mortars, and ballistic missiles).

The lack of SHORAD units dedicated to maneuver brigades creates potential gaps in air defense coverage.

Military personnel are "numb" to UAVs. Recent combat experience in Iraq and Afghanistan indicates troops may be accustomed to friendly UAVs and, therefore, less likely to be concerned about them flying overhead and less inclined to actively search for them in their area of operations.

... troops may be accustomed to friendly UAVs and, therefore, less likely to be concerned about them flying overhead ...

Many military personnel lack UAV recognition training. Without training, it is difficult to observe characteristics visually, which would help them easily distinguish between threat UAVs and friendly systems supporting the mission. This issue is compounded by the proliferation of new UAV designs and off-the-shelf systems sold to many countries.

US Army and joint doctrine have not kept pace with the threat. C-UAS training is not a priority for most units, and many units have not updated plans to adequately address the hazards caused by these aerial devices.

UNDERSTANDING THE THREAT

UAVs pose a significant threat to safety and mission accomplishment by providing the enemy critical intelligence (such as a unit's precise location, composition, and activity). Also, they may provide laser designation for indirect fires or direct attacks using missiles; rockets; small "kamikaze" munitions; or chemical, biological, radiological, and nuclear weapons. Some payload configurations can contain radar and communications jamming or other cyberattack technology.

UAVs may operate autonomously with little or no RF signature or under pilot control using a ground control station (GCS). The following are UAV threat characteristics.

- They include a sensor or weapons package (or both), GCS, and communications equipment to support navigation and data transfer.

- They are available on the open market, often "clones" of US systems, and cheaper than stealth.

- They often rely on Global Positioning System for guidance and targeting and use multiple RF bands including frequency modulation, ultrahigh frequency, satellite communications, and cell phones.

- Small UAVs have a limited range and flight duration, meaning they are frequently operated from within the observed unit's area of operations.

THREAT MITIGATION

Units must conduct a comprehensive air threat analysis as part of the intelligence preparation of the battlefield/intelligence preparations of the environment and use any resources available to mitigate risks associated with any air threat. Defeating the UAV threat begins with the planning process, as follows.

Defeating the UAV threat begins with the planning process ...

- Understand the UAV threat. Conduct a deliberate analysis to ascertain the potential UAV type and GCS likely to be employed, understand their capabilities and employment doctrine, predict where and how they will be employed, and identify their most likely targets.

- Honor the threat. Ensure there are adequate and appropriate resources to counter UAV effects in and around the unit's area of operations. If specialized sensors are not available, establish "air guards" to scan the airspace continuously. Ensure unit leaders understand, and are in compliance with, the area air defense plan (AADP).

- Maintain disciplined flight operations. Although flight clearances for friendly UAVs are sometimes perceived as untimely or overly restrictive, they are critical to ensuring other friendly forces in the area do not engage the unit's UAVs. Ensure flights are in compliance with local airspace coordinating measures to aid in proper identification (ID).

C-UAS CONSIDERATIONS

UAVs are the air threats of the next fight. UAV technology development and employment around the world demonstrates a relevant and viable air threat. Air defense artillery liaison officers cannot discount UAVs in the area of operations because of the relatively small size of these platforms. Air defense artillery liaison officers should consider the following when working with/within the integrated air defense system.

- Take an active role in AADP development to ensure it adequately mitigates threats to the maneuver force.

- Suggest UAV-specific rules of engagement when there is a reliable ability to distinguish unmanned platforms to maximize attrition of low-regret targets. ID and engagement authority for low, slow, small UAVs should rest at the lowest possible tactical level.

- Ensure criteria for "hostile act" and "hostile intent" specifically addresses UAVs and are written in terms any military member can understand, and adequately addresses ground troop protection.

- Consider requesting liberal "Hostile" symbology use and ID forwarding through the air defense and airspace management cell to the common operational picture.

- Ensure all joint data link contributors use a common set of track amplification data (i.e., air type, air platform, and air activity) to categorize the UAV target set.

NATIONAL CAPITAL REGION AND INTERAGENCY SUPPORT

Critical assets within the continental US have been "attacked" by UAV operators. While no deaths have been attributed to these UAVs, it is only a matter of time before these systems are directly or indirectly responsible for loss of life or interference with critical infrastructure in the homeland. In some circumstances, active duty military personnel and military equipment may be required to operate subordinate to civil-military organizations, and the following are considerations for working in this type of environment.

- Per Department of Defense Directive (DODD) 3025.18[1] , *Defense Support of Civil Authorities*, DOD resources may be used in an immediate response to prevent loss of life, mitigate damage to infrastructure, or in support of mutual aid agreements (i.e., title 42, United States Code) to address certain precoordinated conditions or as directed by the President as part of the national response framework.

- All DOD activity within the homeland is conducted in support of a primary federal agency to minimize impact to the American people, infrastructure, and environment.

- Most organic communications systems will not be compatible with the civil organization(s) being supported, thereby increasing reliance on knowledgeable liaison officers.

- Missions may include air defense coverage for the National Capital Region, key power and communications infrastructure, national borders, sporting arenas, political conventions, and presidential inaugurations.

- Technology countering the UAS threat within US borders must be in compliance with existing Federal Aviation Administration and Federal Communications Commission regulations. Military planners cannot assume they are exempt from fines or prosecution for violating civil airspace or spectrum management policies in the interest of thwarting a potential hazard.

... it is only a matter of time before these systems are directly or indirectly responsible for loss of life or interference with critical infrastructure in the homeland.

CONCLUSION

UAV development and fielding is gaining momentum with the US's adversaries; and, with each innovation, they are becoming more capable than the previous generation. US military personnel must assume adversaries are observing targets of vital interest. UAV operations are not limited to the battlefield; they have been used to disrupt daily routines at home and violate traditional security measures surrounding US borders, prisons, nuclear facilities, and premier sporting venues. Not all who benefit from research and training may be performing traditional military missions; civil authorities will also benefit from UAV research and analysis, leverage technology, and request assistance defending airspace around sensitive domestic targets. Leaders, across all warfighting functions, must take an active role in educating themselves and training their units to defeat this threat.

END NOTE

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TEASER FOR AN ... IMPROVING LINK 16 EFFICIENCY AND PROVIDING ADVANCED ENGAGEMENT OPTIONS FOR ANTI-ACCESS/AREA DENIAL OPERATIONS CLASSIFIED ARTICLE

An E-2D Hawkeye (top) and a C-2A Greyhound aircraft assigned to Air Test and Evaluation Squadron 20 fly over the USS Zumwalt (DDG 1000) as the ship travels to its new home port of San Diego, California on October 17, 2016. (Photo by Erik Hildebrandt, USN)

By Dr. Earl W. Burress, Jr. (Ph.D.), Mr. George Dick, and Mr. Steven McDougall

Prior to the existence of the joint tactical air picture (JTAP) tactics, techniques, and procedures (TTP), commanders responsible for integrated air and missile defense (IAMD) operations lacked the TTP necessary to integrate modern Joint Range Extension Application Protocol-C (JREAP-C) and JTAP integrated fire control capabilities into the joint air picture. Without this type of TTP, ambiguities in the joint air picture limit the effective and efficient use of IAMD systems and increase the risk of significant hostile attacks and fratricide. Thus, the Deputy Director, Air Warfare, Office of the Secretary of Defense, chartered the JTAP joint test to develop and test TTP to address these shortcomings, with the Joint Integrated Air and Missile Defense Organization (JIAMDO) and United States Pacific Command as an endorser and sponsor, respectively. The JTAP TTP guides and instructs joint interface control officers (JICOs) and communications planners on the intricacies of planning and implementing a combined internet protocol (IP) and radio frequency (RF) Link 16 architecture. Additionally, the JTAP TTP provides IAMD operators the procedures to execute new integrated fire control engagement options.

The Link 16 network implementation procedures rely on a resilient Department of Defense (DOD) IP network. To ensure the effectiveness of the TTP, JICOs and communication planners must:

1. Request Defense Information Systems Agency, inter-Service, and local cyberspace authorizations with sufficient time to employ them.

2. Prioritize JREAP-C data flow within the networks.

3. Ensure resilient pathways exist to preserve IP continuity in the face of RF degradation or cyberspace attack.

Test results indicated using JREAP-C provided an improvement to the air picture while freeing up time slots for disadvantaged users and making it possible for network designers to optimize the network for integrated fire control engagements. The TTP are applicable to DOD warfighters who intend to use JREAP-C to counter the advanced electronic attack threat, optimize Link 16 time slot duty factor efficiency, or enable JTAP integrated fire control engagements.

The content of this article is taken from the classified document titled, *Joint Tactical Air Picture Tactics, Techniques, and Procedures Fielded: Improving Link 16 Efficiency and Providing Advanced Engagement Options for Anti-Access/Area Denial Operations*, which is available on the Air Land Sea Application Center (ALSA) SECRET Internet Protocol Router Network (SIPRNET) site. To learn details of JTAP TTP and their advantages, visit https://intellipedia.intelink.sgov.gov/wiki/JIAMDO_IAMD_Interoperability_Branch#.28SNF.29_Joint_Tactical_Air_Picture_.28JTAP.29_Joint_Test on SIPRNET (Intelink access required.) For access to the JTAP TTP, contact MAJ Ron Crowther , JIAMDO JTAP action officer, at NIPR: ronald.s.crowther.mil@mail.mil or SIPR: ronald.s.crowther.mil@mail.smil.mil.

END NOTES

Joint Tactical Air Picture Joint Test: Joint Tactics, Techniques, and Procedures for a Clearer and More Accurate Joint Air Picture and Increased Integrated Air and Missile Defense Effectiveness, dated February 2016, For Official Use Only

Joint Tactical Air Picture Final Report, dated January 2016, SECRET

Dr. Earl W. Burress, Jr., (Major, USAF, Retired) serves as technical director for the JTAP joint test.

Mr. George Dick (Chief Warrant Officer 4, USA, Retired) serves as the Patriot System/Link 16 subject matter analyst for the JTAP joint test.

Mr. Steven McDougall (Lieutenant Commander, USN, Retired) serves as a Test Planner/Operations Research Systems Analyst for the JTAP joint test.

The TTP are applicable to DOD warfighters who intend to use JREAP-C to counter the advanced electronic attack threat ...

Soldiers of Alpha Company, 1st Battalion, 94th Field Artillery Regiment, fire a rocket from a M142 high mobility rocket system during a decisive action training environment exercise on October 4, 2016 near Camp Buehring, Kuwait. (Photo by Sgt. Aaron Ellerman, USA)

REVIVING JAAT CAPABILITIES WITH EXISTING JOINT DOCTRINE

An A-10C Thunderbolt II, assigned to 75th Fighter Squadron, performs a low-angle strafe during the 2016 Hawgsmoke competition at Barry M. Goldwater Range, Arizona, June 2, 2016. (Photo by Senior Airman Chris Drzazgowski, USAF)

By Maj Justin Banez, USAF, Maj Joel Bier, USAF, Maj David Gunter, USAF, Maj Steve Joca, USAF, Maj Jeffrey Robb, USMC, Maj John Ryan, USAF, and Maj Gregory Stack, USAF

BACKGROUND

As the Services return to major combat operations and away from counterinsurgency, the United States Army Aviation Center of Excellence (USAACE) looked at reviving the Multi-Service Tactics, Techniques, and Procedures (MTTP) for *Joint Air Attack Team* (JAAT) publication. Concerned that a critical capability gap may have developed over the course of the last 15 years of low-intensity conflict, the USAACE asked the Air Land Sea Application Center (ALSA) to research the problem. ALSA embarked on a study to revive the JAAT mission and the MTTP.

The JAAT mission was intended as a method to integrate artillery and rotary- and fixed-wing aviation ...

A joint working group (JWG) comprised of United States Army, United States Air Force (USAF), and United States Marine Corps (USMC) representatives assembled at Nellis Air Force Base to review the issue in January, 2016. One salient point summarizes the JWG's findings: current joint interdiction and close air support (CAS) frameworks provide the doctrinal structure with which to achieve JAAT mission objectives and capabilities.

The JAAT mission was intended as a method to integrate artillery and rotary- and fixed-wing aviation into close and deep fights. Air mission commanders were pilots specifically qualified to act as strike authorities in support of a ground force commander's JAAT area of operations. The Army maintained JAAT within its Service manuals, but the JAAT mission's lack of use in recent conflicts led the USAF to drop its JAAT qualifications and allot training resources to other areas. In the meantime, the ALSA-published MTTP dissolved into various other joint publications.

Although the USMC never participated in JAAT operations, the nature in which it conducts combined arms warfare with integrated surface and aerial fires displays the intended benefits JAAT was to achieve. Therefore, JAAT was an unnecessary framework for the USMC because their assets operate under common Service missions and doctrine. USMC aviation conducts CAS procedures for missions in proximity to friendly forces and adheres to the strike coordination and reconnaissance (SCAR) and Kill Box MTTP for interdiction operations.

Despite these seeming disparities at the Service-level, the majority of tactical integration guidance resides in current CAS doctrine and ALSA's joint application of firepower MTTP. Sections in these publications on coordinated attack tactics, currently, comprise the bulk of the information previously presented in the JAAT MTTP. Typically underused by the Army, coordinated attack tactics, techniques, and procedures (TTP) are widely used by USMC and USAF aircraft to perform joint attacks across a variety of mission sets, not just CAS. The utility of coordinated attack tactics is the ability to apply them in an unplanned, or ad hoc, environment. For this reason, SCAR, a form of dynamic joint interdiction, relies heavily on coordinated attack procedures.

The utility of coordinated attack tactics is the ability to apply them in an unplanned, or ad hoc, environment.

PROBLEM STATEMENT

The dissolution of the JAAT MTTP leaves the joint force with several issues to manage. First, the joint force must re-educate itself on the existing JAAT-like capabilities in the

Casings fall from a 30mm chain gun suspended beneath an AH-64D Apache helicopter assigned to 1st Attack Reconnaissance Battalion, 82nd Combat Aviation Brigade, during the battalion's aerial gunnery exercise at Fort AP Hill, Virginia on October 24, 2016. (Photo by Sgt. Steven Galimore, USA) current close (i.e. CAS) and deep (i.e. joint interdiction) mission doctrines. Second, the aforementioned existing frameworks still leave command, control, and coordination gaps for CAS integration in the absence of a joint terminal attack controller and may raise questions of the air mission commander's strike authority and responsibilities in the interdiction environment. The last, and most important point, is that JAAT procedures for coordination and integration were not effectively absorbed into joint interdiction doctrine. Although CAS did absorb coordinated attack MTTP, it still lacks the nuances for rotary-wing integration and surface-to-surface fires synchronization.

MISSION REQUIREMENTS

A quick overview of mission requirements is in order before delving into the current coordinated attack doctrine and the updates needed to achieve JAAT-like effects. First, a JAAT-like capability must integrate surface-to-surface fires and rotary- and fixed-wing aviation at the tactical level. The solution must fully integrate into the theater command and control structure to alert the proper air tasking order (ATO) assets to coordinate with artillery or rotary-wing assets that, potentially, are not on the ATO. Therefore, this capability must execute within the ATO planning cycle and achieve product synchronization using a common language and terminology.

… the joint doctrine for a JAAT-like solution must clearly delineate authorities in planning and execution.

Also, the joint doctrine for a JAAT-like solution must clearly delineate authorities in planning and execution. The joint community must establish common expectations and authority for the airborne mission commander or the SCAR (a role within air interdiction similar to the role of a forward air controller (FAC) or FAC (Airborne) in CAS). This capability needs to account for target detection, assuring target destruction using common communication systems, verbiage, and plans executed through common mission types. Furthermore, it is vital that fires are integrated with consideration to appropriate airspace control measures and fire support coordination measures for all forms of combined attacks; including suppression of enemy air defenses, counterair, and counterfire integration.

In addition to identifying essential mission requirements, the United States Army Training and Doctrine Command training guidance should serve as a reference to ensure the replacement nests with the Army higher headquarters' direction. The solution to mass joint fires outside of proximity to friendly forces must adhere to the USAACE commander's guidance. This guidance includes the assumptions that the Army will maintain control of its assets, that the guidance will neither limit Army aviation capability and flexibility nor will hinder Army air-ground operations. The solution must be capable of dynamic and deliberate targeting, and account for how the Army can integrate forces operating above the coordinating altitude.

SOLUTION

Since the joint solution for the close fight exists in Joint Publication (JP) 3-09.3, *Close Air Support*, the JWG focused attention on multi-Service fires not in proximity to friendly forces. The JWG proposed two courses of action (COAs). The first COA recommended all Services conduct SCAR as the standard method to coordinate and mass joint fires while not in proximity to friendly forces. This option requires revising the SCAR and Kill Box multi-Service publications. The second COA recommended the Services conduct JAAT as the method to coordinate and mass joint fires while not in proximity to friendly forces, requiring the USAF, United States Navy (USN), and USMC to rewrite their Service doctrine and TTP. The second option also requires a significant investment in time, effort, and money to incorporate JAAT into qualification courses and training plans—a significant obstacle for all in the current fiscal environment.

The first COA is clear; integrate Army tactics into existing joint doctrine which all Services have approved. Under this COA, SCAR not only breathes new life into the USAF and Army JAAT concept, but it promotes the incorporation of additional USN and USMC strike assets. Not surprising, the ALSA working group recommended the first COA and the USAACE commander agreed.

To implement the JWG's recommendation, several changes must be made to JP 3-03, *Joint Interdiction*; JP 3-52, *Joint Airspace Control*; and the SCAR and Kill Box MTTP. The most relevant doctrine for incorporating joint fires integration outside the proximity of friendly forces is through the SCAR tactical guidance found in JP 3-03 and the SCAR MTTP. The JWG recommended the following major changes to JP 3-03 and the SCAR MTTP:

- Update the publication to incorporate surface-to-surface and rotary-wing fires integration.
- Improve readability for the non-aviation fires community.
- Incorporate Army employment terms.
- Designate SCAR aircrew operating short-of-the-fire-support-coordination line as extensions of the ground commander's fires coordination center.

To address the Army's concern about fixed-wing release authority and airspace coordination when executing attacks not in proximity to friendly forces, we [the authors] turn to SCAR MTTP. The SCAR-designated platform will typically be allocated a purple kill box (or designated geographic area) in which to conduct SCAR; and therefore, owns the roles and responsibilities detailed in JP 3-03. The SCAR coordinator determines how supporting fires assets are integrated and deconflicted to support the ground force commander's intent. As for weapon release authority, clearance for all SCAR assets will remain with the ground commander and may be given in real-time or pre-mission.

While the first COA requires significantly less investment in time; inevitably, there are additional training requirements for SCAR aircrews to incorporate Army-specific TTP associated with rotary-wing and surface fires. Currently, the Army does not train to the SCAR mission, although they are a signatory on ALSA's SCAR MTTP. (The MTTP does not address a role for the Army.) The USAACE-accepted solution is to develop a standardized training syllabus for SCAR. To help educate the joint fires community, ALSA recommended a SCAR "road show" with all joint stakeholders to synchronize efforts during the MTTP's overhaul.

CONCLUSION

The decision for all Services to formally recognize and conduct SCAR as the preferred method to coordinate and mass joint aviation and surface fires outside proximity to friendly forces is a significant step in aligning joint effects. While the term "JAAT" will be deleted from the lexicon, the capability it represents will remain. In fact, the joint community should expect improved capability. Whereas JAAT missions limited the Army to solely USAF support, the use of the SCAR mission set incorporates available USN and USMC assets. Furthermore, the way-ahead eliminates the Army's concerns about limitations to air-ground operations and begins the long-desired formal synchronization of Service capabilities, to include procedures and terms common to all.

While the term "JAAT" will be deleted from the lexicon, the capability it represents will remain.

THE ARMY AND AIR FORCE NEED USAF 13L OFFICERS, JOINT FIRES INTEGRATORS

US Air Force Tactical Air Control Party Airmen from the 227th Air Support Operations Squadron fast rope from a New Jersey Army National Guard UH-60 Black Hawk during Exercise Rail Yard, on Warren Grove Gunnery Range, New Jersey, September 21, 2016. (Photo by Tech. Sgt. Matt Hecht, USAF)

By SMSgt Eric D. Muller, USAF

The following is an example from National Training Center (NTC) and indicative of the type of situation that a 13L is required to face.

The operational order brief provided clear intent: in 24 hours the brigade combat team (BCT) would push across the border, engaging enemy armor. Implied tasks included building priority intelligence requirement-linked. named areas of interest, providing shaping fires with organic assets and division artillery, and deploying the cavalry and scouts. With a condensed planning period, the BCT air liaison officer (ALO) knows the clock is against the staff to build a plan and execute the mission.

Running through the military decision-making process phases with his Army warfighting staff members, the ALO compiles a functional and flexible airspace plan for the brigade, ensuring joint tactical airstrike requests adequately reflect needs. The ALO outlines the scheme of maneuver, event-based triggers, intelligence community-synched priority intelligence requirements (PIR), and pre-planned electronic attacks.

At H-5, the Calvary is in place and sending size, activity, location, and time (SALT) reports back to the brigade, updating the enemy situational template. H-3 comes with the brigade commander's combined arms rehearsal followed by a fires rehearsal where the ALO leads a down-to-the-minute synchronization of intelligence, surveillance, and reconnaissance assets; artillery fires; Army attack aviation; electronic attack *assets; and close air support (CAS) helping the fire support officer ensure massing fires and suppression of enemy air defenses for airborne assets in support of the ground force commander's scheme of maneuver.*

Immediately following the rehearsal, the ALO sends updates to the joint tactical air strike requests and checks the air tasking order (at H-1), disseminating support information to subordinates via high frequency radio as satellite communication has been neutralized by an electromagnetic pulse.

The ALO pushes into planning the next phase of the operation, handing off plans to the current operations tactical air control party (TACP) for execution. By H+5, enemy contact and indirect fire have reduced the TACP (and the rest of the brigade) to 40 percent, requiring the ALO to reposition qualified joint terminal attack controllers (JTACs) in support of the next phase of the assault. With the tactical command post forward deployed to take current operations, the ALO is left with only the noncommissioned officer in charge to run 24-hour operations with the brigade staff planning and executing CAS and forcing strikes delegation to lower echelons, while managing airspace from the brigade tactical operations center.

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TACP Operations Flight Commander/JTAC

12th Combat Training Squadron

October 2016

THE 13L HISTORY

During the past thirty years, the United States Air Force (USAF) TACP member has relied on rated officers for leadership and to perform as ALOs. This reliance has been met with varying levels of success based upon the virtues of a ground-based or an Army-oriented mentality. The TACP career field became accustomed to adapting to leadership changes every two years. The result was an unstable organization with objectives that depend largely on the background and culture of the current commander. For example, leaders default to that with which they are familiar: an A10 pilot attempts to emulate an A10 squadron or a B52 navigator emulates a B52 squadron.

The issue was that many USAF leaders from the flying world were not put in leadership positions until they were lieutenant colonels or senior majors. It is one thing to run a two-ship sortie but it is another issue to lead an entire ground-based, Army trained, TACP squadron. The incentive for pilots was command time, but they were placed into a career field with a different focus, mentality, and culture; this created tension. The leader gained tremendously, but the squadron sometimes suffered from a lack of background, continuity, and familiarity with Army training.

The leader gained tremendously, but the squadron sometimes suffered from a lack of background, continuity, and familiarity with Army training.

In 2009, however, the Air Force, acknowledging the concerns of senior TACP leaders, created a TACP officer/career ALO, designated as a 13L. The new career field had a basis in Army military occupational specialties and special tactics officers with a similar construct. The new position broadened the range of candidates from young and mid-level officers to prior enlisted TACP members, existing ALOs who desired to make a career of the Army, and new recruits from the Air Force Academy. Questions surfaced at the time the career field was created, and they have not lessened; these include the following. How do we properly use an ALO/13L? What does the end state look like? What should be the extent of their responsibilities, training, and development?

Discussions ranged from beginning at battalion/company and expanding to brigade and division levels; remain exclusively at division or corps level echelons; or begin at division and transition to brigade. The matter is subjective based on the member's skills, background, and enlisted members aligned with the new officer. Critical leadership skills should be learned at battalion and slowly progress in scope and influence at each echelon.

Regardless of the echelon, their duties still, and must, require that they are joint force integrators. Leadership has realized the training provided at the Air Liaison Officer Qualification Course (ALOQC) did very little, if anything at all, to prepare and train young officers. The failings can be attributed to the course being leadership focused, rather than having a heavy emphasis on being joint force integrators and mission oriented officers. This training gap leveraged the training down to squadron commanders, which was neither standardized nor effective. The 13L's were meant to become JTACs, but there already exists assigned JTACs on the enlisted side of the house. What, then, was the value added by an ALO? Unsurprisingly, the most effective ALO's were the ones that were prior enlisted, borderline senior noncommissioned officers (NCOs) before they were commissioned. Their years of experience with the Army through the Joint Readiness Training Center (JRTC), NTC, and real world deployments prepared them to deal with the Army, but left unresolved what their additional responsibilities are supposed to be.

THE 13L CAREER PATH

What is the most effective path for an ALO/13L? The answer is subjective, but ALO's must be JTACs, they cannot know what their enlisted JTACs' responsibilities and capabilities are without that foundation. This requirement will bridge the gap in implementing fires.

Furthermore, ALOs/13Ls should be positioned in roles of responsibility based on the needs of the unit. Young enlisted JTACs, ideally, begin at the company level and move up the echelons. Some are not capable and need additional time to learn at brigade and division; some excel and can be placed quickly, based upon need. Regardless of the echelon assigned, the ALO needs to be able to integrate multiple Army aviation, fires, electronic warfare (EW), and airspace to collectively shape a battlefield that is conducive to joint fires integration techniques.

... the ALO needs to be able to integrate multiple Army aviation, fires, electronic warfare (EW), and airspace to collectively shape a battlefield ...

The ALO should train for all levels within the Army; but give priority to becoming a joint fires leader and integrator, and then to becoming a certified JTAC. While the commander should dictate this based on need, it must be accompanied by the understanding that the ALO's most critical job is that of leading and integrating forces. The tactics, techniques, and procedures (TTP) from various echelons and aligned Army forces (such as infantry, airborne, armor, etc.,) should be captured and solidified in an ALO tactics publication equivalent. This will ensure young officers have a baseline for learning their job as joint force integrators. The rated officers still have a need within the Army tactical operation center (TOC). Their expertise and knowledge of airframes are valuable, but the ideal mixture should be a supporting staff with 80% 13Ls and 20% rated officers.

THE NEED FOR A 13L WEAPONS INSTRUCTION SCHOOL REQUIREMENT

There is renewed call for a 13L weapons instructor course which is, essentially, the best of the best for the Air Force. This course can make ones career, similar to the United States Army Ranger School for Army infantry officers, but with a focus on technical expertise rather than developing elite infantry Soldiers. The Weapons Instructor Course molds and develops TTP, shapes the career field, and addresses and implements training initiatives. The ALO/13L Weapons Instructor Course should be quite different than the current enlisted JTAC Weapons Instructor Course. The 13L course should focus on joint fires integration voids left between the Army and Air Force. Small portions of a 13L instructor course can share information with the existing JTAC course, but not at the same tactical level.

Whether at JRTC or NTC, or as a division warfighter, instructor, or JTAC abroad, there is not a joint force integrator linking the Army and Air Force. The 13L should be that integrator. The 13L should gain the knowledge of the Advanced Field Artillery Tactical Data System (FATADS), transportation automated information systems (TAIS), minimum-risk route/air corridors, EW assets, and airspace coordinating measures (ACMs) development at all levels. This knowledge will enable the 13L to become a master of integrating fires, not the counterinsurgency (COIN) version of deconflicting assets to which our forces have grown accustomed.

The COIN fight has taught us not to shoot each other down or fly our planes into other planes. The reality is, the ALO/13L should be the go-to person who understands integration on any battlefield. The 13L should be able to set up all sorts of ACMs depending on the assets and ground force commander's intent. The 13L would tell the TAIS operators what they need to do and advise the division fires officer on the best plan to integrate fires, CAS, mortars, rotary-wing assets, and EW assets into a scenario. This is the future of the 13Ls.

They should be able to educate Army fires officers on integration designed to produce maximum effects on the battlefield, using a variety of fires options. The current Army construct of moving officers around every two years to gain experience makes careers, but contributes to the gaps in fires continuity. By the time a new officer is in place and trained as the brigade fires support officer, that individual is considering the next career move. The high turnover rates lead to inexperienced and untrained staff members. Another JTAC 13L is not what is best for the Army, Air Force, or TACP career field. What is best is for the 13L joint force integrator is to cover the gaps left from the Army change over and the enlisted JTAC tactical level. Potentially, the 13L can bring an operational level of expertise that is unmatched and irreplaceable.

SUMMARY

Fifteen years of COIN has taught us the permissive environment encourages deconflicting assets versus integrating assets on a stagnate battlefield. The Weapons Instructor Course is a necessity for the 13L and for the Army, whether they realize it or not. We need strong leadership aligned with solid senior NCOs. The enlisted Weapons Instructor Course is crucial for enlisted JTACs at the tactical level, but enlisted members are only as strong as their aligned commander allows them to be!

The enlisted Weapons Instructor Course is crucial for enlisted JTACs at the tactical level, but enlisted members are only as strong as their aligned commander allows them to be!

The need for a joint Service integrator within the Army staff, who is a master at implementing various fires and ACMs to achieve the commander's objective, is paramount. The 13L should fill this role by bringing expertise, synergy, and continuity to the commander's operation center and provide continuity and experience to each squadron. A person in this invaluable position will be able to determine the most effective courses of fires integration that maximize effects and protect key attack aircraft by allowing each system to service targets simultaneously. The joint fires integration aspect has gone largely ignored in current exercises and the 13L would provide a key link to synergizing firepower on tomorrow's battlefield.

END NOTES

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TRUE IMPACTS OF SPACE WEATHER ON A GROUND FORCE

By LTC(R) Gregory Sharpe and MAJ Kenneth Rich, USA

INTRODUCTION

It is July 23, 2012 and your artillery battalion is conducting a training exercise with a partner nation in Cambodia. Your battalion tactical operations center is set up, your joint network node satellite communications (SATCOM) van is operating correctly using the superhigh frequency (SHF) band, and you are receiving feeds from your AN/TPQ-53 counter-fire radar observing a live fire exercise. You are able to listen to the forward observers calling for fire on their AN/PRC-117G ultrahigh frequency (UHF) radios. Additionally, you can easily observe the data passed via the Advanced Field Artillery Tactical Data System (AFATDS). All of a sudden, the UHF radio transmission become broken and unreadable, the AFATDS data that does get through has Global Positioning System (GPS) positions hundreds of meters off from previous calls for fire and the Q53 is not picking up any artillery rounds—even though you know the guns are firing. The discrepancies are due to a solar storm.

Luckily, this event is fictional. Although, the largest solar storm recorded, which occurred on July 23, 2012, narrowly missed earth. This solar storm was stronger than the Carrington event of 1859 (the largest storm on record impacted the Earth causing telegraph units to operate without being connected to batteries) and could have caused major damage to interconnected systems of today. Translating space weather events to the impact faced by a ground force is a major obstacle encountered by Army Division Space Support Elements. It is acceptable to discuss generic impacts like "space weather effects radio transmissions and radar" in a basic space weather overview class. Yet, discussion of generic impacts during a high-intensity conflict, (where counter-battery radar provides targetable data on enemy long-range artillery, satellites, and theater-level radars provide ballistic missile warning, and mission command depends on SATCOM) provides little benefit and fails miserably at conveying the true impacts space weather events have on a ground force. No single source is readily available in extant literature that adequately translates space weather events to impacts faced by a ground commander who has no background in astrophysics or electromagnetic wave propagation theory. This paper provides an overview of space weather that arises in the solar-terrestrial system and how space weather impacts can be incorporated into the planning process during heightened solar activity.

> Translating space weather events to the impact faced by a ground force is a major obstacle ...

THE NATURAL SPACE ENVIRONMENT

The natural space environment consists of the sun and the interplanetary space between the sun and near-Earth space environment referred to as the magnetosphere. The magnetosphere is a 1-million-mile magnetic shell surrounding the Earth consisting of radiation belts and associated radiation phenomena which can affect spacecraft components.

Additionally, the Earth's atmosphere consists of several layers; the most important portion with respect to space weather effects is the ionosphere. The ionosphere is a region in Earth's upper atmosphere from approximately 60 to 600 kilometers (km) and consists of the D, E and F layers. The D layer extends to approximately 60 to 90 km above the Earth. Radio waves traveling through this layer lose energy, resulting in some absorption in the frequency range up to 10 megahertz (MHz). The E layer extends from approximately 90 km to 140 km above the Earth and consists of ionized gasses which exist only during daylight hours. During periods of high-intensity solar activity, the E layer can contain regions of high ionization called sporadic E.

The F layer extends from approximately 140 to 600 km above the Earth and separates into two layers, F1 and F2, during the day. According to the Encyclopedia Britannica, the F layer has the greatest concentration of free electrons and is important for high frequency (HF) radio wave reflection and long distance propagation for frequencies from 10 to 35 MHz. Ultimately, all satellites must communicate their radio frequency signals through the ionosphere to reach terrestrial users. Depending upon the frequency of the radio signal, the ionosphere can significantly degrade associated systems' performance.

POSSIBLE MITIGATION FACTORS IN THE SPACE SEGMENT

The strategies for dealing with space weather effects have different forms. In some cases this requires better equipment design, with increased reliability or economy. Appropriate electrical connection of electricity distribution subsystems, shielding vulnerable satellite components against electrical discharge or radiation, and controlling the electric potential of pipelines to avoid corrosion are some examples. In other cases, day-to-day or hour-to-hour space weather prediction and monitoring can be used to alter operational behavior. To protect a satellite's electronics, a satellite might be placed into safe mode during severe solar activity. In this instance, the satellite will not be functional for the ground force. For SATCOM, the Regional Satellite Communications Support Center (RSSC) should notify the end users of pending safe mode operations. The geographic combatant commands will then re-prioritize the remaining SATCOM assets and the RSSC will move users, accordingly. Links not determined to have priority will have to communicate without SATCOM until the solar activity settles. If an intelligence, surveillance and reconnaissance (ISR) satellite is required to mitigate threats, the collection managers will need to request additional airborne ISR capability or wait until the solar activity lessens to collect information as long as the latest time of intelligence value is not exceeded.

SPACE WEATHER

Space weather effects can lead to disruption of not only satellites that operate GPS, but terrestrial power grids as well. Additionally, these effects can not only pose risk to astronauts operating beyond a low-earth orbit, but could potentially cause rerouting of flights over the polar regions of the Earth (Stormy, 2012).

Space weather effects can lead to disruption of not only satellites that operate GPS, but terrestrial power grids as well.

Everyday life, however, is not as affected by space weather as it is by meteorological weather. But as technology has advanced, the consequences to a broad range of technologies have become more prominent. Current capabilities can continuously observe the sun in the range covering x-rays to ultraviolet (UV) rays and many missions have set out to study the sun-Earth connection. Consequently, these observations demonstrated the connection between events on the sun and the space weather in the near-Earth environment. Although many questions remain, space weather prediction has become a possibility (Glover et al, 2002). Space weather, much like terrestrial weather, is an everyday occurrence. The complex interaction of the sun and Earth lead to several daily occurrences that may impact operations for a ground force. Just as terrestrial weather occasionally has storms, space weather occasionally causes geomagnetic storms. This section will explain the basics of space weather without requiring a background in heliophysics or magnetohydrodynamics.

The sun is a blackbody radiator that emits radiation in all portions of the electromagnetic spectrum. Visible and infrared radiation output, however, is more predictable and constant (Jursa, 1985). The sun's complex interactions lead to phenomenon such as solar wind, solar radio bursts, solar flares, and coronal mass ejections (CME). When the sun's solar wind is especially strong, like during a CME, and lasts for a long period of time, it can lead to geomagnetic storms. These storms can last up to five days, but occur infrequently.

Solar radio bursts and solar flares are unpredictable and the effects reach Earth in approximately 8 minutes. Therefore, their effects cannot be mitigated, but an awareness of their possibility can lead to mitigating factors to lessen their impact. CMEs are interrelated with sunspots. CMEs occur from sunspots, but sunspots do not predict CMEs. Solar radio bursts and solar flares accompany CMEs, but CMEs also result in a mass of energized particles that can take between 1 and 2 days to reach Earth. The energized particles cause additional interaction with Earth and increased ionization. Depending on the strength of the CME, the resulting geomagnetic storm can lead to effects lasting from tens of minutes to several days; the stronger the storm and wind, the greater the ionization, resulting in longer duration for the outages.

... CMEs also result in a mass of energized particles that can take between 1 and 2 days to reach Earth.

A DESCRIPTION OF POSSIBLE EFFECTS

In order to assist the Space Support Element in translating space weather into observable effects for a ground force, we created tables 1 through 3. The tables describe probable affects based on the National Oceanic and Atmospheric Administration (NOAA) space weather scales for space events. They describe specific exemplary equipment found in the current inventory and describe the affects as a ground commander would better understand them in order to better add information to the composite risk management process.

Clutter Due to Solar Radio Bursts

Solar emissions come in many types and each is distinctive with regard to its characteristics and impacts. Moreover, low energy particle streams composed of electrons and protons arrive at Earth within 2 to 4 days and cause ionospheric and geomagnetic storms lasting from hours to a few days. These particles interact with the magnetosphere and are most frequently experienced on the night side of the Earth (Gehred, 2008).

Solar radio bursts are radio transmissions from the sun and are subdivided into five classifications. If a radar's look angle is directed at the sun (main or side lobes) when a solar radio burst occurs, and the burst is in the frequency range of the radar, the additional clutter may be more than the constant false alarm rate mechanism normally accounts for and may cause effects similar to jamming. For non-phased array radars, the clutter will result in a decrease in track volume. For phased array radars the clutter will result in a more porous track volume. Therefore, solar radio bursts can affect the probability of detection of counter fire radars such as the AN/TPQ-53 or the air traffic control Sentinel radar.

Scintillation

Ionospheric scintillations are amplitude and phase changes in radio signals caused by density irregularities in the ionosphere resulting in degraded received signals if the scintillation is greater than the receiver fade margin (Knight, 2000). Due to the inverse power law, the effects are only significant up to a frequency of 2 Gigahertz (GHz), but can create some effects up to 4 GHz under the right conditions (Tanskanen et al., 2001). Two peak times, near noon and near midnight, exist for scintillation in the polar (50° and 90° latitudes) and equatorial (0° to 20° latitude) regions (Aarons, 1997). Scintillation may affect mid-latitude systems if the look angle to the satellite crosses the ionosphere within the scintillation

Table 1. Effects of Space Weather in Mid-Latitude Regions
(Effects on THE sunlight side of THE Earth only)

Definitions	
Normal	Normal space weather
Moderate	NOAA Solar Radiation Storm levels S1 and S2, NOAA Radio Blackout levels R1 and R2, NOAA Geomagnetic Storm levels G1 and G2
Severe	NOAA Solar Radiation Storm levels S3–S5, NOAA Radio Blackout levels R3–R5, NOAA Geomagnetic Storm levels G3–G5

	Normal	Moderate	Severe	Reason	Frequency effected	Example system
Firefinder radar	No effect	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	**Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed**	**Type IV solar radio burst if the sun is in the main or side lobe of the radar during an event**	**2–4 GHz**	**Q53, Q36, Q37**
Tactical missile/air warning radar	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	**Degraded range and elevation angle accuracy for hours after solar event**	**Models do not replicate increased ionization levels in ionosphere. Look angle of radar intersects ionosphere at approximately 1/3 of the range.**	**4–6 GHz**	**Patriot**
Theater ballistic missile defense capability	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after a solar event	**Degraded range and elevation angle accuracy for hours after solar event**	**Models do not replicate increased ionization levels in ionosphere**	**8–12 GHz**	**THAAD**
Air traffic control radar	No effect	No effect	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	Type IV solar radio burst if the sun is in the main or side lobe of the radar during an event. Radar operates below the ionosphere (highest recorded aircraft 37.6 km < 60km ionosphere)	1–2 GHz	AN/ARN-153
Static ballistic missile warning radar	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after a solar event	Degraded range and elevation angle accuracy for hours after solar event	Models do not replicate increased ionization levels in the ionosphere. Scintillation in auroral zones lower in latitude than normal	300 MHz–3 GHz	BMEWS at Thule or Fylingdales
Space situational awareness radar	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	Models do not replicate increased ionization levels in ionosphere. Scintillation in auroral zones lower in latitude than normal	300 MHz–1 GHz	AN/FPS-85
HF radio	No effect	Increased LUF, limited blackout of frequencies in 3 MHz–20 MHz range for up to 10 minutes, short wave fade, change in area coverage	Increase LUF, decreased MUF, limited blackout of frequencies in 3 MHz–30 MHz range for several hours, short wave fade, change in area coverage	D, E and F layer density	3 MHz–30 MHz	AN/PRC-150

Table 1. Effects of Space Weather in Mid-Latitude Regions
(Effects on THE sunlight side of THE Earth only)

Definitions	
Normal	Normal space weather
Moderate	NOAA Solar Radiation Storm levels S1 and S2, NOAA Radio Blackout levels R1 and R2, NOAA Geomagnetic Storm levels G1 and G2
Severe	NOAA Solar Radiation Storm levels S3–S5, NOAA Radio Blackout levels R3–R5, NOAA Geomagnetic Storm levels G3–G5

	Normal	**Moderate**	**Severe**	**Reason**	**Frequency effected**	**Example system**
Tactical FM/SINCGARS	No effect	No effect	No effect	Operates LOS	30 MHz–87.975 MHz	AN/PRC 119
VHF radio	No effect	No effect	Signal degradation, signal polarization if using linear polarization	Scintillation, Faraday Rotation	30 MHz–300 MHz	AN/PRC-117G, AN-PRC 52
UHF radio	No effect	No effect	Signal degradation	Scintillation	300 MHz–3 GHz	AN/PRC-117G, Iridium, INMARSAT
SHF radio	No effect	No effect	Signal degradation between 3 GHz and 4 GHz only	Radio frequencies not effected by ionosphere density, scintillation or TEC	3 GHz–30 GHz	
EHF radio	No effect	No effect	No effect	Radio frequencies not effected by ionosphere density, scintillation or TEC	30 GHz–300 GHz	SMART-T
GPS receiver*	No effect	No effect	Outages of single frequency GPS receivers for hours, position errors up to 100 Meters horizontal and 200m vertical	Scintillation from auroral zones lower in latitude than normal, TEC	L Band	Civilian GPS receiver
Electrical transformers	No effect	Low probability that high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage	Power systems may experience voltage alarms, protective system problems or grid outages, long-duration storms may cause transformer damage	Geomagnetic induced currents trip SCADA sensors overloading power grid zones and transformers	N/A	

**Dual frequency GPS receivers have a better algorithm for factoring the effects of atmospheric scintillation. GPS studies have shown receivers in a scintillation environment have a low probability of losing lock with multiple satellites simultaneously (Knight, 2000).*

Legend:
BMEWS—ballistic missile early warning system
EHF—extremely high frequency
FM—frequency modulation
GHz—gigahertz
GPS—Global Positioning System
HF—high frequency
INMARSAT—-international maritime satellite
km—kilometer
LOS—line of sight
LUF—lowest usable frequency
MHz—megahertz
MUF—maximum usable frequency
N/A—not applicable
NOAA—National oceanic and Atmospheric Administration
SCADA—supervisory control and data acquisition
SHF—super high frequency
SINCGARS—single-channel ground and airborne radio system
SMART-T—Secure Mobile Anti-Jam Reliable Tactical Terminal
TEC—total electron content
THAAD—terminal high altitude area defense
UHF—ultrahigh frequency
VHF—very high frequency

Table 2. Effects of Space Weather in Mid-Polar Regions (Effects on THE sunlight side of THE Earth only)						
Definitions						
Normal			Normal space weather			
Moderate			NOAA Solar Radiation Storm levels S1 and S2, NOAA Radio Blackout levels R1 and R2, NOAA Geomagnetic Storm levels G1 and G2			
Severe			NOAA Solar Radiation Storm levels S3–S5, NOAA Radio Blackout levels R3–R5, NOAA Geomagnetic Storm levels G3–G5			
	Normal	**Moderate**	**Severe**	**Reason**	**Frequency ef-fected**	**Example system**
Firefinder radar	No effect	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	**Type IV solar radio burst if the sun is in the main or side lobe of the radar during an event**	**2–4 GHz**	**Q53, Q36, Q37**
Tactical missile/air warning radar	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	**Models do not replicate increased ionization levels in ionosphere. Look angle of radar intersects ionosphere at approximately 1/3 of range.**	**4–6 GHz**	**Patriot**
Theater ballistic missile defense capability	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	**Models do not replicate increased ionization levels in ionosphere**	**8–12 GHz**	**THAAD**
Air traffic control radar	No effect	No effect	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	Type IV solar radio burst if the sun is in the main or side lobe of the radar during an event, Radar operates below the Ionosphere (highest recorded aircraft 37.6 km < 60km ionosphere)	1–2 GHz	AN/ARN-153
Static ballistic missile warning radar	Low probability of degraded range and elevation angle accuracy for minutes to hours during daily scintillation windows	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	Models do not replicate increased ionization levels in ionosphere. Scintillation in auroral zones lower in latitude than normal	300 MHz–3 GHz	BMEWS at Thule or Fylingdales
Space Situational Awareness radar	N/A	N/A	N/A	N/A	N/A	N/A
HF radio	No effect	Increased LUF, limited blackout of frequencies in 3 MHz–20 MHz range for up to 10 minutes, short wave fade, change in area coverage	Increase LUF, limited blackout of frequencies in 3 MHz–30 MHz range for several hours, short wave fade, change in area coverage	D, E and F layer density	3 MHz–30 MHz	AN/PRC-150

Table 2. Effects of Space Weather in Mid-Polar Regions
(Effects on THE sunlight side of THE Earth only)

Definitions	
Normal	Normal space weather
Moderate	NOAA Solar Radiation Storm levels S1 and S2, NOAA Radio Blackout levels R1 and R2, NOAA Geomagnetic Storm levels G1 and G2
Severe	NOAA Solar Radiation Storm levels S3–S5, NOAA Radio Blackout levels R3–R5, NOAA Geomagnetic Storm levels G3–G5

	Normal	**Moderate**	**Severe**	**Reason**	**Frequency effected**	**Example system**
Tactical FM/SINCGARS	No effect	No effect	No effect	Operates LOS	30 MHz–87.975 MHz	AN/PRC 119
VHF radio	Degraded signal during daily scintillation periods, possible shift in signal polarization	Degraded signal during daily scintillation periods, possible shift in signal polarization	Degraded signal during daily scintillation periods, degraded signal for minutes to hours after a solar event; possible shift in signal polarization	Scintillation, Faraday Rotation	30 MHz–300 MHz	AN/PRC-117G, AN-PRC 52
UHF Radio	Degraded signal during daily scintillation periods	Degraded signal during daily scintillation periods	Degraded signal during daily scintillation periods, degraded signal for minutes to hours after a solar event	Scintillation	300 MHz–3 GHz	AN/PRC-117G, Iridium, INMARSAT
SHF radio	Degraded signal during daily scintillation periods between 3 GHz and 4 GHz only	Degraded signal during daily scintillation periods between 3 GHz and 4 GHz only	Degraded signal during daily scintillation periods between 3 GHz and 4 GHz only, degraded signal for minutes to hours after solar event in frequencies between 3 GHZ and 4 GHz	The majority of radio frequencies are not effected by ionosphere density, scintillation or total electron content	3 GHz–30 GHz	
EHF radio	No effect	No effect	No effect	Radio frequencies not effected by ionosphere density, scintillation or total electron content	30 GHz–300 GHz	SMART-T
GPS receiver*	No effect	Outages of single frequency GPS receivers for minutes, position errors up to 100 meters (m) horizontal and 200m vertical	Outages of single frequency GPS receivers for hours, position errors up to 100m horizontal and 200m vertical	Scintillation from auororal zones, TEC	L Band	Civilian GPS receiver
Electrical transformers	No effect	High-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage	Power systems may experience voltage alarms, protective system problems or grid outages, long-duration storms may cause transformer damage	Geomagnetically induced currents trip SCADA sensors overloading power grid zones and transformers	N/A	

*Dual frequency GPS receivers have a better algorithm for factoring out the effects of atmospheric scintillation. GPS studies have shown receivers in a scintillation environment have a low probability of losing lock with multiple satellites simultaneously (Knight, 2000).

Legend:
BMEWS—ballistic missile early warning system
EHF—extremely high frequency
FM—frequency modulation
GHz—gigahertz
GPS—Global Positioning System
HF—high frequency
INMARSAT—-international maritime satellite
km—kilometer
LOS—line of sight
LUF—lowest usable frequency
MHz—megahertz
N/A—not applicable
NOAA—National oceanic and Atmospheric Administration SCADA— supervisory control and data acquisition
SHF—super high frequency
SINCGARS—single-channel ground and airborne radio system
SMART-T—Secure Mobile Anti-Jam Reliable Tactical Terminal
TEC—total electron content
THAAD—terminal high altitude area defense
UHF—ultrahigh frequency
VHF—very high frequency

Table 3. Effects of Space Weather in Equatorial Regions (Effects on THE sunlight side of THE Earth only)

Definitions	
Normal	Normal space weather
Moderate	NOAA Solar Radiation Storm levels S1 and S2, NOAA Radio Blackout levels R1 and R2, NOAA Geomagnetic Storm levels G1 and G2
Severe	NOAA Solar Radiation Storm levels S3–S5, NOAA Radio Blackout levels R3–R5, NOAA Geomagnetic Storm levels G3–G5

	Normal	Moderate	Severe	Reason	Frequency effected	Example system
Firefinder radar	No effect	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	Type IV solar radio burst if the sun is in the main or side lobe of the radar during an event	2–4 GHz	Q53, Q36, Q37
Tactical missile/ air warning radar	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	Models do not replicate increased ionization levels in ionosphere. Look angle of radar intersects ionosphere at approximately 1/3 of range.	4–6 GHz	Patriot
Theater ballistic missile defense capability	No effect	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	Models do not replicate increased ionization levels in ionosphere	8–12 GHz	THAAD
Air traffic control radar	No effect	No effect	Non-phased array radar: track volume decrease, increased minimum range to track, reduced probability of detection at high angle. Phased array: more porous track volume, increased track time needed	Type IV solar radio burst if the sun is in the main or side lobe of the radar during an event. Radar operates below the Ionosphere (highest recorded aircraft 37.6 km < 60km ionosphere).	1–2 GHz	AN/ARN-153
Static ballistic missile warning radar	Low probability of degraded range and elevation angle accuracy for minutes to hours during daily scintillation windows	Low probability of degraded range and elevation angle accuracy for minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	Models do not replicate increased ionization levels in ionosphere. Scintillation in equatorial zones	300 MHz–3 GHz	BMEWS at Thule or Fylingdales
Space Situational Awareness radar	Low probability of degraded range and elevation angle accuracy for minutes to hours during daily scintillation windows	Low probability of degraded range and elevation angle accuracy to minutes to hours after solar event	Degraded range and elevation angle accuracy for hours after solar event	Models do not replicate increased ionization levels in ionosphere. Scintillation in equatorial zones	300 MHz–1 GHz	AN/FPS-85

Table 3. Effects of Space Weather in Equatorial Regions (Effects on THE sunlight side of THE Earth only)	
Definitions	
Normal	Normal space weather
Moderate	NOAA Solar Radiation Storm levels S1 and S2, NOAA Radio Blackout levels R1 and R2, NOAA Geomagnetic Storm levels G1 and G2
Severe	NOAA Solar Radiation Storm levels S3–S5, NOAA Radio Blackout levels R3–R5, NOAA Geomagnetic Storm levels G3–G5

	Normal	**Moderate**	**Severe**	**Reason**	**Frequency effected**	**Example system**
HF radio	No effect	Increased LUF, limited blackout of frequencies in 3 MHz–20 MHz range for up to 10 minutes, short wave fade, change in area coverage	Increase LUF, limited blackout of frequencies in 3 MHz–30 MHz range for several hours, short wave fade, change in area coverage	D, E and F layer density	3 MHz–30 MHz	AN/PRC-150
Tactical FM/ SINCGARS	No effect	No effect	No effect	Operates LOS	30 MHz–87.975 MHz	AN/PRC 119
VHF radio	Degraded signal during daily scintillation periods, possible shift in signal polarization	Degraded signal during daily scintillation periods, possible shift in signal polarization	Degraded signal during daily scintillation periods, degraded signal for minutes to hours after solar event, possible shift in signal polarization	Scintillation, Faraday Rotation	30 MHz–300 MHz	AN/PRC-117G, AN-PRC 52
UHF radio	Degraded signal during daily scintillation periods	Degraded signal during daily scintillation periods	Degraded signal during daily scintillation periods, degraded signal for minutes to hours after solar event	Scintillation	300 MHz–3 GHz	AN/PRC-117G, Iridium, INMARSAT
SHF radio	Degraded signal during daily scintillation periods between 3 GHz and 4 GHz only	Degraded signal during daily scintillation periods between 3 GHz and 4 GHz only	Degraded signal during daily scintillation periods between 3 GHz and 4 GHz only, degraded signal for minutes to hours after solar event in frequencies between 3 GHZ and 4 GHz	Majority of radio frequencies not effected by ionosphere density, scintillation or total electron content	3 GHz–30 GHz	
EHF radio	No effect	No effect	No effect	Radio frequencies not effected by ionosphere density, scintillation or TEC	30 GHz–300 GHz	SMART-T
GPS receiver*	No effect	Outages of single frequency GPS receivers for minutes, position errors up to 100m horizontal and 200m vertical	Outages of single frequency GPS receivers for hours, position errors up to 100 Meters horizontal and 200m vertical	Scintillation in equatorial region, TEC	L Band	Civilian GPS receiver
Electrical transformers	No effect	No Effect	No Effect	N/A	N/A	

** Dual frequency GPS receivers have a better algorithm for factoring out the effects of atmospheric scintillation. GPS studies have shown receivers in a scintillation environment have a low probability of losing lock with multiple satellites simultaneously (Knight, 2000).*

Legend:
BMEWS—ballistic missile early warning system
EHF—extremely high frequency
FM—frequency modulation
GHz—gigahertz
GPS—Global Positioning System
HF—high frequency
INMARSAT—-international maritime satellite
km—kilometer
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SMART-T—Secure Mobile Anti-Jam Reliable Tactical Terminal
TEC—total electron content
THAAD—terminal high altitude area defense
UHF—ultrahigh frequency
VHF—very high frequency

belt. Dual frequency radars can use an algorithm to better correct for ionospheric disturbances, such as scintillation. Severe scintillation will cause UHF radios, such as the AN/PRC-117G, to experience difficulty receiving and transmitting clearly. Additionally, single channel, civilian or military GPS receivers (without the cryptological key loaded) may experience errors up to 100 meters horizontally and 200 meters vertically. Similarly, static space surveillance or ballistic missile radars may experience range and elevation errors.

Faraday Rotation

A Faraday rotation is a phenomenon that rotates the polarization of light as it passes through the ionospheric plasma (Kishore, n.d.). It can affect space based synthetic aperture radar (SAR) imagery if the ionosphere density differential is more than the algorithms can account for. Single frequency, linearly polarized radio waves may also be affected by this phenomenon.

SPACE ENVIRONMENT EVENTS AND THE IMPACT TO A GROUND FORCE

Our greatest space environment concern is the effect it has on ground systems we rely upon. To determine the impact to the warfighter, the source of the environmental effect must be linked to the associated system being affected. Communications-on-the-move capability, for example, is provided by SATCOM. If the user has adequate warning that space weather will disrupt SATCOM at certain times, the ability to mitigate the effect by planning for alternate methods (such as terrestrial communication or other SATCOM capabilities) is available. By being able to determine the source is environmental not only mitigates down time, but can help the user distinguish environmental factors from a hostile attack (Hand et al., 2006).

Increased ionosphere ionization is the largest contributor to space weather issues. This includes thickening layers, increasing ionized plasma flow, and lowering normal heights of the layers that cause reflection, refraction, and absorption not normally experienced. Some effects are instantaneous, but others can be predicted. After the sun ejects magnetic streams and charged particles, it could take up to four days to cause magnetic storms on Earth. Therefore, planners would have an opportunity to develop solutions to problems based on more accurate forecasts of the impact timing (Wagner, 2012). The possible effects listed in the tables are all related to the increased ionization of the ionosphere caused by increased x-rays and UV rays from solar wind or an injection of energized particles by CMEs. Additionally, space weather reports are available from the Air Force and NOAA at http://www.afweather.af.mil/space-weather.asp and http://www.swpc.noaa.gov/SWN/index.html, respectively. The times for CMEs can be used to predict actual times and make recommendations to ground force commanders using the tables.

REGIONS

The tables we created provide the military space professional a description of probable effects on common equipment associated with an Army ground unit. To create the tables, we conducted research into the general effects of space weather. We started with military sources, such as the United States Air Force Space Environment Standard (MIL-STD-1809) and the Handbook of Geophysics and the Space Environment to obtain a general description of space weather and its possible effects. From there, we searched for more specific information. Russell wrote about how solar wind interacts with the magnetosphere and how these interactions create geomagnetic storms. Additionally, understanding the currents lead us to conclude the effects will be greater on ground equipment on the dayside, while satellite based effects would be greater at night (Russell, 2000). Iyer,

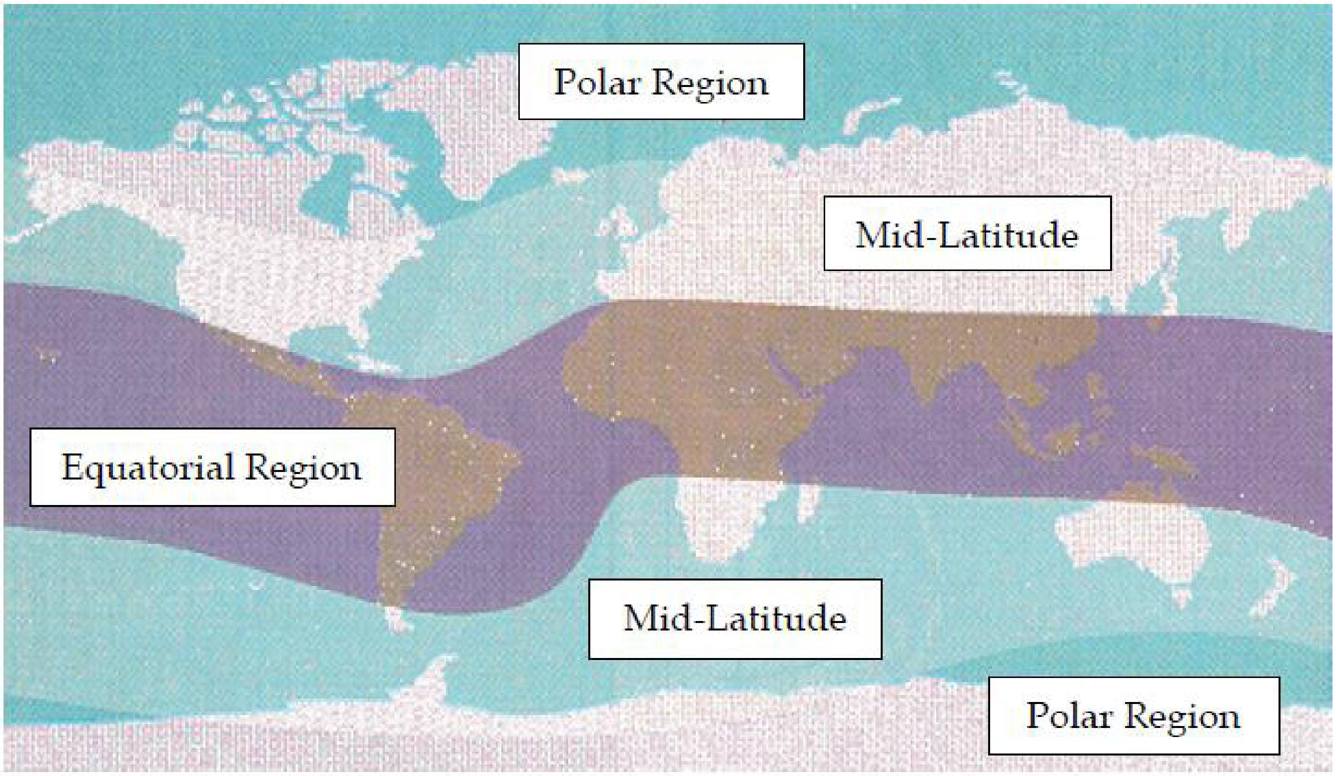

Figure 1. Map of the world showing the approximate locations of the polar, mid-latitude and equatorial regions (Knight, 2000).

et al. (2006) expanded our knowledge of CMEs and their possible effects on the F-layer and TEC. Marusek's (2007) analysis of the Carrington event and its possible effects on a ground force commander's operation was integral to framing the table descriptions. We learned more about different types of scintillation from Ho, et al (2002) and how the ionospheric scintillation effects radio wave propagation from Bourdillon (2008). Tanskanen et al (2001), in their Space Weather Effects catalogue, helped narrow the effects to specific frequencies and; therefore, specific systems. NOAA's website was useful in describing radio wave propagation and how they are affected by geomagnetic storms. Our understanding of the history of scintillation and its effects was expanded by Aarons (1997).

... the next step was to determine how various pieces of military equipment operate and in what frequency range.

CONCLUSION

Several authors provided insight into specific phenomena and effects that directly refer to military technology. As members of the Army, with little practical background in physics, the Faraday Rotation was completely new to us and Kishore's (n.d.) unpublished work was crucial in understanding the phenomenon. When describing effects of Faraday Rotation that a ground commander would care about, Gilman's work (Gilman et al., 2013) describing its effect on SAR images was informative. Lanzerotti (2004) wrote about the impact of solar radio effects on wireless communication systems, radar, and GPS. Knight (2000) added to our understanding of scintillation's effects on GPS receivers in his very informative piece on the effects of space weather on GPS.

After doing the research, the next step was to determine how various pieces of military equipment operate and in what frequency range. We determined what portions of the electromagnetic spectrum the military uses referring to the Department of Defense strategic spectrum plan for 2007. Various field and technical manuals yielded equipment specification and spectrum usage. Skolnik (1970) educated us on how radar works in his seminal *Radar Handbook*. Other military writers, such as Hand and France (2006), further identified possible effects.

The last step was determining what severe space weather is and how often it occurs. We used the NOAA space weather scales and the Air Force Space Weather Agency website as bases for the discussion of severity. Additionally, Baker's, et al. (2012) discussion of severe space weather storms further stratified severe space weather and catastrophically severe space weather. Riley (2014) helped us determine how rarely severe space weather events occur.

The literature about how space weather effects the ionosphere, magnetic fields, and the electromagnetic spectrum informed us on the possible effects. Reading technical manuals on Army equipment gave us a background enabling us to describe effects. Comparing Army equipment to effects from literature allowed us to posit specific impacts for types of equipment. We then used staff officer experience, at various levels of Army staff, to shape a table to help space professionals describe potential space weather related effects to their commander.

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BREVITY *Multi-Service Brevity Codes* **Distribution Restricted**	26 JUL 16	ATP 1-02.1 MCRP 3-30B.1 NTTP 6-02.1 AFTTP 3-2.5	Description: This publication defines multi-Service brevity which standardizes air-to-air, air-to-surface, surface-to-air, and surface-to-surface brevity code words in multi-Service operations. **Status: Current**
ISR Optimization *Multi-Service Tactics, Techniques, and Procedures for Intelligence, Surveillance, and Reconnaissance Optimization* **Distribution Restricted**	14 APR 15	ATP 3-55.3 MCRP 2-2A NTTP 2-01.3 AFTTP 3-2.88	Description: This publication provides a comprehensive resource for planning, executing, and assessing surveillance, reconnaissance, and processing, exploitation, and dissemination operations. **Status: Current**
TACTICAL CHAT *Multi-Service Tactics, Techniques, and Procedures for Internet Tactical Chat in Support of Operations* **Distribution Restricted**	24 JAN 14	ATP 6-02.73 MCRP 3-40.2B NTTP 6-02.8 AFTTP 3-2.77	Description: This publication provides commanders and their units guidelines to facilitate coordinating and integrating tactical chat when conducting multi-Service and joint force operations. **Status: Current**
TACTICAL RADIOS *Multi-Service Communications Procedures for Tactical Radios in a Joint Environment* **Approved for Public Release**	5 NOV 13	ATP 6-02.72 MCRP 3-40.3A NTTP 6-02.2 AFTTP 3-2.18	Description: This is a consolidated reference for TTP in employing, configuring, and creating radio nets for voice and data tactical radios. **Status: Revision**
TAGS *Multi-Service Tactics, Techniques, and Procedures for the Theater Air-Ground System* **Distribution Restricted**	30 JUN 14	ATP 3-52.2 MCRP 3-25F NTTP 3-56.2 AFTTP 3-2.17	Description: This publication promotes Service awareness regarding the role of airpower in support of the JFC's campaign plan, increases understanding of the air-ground system, and provides planning considerations for conducting air-ground ops. **Status: Current**
UHF SATCOM *Multi-Service Tactics, Techniques, and Procedures Package for Ultra High Frequency Military Satellite Communications* **Distribution Restricted**	9 AUG 13	ATP 6-02.90 MCRP 3-40.3G NTTP 6-02.9 AFTTP 3-2.53	Description: Operations at the JTF level have demonstrated difficulties in managing a limited number of UHF SATCOM frequencies. This publication documents TTP that will improve efficiency at the planner and user levels. **Status: Project Assessment**

FUTURE AIR LAND SEA BULLETINS (ALSB)

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- Be in MS Word format
- Include the author's name, unit address, telephone numbers, and email address
- Include current, high-resolution, 300 dpi (minimum), original photographs and graphics. Public affairs offices can be good sources for photographs or graphic support.

Article and photo submission deadlines are below. Early submissions are highly encouraged and appreciated.

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10-14 Apr	Airfield Opening	Joint Base Langley-Eustis, VA	Land Branch alsaB@us.af.mil
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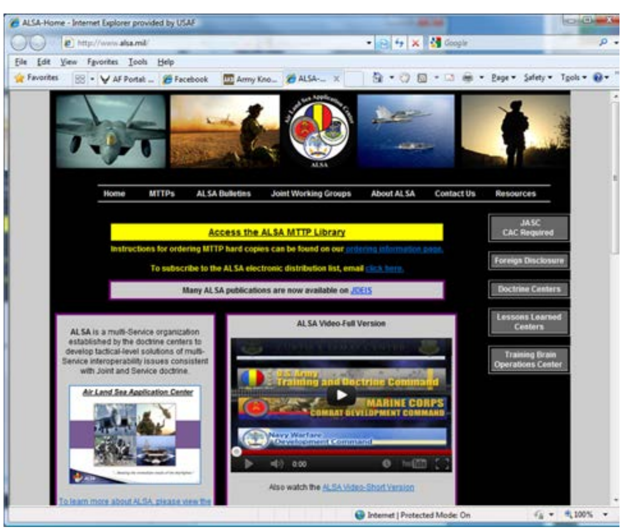

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