Space Doctrine Publication 3-104

ELECTROMAGNETIC SPECTRUM OPERATIONS

DOCTRINE FOR SPACE FORCES



UNITED STATES

SPACE FORCE

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Foreword

United States Space Force (USSF) doctrine guides the proper use of military spacepower in support of the Service's core functions. It establishes a common frame of reference on the best way to plan and employ Space Force Guardians as part of a broader joint force. This doctrine provides official advice to execute and leverage spacepower. It is not directive—rather, it provides Guardians an informed starting point for decision making and strategy development.

Space Doctrine Publication (SDP) 3-104, *Electromagnetic Spectrum Operations*, as operational doctrine for the USSF, describes the official advice and best practices for conducting operations within the electromagnetic spectrum (EMS) to gain and exploit a position of advantage in the space domain and supporting joint operations in all other domains.

Operations in the EMS allow the joint force to shape and exploit the operational environment in all domains. Use of the EMS is essential for space operations, enabling our core functions and our ability to support joint all-domain operations (JADO). However, like space, the EMS is increasingly contested, congested, and constrained. Guardians are competing for control in the EMS as a contributor to space superiority. Understanding the environment is important for Guardians exploiting, protecting, or managing the EMS to ensure the United States (US) and its allies can access the EMS while denying the adversary the same at the times and places of our choosing.

I encourage you to study and learn from the best practices of our Service compiled in this volume. Semper Supra!



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Space Force Doctrine

Space Force doctrine guides the proper use of spacepower and space forces in support of the Service's core functions. It establishes a common framework for employing Guardians as part of a broader joint force. Doctrine provides fundamental principles and authoritative guidance as an informed starting point for decision-making and strategy development. Since it is impossible to predict the timing, location, and conditions of the next conflict, commanders should be flexible in the implementation of this guidance as circumstances or mission dictate.

The Space Force doctrine hierarchy includes four levels of doctrine and a glossary. Each level builds on the one above it, reflecting the role of Guardians in every specialty area. A set of six keystone doctrine publications follows the Space Capstone Publication*, Spacepower*. Below the keystone level, the Space Force is developing multiple operational-level doctrine publications, each expanding on a specific area. Tactical doctrine provides details at the level of specific systems and tactics, techniques, and procedures. As the mission evolves, the Space Force will add to the doctrine hierarchy.

Space Doctrine Publication (SDP) 3-104, *Electromagnetic Spectrum Operations*, introduces the EMS and the role of electromagnetic spectrum operations (EMSO) in space operations.

- Chapter 1 introduces the EMS, EMSO, and key terms, threats, and hazards relevant to EMSO.
- Chapter 2 addresses different types of EMSO and how each relates to space operations.
- Chapter 3 discusses EMSO as part of JADO, highlighting its application across the competition continuum, and relative to the joint functions. This chapter also compares the relationship of EMSO to the other domains, cyberspace, and the information environment, and examines EMSO in operations (including planning, execution, and assessment).
- Chapter 4 discusses EMSO-related authorities and the roles and responsibilities of organizations conducting EMSO, including at the component field command (C-FLDCOM) level.

The Electromagnetic Spectrum

The electromagnetic spectrum (EMS) as depicted in figure 1, is a maneuver space consisting of all frequencies of electromagnetic radiation. Military and non-military actors use the EMS to transmit and receive electromagnetic energy. The EMS, typically depicted in terms of frequency bands based on physical characteristics of electromagnetic wave propagation, includes radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, x-rays, and gamma rays.

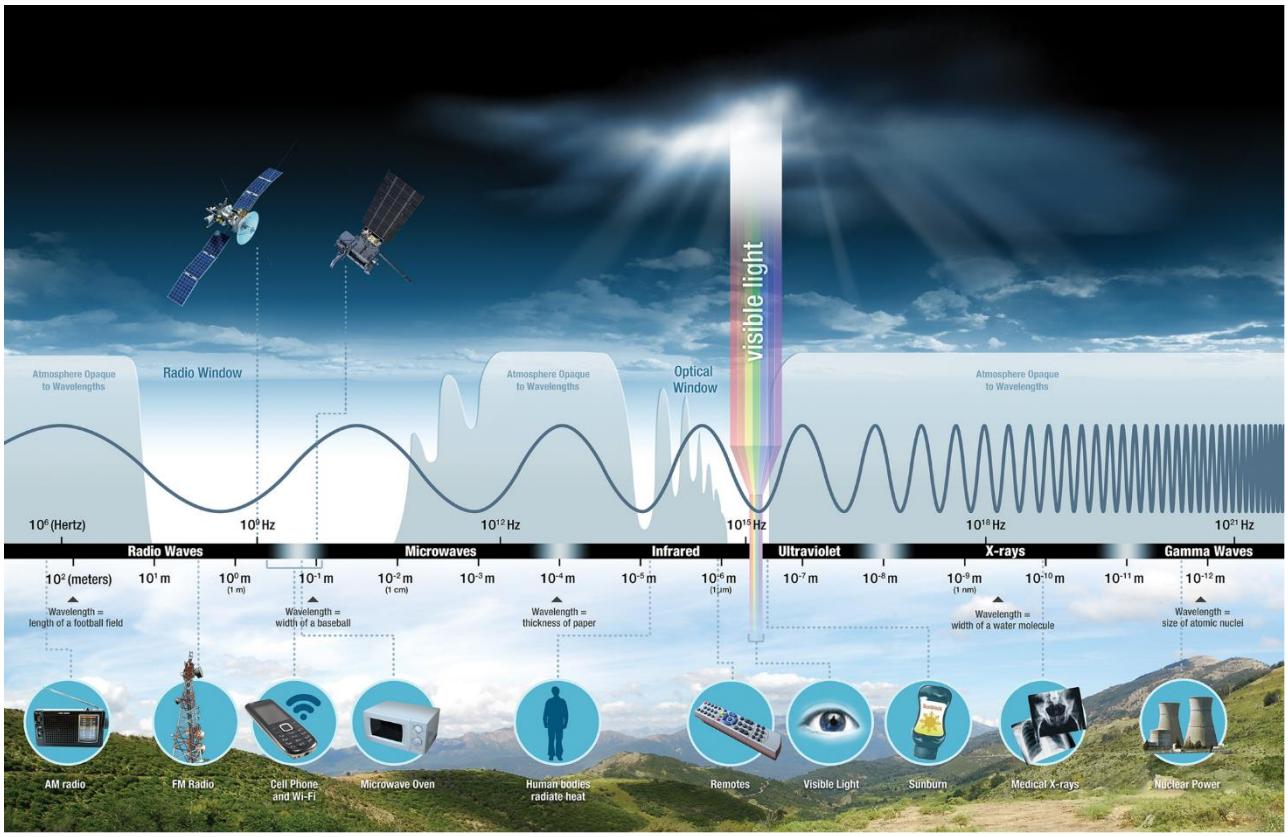


Figure 1. The electromagnetic spectrum

Electromagnetic Spectrum Operations

Electromagnetic spectrum operations (EMSO) are coordinated military actions to exploit, attack, protect, and manage the electromagnetic environment. These actions include and impact all joint force transmission and reception of electromagnetic energy. Operations within the EMS can simultaneously take place across multiple domains. For example, a communications path–whether wired or wireless–may exist in the EMS and any domains it passes through. Understanding these relationships is important because of the unique influence other domains can have on the use of the EMS within that environment.

Use of the EMS is pervasive and dynamic throughout civil, military, and commercial life for a multitude of applications. The EMS is indispensable for all space operations, providing access for global communications, space domain awareness, unrestricted overflight for space-based sensing and targeting, missile warning and tracking, and positioning, navigation, and timing support to JADO.

a. **Pervasive.** The EMS permeates all parts of the operational environment. All space systems, along with systems in other domains operate within the EMS. If not managed and protected, the EMS can become a source of vulnerabilities for space operations.

b. **Dynamic.** The EMS is constantly changing due to natural environmental effects and as friendly and adversary capabilities expand and change. Events in the EMS can occur more quickly than operations anticipate or respond, requiring rapid decision making. In many cases, the first indicator of an EMS event is the event itself.

EMSO as part of space operations can be complicated by physical challenges.

a. **Predictability**. While inherently dynamic, EMSO in, from, and to the space domain has predictable elements such as orbital characteristics and spectrum allocation. The adversary can use those associated elements to conduct informed counter-EMSO.

b. **Distance.** Due to the properties of signal propagation, all signals in free space attenuate over distance challenging timely access to space systems.

c. **Interference.** Intentional or unintentional electromagnetic interference (EMI), whether natural or human-made, can affect space operations through the EMS. Natural and human-caused physical phenomenon including terrain, terrestrial and space weather, atmospheric conditions, and transmitters can also affect spacecraft and signals transmission.

Like the space domain, the EMS is increasingly contested, congested, and constrained. Understanding the potential impact of these conditions is important for any operation relying on the EMS—whether for communications, sensing the electromagnetic environment, or offensive or defensive actions.

a. **Contested.** Vulnerabilities, threats, and hazards in the EMS and dependence on it for military operations in all domains provide adversaries with opportunities to deny access or degrade quality. Guardians need to be aware of the potential impacts to space operations, and options to counter threats, protect systems, or establish control in the EMS.

b. **Congested.** The increased number of spacecraft (friendly, neutral, adversarial, and commercial) along with the increased demand for space-based capabilities, has caused a corresponding increase in the number of emitters. The number of emitters sending signals in, from, and to space results in increased EMI and risk of obstruction of space operations.

c. **Constrained.** Physics, international and domestic laws and regulations, and current technology limit access to the EMS for all users. Electromagnetic radiation has unique

physical properties that constrain its use (e.g., short- or long-range communications, sensing). Additionally, use of the EMS is subject to international treaties, and nation-state laws and regulations. Technology bounds those portions of the EMS that are accessible and exploitable (i.e., advances in technological capabilities will result in expanded use of the EMS).

Use of the EMS and military operations are often complex and interwoven, requiring detailed prioritization, integration, and synchronization to achieve the commander's objectives, while minimizing and mitigating unintentional EMI. EMSO can also require coordination and deconfliction with external organizations including other parts of the United States government, our allies, partners, commercial users, and academic entities.

Conditions in the operational environment at a given place and time dictate the level of control in the EMS necessary to ensure operations. Each of these conditions, ranging from parity to supremacy, may be localized in frequency, time, and location to create favorable conditions for friendly or adversarial operations. The natural environment also plays a role in the ability of friendly or adversary forces to achieve any of these levels of control.

a. **Parity.** Parity conditions occur when friendly and adversary forces retain similar EMSO capabilities and comparable access to the EMS. Parity can range from both forces able to have unfettered use of the EMS to both forces completely denied use of the EMS.

b. **Superiority.** Superiority is the degree of control in the EMS that permits the conduct of operations at a given time and place without prohibitive interference, while affecting the adversary's ability to do the same.

c. **Supremacy.** Supremacy occurs only when forces can completely deny an adversary's use of the EMS while retaining use for their own forces.

Electromagnetic Portion of Operating Environment

The electromagnetic portion of the operating environment is a composite of the actual and potential electromagnetic energy radiation, conditions, circumstances, and influences that affect the employment of capabilities and the decisions of the commander. Electromagnetic environmental effects include the existing background radiation and the radiation (and potential radiation) from friendly, neutral, and adversary systems within the area of influence. These effects can take the form of intentional or unintentional EMI, electromagnetic pulse from a weapon system, electromagnetic radiation hazards to systems and their components, infrastructure, or personnel, and other environmental effects such as space weather, lightning, and precipitation static. Managing electromagnetic compatibility is also critical for systems that radiate or receive signals through the electromagnetic spectrum. Failure to properly manage systems using the EMS can result in unacceptable or unintentional degradation due to electromagnetic environmental effects.

Electromagnetic environmental and operational effects in, from, and to the orbital, terrestrial, and link segments impact EMSO relative to space operations. The orbital segment includes

electromagnetic radiation internal to or interacting with any system on orbit. The terrestrial segment includes electromagnetic radiation related to ground-based infrastructure that receives and transmits signals, the facilities that host space systems, and the personnel. The link segment is the electromagnetic connection between the terrestrial and orbital segments.

a. **Threats.** Threats are intentional human-made effects in the EMS or against systems and equipment that support EMSO. Any of these types of threats could impact the ability to conduct space operations in any segment (orbital, terrestrial, link). These avenues of attack apply to both friendly and adversary EMSO.

   1) **Physical Attack.** Physical attack or sabotage presents a danger to EMSO and the space operations that rely on the EMS. Examples of terrestrial nodes include operations centers, command and control (C2) nodes, terrestrial components of space systems, electromagnetic warfare systems, and communications relays. An anti-satellite attack also impacts EMSO by degrading or destroying the affected spacecraft and any ability it provides to exploit the EMS.

   2) **Electromagnetic Attack.** An electromagnetic attack can include attacks on personnel, facilities, or equipment with the intent of degrading, damaging, or destroying the ability to use the EMS for combat operations. Directed energy threats, a type of electromagnetic attack, include lasers and high-power radio frequency, high-power microwave, particle-beams, and electromagnetic pulse (EMP).

      - **Lasers.** Lasers transmit light (photons) to electromagnetic systems with sufficient energy to temporarily disrupt capabilities or permanently degrade or destroy spacecraft subsystems.

      - **High-Power Radio Frequency.** Ground- or space-based emitters fire high-power bursts of electromagnetic energy at a spacecraft imparting disruptive electromagnetic fields into the wiring and electrical components to disrupt or damage the computer processing subsystems.

      - **High-Power Microwave.** Ground- or space-based emitters fire short duration, high-peak power bursts of electromagnetic energy at microwave frequencies in a narrow beam targeting a single system to disrupt or damage electrical components.

      - **Particle-Beam.** Particle-beam weapons systems stream atomic or subatomic particles directed at a spacecraft generating bursts of electromagnetic radiation that can affect EMS-dependent systems and temporarily impact use of the EMS.

      - **Electromagnetic Pulse.** An EMP is a burst of electromagnetic radiation resulting from a rapid acceleration of charged particles. An EMP can be produced naturally (e.g., lightning) or intentionally such as through high-altitude nuclear detonation or other non-nuclear weapons. An EMP (naturally occurring or human-caused) can induce damaging voltages and currents into unprotected electronic circuits and components of affected spacecraft and terrestrial nodes producing effects ranging from communication link disruption to permanent electronic destruction

and data loss. The radiation event generated by a nuclear detonation is longer lasting and could damage spacecraft components and shorten their effective operational lives from years to days. A single EMP can affect a large geographic area or area of space, expanding rapidly and posing a threat to the use of the EMS for more than just the targeted facility, system, or spacecraft.

3) **Offensive Cyberspace Operations.** Cyberspace attacks may disrupt or deny space-based or terrestrial-based computing functions used to conduct or support spacecraft operations and to collect, process, and disseminate mission data. These actions can limit the ability to access information passed through the EMS.

b. **Hazards.** Hazards are events and effects in the natural environment or unintentional human-caused effects in the EMS that introduce the potential for damage to systems or components or interference with EMSO in any segment.

1) **Electromagnetic Interference.** The demand placed on the electromagnetic spectrum continues to grow as the number of spacecraft, space services, and users increases. Increased congestion limits the available spectrum and increases the potential for unintentional interference with friendly signals. EMI constitutes any electromagnetic disturbance - induced intentionally or unintentionally—that interrupts, obstructs, or otherwise degrades or limits the effective performance of EMS-dependent systems. To further complicate the issue, international spectrum management practices create uncertainty in gaining access to the required spectrum and impose limitations on power, bandwidth, and coverage.

2) **Environmental.** Environmental hazards include terrestrial weather, space weather, and atmospheric events. Environmental hazards can generate substantial impacts on the EMS and space operations. Space and terrestrial weather can affect spacecraft, their communications links, and space systems in the terrestrial segment. For example, solar storms can have a direct impact on the functioning and survivability of spacecraft, while thunderstorms and cloud cover may affect the functionality of the terrestrial and link segments, and the ability to conduct EMSO. Knowledge of environmental conditions, both current and future, allows commanders to anticipate, exploit, and mitigate impacts that may degrade operations and affect the ability to attribute and differentiate adversary actions.

The space environment introduces many unique factors in the use of the EMS. For example, the Van Allen Belts are bands of radiation that can affect the operation of spacecraft in certain orbits. Cosmic rays can introduce errors on spacecraft and the transmission of electromagnetic signals. The sun is very active across the entire EMS which introduces unique effects for the propagation of electromagnetic radiation. The lack of atmosphere in space both impedes and facilitates the use of EMS. The atmosphere itself absorbs electromagnetic radiation resulting in a varying attenuation of certain wavelengths. This attenuation results in reduced utility of those wavelengths between a spacecraft and terrestrial components. However, those wavelengths may still be useful between spacecraft for cross-link communications

where the lack of atmosphere facilitates EMS use by negating the effects of atmospheric attenuation. However, this also introduces a higher probability of interception.

Chapter 2 Electromagnetic Spectrum Operations

Military forces rely on the EMS to sense, communicate, maneuver, and conduct warfighting operations across all domains. This occurs across radio and radar frequencies, infrared, visible, ultraviolet, and any other free-space electromagnetic radiation. Space operations occur across the entire EMS supported by EMSO actions undertaken by a joint force in the operating environment to exploit or use the spectrum, deceive the adversary, or to conduct electromagnetic warfare. The joint force alongside our allies and partners employs EMSO to achieve unity of effort and the commander's objectives. These actions, integrated with management of the electromagnetic portion of the operating environment, enable joint force operations across the entire spectrum and within every domain.

The relationship between EMSO and space operations is integral to the Space Force's mission and broader national security objectives. EMSO are foundational to ensuring operational effectiveness, security, and superiority in the space domain. Space operations are fundamentally dependent on the EMS for a wide range of activities, including spacecraft communications, navigation, remote sensing, and C2. Space-based intelligence, surveillance, and reconnaissance (ISR) platforms rely on the EMS to collect and transmit data. EMSO also contribute to space domain awareness by enabling the monitoring and analysis of electromagnetic emissions from objects in space. This helps in identifying and tracking spacecraft, debris, and potential threats, providing critical information for decision-makers. Spacecraft rely on various frequencies within the EMS to transmit data, communicate with ground stations, and perform their missions. The EMS is essential for controlling spacecraft and commanding payloads on-orbit. EMSO are essential in enabling these space operations by ensuring the EMS is available, secure, and free from interference. This involves managing the spectrum to optimize performance, protect against threats and hazards, and to ensure US, allied, and partner space operations occur without prohibitive disruption.

In the space domain, EMSO are crucial for maintaining space superiority. The joint force uses EMSO to deceive the adversary, and to deny, disrupt, degrade, or when necessary, destroy adversary space capabilities. By managing, protecting, and conducting surveillance in and of the EMS, and conducting electromagnetic warfare, the Space Force can prevent adversaries from effectively communicating, navigating, or gathering intelligence, thereby diminishing their operational capabilities in the space domain and in support of operations in other domains.

EMSO are also key to ensuring US space operations are interoperable with allies and partners. This involves coordinating spectrum use, sharing EMS-related intelligence, and conducting joint EMSO (JEMSO) to support coalition objectives in the space domain. This strengthens alliances and deters adversaries by demonstrating a united and technologically superior front.

Exploiting the Electromagnetic Spectrum

Sensing and communications systems as part of space operations exploit the EMS through detection and transmitted via the EMS for tactical, operational, or strategic purposes. This

includes missions exchanging information and data—like positioning, navigation, and timing, spacecraft communications, C2, spacelift, and range control. Space-based and terrestrial sensors track missiles and spacecraft, gather intelligence, and collect space and terrestrial environment data by exploiting the EMS.

Space Forces establish and work to maintain the ability to provide persistent, global access to support identification of friendly and adversarial electromagnetic emissions that may impact operations. Passive sensing, detection, identification, characterization, and geolocation of electromagnetic signals supports development of an accurate electromagnetic order of battle and provides situational awareness for commanders needing to conduct operations using the EMS. These types of operations in the EMS are also crucial for establishing conditions for electromagnetic warfare and the ability to target and conduct fires through EMS. Electromagnetic surveillance enables the detection, identification, and geolocation of potentially threatening electromagnetic emissions that an adversary may use for intelligence collection, surveillance, communications, navigation, timing, or targeting friendly operations and assets. This is an essential first step in any follow-on electromagnetic warfare activity. In an electromagnetic warfare context, exploitation takes full advantage of radiated electromagnetic energy to collect, characterize, locate, and track electromagnetic radiation sources to support current and future operations.

Deception

Military operations use deceptive EMSO to deliberately mislead the adversary through manipulation, distortion, or falsification of information to cause the adversary to take specific actions (or inactions) that will contribute to accomplishment of the friendly mission. It also includes management or concealment of friendly EMS signals to induce the adversary to react in a manner prejudicial to their interests. Deceptive EMSO manipulate the adversary's decision-making loop, making it difficult to distinguish between reality and a false perception of reality. Guardians should coordinate any deception efforts related to space operations with the broader joint force at the appropriate command echelons including EMSO and operations in the information environment channels to leverage requisite authorities for approval, execution, and assessment of deception plans. Ensuring an integrated all-domain perspective is important during the development of a deception plan, the messaging plan, and the overall operations or campaign plans. Well-planned and executed operations security is critical to an effective deception plan.

Electromagnetic Warfare

Electromagnetic warfare includes all military actions using electromagnetic and directed energy (e.g., radio frequency jammers, laser dazzlers, millimeter wave, microwave capabilities) to control the EMS or to attack an adversary. This includes the radiation of electromagnetic energy against validated targets to deny, disrupt, degrade, or destroy an adversary's facilities, individuals, virtual entities, equipment, or organizations to achieve desired effects. Electromagnetic warfare is critical in gaining and maintaining the necessary degree of control to

ensure freedom of action, and freedom of maneuver, within contested and congested operational environments in all domains.

As part of joint operations, electromagnetic warfare includes three unique but interrelated aspects: electromagnetic attack, electromagnetic support, and electromagnetic protection. For the Space Force, conducting electromagnetic warfare includes warfare as part of space control, and theater electromagnetic warfare conducted as part of global mission operations. Theater electromagnetic warfare for space operations includes electromagnetic attack, electromagnetic protection, and electromagnetic surveillance (referred to as electromagnetic support in joint operations).

a. **Space Control Electromagnetic Warfare.** As a type of electromagnetic attack, space control electromagnetic warfare are those combat operations on the link segment of the space architecture conducted using fires in the EMS to control the space domain.

   Guardians are prepared to employ space control electromagnetic warfare to support the joint force, to protect space operations, and to maintain control in the space domain. Offensive space control electromagnetic warfare operations target and negate an adversary's ability to use space or counterspace systems. Defensive space control electromagnetic warfare operations focus on protecting friendly space systems against adversary attacks.

   As with all types of electromagnetic attack, space control electromagnetic warfare relies on the other aspect of electromagnetic warfare, protection, and surveillance, to manage the EMS and provide situational awareness critical to any operation.

b. **Theater Electromagnetic Warfare.** Theater electromagnetic warfare includes all actions taken in the electromagnetic spectrum to protect or prevent the ability to communicate using space-based platforms. As part of global mission operations, theater electromagnetic warfare delivers space effects in support of military operations, and provides a space-enabled combat edge, ensuring the United States can out-see, out-shoot, out-maneuver, and out-communicate any adversary.

   For Guardians, and space operations, theater electromagnetic warfare includes the aspects of attack, protection, and surveillance.

   1) **Electromagnetic Attack.** Electromagnetic attack involves the use or transmission of energy through the EMS to degrade, neutralize, or destroy an adversary's combat capabilities. Combatant commanders conduct electromagnetic attack operations to secure and maintain a desired degree of control and freedom of action in the EMS, and to deny the adversary the same. For space operations electromagnetic attack exploits weaknesses in an adversary's ability to operate in, from, and to the space domain, and counteracts the adversary's space capabilities across the EMS.

      Electromagnetic attack effects fall on a continuum from temporary (reversible) to permanent (non-reversible) disruption, denial, degradation, or destruction of adversarial operational capabilities in the EMS.

- **Disrupt.** Disruption can temporarily interrupt the operations of adversary EMS-dependent systems. Effective disruption limits adversary combat capabilities by interfering with the adversary's use of the EMS. Disruption can confuse or delay adversary action and act as a force enabler for additional EMS fires against adversary forces.
- **Deny.** Denial reduces an adversary's full capabilities in the EMS or portion of the EMS, or the information derived from EMSO.
- **Degrade.** Degradation permanently reduces the effectiveness or efficiency of adversary EMS-dependent systems. Effective degradation can stimulate the adversary to reveal previously unknown alternate capabilities or responses and might be adequate to achieve overall mission success.
- **Destroy.** Destruction of system or capability by electromagnetic attack ensures it can neither function nor be restored to a usable condition in a time frame relevant to the current operation. The duration of the destructive effects depends on an adversary's reconstitution capability. The destruction of high-value assets such as C2 nodes can reduce an adversary's ability to continue the fight.

2) **Electromagnetic Protection.** Electromagnetic protection includes actions taken to protect personnel, facilities, and equipment from any effects of friendly or adversary use of the EMS to include intentional and inadvertent EMI that could degrade, neutralize, or destroy friendly combat capabilities. Electromagnetic protection enables the use of the EMS to conduct space control electromagnetic warfare and electromagnetic attack, as part of theater electromagnetic warfare.

   Recognizing the different types of EMI allows space operations planners to use appropriate measures to counter or mitigate electromagnetic environmental effects and protect against potential human-generated effects. Electromagnetic protection operations ensure forces can operate in a contested and congested environment despite the adverse effects of electromagnetic radiation regardless of the source (friendly, neutral, enemy, or natural). This includes deconflicting fires in the EMS from friendly capabilities and planning for and mitigating any friendly EMI.

   For space operations, examples of electromagnetic protection include shielding, frequency agility, variable pulse repetition frequency, spread-spectrum processing, electromagnetic hardening, wartime reserve modes, anti-jam or anti-spoof for global navigation spacecraft systems, and emission control. Other means to counter and defeat adversary attempts to exploit the EMS include side-lobe nulling, interference excision capabilities, EMS management, and deconfliction.

   One of the primary roles of EMSO in, from, and to the space domain is to protect space-based assets from electromagnetic threats, such as jamming, spoofing, and directed energy attacks. The ability to provide effective electromagnetic protection begins with the design and acquisition of Space Force equipment and systems. The Space Force employs EMSO to detect and counter these threats, ensuring the

resilience of critical space systems in the orbital, terrestrial and link segments. Integration of electromagnetic protection and system security measures can help protect space systems from adversary actions and ensure the ability to operate in a contested, degraded, and operationally limited operating environment.

To effectively protect space-enabled EMSO, commanders should know their own EMS capabilities and those of the adversary. Adversaries recognize potential vulnerabilities of EMS-dependent systems and may attack critical weapons systems control functions and associated communications nodes. To mitigate these possibilities, commanders and their staff should become well-versed in the employment of weapons systems, electromagnetic warfare capabilities, and navigation warfare to support operational objectives and contribute to the protection of EMSO. They should also be prepared to assess potential second- and third-order effects, including potential harm to civilians.

The EMS is a dynamic environment that requires commanders to create and maintain order in the EMS, retain access to the EMS for friendly forces, while remaining agile and unpredictable in the face of a capable adversary. For example, commanders create orders for space-based communications by assigning discreet frequencies to specific users. While this aids EMS management, it also simplifies adversary targeting. If an acquisition program did not integrate frequency agility during system development, procedural implementation during operations can still help complicate adversary targeting, but at the cost of greater complexity and workload for friendly forces. Balancing the risks of increasing the complexity of operations against the risks of adversary action is crucial to effective EMS operations and protection of EMS capabilities.

3) **Electromagnetic Surveillance.** Electromagnetic surveillance (referred to as electromagnetic support in joint doctrine) involves actions to search for, intercept, identify, and locate or localize sources of intentional and unintentional radiated electromagnetic energy. This allows for immediate threat recognition, threat recognition, targeting, planning, and conducting future operations. Electromagnetic surveillance effects (detect and exploit) support signals intelligence (SIGINT) production, targeting for space control electromagnetic warfare, attack as part of theater electromagnetic warfare, situational awareness of the operational environment, and measurement and signature intelligence.

   - **Detect.** Electromagnetic surveillance measures enable the detection and identification of potential threat electromagnetic emissions. It is the essential first step in any electromagnetic warfare activity.
   - **Exploit.** Exploitation as an electromagnetic surveillance effect builds on detection, collecting, characterizing, locating, and tracking electromagnetic radiation sources to support current and future operations. Exploitation may be enhanced or enabled by electromagnetic attack to stimulate EMS-dependent systems or by encouraging adversary use of exploitable systems.

Electromagnetic surveillance activities also support the conduct of battle damage assessment and development of battle damage indicators. Electromagnetic surveillance and SIGINT missions often share the same or similar assets. When appropriate, EMS and SIGINT authorities may task those assets to simultaneously collect information that meets both requirements. The SIGINT tasking authority for ISR missions determines if those sensor platforms may be available to also perform electromagnetic surveillance. For example, the joint force can use data collected for intelligence purposes to meet immediate EMS surveillance requirements. Similarly, the intelligence community can further exploit data collected for EMS surveillance purposes to meet its own requirements. Electromagnetic surveillance and ISR both involve sensors detecting emitters in the EMS, and those same sensors can also tip or cue the other for further exploitation or targeting.

Managing the Electromagnetic Spectrum

Spectrum management is a function within EMSO. Spectrum management is the operational, engineering, and administrative procedures to plan and coordinate operations within the electromagnetic operational environment. Unfettered access to selected portions of the EMS is vital for C2, weapon system effectiveness, and the protection of critical assets. The joint force uses established tools and processes for spectrum management, ensuring access to and the ability to protect our critical assets in all three segments. By maintaining control over the EMS in the space domain, the joint force can deter potential adversaries from taking hostile actions. The ability to manage the spectrum to enable electromagnetic warfare sends a clear signal that US space capabilities are resilient and capable of responding to any threat in the EMS. Any system operating in the EMS is susceptible to electromagnetic environmental effects.

Any spectrum-dependent device that has electromagnetic compatibility issues may experience increased electromagnetic vulnerability in the areas of safety, interoperability, and reliability. Electromagnetic vulnerability is the extent to which spectrum-dependent devices suffer levels of operational degradation because of exposure to electromagnetic environmental effects, whether natural or human caused. Ensuring electromagnetic compatibility to reduce unintentional or unacceptable impacts on other users, deconflicting frequency use, and mitigating EMI between friendly systems are all means to manage the EMS and reduce the impact of electromagnetic environmental effects.

Effective EMS management is essential to integrate and deconflict multinational force use of the EMS, including considerations to mitigate harm to civilians and civilian use of the EMS. The number, sophistication, and variety of systems operated by our allies and partners make EMS management far more demanding in multinational operations. The differences in cryptographic equipment, training, languages, rules of engagement, and security barriers make planning and executing fires in the EMS more challenging. An increasing dependence on the EMS requires close coordination between the joint force, allies, and partners.

Electromagnetic Spectrum Operations Across the Competition Continuum

The competition continuum shown in figure 2 describes three broad categories of strategic relationships—cooperation, competition below armed conflict, and armed conflict/war, to distinguish and clarify options for using military force. During campaigns and operations, the joint force cooperates with allies and partners, competes against adversaries, and fights with enemies concurrently in the same operating environment. Within those relationships, the joint force seeks to assure our allies and partners, deter adversaries, and when necessary, compel or force behavior changes.

Military operations in all domains and throughout the competition continuum use the EMS to conduct missions that include using or exploiting the EMS, deceiving the adversary, or conducting fires. Every operation in the EMS is dependent on the management and protection of the electromagnetic portion of the operating environment. The joint force manages EMS activities and actions across the competition continuum and throughout the battlespace in accordance with commander's objectives. Integrating EMSO into joint campaigns and operations maximizes their effectiveness in cooperation, competition, and conflict.

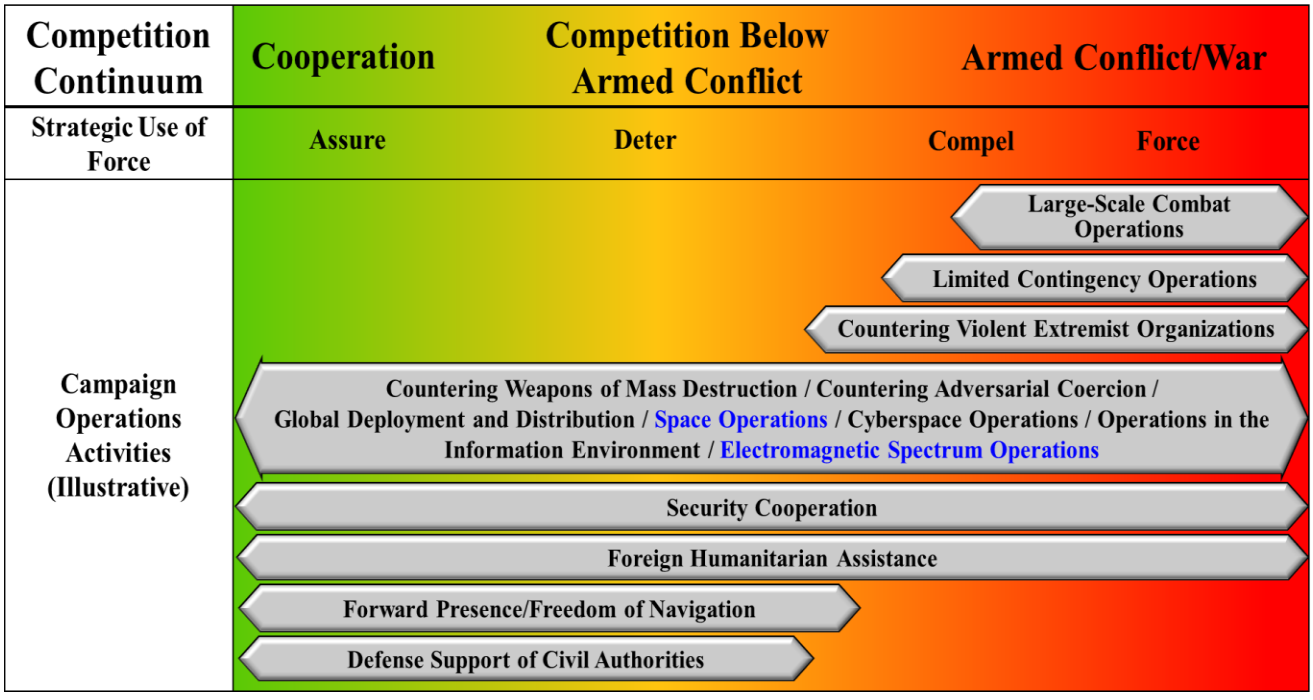


Figure 2. The competition continuum

a. **Cooperation.** In cooperation, the focus is on building relationships, establishing frameworks for collaboration, and laying the groundwork for mutual understanding and capability development. Cooperation emphasizes proactive engagement with allies,

partners, and commercial entities to enhance collective capabilities and ensure readiness for any potential transition across the competition continuum. EMSO require cooperation with allies and partners, integrating capabilities for a combined effect.

Space capabilities are critical to EMS superiority, enabling early detection, tracking, and response. The integration of space capabilities within EMSO is essential, allowing for advanced situational awareness and operational preparation. Cooperative activities should include technical information sharing, training, and capacity building in the EMS environment to integrate space capabilities. Guardians should consider the actions described in the areas below to ensure and enable effective EMSO across JADO, and to prepare and protect space capabilities for operations as actions progress through the competition continuum.

1) **Joint Capability Development.** Collaborate with allied and partner nations to jointly develop, refine, and distribute EMS capabilities, including research and development efforts that address emerging threats and leverage shared technological advancements. Establish joint and coalition training programs that focus on EMSO to foster a common understanding of tactics, techniques, and procedures for employing EMS-related capabilities in, from, or to any domain, including space.

2) **Information Sharing.** Develop and formalize information-sharing agreements that enable the timely exchange of EMS-related intelligence, threat assessments, and technological developments. Develop and sustain security protocols that protect EMS-related and enabling space capabilities from threats. Create joint working groups or liaison teams that focus on specific areas of EMSO, ensuring continuous dialogue and cooperation on spectrum management and defense. Develop and standardize interoperability protocols for EMS use and sharing in space operations among allies, partners, and commercial entities. Establish shared monitoring capabilities that allow for real-time awareness of the EMS environment in space, including the tracking of potential interference sources and emerging threats.

3) **Joint Exercises and Wargaming.** Conduct joint exercises and wargaming scenarios with allies and partners to build interoperability and trust, identify gaps in capabilities or procedures, and enhance collective readiness. Develop scenarios that simulate and create EMS challenges and simulate space operations with integrated EMSO, using an operationally represented operating environment, and focusing on coordination between space assets and ground-based EMS capabilities.

4) **Public-Private Partnerships.** Establish public-private partnerships that focus on EMS innovations, ensuring that commercial providers can align their advancements in spectrum technology with national security needs. Facilitate regular dialogues with commercial space companies to understand their priorities relative to space operations and the EMS, fostering a collaborative environment that benefits both military and civilian sectors. Develop protocols to protect commercial space assets from potential adversary attacks, recognizing their critical role in supporting military operations.

Work with commercial providers to enhance the cybersecurity resilience of their systems, ensuring that they can continue to support military operations.

5) **Shared Research and Development.** Engage in joint research and development initiatives with commercial industry, particularly in areas such as spacecraft communications, cybersecurity, signal processing techniques, and spectrum management technologies. Encourage the development of dual-use technologies that can serve both commercial and military needs, ensuring the ability to rapidly integrate commercial advancements into military operations if necessary.

6) **Regulatory Collaboration**. Work with national and international regulatory bodies to ensure that commercial spectrum use aligns with military requirements, minimizing risk of interference with critical EMS operations. Advocate for policies that support norms and agreements for the secure and efficient use of the electromagnetic spectrum, and responsible use of the EMS in space, balancing commercial innovation with military readiness.

b. **Competition Below Armed Conflict.** In competition below armed conflict the joint force continues many of the activities it began in cooperation, while operating in a state of heightened vigilance, taking actions to maintain strategic advantages and deter potential adversaries. In competition, actors begin to project power, influence, and readiness without escalating to open conflict. The United States and its allies, the focus shifts to ensuring EMS resources are available and protected, and that military operations can adapt to rapidly changing circumstances. EMSO in competition are an ongoing effort to establish and maintain superiority in the electromagnetic spectrum. Joint forces must continuously adapt to changes in the strategic environment, using the EMS to support the other national instruments of power such as diplomatic, informational, and economic activities. Guardians continuously monitor the EMS to detect and identify any attempts by adversaries to gain an advantage in the spectrum. This includes tracking both space and terrestrial spectrum usage to protect US and allied operations against compromise. Nonlethal EMS-enabled activities, such as cyberspace operations, intelligence gathering, and operations in the information environment, are key to maintaining a competitive advantage below the threshold of armed conflict. These operations can disrupt adversary capabilities without escalating to full-scale conflict.

In competition below armed conflict, Guardians are building on the actions begun in cooperation, including capability development, information sharing, exercises and wargaming, public-private partnerships, shared research and development, and regulatory collaboration. Additional actions, such as those listed below move space forces to an increased level of readiness.

1) **Activate Agreements.** Activate mutual support agreements that allow for the sharing of EMS resources, such as frequency bands and spacecraft assets, to bolster collective resilience, operational flexibility, and situational awareness for the health and status of friendly assets in the EMS. Implement standardized, pre-established frameworks for rapid EMS deconfliction, prioritization, and reporting in coalition operations,

ensuring all partners can effectively contribute to joint missions. Continuing to work with commercial entities and regulators helps ensure commercial spectrum usage does not interfere with military operations and maintain clear protocols for spectrum deconfliction.

2) **Implement Monitoring.** Implement continuous EMS monitoring to detect and analyze any attempts by adversaries to disrupt or exploit the spectrum in space. This includes tracking both intentional and unintentional EMI with spacecraft communications and other space-based systems. Due to limited monitoring resources, Guardians will need to categorize signals and strengthen protective measures for space operations, including spacecraft, communications links, and ground stations, against potential EMI, jamming, or cyberspace threats.

3) **Pre-position Assets and Develop Operational Plans.** Pre-position space assets and develop operational plans that emphasize the ability of the United States and its allies to operate without interference in the EMS while deterring potential adversaries. Coordinating EMS operations with allies ensures unity of effort for any actions taken in space, increasing the difficulty for adversaries to exploit EMS vulnerabilities. Establish pathways to integrate commercial EMS-dependent assets into military. Engage commercial providers to develop a plan to protect and optimize their capabilities for military wartime use. Consider deploying advanced encryption, anti-jamming technologies, and redundant communication pathways. Identify potential capability and resource shortfalls and include requests for additional assets in contingency plans.

4) **Prepare for Fires.** This activity sets up execution in the EMS, such as jamming or disabling adversary space assets that threaten US or allied interests. This could involve deploying space-based or ground-based space control electromagnetic warfare or theater electromagnetic warfare assets to disrupt adversary communications and navigation systems. Implement and activate resilient space architectures that can withstand EMS attacks, including the use of disaggregated spacecraft constellations, quick-reaction launch capabilities for spacecraft reconstitution, and hardened communication links. Ensure US and allied space operations have prioritized and protected access to critical spectrum bands, enabling uninterrupted C2, intelligence gathering, and communication. Work closely with allies and commercial partners to execute coordinated electromagnetic defenses, sharing intelligence, threat data, and technical capabilities to protect shared space assets. Engage commercial space entities in contingency planning to ensure their assets and capabilities can support military operations, if required, and have a plan to protect them from adversary actions.

c. **Armed Conflict/War.** As tensions rise, the importance of coordinated spectrum-related efforts with allies, partners, and commercial entities becomes more pronounced. The Space Force's focus shifts to ensuring EMS resources are available, protected, and can rapidly adapt to changing circumstances in support of joint operations. During armed

conflict/war, space-enabled EMSO include targeting the adversary to deny their ability to operate in the spectrum and to protect friendly operations. Guardians supporting joint forces should employ EMS capabilities and conduct actions such as those listed below to achieve these objectives, integrating them with broader combat operations.

1) **Integrated Planning**. Integrate EMSO into campaign and operational planning with the joint force, allies, and partners, ensuring all participants are contributing to a coherent strategy that maximizes collective EMS advantages. Ensure planning addresses not only fires in the EMS but management and protection to allow continued use and exploitation for other missions. Leverage the Joint Electromagnetic Spectrum Operations Cell (JEMSOC) with allies and partners to provide a unified C2 structure for EMSO. Guardians should work to fully integrate EMSO for space operations with broader joint operations and ensure they have synchronized space capabilities with operations in the other domains and in the information environment. The JEMSOC synchronizes and integrates the planning and operational use of electromagnetic sensors, assets, and processes within a specific joint operations area to reduce uncertainties concerning the threat, environment, time, and terrain.

2) **Resource Sharing**. Implement rapid resource sharing and allocation strategies to ensure the joint force, allies, and partners have the EMS resources necessary to achieve their mission objectives, including access to secure communication channels and shared space capabilities. Activate pre-established contingency contracts with commercial space companies to provide additional capabilities, such as launching replacement spacecraft or expanding ground station support, to sustain operations under combat conditions.

3) **Fires.** Prosecuting adversary actions via space-enabled EMSO includes the development, selection, and prioritization of targets and matching appropriate responses to achieve effects. These responses or actions can include jamming, spoofing, or even physically disabling spacecraft or ground control stations to disrupt, deny, degrade, or destroy the adversary's ability to use the EMS for their operations while maintaining helping maintain US and allied superiority in space and the EMS.

4) **Integrated Defensive Measures.** Maximize the use of defensive measures to protect US and allied space assets from enemy EMSO. This includes using frequency agility, spread spectrum techniques, and other tactics to ensure continuity of operations despite adversarial attempts to disrupt them. This integration allows for coordinated attacks on enemy EMS capabilities and comprehensive defense against multifaceted threats. Use redundant systems and agile operational concepts that can quickly adapt to losses or disruptions in the EMS, ensuring that critical space-based functions such as navigation, ISR, and communications remain operational. Coordinate with allies to manage spectrum use dynamically, ensuring coalition forces maintain access to the EMS while allowing for the potential to deny it to the adversary.

Electromagnetic Spectrum Operations for Space Operations Across the Joint Functions

EMSO for space operations allow joint forces to synchronize lethal and nonlethal effects, enhancing their ability to neutralize threats and achieve mission objectives. EMS-enabled space capabilities are essential to every joint function, supporting the ability to maintain situational awareness, conduct C2 operations, ensure support to forces, position forces, and conduct fires.

a. **Command and Control**. Space-enabled EMS capabilities are vital for synchronized C2 of globally-dispersed forces as part of JADO. Space-based assets provide the backbone for global communications networks, allowing commanders to maintain continuous and secure links with their forces, regardless of geographic location. By leveraging the EMS from space, joint forces can execute coordinated operations across multiple domains, with the assurance their command structures remain intact and responsive. Protecting EMS capabilities is critical to denying adversaries the ability to disrupt C2 forces and degrade mission effectives.

b. **Intelligence.** Space-enabled EMSO are a critical enabler of intelligence operations, including planning, collection, processing, exploitation, and dissemination of information. Space-based sensors equipped for intelligence collection rely on the EMS to gather and transmit intelligence, and conduct surveillance and reconnaissance, which is crucial for understanding the operational environment, strategic decision making, and targeting. When proper authorities allow for collection, these sensors provide persistent global coverage for the near real-time monitoring of adversary movements and activities. Terrestrial-based space operations sensors and the integration of intelligence from other sources complement these capabilities. The intelligence gathered through space-enabled EMS capabilities allows joint forces to develop a comprehensive understanding of the battlespace, enhancing their ability to predict, anticipate and respond to threats.

c. **Fires.** EMSO allow joint forces to synchronize lethal and nonlethal effects, enhancing their ability to neutralize threats and achieve mission objectives. Space-enabled electromagnetic capabilities exploit the EMS to enable joint fires by providing the necessary communications links and targeting data required for precision strikes. These capabilities ensure the joint force can execute fires with precision, even in challenging environments where interference may have compromised terrestrial communication. Additionally, electromagnetic warfare systems support fires against adversary targets which can complement and enhance more traditional fires.

d. **Movement and Maneuver.** Use of the EMS in the space domain is essential to optimally position forces and execute operations at the time and place of the joint force commander's (JFC) choosing, thereby achieving operational and strategic objectives. Space-based navigation systems provide the accurate positioning data necessary for the maneuvering of forces, whether on land, at sea, in the air, or in cyberspace. Additionally, space-based communications enable joint forces to coordinate their movements across vast distances, beyond the line of sight, and in contested or denied environments. Terrestrial and space-based space domain awareness systems which rely on the EMS, enable maneuver of spacecraft supporting and protecting joint force operations, and

maneuver of capabilities executing joint force operations in other domains. Properly managed and protected EMSO allow joint forces to maneuver with confidence, knowing they can maintain situational awareness and communication with command elements.

e. **Protection.** Space-based EMS capabilities are crucial for the protection of joint forces, enabling the detection and mitigation of threats across all domains and preserving operational effectiveness and mission success. Spacecraft equipped with early warning systems and missile detection technologies use the EMS to monitor potential threats, providing critical alerts that allow joint forces and national command authorities to take protective actions. Access to space-based communications systems helps ensure joint forces can maintain secure links even when under electromagnetic attack, preserving their ability to coordinate defensive or protective measures. Space-enabled EMSO enhance the protection of critical infrastructure, forces, and information networks, ensuring joint operations can continue without disruption.

f. **Sustainment.** Space-enabled EMSO are a key enabler of sustainment operations, enabling force providers to sustain operations and personnel across vast distances. Space-based communications networks provide the links necessary for managing the supply chain, coordinating resupply missions, and ensuring personnel support throughout the operational environment for the duration of operations. These capabilities are especially critical in operations that span multiple continents or in environments where terrestrial communications infrastructure is inadequate or compromised. Space-based EMSO are vital to the joint force's ability to sustain operations efficiently, extending operational reach and endurance.

g. **Information.** Electromagnetic capabilities operated in, from, and to the space domain are integral to information activities, enabling the transmission, reception, exploitation, disruption, degradation, or denial of critical information that shapes the operational environment. Space operations facilitate the global dissemination of messages and the coordination of operations in the information environment and cyberspace operations. These space-enabled electromagnetic capabilities enable military forces to conduct information activities on a global scale, influencing adversary behavior, protecting friendly information, and ensuring communications networks remain secure. Space-enabled EMSO allow the joint force to project influence, disrupt adversary information campaigns, and maintain the integrity of their own information systems. The decisive effect of space-enabled EMSO in the information environment is the ability to control the information environment, thereby shaping perceptions and behaviors to achieve strategic objectives.

Integration of Electromagnetic Spectrum Operations

a. **Air, Land, Maritime, and Space Domains.** The Space Force's capabilities are crucial for providing persistent, global coverage that supports joint operations in the air, land, and maritime domains. Space assets can detect, monitor, and influence electromagnetic activities across the planet, enhancing situational awareness and enabling the effective

coordination of joint forces. Terrestrial operations leverage the EMS to access space capabilities such as beyond line-of-sight communications, multi-domain awareness, and remote sensing. Space-based platforms enable the extension of military operations into areas that may be beyond the reach of traditional terrestrial, airborne, or maritime assets by ensuring continuous access and denying adversaries the same in contested environments. Space operations play a key role in synchronizing EMSO, including fires, ensuring that actions in space complement and enhance all aspects of JADO.

b. **Operations in the Information Environment and Cyberspace.** Operations in the information environment, cyberspace operations, and EMSO are inherently interconnected, and essential to operations in, from, and to the space domain. These operations provide effects both independently and dependently upon each other while executing their respective missions in support of and supported by space operations.

   The three segments of space systems–terrestrial, link, and orbital– all rely on cyberspace operations and EMSO to protect our use of the different segments and enable operations in and through them. In the space domain, cyberspace operations rely on the EMS to transmit and execute capabilities. These mission sets can provide integrated offensive or defensive effects in the information environment, the electromagnetic portion of the operating environment, and cyberspace in support of US, joint, and allied space operations. While EMSO can provide the means to achieve effects in cyberspace, EMSO can also help degrade and disrupt adversary information and cyberspace operations. Cyberspace capabilities enable offensive and defensive operations in space. EMSO provide the logical and physical backbone for cyberspace access in the space domain. Information operations include offensive and defensive information warfare through cyberspace.

Electromagnetic Spectrum Operations in Joint Operations

Effective joint operations require the integration of EMSO from planning through execution and assessment. EMSO as part of the joint planning process provides the basis for the prioritization, integration, and synchronization of EMS activities across the Services and combatant commands in support of the joint force in every domain and area of responsibility. Guardians conducting EMSO as part of the joint force are responsible for:

a. Planning and conducting assigned EMS activities that enable and enhance space operations.

b. Executing activities that shape the electromagnetic portion of the operating environment to support space and JADO and enable unity of effort.

c. Executing EMS activities in support of other Services.

d. Assessing Space Force's EMS capabilities and EMS-enabled space capabilities.

a. **Planning.** The JEMSOC on behalf of the combatant commander (CCDR) manages the prioritization, integration, synchronization, and deconfliction of all JEMSO to attain EMS

superiority, achieve the commander's objectives, mitigate EMI, and avoid friendly fire incidents in the EMS. As part of the joint planning process, the commander's guidance and estimate form the basis for determining component objectives and measures of effectiveness and performance for JEMSO activities. JEMSO planning also includes any multinational force commander to ensure deconfliction and coordination for the conduct of fires in the electromagnetic portion of the operating environment. EMSO considerations for current and future operations planning include frequency deconfliction, target deconfliction, and deconflicting fires across domains to prevent fratricide.

1) **Current Operations.** At the start of planning, an assessment of the electromagnetic portion of the operating environment provides understanding of the electromagnetic landscape, identifies potential adversary use of EMS, and highlights spectrum-related challenges. EMSO are critical contributors to all space operations. Guardians should consider and advise planning for EMSO and the potential impact to operations in any of the space segments.

   Early in the process, planners establish spectrum-related objectives that align with the overall mission goals, such as achieving spectrum superiority or ensuring uninterrupted communications. EMSO planning for space operations is based on an EMS operations directive from the combatant command and C-FLDCOM guidance detailing EMS requirements and planned EMS activities in the CCDR's area of responsibility. During mission analysis, planners consider how to leverage the EMS to support the mission. This includes identifying critical EMS-dependent systems and potential vulnerabilities. Understanding the enemy's EMS capabilities and how they could interfere with or disrupt friendly operations is crucial for developing effective courses of action. Each course of action developed should include a plan for EMSO, detailing how friendly forces will protect their own EMS use while potentially disrupting the adversary's. Guardian planners identify and review existing EMS management guidance, such as the joint restricted frequency list, joint communications-electronics operating instructions, and joint spectrum interference resolution procedures. Planners compare courses of action based on their feasibility in the operational environment and the risks associated with potential EMS threats. The selected courses of action should offer the best chance of maintaining EMS superiority.

   Guardians conduct detailed planning for all mission requirements, including EMS activities needed to support their physical and temporal scheme of maneuver. The Commander, Space Forces submits plans for the specific execution period to the JEMSOC, chair of the JEMSO working group. The JEMSOC prioritizes, synchronizes, and deconflicts proposed functional component EMS activities and obtains commander approval.

   As part of integrating EMSO into the joint planning process, Guardian planners should consider phase transitions, decision points, conflict termination, redeployment, flexible response and deterrence options, and procedures to capture lessons learned.

Incomplete planning for conflict termination and the end state can result in the waste of valuable resources, aggravate a tenuous peace, cause a return to hostilities, or lead to unintended consequences.

2) **Future Operations.** Planning for future operations includes forecasting potential EMS challenges that might arise in future operations, such as increased adversary EMS capabilities or the introduction of new technologies that could affect spectrum use. Planners develop EMSO contingency plans that address potential disruptions or threats to the operating environment in future operations. These plans might include alternative communications strategies, backup systems, or pre-positioned assets to ensure spectrum continuity. Ensuring long-term EMS superiority involves planning for the sustained protection of the EMS across multiple potential future conflicts. This includes leveraging new technology, building resilient systems, training personnel, and establishing alliances to maintain a competitive advantage in the EMS. EMSO planning for future operations also involves coordinating with allies and partners to ensure interoperability, mutual support, and unity of effort in the electromagnetic portion of the operating environment during future operations.

   Space-based electromagnetic capabilities allow for the continuous collection and dissemination of intelligence, providing real-time insights that can inform immediate future operational decisions. This is particularly important in scenarios where the situation on the ground is fluid, and rapid adjustments are necessary to maintain operational momentum. The EMS enables the synchronization of space-based and terrestrial forces, ensuring all elements of the joint force can operate in concert. This coordination is essential for executing complex maneuvers and achieving operational objectives in a timely manner.

3) **Operations Order.** On behalf of the JFC, the JEMSOC normally publishes and distributes an EMS operations order daily. The JFC is responsible for control for the entire joint operational area but may delegate specific EMS control authority to the component commanders through EMS operations directive guidelines. The CCDR may also elect to task the component commanders to generate EMS operations directive annexes for their assigned operations. Regardless, the JEMSOC provides continuity along operational boundaries and ensures integration within the EMS operations directive guidelines. The EMS operations order contains the following information:

   - Operational objectives.
   - Boundary changes in the electromagnetic portion of the operating environment.
   - Rules of engagement and special instructions.
   - EMS use prioritization.
   - EMS frequency allotments (including electromagnetic-parametric restrictions).

- Specific transmission authorizations when needed for specific regions of the EMS may require finer control.
- Activate and deactivate EMS coordination measures (joint restricted frequency list or others as required).
- EMSO support/surveillance activities.

b. **Execution.** Successful EMSO are vital for preventing disruption to ongoing operations by adversarial actions or unintended interference. Current operations require continuous management of the EMS to adapt to the dynamic operational environment. This involves monitoring the EMS for any changes or threats and making real-time adjustments to frequencies, power levels, and communications protocols. During execution of current operations, EMSO focuses on protecting critical communications, navigation, and intelligence, surveillance, and reconnaissance systems from jamming, spoofing, or other forms of electromagnetic warfare. EMSO provides commanders with real-time spectrum data that can influence tactical decisions, such as changing communications methods or re-prioritizing spectrum resources to ensure mission success.

   If delegated authority for specific portions of the electromagnetic portion of the operating environment, the Space Force component conducts EMSO prioritization, integration, and synchronization for the space domain. The Space Force component would generate and forward any orders containing EMSO guidance to applicable Space Force units. Timely order changes are essential to alert all EMS users, including allies and partners, to avoid friendly EMI and unintended engagements against civil and neutral receivers, and to increase operational effectiveness.

   EMSO in, from, and to space provides critical support to JADO including:

   1) **Continuous Monitoring.** Space-based EMSO enable continuous monitoring of the operational environment. This allows commanders and their staff to observe the effects of operations in real-time, ensuring that assessments are based on the most current and accurate information available. EMSO units should share feedback and reporting to enable situational awareness and EMI resolution and deconfliction.

   2) **Data Collection and Analysis.** Space-based electromagnetic capabilities provide essential data needed for assessment, including sensor-derived signatures and communications intercepts. The joint force and the Guardians supporting the CCDR use this data to measure the performance and efficacy of operations against predefined objectives, allowing for a detailed analysis of the effectiveness of both lethal and nonlethal actions.

   3) **Enhanced Situational Awareness.** Space-based EMSO support the rapid dissemination of assessment findings to commanders, enabling them to make timely adjustments to ongoing operations. Feedback and data sharing is critical for adapting strategies and tactics to evolving conditions, ensuring that operations remain aligned with the commander's objectives. Through space-enabled EMSO, joint forces can maintain a comprehensive understanding of the operational environment. This

enhanced situational awareness is crucial for monitoring and directing current operations, accurately assessing progress toward objectives, and making informed decisions about future courses of action.

c. **Assessment.** Throughout the execution of EMSO in, from, and to the space domain, Space Forces-Space tracks and monitors EMI as a part of EMI resolution and informs the commander of intentional EMI on blue assets. During the assessment process, Guardians focus on determining the overall effectiveness of EMSO, identifying areas for reattack, evaluating any collateral damage to include second- and third-order effects, and providing inputs into the on-going current operations, future operations planning, and the joint planning process. The JEMSOC creates an assessment plan based on the JFC's objectives. In addition to accomplishing assessments to support the JFC, component commanders may require their own assessment criteria for component operations.

For space operations, this assessment occurs across all three segments (orbital, terrestrial, and link) where Space Force capabilities exploit the EMS, fires within the EMS to support joint operations, or fires in the EMS support space operations. Using the measures of effectiveness and measures of performance developed in the planning phase, EMSO planners and analysts determine whether they were effective in meeting the commander's objectives. Conducting a combat assessment requires close synchronization and integration between intelligence, operations, and fires personnel.

Throughout the assessment process, the joint force and Service components capture lessons learned using the joint lessons learned process. The Space Force disseminates lessons learned to the relevant Space Force organizations, other components, the combatant command, allies, and partners as appropriate depending on the urgency.

Chapter 4: Authorities, Roles, and Responsibilities

United States Strategic Command is the Department of Defense (DoD) EMS enterprise operational lead for JEMSO. The combatant command coordinates military actions taken by the JFC to achieve EMS superiority, including conducting maneuvers, exploiting, and achieving unity of effort in the electromagnetic portion of the operating environment.

Authorities

On behalf of the JFC, the JEMSOC normally executes electromagnetic attack control authority and EMS management at the combatant command, subordinate command, or joint task force level. Other actions in the EMS, such as use of directed-energy weapons, may require additional coordination or control authorities.

a. **Electromagnetic Attack Control Authority.** The electromagnetic attack control authority is the authority delegated to a person or position to issue fire and cease fire commands to a unit employing the intentional transmission of electromagnetic energy to engage a target. This authority is inherent for commanders with assigned authority for fires in the EMS. The commander should delegate electromagnetic attack control authority to the lowest appropriate echelon with situational awareness in the electromagnetic portion of the operating environment where the electromagnetic fires will occur and the ability to maintain positive communications with the entity controlling the electromagnetic attack capability.

b. **EMS Management.** On behalf of the JFC, the combatant command's Joint Frequency Management Office executes all aspects of the JEMSO spectrum management lifecycle. These roles include spectrum management plans, policy, frequency assignment authority, host nation coordination, joint communications-electronic operation instruction generation authority, joint restricted frequency list development and promulgation, electromagnetic warfare deconfliction, and EMI investigation. The C-FLDCOM EMSO cell will coordinate with the respective Joint Frequency Management Office or JEMSOC to conduct host nation coordination for space operations.

Component Field Command

To accomplish a combatant command's responsibilities for EMSO, the Space Force C-FLDCOM commander exercises operational control over assigned and attached Space Force forces. When designated as Joint Force Space Component Commander, the commander exercises tactical control over Space Force and other EMS forces made available.

The CCDR normally delegates authorities to the components that have the C2 over specific EMSO. For example, if the CCDR delegates EMS authorities to Space Forces-Space, the commander may further delegate that role to the Combined Space Operations Center for overall responsibility within the CCDR's area of responsibility. An organization delegated EMS

authorities conducts EMSO prioritization, planning, coordination, monitoring, and assessment on behalf of the CCDR. The organization delegated EMS authorities should coordinate EMSO orders, plans, prioritized user requirements, and frequency authorizations via the JEMSOC to ensure synergistic effects and deconfliction of the EMS and EMSO with other Services.

When United States Space Command delegates EMS authorities to Space Forces-Space, Guardians are responsible for the following operations in the EMS and space in support of the joint force.

a. Implement policy and guidance for EMSO planning and execution.

b. Obtain EMS clearance (or approval) as applicable through the JEMSOC.

c. Coordinate operational EMS issues with the JEMSOC and C-FLDCOM staff.

d. Coordinate with JEMSOC to ensure frequency allocations and assignments meet technical parameters under host nation agreements.

e. Coordinate with regional and global EMS offices, and when necessary, ally and partner organizations and operations centers, for operational EMS deconfliction.

f. Coordinate with foreign disclosure offices on classification of EMS reports for ally and partner nation releasability.

g. Authorize EMS use by assigned and attached forces to execute EMSO.

h. Convey guidance through the applicable organizations for achieving the desired degree of EMS control through the respective concept of operations.

i. Provide the commander's intent and critical information requirements.

j. Resolve EMS user prioritization issues not resolved at a lower level.

k. Maintain coordination with allies and partners to ensure consideration for mutual EMS support for space operations planning and execution.

l. Ensure procedures and policies are in place for the safeguarding, use, and transfer of reprogrammable EMS-dependent system waveforms.

m. Execute and provide feedback for policy and guidance of EMS coordination measures and the joint restricted frequency list.

n. Advise the C-FLDCOM commander on EMS employment, force planning, and management of EMS resources for which the commander has operational control or has established supported or supporting relationships.

o. Support planning, execution, and assessment of EMS operations in, from, or to space in support of space operations and JADO.

p. Identify EMS capabilities and limitations of all components and the potential effects on operations.

q. Provide requirements for additional EMS forces and capabilities.

r. Develop, coordinate, and integrate the EMS plan for submission to the JEMSOC to support the CCDR's objectives.

s. Develop EMS requirements based on JEMSOC guidance and space operations control order.

t. Provide communications-electromagnetics operating instructions for space component forces.

u. Plan, coordinate, and monitor EMS related communications security procedures and assets.

Space Force Organizations Supporting Electromagnetic Spectrum Operations

Every Space Force organization exploits the EMS to deliver capabilities to the joint force. Specific Space Force units are engaged in protecting or managing the EMS, taking actions to deceive the adversary, conducting electromagnetic warfare, or providing data to support EMSO.

a. **Field Commands.** Space Systems Command and Space Operations Command provide ground- and space-based environmental observations of the natural space domain. Guardians fuse this data with space and terrestrial environmental knowledge provided by the United States Air Force, United States Navy, civil and international partners to assess natural impacts on the electromagnetic portion of the operating environment and on both friendly and adversary systems and services. The Space Domain Awareness Environmental Toolkit enables operators to exploit that knowledge of the natural environment for offensive, defensive and resource protection operations across EMS capabilities.

b. **Mission Delta 3.** Mission Delta 3 is the Space Force's electromagnetic warfare element. Guardians of Mission Delta 3 are combat ready professionals trained to integrate, synchronize, and execute fires in the EMS as part of the joint force. As part of their mission, Mission Delta 3 also integrates and synchronizes fires in the EMS with allies and coalition partners, supporting joint operations across all domains.

c. **Space Delta 5.** Space Delta 5 is the Space Force's C2 element for theater forces. Guardians of Space Delta 5 are responsible for maintaining global awareness of operational environments, maintaining global awareness of the status of space forces, enabling data-driven decisions by the operational commander, and tasking the operational commander's forces. Their mission includes addressing EMSO equities for the C2 of space forces.

d. **Space Delta 7**. Space Delta 7 is the operational intelligence, surveillance, and reconnaissance element of the Space Force. Guardians of Space Delta 7 provide critical, time sensitive, and actionable intelligence for operations in the EMS and space domain to allow for the detection, characterization, and targeting of adversary space and EMS capabilities.

e. **Space Delta 8.** Space Delta 8 is the satellite communications element for the Space Force. Space Delta 8monitors the EMS to detect, characterize and mitigate intentional and unintentional EMI as part of the satellite communications mission, ensuring space-based communications for the joint force.

f. **Space Delta 15.** Space Delta 15 is the Space Force's C2 element for the protection and defense of forces in the space domain. Guardians of Space Delta 15 deliver integrated space battle management, intelligence, and cyberspace capabilities in support of operational C2 of assigned and attached forces, as well as creating unity of effort in space defense, data sharing and intelligence cooperation. Space Delta 15's mission addressing EMSO for the protection and defense of space forces.

g. **National Space Intelligence Center.** The National Space Intelligence Center is the Space Force's Service-level intelligence center. Guardians assigned to the National Space Intelligence Center are responsible for the analysis of foreign electromagnetic and cyberspace threats in, from, and to space. The National Space Intelligence Center also conducts space unique measurement and signatures intelligence, geospatial intelligence, foreign instrumentation, SIGINT, and other space SIGINT processing, exploitation, and analysis.

Department of Defense Support to Electromagnetic Spectrum Operations

Three primary organizations within the DoD provide intelligence data support critical to EMSO.

a. **Defense Information Systems Agency, Program Executive Office for Spectrum.** The Program Executive Office for Spectrum delivers and assures electromagnetic spectrum C2, information-sharing capabilities, and a globally-accessible enterprise information infrastructure in direct support to CCDRs, national-level leaders, and other mission and multinational partners.

b. **National Security Agency/ Central Security Service.** National Security Agency/ Central Security Service provides SIGINT and cybersecurity products and services and enables computer network operations to gain a decisive advantage for the Nation and our allies. The Central Security Service provides cryptologic support, knowledge, and assistance to the military cryptologic community.

c. **National Geospatial-Intelligence Agency.** National Geospatial-Intelligence Agency provides timely, relevant, accurate and actionable geospatial-intelligence. National Geospatial-Intelligence Agency enables the US intelligence community and the DoD to fulfill the president's national security priorities to protect the nation.

d. **Defense Intelligence Agency.** The Defense Intelligence Agency provides timely, relevant, accurate and actionable measurements and signature intelligence. Defense Intelligence Agency is responsible for collecting, processing, exploiting, and correlating timely scientific and technically derived data that provides insight into our adversary's

EMSO capabilities, operations and activities and enhances decision advantage over acute and persistent threats.

e. **Joint Electromagnetic Spectrum Operations Center.** Thes Joint Electromagnetic Spectrum Operations Center, supported by its units for electromagnetic warfare and readiness, provides EMS support to the warfighter, including the identification and assessment of current and emergent electromagnetic warfare and EMS superiority requirements, technologies, and capabilities to enable global access and freedom of maneuver across all domains and joint functions throughout the competition continuum. The Joint Electromagnetic Warfare Center provides operational electromagnetic warfare subject matter expertise, deployable experts, modeling, advocacy of evolving electromagnetic warfare capabilities, training, assessments, and products to enable EMS superiority. The Joint Center for Electromagnetic Readiness assesses joint force readiness and JEMSO capabilities. The Joint Electromagnetic Spectrum Operations Center is the approval authority for electromagnetic warfare or planned interference against global positioning system signals in tests, training, and exercises conducted or sponsored by DoD entities.

Appendix A – Acronyms, Abbreviations, and Initialisms

C2	command and control
CCDR	combatant commander
C-FLDCOM	component field command
DoD	Department of Defense
EMI	electromagnetic interference
EMP	electromagnetic pulse
EMS	electromagnetic spectrum
EMSO	electromagnetic spectrum operations
JADO	joint all-domain operations
JEMSO	Joint Electromagnetic Spectrum Operations
JEMSOC	Joint Electromagnetic Spectrum Operations Cell
JFC	joint force commander
JFMO	Joint Frequency Management Office
SDP	Space Doctrine Publication
SIGINT	signals intelligence
STARCOM	Space Training and Readiness Command
US	United States
USSF	United States Space Force

Appendix B – Glossary

cyberspace operations - The employment of cyberspace capabilities where the primary purpose is to achieve objectives in or through cyberspace. (*Department of Defense Dictionary of Military and Associated Terms* /Joint Publication 3-0, *Joint Campaigns and Operations*)

defensive space control electromagnetic warfare - Protection against enemy ability to attack friendly systems. (Space Force Doctrine Document -1, *The Space Force)*

electromagnetic attack – (1) Division of electromagnetic warfare involving the use of electromagnetic energy, directed energy, or antiradiation weapons to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability and is considered a form of fires. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)* (2) Transmit energy through the electromagnetic spectrum to disrupt or degrade a terrestrial target's ability to receive signals or deliver data. (Space Force Doctrine Document -1, *The Space Force)*

electromagnetic compatibility - The ability of systems, equipment, and devices that use the electromagnetic spectrum to operate in their intended environments without causing or suffering unacceptable or unintentional degradation because of electromagnetic radiation or response. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic environment - The resulting product of the power and time distribution, in various frequency ranges, of the radiated or conducted electromagnetic emission levels encountered by a military force, system, or platform when performing its assigned mission in its intended operational environment. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic environmental effects - The impact of the electromagnetic environment upon the operational capability of military forces, equipment, systems, and platforms. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic hardening - Action taken to protect personnel, facilities, and/or equipment by blanking, filtering, attenuating, grounding, bonding, and/or shielding against undesirable effects of electromagnetic energy. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic interference - Any electromagnetic disturbance, induced intentionally or unintentionally, that interrupts, obstructs, or otherwise degrades or limits the effective performance of electromagnetic spectrum-dependent systems and electrical equipment. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic jamming - The deliberate radiation, reradiation, or reflection of electromagnetic energy for the purpose of preventing or reducing an enemy’s effective use of

the electromagnetic spectrum, with the intent of degrading or neutralizing the enemy's combat capability. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic protection – (1) Division of electromagnetic warfare involving actions taken to protect personnel, facilities, and equipment from any effects of friendly or enemy use of the electromagnetic spectrum that degrade, neutralize, or destroy friendly combat capability. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)* (2) Protect personnel, facilities, and equipment from intentional or inadvertent electronic interference. (Space Force Doctrine Document -1, *The Space Force)*

electromagnetic pulse - A strong burst of electromagnetic radiation caused by a nuclear explosion, energy weapon, or by natural phenomenon that may couple with electrical or electronic systems to produce damaging current and voltage surges. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic spectrum management - The operational, engineering, and administrative procedures to plan and coordinate operations within the electromagnetic operational environment. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic spectrum operations - Coordinated military actions to exploit, attack, protect, and manage the electromagnetic environment. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic spectrum superiority - That degree of control in the electromagnetic spectrum that permits the conduct of operations at a given time and place without prohibitive interference, while affecting the threat's ability to do the same. (Department of Defense Dictionary of Military and Associated Terms / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations*)

electromagnetic support - Division of electromagnetic warfare involving actions tasked by, or under direct control of, an operational commander to search for, intercept, identify, and locate or localize sources of intentional and unintentional radiated electromagnetic energy for the purpose of immediate threat recognition, targeting, planning and conduct of future operations. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic surveillance - The search for interception, identification, location, or localization of sources of intentional or unintentional radiated electromagnetic energy for the purpose of immediate threat recognition, targeting, planning, or future operations. (Space Force Doctrine Document -1, *The Space Force)*

electromagnetic vulnerability - The characteristics of a system that cause it to suffer a definite degradation (incapability to perform the designated mission) as a result of having been subjected to a certain level of electromagnetic environmental effects. (*Department of Defense Dictionary*

of Military and Associated Terms / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

electromagnetic warfare – (1) Military action involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy. Also called EW. See also directed energy; electromagnetic attack; electromagnetic protection; electromagnetic support. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)* (2) Combat operations on the link segment through electromagnetic spectrum fires to control the space domain. (Space Force Doctrine Document -1, *The Space Force)*

electromagnetic warfare frequency deconfliction – Actions taken to integrate those frequencies used by electromagnetic warfare systems into the overall frequency deconfliction process. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

frequency deconfliction – A systematic management procedure to coordinate the use of the electromagnetic spectrum for operations, communications, and intelligence functions. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

joint electromagnetic spectrum operations - Military actions undertaken by a joint force to exploit, attack, protect, and manage the electromagnetic environment. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations)*

offensive space control electromagnetic warfare - Negate enemy ability to use space or counterspace systems. (Space Force Doctrine Document -1, *The Space Force)*

operations in the information environment - Military actions involving the integrated employment of multiple information forces to affect drivers of behavior. (*Department of Defense Dictionary of Military and Associated Terms* / Joint Publication 3-04, *Information in Joint Operations*)

theater electromagnetic warfare - Actions taken in the electromagnetic spectrum to protect or prevent the ability to communicate using space-based platforms. (Space Force Doctrine Document -1, *The Space Force)*

Appendix C – References

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