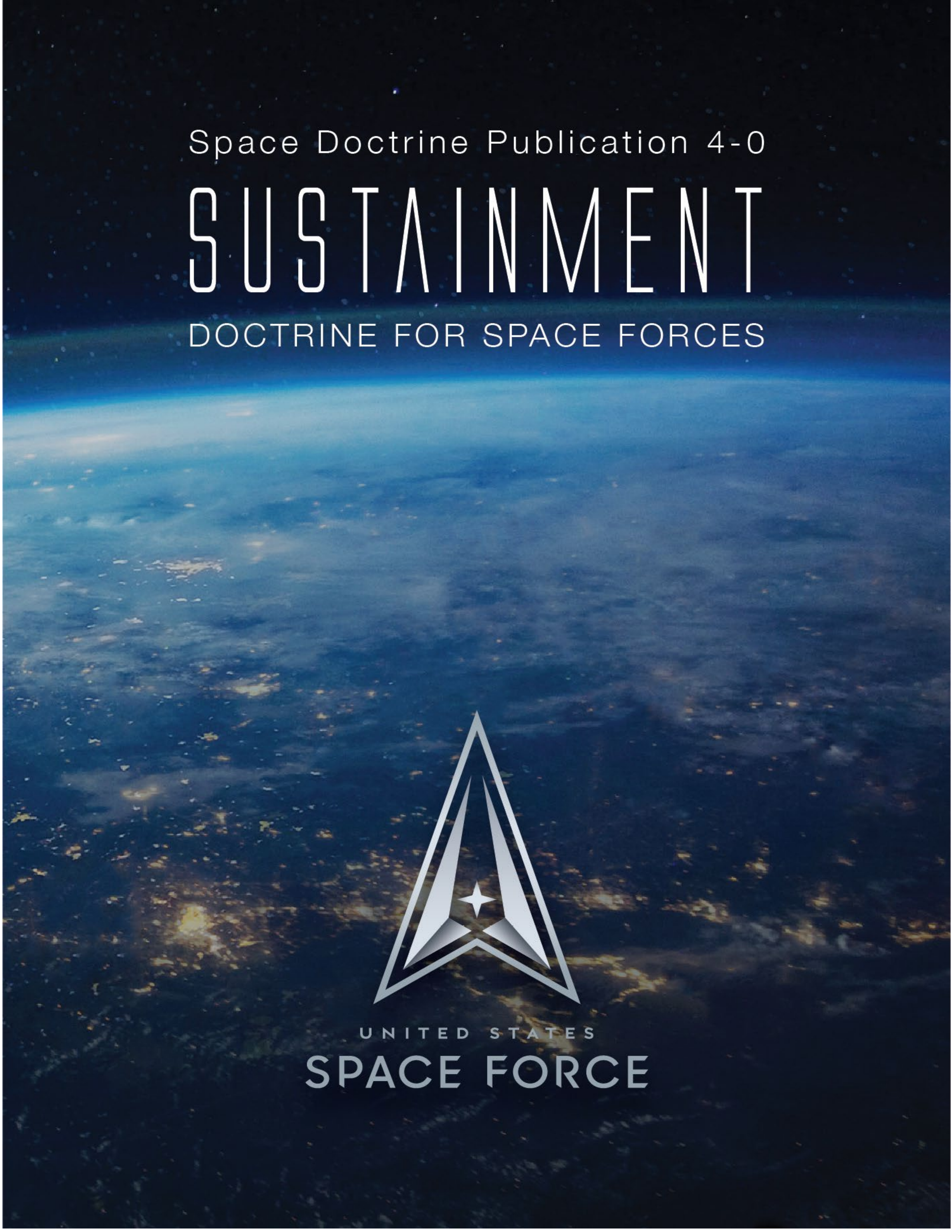
Space Doctrine Publication 4-0

SUSTAINMENT

DOCTRINE FOR SPACE FORCES



UNITED STATES

SPACE FORCE

Space Doctrine Publication (SDP) 4-0, *Sustainment*

Space Training and Readiness Command (STARCOM)

OPR: STARCOM Delta 10: Dec 2022

Foreword

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

Space Doctrine Publication (SDP) 4-0, *Sustainment*, aligns with current Space Force doctrine and the Chief of Space Operations' Planning Guidance. It articulates extant best practices and lessons learned for sustainment of space forces.

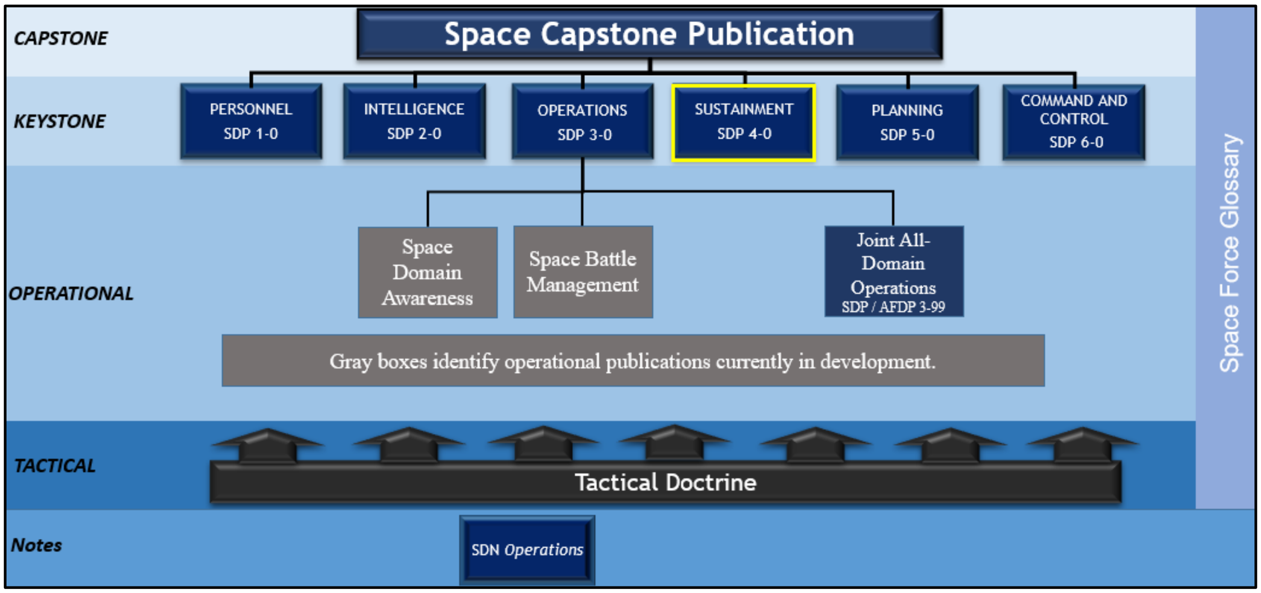
Strength and security in space provides national leaders with independent options and enables freedom of action in both space and other warfighting domains while contributing to international security and stability. Effective sustainment of weapon systems, critical infrastructure, logistics capabilities, and force protection measures is critical for enabling military space forces to conduct consistent and enduring space operations that fulfill the cornerstone responsibilities of the Space Force: preserve freedom of action, enable joint lethality and effectiveness, and provide independent options.

I encourage all Guardians to study and learn from the knowledge compiled in this publication. Semper Supra!

SHAWN N. BRATTON
Major General, USAF
Commander, Space Training and Readiness Command

Space Force Doctrine

Space Force doctrine guides the proper use of military spacepower in support of the Service's cornerstone responsibilities. It establishes a common framework for employing Guardians as part of a broader joint force. Doctrine provides fundamental principles and authoritative guidance for the employment of military spacepower and an informed starting point for decision-making and strategy development. Since we cannot predict the timing, location, and conditions of the next fight, commanders should be flexible in the implementation of this guidance as circumstances or mission dictate. Where the United States Space Force (USSF) is developing new policies, processes, or structures, call-out boxes (light blue boxes with rounded corners) highlight those for the reader. As the USSF officially implements these changes, Space Training and Readiness Command (STARCOM) Delta 10 will update this publication.



Space Force Doctrine Hierarchy

Space Doctrine Publication (SDP) 4-0

Space Doctrine Publication (SDP) 4-0, one of six planned keystone doctrine publications, presents Space Force sustainment activities to support the freedom to operate in, from, and to space.

- Chapter 1 introduces the operational environment and outlines the fundamentals of sustainment
- Chapter 2 discusses sustainment and the competition continuum
- Chapter 3 covers sustainment in relation to the three segments of space systems (on-orbit, terrestrial, and link) and identifies some challenges to the sustainment of space capabilities
- Chapter 4 presents roles, responsibilities, and relationships of organizations directly supporting the sustainment of space operations

Table of Contents

Table of Figures

Chapter 1: Introduction

Purpose

Access to and the ability to operate freely in space are vital to national interests. This publication presents the United States Space Force's (USSF) current body of knowledge pertaining to the sustainment of space forces and capabilities. It provides the Guardian's perspective on the best way to approach sustainment of operations in the space domain throughout the competition continuum. It also identifies considerations for interaction with governmental and nongovernmental agencies, multinational forces, and other interorganizational partners.

Operational Environment

Space operations are unique and challenging because their operational environment (OE) spans multiple domains (e.g., air, maritime, land, and cyber). While the physical dimension of the space domain encompasses the orbital environment and the spacecraft operating within, the space system architecture—orbital segment, terrestrial segment, and link segment—traverses multiple domains and dimensions making defensive and offensive space operations inherently global and multi-domain. Thus, the operational environment for conducting space operations, and therefore sustaining space capabilities, is inherently global and multi-domain. The operational tempo for space systems differs from those for aircraft and missile systems. While major maintenance or maneuver activities may not be required regularly, there is a potential for major impact to operations in other domains when Guardians are required to take space-based or terrestrial-based space assets offline for maintenance activities. For example, warfighters rely on Global Positioning System (GPS), satellite communications, and space-based missile warning on a 24/7 basis; taking these systems offline for maintenance can disrupt or degrade operations and place warfighters at increased risk. Maintenance downtime on launch systems in the terrestrial domain can prevent responsive delivery of payloads to orbit. In addition, maintenance downtime on simulators, emulators, and other software development platforms can delay the delivery of critical software updates that provide new capabilities or are required for space systems to function properly.

a. **Orbital (Space) Segment.** The space environment contains numerous physical hazards and presents a dynamic and hostile OE. Every launch vehicle that travels from the terrestrial segment into the orbital segment remains an environmental consideration throughout the space access, maneuver, payload separation or deployment, and launch vehicle disposal phases of its mission. Currently, the limited ability to conduct physical maintenance (e.g., replace parts) of on-orbit spacecraft limits the options to respond to degradation or damage. On-orbit maintenance is generally limited to software updates or commands directing the satellite to use redundant systems already onboard. Space operators perform these types of maintenance remotely while the system is still operating. On-orbit refueling of spacecraft is also a limiting factor. As a result, most current space system lifespans are limited by the amount of onboard propellant they have when launched. Propellant is required for conducting station-keeping, orbit-raising, collision avoidance, end-of-life disposal, and many other types of on-orbit maneuvers.

b. **Terrestrial Segment.** The terrestrial segment consists of characteristics that offer substantial challenges to the sustainment of space capabilities that include, but are not limited to the following:

- Geographically dispersed systems. Maintenance and sustainment of terrestrial control stations, antennas (mobile and fixed), tracking stations, and other support equipment often requires on-site maintenance performed at geographically dispersed operating locations around the globe. This can create challenges in getting necessary personnel or parts on site. Operations, sustainment, and acquisitions professionals should consider ground, air, and sea ports of debarkation when assessing requirements and timelines to deliver the parts necessary to maintain operations. The Force Activity Designator, urgency of the item, and location of the site will aid in determining the mode of transportation. For example, the GPS control segment consists of a global network of ground facilities that track the GPS satellites, monitor their transmissions, perform analyses, and send commands and data to the constellation (figure 1). Space Force, via Space Operations Command (SpOC), provides and sustains operationally ready units and personnel in the terrestrial segment to deploy and employ space capabilities for the joint force commander (JFC).

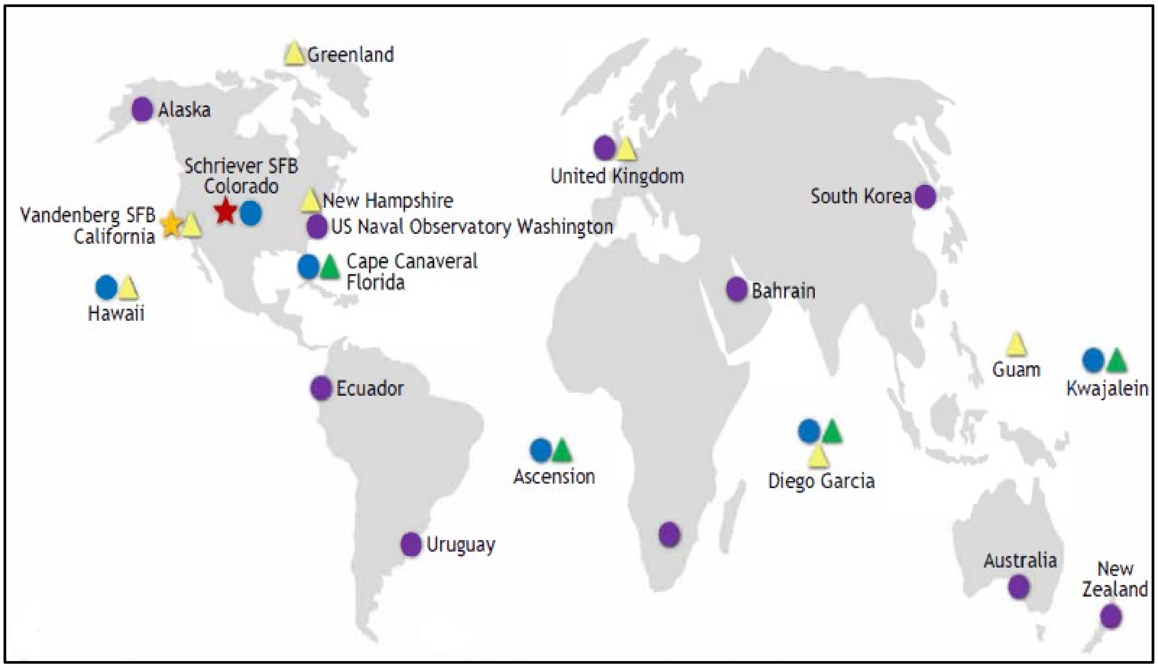


Figure 1. Global Positioning System Control Segment

- Obsolescence of systems. Terrestrial space systems often operate beyond their planned life expectancy. As a result, terrestrial space systems require significant support from Space Systems Command (SSC), the Missile Defense Agency, and other procurement authorities to provide engineering solutions and solve compatibility issues with well-defined sustainment requirement contracts.

- Harsh operating environments. Terrestrial space systems, dispersed around the globe, can be exposed to all types of weather. The environments they operate in drive constant infrastructure upkeep to keep the elements out and prevent corrosion.

The terrestrial segment includes extensive assets and infrastructure relating to sustainment of launch systems. This includes production and transport of vehicle systems, launch site infrastructure, provision of launch commodities and supplies (such as propellants), range infrastructure, and worldwide tracking sites.

c. Link Segment. Spacecraft on orbit require line-of-sight access to a ground station—or ability to crosslink to another spacecraft with access—in order to receive telemetry and tracking data from or send commands to the spacecraft. While some systems have dedicated ground systems for these activities, others are required to share limited resources (e.g., Satellite Control Network) to conduct telemetry, tracking, and commanding (TT&C). In general, link segments can be vulnerable to jamming or spoofing by adversaries, which could obstruct critical commanding or software updates. For launch vehicles, telemetry links are essential to tracking vehicle performance, and most modern launch vehicles depend on links from GPS satellites to ensure successful flight and accurate orbit insertion.

Fundamentals of Sustainment

Sustainment is the provision of logistics and personnel services to maintain operations until mission accomplishment and redeployment of the force. It is identified as one of seven joint functions—related capabilities and activities grouped together to help JFCs integrate, synchronize, and direct joint operations—and includes the provision of logistics, financial management, physical infrastructure, personnel services, and health service support necessary to maintain operations. Sustainment activities occur in a complex environment spanning the globe and multiple domains. Sustainment capabilities can come from a variety of military forces, other governmental organizations, nongovernmental organizations, or multinational forces. The essential challenge is to support increasing demand with constrained resources in a potentially contested environment. Understanding the global environment is essential to plan, execute, synchronize, assess, and coordinate sustainment operations.

Sustainment facilitates uninterrupted operations through means of adequate logistics support. Services accomplish this through supply systems, maintenance, and other services, which ensure continuing support through the lifecycle of the weapon system.

Acquirers should design sustainment into any system. Sustainment professionals cannot perform their duties properly, effectively, or efficiently if system sustainment is not part of system design. Sustainment professionals should consider all aspects (e.g., funding, other systems, personnel, processes) affecting a system’s supportability posture to ensure the system performs its mission as intended and expected. System designs should consider eliminating unique hardware (where possible) and reducing logistics footprints to the greatest extent possible.

a. **Principles of Sustainment.** The nine principles of sustainment are essential to achieving the Space Force's cornerstone responsibilities of preserving freedom of action, enabling joint lethality and effectiveness, and providing independent options.

1) **Integration** is combining all of the sustainment elements within operations assuring unity of command and effort. It requires deliberate coordination and synchronization of sustainment with operations across all elements of the competition continuum. One of the primary functions of the sustainment staff is to ensure the integration of sustainment with operations to guarantee mission readiness.

2) **Anticipation** is the ability to foresee operational requirements and initiate necessary actions. Professional judgment resulting from experience, knowledge, education, intelligence, and intuition shapes anticipation. Commanders and staffs need to understand, visualize, and communicate future operations and identify appropriate or required support. They should then start the process of acquiring the resources and capabilities that best support the operation. Commanders integrate risk management into the operations process to identify threats, assess those threats, and anticipate the capabilities, processes, or controls, required to mitigate the risk of gaps in support.

3) **Responsiveness** is the ability to react to changing requirements and meet the needs to maintain support. It is providing the right support in the right place at the right time. It includes the ability to meet operational needs rapidly.

4) **Simplicity** relates to processes, procedures, and equipment to minimize the complexity of sustainment. Unnecessary complexity of processes and procedures leads to confusion. Clarity of tasks, standardized and interoperable procedures, and clearly defined command relationships contribute to simplicity.

5) **Economy** is providing sustainment resources in an efficient manner that enables the commander to employ all assets to the greatest effect possible and within acceptable levels of risk. Eliminating unnecessary redundancy of capabilities (i.e., duplication of efforts) and capitalizing on joint interdependencies, to include shared capabilities with allies and partners, further enhance the principle of economy. Disciplined sustainment assures greatest possible tactical endurance and constitutes an advantage to commanders.

6) **Survivability** consists of a quality or capability of military forces to avoid or withstand hostile actions or environmental conditions while retaining the ability to fulfill their primary mission. Hostile actions and environmental conditions can disrupt the flow of sustainment and significantly degrade forces' ability to conduct and sustain operations. In mitigating risks to sustainment, commanders are often forced to rely on the use of redundant sustainment capabilities and alternative support plans.

7) **Continuity** is the uninterrupted provision of sustainment across the competition continuum. Continuity assures confidence in sustainment allowing commanders freedom of action, operational reach, and endurance.

8) **Improvisation** is the ability to adapt sustainment operations to unexpected situations or circumstances affecting a mission. It includes creating, arranging, or fabricating resources to meet requirements. It may also involve changing or creating methods that adapt to a changing OE. Sustainment leaders should work closely with acquisition professionals and operational leaders to visualize complex operations and support contingency planning requirements development. These skills and contingency plans enable commanders to improvise operational and tactical actions when enemy actions or unexpected events disrupt sustainment operations.

9) **Interoperability** is the ability to act together coherently, effectively, and efficiently to achieve tactical, operational, and strategic objectives. It is in the best interests of the United States (US) that its Armed Forces be interoperable with our multinational partners. The Space Force advances interoperability by promoting materiel and operational standardization between allies and possible coalition partners.

b. **Integrated Lifecycle Management.** Integrated Lifecycle Management governs all aspects of infrastructure, resource management, and business systems necessary for the successful acquisition of systems, subsystems, end items, and services to satisfy validated warfighter or user requirements. The management of systems throughout their lifecycle involves a multi-functional collaborative effort among the requirements, acquisition and sustainment, test, information operations, and intelligence communities.

c. **Maintenance.** The Space Force employs a maintenance structure of depot- and organizational-level maintenance to repair and maintain assets. These levels separate maintenance functions and actions depending on level of repair complexity, level of certified personnel, and type of required equipment, tools, or facilities to accomplish the maintenance. Maintenance planning provides optimal availability of ready, reliable systems at best value.

1) **Depot-Level Maintenance.** The purpose of depot-level maintenance is to perform maintenance requiring major overhaul or a complete rebuilding of parts, assemblies, subassemblies, and end items. Depot maintenance includes the manufacture of parts, modifications, testing, and reclamation as required; provides a source of serviceable equipment; and supports organizational maintenance by providing technical assistance or performing maintenance tasks beyond their responsibility. Depot maintenance is the most complex and extensive level of maintenance work and is a significant tie between the nation's industrial base and military operations. Depot maintenance includes all aspects of software maintenance/sustainment, which are those activities after initial operating capability of fielding, necessary to:

i. Correct defects and/or improve performance.

ii. Upgrade or modify to adapt and/or perfect the fielded software baseline to a changing/changed environment. Maintenance/sustainment can include the modifications or upgrades necessary to ensure safety and relevance in operations and interoperability with other systems.

2) **Organizational-Level Maintenance.** The purpose of organizational-level maintenance is to return systems to operational use. Organizational maintenance encompasses on-line maintenance and repairs necessary for day-to-day operations, as well as the intermediate, offline repair of components and end items for weapon systems and supply chains. Organizational maintenance is less complex than depot-level maintenance and serves as the link between strategic capabilities and tactical requirements. Accomplishing organizational-level maintenance brings an inherent level of mission downtime risk; thus, commanders and sustainment professionals should plan, resource, and continuously assess organizational-level maintenance throughout capability life cycles.

d. **Infrastructure.** For fixed facilities, building infrastructure—to include heating, ventilation, and air conditioning systems; power supply; and water supply—is as vital to operations as the system itself. Facilities requirements for space systems should be identified as early as possible and consider compatibility, security, and capacity with existing infrastructure. As one of the integrated product support elements, the sustainment strategy should include a robust recurring maintenance program and reduce or eliminate unscheduled mission downtime. For Service-level resource planning and advocacy, the Space Force leverages the US Air Force and its organizations to ensure Space Force installations, geographically separated unit, site, and field command requirements are prioritized and executed transparently and methodically. Standardized processes allow Space Force and Air Force leaders to apply cross-functional collaborative resourcing for the maintenance, repair, and construction of real property facilities and infrastructure. However, final approval of all projects and designation of budgeting priorities resides with the Space Force. The proper planning, programing, budgeting, and execution of infrastructure projects ensures resiliency requirements are met, failing components are replaced in a timely manner, and obsolete equipment (e.g., generators) is updated such that off-the-shelf replacement parts are readily available.

e. **Host-Nation Support.** Host-nation support (HNS) is a means to enable deployed forces to operate for extended periods away from national resources or sources of domestic support. While not uniquely a sustainment activity, it is a key enabler and provides effective support to military activities. Host-nation support achieves efficiencies and synergies through the best use of all of a host nation's (HN) available, pre-arranged resources. Host-nation agreements provide a viable means to adjust and tailor support requirements. Sources of HNS are organic military resources, supplies, and services from other government agencies or commercial entities that the HN contracts, coordinates, and controls. A significant element of the sustainment activity support comes from the HN or through direct commercial contracts. Both methods of support rely on the commercial market and, consequently, may not have the same levels of resilience as the force. Commercial organizations, structures, and resources obtained through HNS may be more susceptible to direct or indirect action by an adversary or internal unrest, therefore require more risk mitigation.

To develop a proper support strategy, it is important to know the makeup of the operations and maintenance (O&M) team (e.g., US, contractors, allies, partners). O&M contracts should consider the presence of allies and partners to ensure they receive the same level of training/orientation and support as US service members. Sustainment planners should review current international agreements and ensure allies are considered in O&M and sustainment decisions and processes to improve supportability of the system.

f. System Reliability, Availability, and Maintainability (RAM) Metrics. Maintaining high readiness levels is dependent on having a robust RAM program enabling the ability to identify system deficiencies and negative trends before they affect operational capability. RAM refers to three related characteristics of a system and its operational support: reliability, availability, and maintainability.

- **Reliability** is the probability of an item to perform a required function under stated conditions for a specified period under stated conditions. Reliability is a function of the environment and the stresses it places on a system. The conditions of use include, but are not limited to, the environment of operation, maintenance as specified, and operation within the design specifications. It is critical because it contributes to a system's warfighting effectiveness as well as its suitability in terms of logistics burden and the cost to fix failures. Reliability is also one of the most critical elements in determining the logistics infrastructure and footprint. Some parameters used to determine reliability include failure rate, mean time between failure, and mean time to failure.
- **Availability** is a measure of the degree to which an item is in an operable state and can be committed at the start of a mission. Sustainment professionals can measure availability by the number of minutes a system is operational in a 24-hour period, the number of days a system is operational in a year, or some other measurement and timeframe appropriate for the given system and the mission it supports. For example, sustainment professionals might calculate availability by subtracting all the days a system is in a "not available for operations" status (e.g., non-mission capable for maintenance or non-mission capable for supply) from 30 and dividing the difference by 30 to come up with an availability percentage. Operational availability and operational dependability are the primary metrics used to determine the health of a weapon system. Operational dependability refers to the probability a weapon system will remain operational throughout a mission if all scheduled maintenance actions are stopped.
- **Maintainability** is the ability of an item to be retained in, or restored to, a specified condition when personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair, perform maintenance. Many different parameters, such as mean time to repair, maximum time to repair, and maintenance ratio, can determine maintainability. The primary objective of developing maintainability and reliability requirements

for a system is to reduce the time it takes a properly trained maintainer to detect and isolate failures and repair them.

RAM, as well as other characteristics such as survivability and interoperability, is generally difficult to retrofit. Thus, it is paramount to factor them into a system or architecture early in the design and development process when life cycle sustainment costs are locked in. There is value in influencing the design of Department of Defense (DOD) and allied international systems (if intended to connect to an operational US system), as well as emerging commercial standards, as early as possible in the development and acquisition cycles to optimize future system compatibility, interoperability, life cycle cost, and the complexities of sustainment.

Chapter 2: Sustainment and the Competition Continuum

Competition continuum (figure 2) describes a world of enduring competition conducted through a mixture of cooperation, competition below armed conflict, and armed conflict. The Space Force delivers capabilities for space operations throughout the continuum. Sustainment solutions, challenges, and priorities for those capabilities change in relation to the situation. For example, the ability to acquire new technology and posture space systems during cooperation provides elevated deterrence from attack across the continuum. A successful sustainment and maintenance plan for ground stations and on-orbit repairs during the armed conflict element mitigates risks and capability losses.

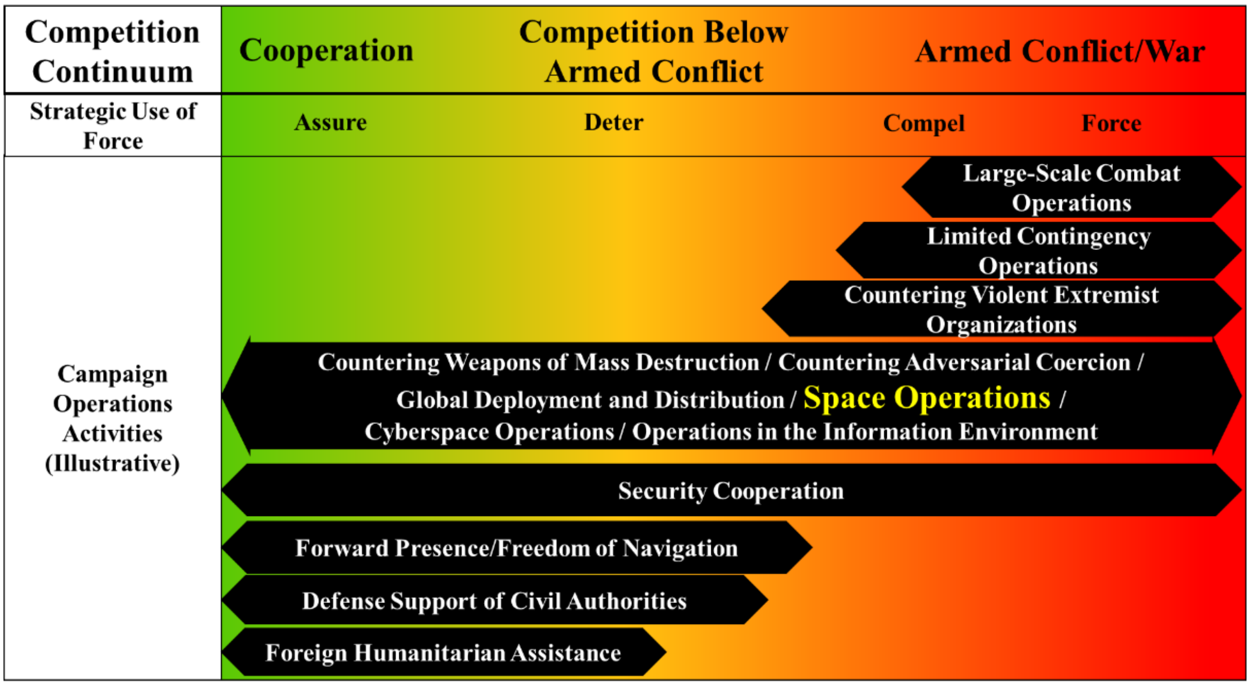


Figure 2. Competition Continuum

Cooperation and Adversarial Competition below Armed Conflict

In the continuum model above, sustainment operations to the left of armed conflict/war focus on building resources (human and materiel), projecting the force, protecting assets, and establishing sustainment processes and positions. During these elements, focus is on recruiting and training personnel to increase competency and ensure readiness of Guardians to conduct operations in support of armed conflict/war. Adversarial competition below armed conflict is also the time to stockpile materiel. One example might be the prepositioning of spare parts for remote space surveillance network sensors or satellite control network sites to prevent long outages caused by shipping delays or out-of-stock parts. Another example of this could be spare satellites on orbit to fill gaps in a constellation; however, rapidly evolving capabilities make it difficult and expensive to stock on-orbit spares for low-density constellations.

For the Space Force, operations include projecting power in, to, and from space, and around the globe through distribution of fixed and mobile terrestrial space assets. Distribution is a vital logistical function that is much easier (and more successful) below the level of armed conflict/war. The Space Force should establish robust (redundant and resilient) sustainment capabilities at key locations through the cooperation and adversarial competition below conflict elements. Resource buildup often requires significant lead-time in order to secure funding, train personnel, and produce supplies. Sustainment and logistics personnel should consider a number of items during the cooperation element of the competition continuum:

a. Supply. Actions should be taken to order, receive, store, and issue all materiel needed for servicing and maintaining energy, power, resources, and capabilities, both in garrison and deployed, to supply the mission, forces, and infrastructure. Supply plans should analyze past demand and anticipate commercial/contingency services (i.e., power, water), and materiel parts failures to forecast services and materiel needed to support current operations and validate future requirements. The completed analysis should be included in applicable acquisitions—current and future—with relevant terrestrial requirements.

b. Maintenance. Routine maintenance and modification actions are required to prepare mission elements to conduct assigned missions. These can include, but are not limited to, corrosion control and replacement of consumable materiel and components. Commanders should be prepared to balance required operational availability (uptime) with scheduled and unscheduled maintenance requirements (downtime) to maximize system reliability, effectiveness, and longevity.

c. Critical Infrastructure. Commanders should maintain oversight of system status and understand the vital requirements of the mission systems to maximize coordination of scheduled utility downtime with system downtime. They should also acknowledge assessment results defining required redundancies, oversee maintenance and testing of redundancies, direct project planning and maintenance of hardening plans to achieve the required hardening and system readiness, and report infrastructure readiness of task critical assets. Space Force sustainment professionals should integrate combatant command critical infrastructure priorities in facilities sustainment, restoration, and modernization and military construction integrated priority lists to meet the most critical warfighting mission needs first.

d. Operational Contract Support. Operational units should create and maintain peacetime contracts with flexibility for non-steady state operations to ensure readiness to conduct operations across the competition continuum.

Sustainment Operations during Armed Conflict/War

Sustainment operations during armed conflict differ from operations that precede armed conflict. Adversaries will create contested environments to delay, disrupt, or destroy resupply chains to deny access to capabilities. Immediately before transition from adversarial competition below armed conflict to armed conflict/war is the ideal time to surge production of supplies. Funding is likely available during these times with a sense of urgency to provide the necessary supplies for mission accomplishment. To support operations, prepositioning critical spares at remote terrestrial operating locations is key to prevent extended outages waiting for replacement parts to arrive. This requires consideration of the availability of appropriate storage (e.g., capacity, climate control) necessary to pre-position critical spare parts effectively. Once conflict begins, the sustainment operations should focus on replenishment and maximizing operational capability. Repositioning on-orbit satellites may be required to best support a specific geographic area or fill a gap in a constellation caused by an outage. Rushing a replacement part to a remote space surveillance network site may also be required to return it to an operational status. While supporting operations in armed conflict/war, deferring scheduled maintenance is an option; however, it may shorten the lifespan of equipment. Decisions on sustainment priority or conservation are key to successful sustainment of operational capabilities. Additionally, sustainment planners should consider potential increases to force protection of sustainment operations, as required. Sustainment and logistics personnel should consider a number of items while transitioning to, from, and during periods of armed conflict/war. They can coordinate to preplan and provide the following as services from the Base Operating Support-Integrator assigned in the region and via a base operations support agreement:

a. **Positioning.** Position mobile space assets in theater to support joint operations, as required, through (joint) reception, staging, onward movement, and integration of forces in the operational area. To successfully execute terrestrial expeditionary combat support, the following should be assessed:
   - Seaport opening and handling of munitions
   - Aerial port cargo handling, expeditionary airfield operations, and enroute support (strategic mobility)
   - Rail assets, over-the-road trucking, container handling capability, and petroleum, oil, and lubricant (POL) storage/distribution
   - Military heavy construction, specialized military construction, port operations support, engineering services, environmental units, and maintenance/munitions storage structures.
   - Hospitalization, tactical and strategic evacuation, resupply of medical materials, HNS, and elements of force health protection
   - Water production and distribution; electrical power; wastewater collection; heating, ventilation, and air conditioning; laundry; bath; food; shelter; mortuary; and decontamination services
   - General support theater maintenance, intermediate maintenance (i.e., central intermediate repair facilities), and continental US depot capability
   - Degradation of aerial ports of debarkation, seaports of debarkation, impact on HN, and contractor support bases
   - Security Forces, force protection of assets, and storage of classified assets requiring 24/7 monitoring

b. **Supply.** The functional capabilities that contribute to the supply chain include management of supplies and equipment; inventory management; management of global supplier networks; and assessment of global (forward-deployed and pre-positioned) requirements, resources, capabilities, and risks. Sustainment planners should forecast and plan for increased requirements at critical and/or geographically separated locations, as required by JFCs.

c. Maintenance. Maintenance professionals should synchronize service maintenance as much as possible to provide the most effective capabilities available to JFCs. Commanders may extend or temporarily waive scheduled maintenance requirements to maximize operational availability during surge operations. This could result in lengthy down time in order to return to full capacity following surge operations.

d. Critical Infrastructure. Sustainment professionals should minimize downtime of utilities they control by coordinating scheduled maintenance actions with operations. Sustainment professionals should identify, fund, and schedule facility upgrades to meet Space Force-defined resiliency, survivability, and endurability requirements. In addition, where the local community or HN provides utilities, sustainers should understand where this creates vulnerabilities and implement continuity of operations plans for critical capabilities. The dependency on HN utilities can have rippling effects and may impact ports, airfields, warehouses, depot resupply, maintenance facilities, medical facilities, beddown of forces capabilities, noncombatant evacuation operations facilities, POL storage & distribution, utility production capability, munitions storage, communication facilities, lines of communication, main supply routes, and basic expeditionary airfield resources assets and similar for future DOD and Space Force space logistics-related facilities.

e. Operational Contract Support. Implement flexible aspects of contracts to support operations during armed conflict/war, as required by combatant commanders. When writing or modifying statements of work for contracts, sustainment planners should ensure space systems operated and supported by contractors have specific requirements of the contractors (e.g., deploy to, live, and work at undisclosed locations) upon entering the armed conflict element of the competition continuum.

f. Reconstitution. Reconstitution is the restoration of functionality to an acceptable level for a particular mission, operation, or contingency after severe degradation. It includes both equipment and personnel. Reconstitution maintains control over resources and maximizes asset recovery. The objective is to replenish the force, primarily for future operations, but may also be necessary during armed conflict. One unique capability the Space Force should carefully plan for is conducting space access operations, in particular for reconstitution. The National Space Policy calls for "rapid launch options to reinforce or to reconstitute priority national security space capabilities in times of crisis and conflict." Spacelift operations require planning and lead-up operations to build, integrate, and deliver a payload or payloads to orbit. Reconstitution of ground systems, whether damaged or degraded by natural causes (e.g., flood, hurricane, or lightning) or adversary attack, is critical to ensuring continuous space operations. SSC serves as the single point of entry for assured access to space for all DOD launch requirements and as the service provider for all critical space mission partners.

Chapter 3: Sustainment Capabilities

The Department of the Air Force (DAF) leads the acquisition of space capabilities for the DOD. In addition, the Space Force provides rapid capabilities in response to emerging threats by providing processes to expedite delivery and deployment of capabilities in response to combatant commander requirements. The Space Force also leverages commercial industry and international partnerships in its efforts to ensure robust acquisitions and logistics. In carrying out its responsibilities, the Space Force plans for and provides sustainment and replacement of terrestrial, on-orbit, and some portions of the link segment capabilities. The approach to sustain these systems is different for each of the segments.

Successful sustainment of space capabilities across the competition continuum requires the understanding that space is a warfighting domain. Space Force elements should understand that sustainment of capability—including positioning, execution, and reconstitution of terrestrial, link, and orbital segments of space systems—are ongoing processes happening simultaneously across all three segments. These processes should take into consideration the ability to continue sustaining those capabilities beyond the cooperation element and into the adversarial conflict below armed conflict and armed conflict/war elements of the continuum.

On-Orbit Sustainment

The orbital (space) segment comprises all spacecraft in orbit beyond Earth's atmosphere. The Space Force supports the joint force sustainment activities with unique on-orbit capabilities for supporting many of the core logistics functions. Management of constellation health and positioning of on-orbit assets is an ongoing process to respond to changes in the OE and requirements from the JFC. These processes require operators to communicate regularly with SSC acquirers and sustainers to ensure requirements synchronize with sustainment of current capabilities and delivery of future capabilities. Each orbital asset has a finite life span relative to onboard fuel, power, or other life-limited components. Sustainment of the orbital segment should include consideration for capability improvements and planning for end-of-life disposal. Today, capability improvements can only be implemented either through updates to on-board software or changes in tactics, techniques, and procedures relative to use of the asset. Both paths can be implemented independently, but usually occur together as a combined effort to maintain or improve capabilities.

Future On-Orbit Sustainment

Already demonstrated in the commercial sector, orbital sustainment will allow military space forces to replenish consumables and expendables on spacecraft when that option is more practical than recovery back to Earth or disposal/reconstitution. Orbital sustainment also enables spacecraft inspection, anomaly resolution, hardware maintenance, and technology upgrades. Orbital recovery allows for the recovery of personnel or military equipment from the space domain. This includes objects such as reusable spacecraft and launch systems.

a. **Space Access, Mobility, and Logistics (SAML).** SAML includes the movement, deployment, assembly as needed, and support of military equipment in, to, and from the space domain. The ability to control and exploit the space domain always begins with physical access to orbit. SAML starts with the ability to launch military equipment into the proper orbit in a safe, secure, and reliable manner. During conflict, space launch needs to be dynamic and responsive, providing the ability to augment or reconstitute capability gaps from multiple locations. In-space docking of multiple orbital assets is a pervasive and enabling operational capability providing physical connectivity that is a prerequisite to accomplishing many future mobility and logistics tasks. In addition, Space Force is the lead Service for ongoing studies and technology assessments to determine the viability of using rockets as a rapid, global cargo delivery platform to support military missions including rapid response, urgent resupply, and humanitarian aid delivery.

b. **Coordination.** Sustainment of certain on-orbit assets require extensive coordination both within the US Government and externally with the international community. An example of this is the maintenance of geosynchronous slots supporting Military Satellite Communications activities. Each slot used for communications should be deconflicted and prioritized to ensure each agency requiring bandwidth has access to the right locations in support of their unique missions. The registration and maintenance of locations and frequencies requires coordination with the International Telecommunications Union, which is responsible for assigning and de-conflicting these limited locations across the international community.

c. **Debris Mitigation**. Orbital sustainment activities also need to account for environmental sustainment. The exponential increase in the number of active and inactive objects in space demands that Guardians consider compliance with Orbital Debris Mitigation Standard Practices, conjunction de-confliction/maneuvers, and end-of-life disposal plans early and throughout the life of the system. The Space Force coordinates end-of-life planning to ensure it does not create additional debris or negatively impact the space environment.

d. **Positioning, Execution, and Reconstitution.** One consideration and challenge for the orbital segment is the concept of positioning, execution, and reconstitution. In space operations, the assets are on orbit regardless of where the joint force is operating on the competition continuum. In executing sustainment activities for the orbital segment, the main difference is in the focus. During cooperation, the focus is on efficiently managing constellations and assets to minimize fuel usage and maximize operational support to the other services. During armed conflict/war, sustainment of the orbital segment would focus on reconstitution type activities such as quickly returning degraded assets to operations or maneuvering assets, as necessary, to maximize capabilities. For example, the loss of a satellite in a constellation may require the repositioning of one or more remaining satellites in order to maximize coverage either globally or over a particular area of responsibility (AOR).

Reconstitution of on-orbit capabilities should also account for future concepts of on-orbit mobility, rapid access to space through launch of new assets on tactically defined timelines, and on-orbit logistics and maintenance. Planning for these capabilities should include the entire cycle from production of a new on-orbit asset, through processing, launch, refueling, maneuver, and maintenance of the capability.

On-Orbit Refueling

Commercial companies are exploring several concepts to conduct on-orbit fluid transfer between spacecraft to address maneuver without regret and mission extension (logistics) concepts. In addition to actual fluid transfer, other concepts for life extension exist to include "jet-pack" systems, which dock with and take over station-keeping functions for the client spacecraft. Commercial industry demonstrated this functional capability in 2020 by docking a servicing spacecraft with an Intelsat satellite and extended its operational lifespan by conducting station-keeping maneuvers for the satellite. Multiple commercial companies are also exploring entering the fluid transfer market, some with plans to field on-orbit capabilities in the next 5-10 years. These and similar capabilities present new opportunities for space sustainment operations and improve operations, training, and space access capabilities.

e. **Rendezvous, Proximity Operations, and Docking.** Rendezvous, proximity operations, and docking are prerequisite enabling capabilities for routinely accomplishing many future autonomous mobility and logistics tasks in space, including post-deployment orbit raising of spacecraft by orbital transfer vehicles. Rendezvous is a mission phase that begins when a visiting spacecraft locates and identifies a target spacecraft and maneuvers closer to the target vehicle. Proximity operations commence when a visiting vehicle enters the keep-out sphere established for the target vehicle. Proximity operations encompass multiple potential mission phases before and after contact with the target vehicle including fly-

In-Space Assembly and Modular Hardware Change-Out

Certain future orbital assets may be too large or complex to permit full deployment by a single launch. In-space assembly capabilities may enable modules deployed by multiple launches to connect through robotic or other autonomous/semi-autonomous techniques to achieve full deployment and operability. Likewise, hardware repair, hardware replacement, or technology upgrades through module change-out may become feasible and practical.

around and inspection, final approach, undocking, and departure. This also includes all maneuvers within the keep-out sphere associated with the target vehicle, to include docking with another vehicle.

Terrestrial Sustainment

The terrestrial segment encompasses all the equipment within the terrestrial domains required to operate or exploit a spacecraft. This includes control stations, antennas, tracking stations, radars, launch sites, launch platforms, user equipment, and facility critical infrastructure. The Space Force supports terrestrial capabilities, both fixed and mobile in all elements of the competition continuum. Mobile and fixed Space Force assets are postured to support space operations, as required by the JFC. Sustainment operations should include resupply of the following, at a minimum: food, fuel, critical infrastructure redundancy, primary and alternate sources of electricity, heating/cooling, water, sewer, and trash removal. Personnel need the support that provides the resources to operate the installations and medical support. Space Force planners should expect to coordinate with and receive sustainment support from service components assigned to, and directed by, the supported combatant command.

a. **Required Support.** The unique challenges and operational requirements to the Space Force necessitate that the Service employs a lifecycle management approach of sustainment concerning weapon system RAM. SSC plays a major role in weapon system sustainment by coordinating operational requirements, establishing sustainment contacts with the commercial vendor, and integrating the system-of-systems with the DOD and other agencies. The Air Force, Marine Corps, Army, Navy, and commercial partners support Space Force terrestrial assets in locations that span the globe. Examples include planning for the use, and support, of the assigned lead Service for the distribution of spare parts; the transportation of passengers and equipment for mobile capabilities; connectivity to communications networks; requesting operational contract support such as fuel delivery; and providing of food, water, and security to both fixed and forward deployed operating locations.

b. **Maintenance Priorities.** While the Space Force conducts most space operations from locations in the continental US, they support operations across the globe. Therefore, the Space Force should prioritize maintenance and sustainment of critical systems that support space capabilities based on the operations they are supporting. For example, heating, ventilation, and air conditioning systems that cool control system equipment are integral to keeping satellite control systems operational by preventing malfunction from overheating. These considerations go beyond basic installation management. Failure to prioritize activities appropriately to maintain or restore these functions could have significant operational impact on major combat operations.

   Similarly, commanders should give special attention to planning for maintenance (scheduled and unscheduled) and sustainment during periods of time when operational elements are supporting joint operations in high intensity conflict. While commanders may elect to delay scheduled periodic maintenance to ensure continuous support to operations, those delays can, and will, eventually result in reduced capability and risk of major degradation from lack of maintenance. Both operational and sustainment elements should plan and coordinate for changes to maintenance priorities across the competition continuum to maximize operational effectiveness while minimizing negative long-term effects to the systems.

c. **Personnel.** The sustainment function of personnel services includes personnel management, readiness, and replenishment. Some elements of personnel management concerning recruitment, retention, and reconstitution of forces are unique to the Space Force. The small size of the Space Force brings unique challenges to how it can balance training, operations, and other institutional requirements. For space sustainment operations, the focus should be on maintaining technical proficiency in core disciplines without affecting the ability to conduct operations. This includes reconstitution and replenishment of personnel, which requires close coordination between organizations to ensure sustainment of personnel requirements through the recruiting and training pipelines, combined with efficient transition of Guardians from training into positions directly supporting operations, systems support functions, and operational systems development. This also includes the training of Airmen who are directly responsible for the protection and sustainment of critical Space Force facilities and infrastructure (e.g., radars, command and control nodes, critical communications, and link segments) around the globe.

d. **Host-Nation Support.** The terrestrial segment of space systems consists of fixed space surveillance network sites, fixed TT&C facilities (e.g., satellite control network sites), and mobile systems dispersed around the globe. As a result, many of these capabilities operate in foreign territories, resulting in sustainment challenges. HN agreements are a key component to ensure that HNS can effectively support operations. Some key considerations for sustainment professionals under these circumstances include site security and training for HN operators and maintainers (when required).

Link Sustainment

The link segment comprises the signals in the electromagnetic spectrum that connect the terrestrial segment and the orbital segment. Uplink signals transmit data from terrestrial assets to spacecraft. Downlink signals transmit data from a spacecraft to terrestrial assets (e.g., ground stations, ships, aircraft). Crosslink signals transmit data from one spacecraft to another. This link normally includes TT&C signals necessary for controlling the spacecraft and payload. In addition, the TT&C link is necessary to downlink important data regarding status of the spacecraft for sustainment requirements.

Preparation for, and execution of, sustainment activities for space systems need to be well thought out and preplanned to ensure disruptions are limited and risks to the spacecraft are mitigated. One threat to sustainment operations on orbit is the potential for adversaries to degrade or deny transmission and/or receipt of critical TT&C communications through either jamming or cyberspace activities. The link segment provides the means to connect space systems from different domains with each other (e.g., ground-to-ground, ground-to-space, and space-to-ground). The link segment accomplishes this via the electromagnetic spectrum or terrestrial links to perform space operations as well as sustain terrestrial and on-orbit space capabilities. The link segment also provides the ability to operate various ground-based systems remotely; send commands to and receive telemetry and tracking data from on-orbit spacecraft; and command and control distributed forces within the space architecture.

The link segment is composed of a compilation of services provided by organic and non-organic (e.g., commercial) organizations. The link environment is contested and congested, complicated or disrupted by directed cyberspace attacks or signal interruptions resulting from natural, adversarial, or friendly electromagnetic interference. Sustainment of the link segment requires well-defined requirements implemented in service-level agreements combined with strong relationships and cooperation with allies and partners to maintain robust link architectures. Link segment sustainment plans should consider the link segment as operating in degraded environments and include recovery actions, considerations for alternate routing, and redundant systems. The plans should mitigate risks by incorporating primary, alternate, contingency, and emergency plans. The Space Force relies heavily on processes put in place by service providers and agreements to complete its mission objectives across the competition continuum.

Link Connectivity

Signal interference and congested frequencies are significant concerns resulting from the increasingly congested and contested space domain. Organizations such as the Space Development Agency are working to deliver low-latency, reliable connectivity for the warfighter through development of modernized waveforms and software defined solutions. Opening up secure lines of communication via new waveforms will allow warfighters to utilize uncompromised communications capabilities across the battlespace.

Successful sustainment of space capabilities across all three segments depends on the integration of sustainment processes with operations. From a sustainment perspective, the Space Force is responsible for those aspects of military operations required to deliver the required capabilities to the JFC. These include design and development; acquisition, storage, movement, distribution, maintenance, and disposition of materiel; acquisition or construction, maintenance, operation, and disposition of facilities; and acquisition or furnishing of services for space assets and personnel. Currently, the Air Force augments these activities with personnel and other support to include legal, religious affairs, finance, contracting, weather, and mortuary affairs. Other programs offered include equal opportunity and diversity, medical readiness and health programs, family advocacy and readiness programs, sexual assault prevention and response; base services, such as exchanges and commissaries; and morale, welfare, and recreation programs.

Challenges to Space Sustainment

The Space Force faces a number of challenges in the sustainment of terrestrial and on-orbit space systems. The ability of the acquisition and sustainment communities to address these sustainment challenges is crucial to mission success in providing enduring space capabilities to the joint force. Challenges specific to space operations include, but are certainly not limited to, high-demand, low-density (HDLD) nature of space capabilities, aging systems, and rapid fielding processes currently being implemented to modify existing capabilities or add new capabilities.

a. **High Demand, Low Density Capabilities.** The HDLD nature of space capabilities can make sustainment activities particularly challenging for systems throughout their lifecycles. The Space Force, when acquiring new systems, should focus on the supportability of the required space capability to emphasize sustainment during the system design and development. This should also be a key component during development of every mission's concept of operations to ensure the Space Force fields new systems with unique sustainment functions and features (e.g., refueling, docking, and upgrade interfaces and capabilities) in mind, and with the correct critical infrastructure configuration to support mission readiness. For legacy systems, sustainment activities are particularly challenging due to them operating well beyond their initial design life. Sustainment activities such as system upgrades, modifications, or normal maintenance activities require proper coordination between operators, users, and sustainment professionals to minimize operational impacts and ensure proper mission coverage during those events. Logistics planners should establish controls to maintain minimum stock level and contracts for fabrication of the items even when the items are no longer available. Future designs should consider flexible line replaceable units and easily upgraded software, where possible.

b. **Aging Space Systems.** The Space Force typically retains capabilities in the inventory well beyond their projected life expectancy; some operational systems are over 50 years old. The Space Force also repurposes a number of space assets to provide additional capabilities or meet new mission requirements in lieu of starting new acquisitions. Aging systems and support infrastructures being past their intended lifespan results in them experiencing obsolescence and diminishing manufacturer resources. It is also driving materiel shortages and cybersecurity issues while hindering the ability to keep up with new requirements. As these technologies continue to grow older, training and replenishing manpower becomes particularly difficult because the required expertise no longer matches available skills.

c. **Rapid Fielding Programs.** The Space Force often uses rapid fielding processes to upgrade or modify existing capabilities, which drives adjustment to the existing sustainment tail to match the new sustainment posture. Rapid fielding programs also enable the accelerated delivery of new capabilities needed to stay ahead of evolving threats. It is important for sustainment professionals to plan for sustainment obstacles and employ innovative approaches during acquisition to enable the system's sustainment capabilities to evolve after initial fielding to fulfill operational needs more effectively.

Examples include use of reliability growth strategies, implementation of resilient infrastructure coordinated with existing base support agencies, technology insertion, interim contractor support, and incremental or follow-on deliveries of sustainment items and documentation. A lifecycle sustainment plan should document how sustainment will be performed for rapid fielding programs. The plan should include funding the sustainment of these systems through the Future Years Defense Program.

d. **Early Use prior to Operational Acceptance.** Early use is another sustainment consideration a logistician should factor into their support strategy. A combatant commander can request the use of an asset before the formal operational acceptance process is complete. While the formalized operational acceptance process is necessary to round out the Research, Development, Test, and Evaluation and O&M processes of standing up new systems, enabling flexibility in the employment of capabilities is imperative to the real-time success of space systems.

As the servicing Major Command (MAJCOM) for the Space Force in the continental United States, Air Force Materiel Command (AFMC) provides security, civil engineering, base operations support, installation and mission support, and materiel services to the Space Force. Sustainment planners should coordinate with the servicing MAJCOM supporting Space Force systems to ensure consideration regarding appropriate infrastructure and proper security forces for the system.

Chapter 4: Roles, Responsibilities, and Relationships

> *During the analysis that led to the creation of the USSF, Congress identified over 60 offices responsible for elements of space policy, oversight, and guidance, with nearly 30 more who influence space architecture. We will work across the Department to unify and harmonize efforts.*
>
> *Chief of Space Operations' Planning Guidance, 9 November 2020*

The Space Force is a light, lean, and agile force focused on space operations. Its mission is to organize, train, and equip space forces in order to protect US and allied interests in space and provide space capabilities to the joint force. Space Force responsibilities include developing Guardians, acquiring military space systems, maturing military doctrine for space power, and organizing space forces to present to combatant commanders. Space sustainment should then focus on Space Force mission and readiness requirements while considering the interdependencies of internal and external support provided by the other services, commercial providers, and other DOD agencies. During its standup, the Space Force took a federated approach to differentiate sustainment roles and responsibilities between headquarters and field command levels. Headquarters will provide policy, guidance, oversight, enterprise planning, programming, and resourcing of organize, train, and equip functions. Field commands and component-field commands will develop, implement, field, and execute organize, train, and equip functions focused on readiness, training, and operations.

Office of the Chief of Space Operations

The Office of the Chief of Space Operations (OCSO) is comprised of four directorates: Human Capital, Operations, Strategic Requirements, and Technology and Innovation. The Mission Sustainment directorate (SF/S4O) reports directly to the Chief Operations Officer, as the service-level advisor for the sustainment of Space Force operations. The SF/S4O is responsible for standardization and normalization of space capability sustainment by developing and publishing sustainment policies and procedures that apply to all Space Force units; advocating for sustainment funding during budgeting decisions; working to improve space capability sustainment funding levels; and ensuring funding and planning of proper sustainment tails for new programs. The SF/S4O works closely with the Global Force Management and Readiness directorate (SF/S7O) to define and design sustainment metrics and readiness reporting; enhances collaboration between stakeholders; and develops infrastructure resilience requirements and security planning factors for future space capability.

a. **Space Systems Command.** SSC is one of the Space Force field commands responsible for developing, acquiring, equipping, fielding, and sustaining lethal and resilient space capabilities for warfighters. As part of fielding, SSC is responsible for developmental testing, launch operations, on-orbit checkout, sustainment, and maintenance of military satellite constellations, their supporting ground stations, and other DOD space systems. This includes, but is not limited to the following sustainment activities:

- Develop and update life cycle sustainment plans
- Manage weapon system sustainment portfolios with Air Force Materiel Command
- Oversee the SAML portfolio of services and capabilities
- Ensure contracts include surge capabilities and adequate response times for increased flexibility
- Procure launch services and delivering on-orbit capabilities for warfighters, combatant commanders, intelligence, civil and commercial sectors, as well as responsibility for range sustainment programs supporting launch and test
- Manage acquisition lifecycle from research and development, to prototyping, to production line systems
- Ensure interoperability of space systems across mission portfolios and systems

b. **Space Operations Command.** SpOC is the Space Force field command charged with generating, presenting, and sustaining combat-effective warfighting capabilities to US Space Command. More specifically, pertaining to mission sustainment, SpOC is responsible for the following:

- Human capital issues to include organizational change requests; manpower recommendations; promotions; and Guardian/Airman development, evaluations, and recognition
- Maintenance and sustainment support, logistics, compliance, and resilience of fielded space mission systems and weapon systems
- The delivery, integration, and sustainment of capabilities generated and employed at the Space Delta and/or Space Force component levels
- Interlinking Space Deltas, Space Base Deltas, Mission-Area Teams, and Program Managers to optimize reliability, maintainability, and survivability of our fielded systems while improving and tracking the readiness posture of critical installation capabilities, which directly support our space missions
- Overseeing the delivery and sustainment of battle management command, control, and communications capability solutions at the Deltas and combatant commands
- Performing validation and verification analysis supporting operations acceptance decisions for new or modified space domain awareness sensor systems and space domain awareness command and control systems capabilities
- Managing and executing the Advanced Concepts and Missions Process to assess, sponsor, and transition new and innovative technologies/concepts through the process to programs of record and warfighter operations

- Development, assessment, and reporting of infrastructure resilience requirements, to include uninterruptable power supplies, for space task critical assets

c. **Space Training and Readiness Command (STARCOM).** STARCOM prepares combat-ready forces to fight and win in a contested, degraded, and operationally-limited environment through the deliberate development, education and training of space professionals; development of space warfighting doctrine, tactics, techniques, and procedures; and the test and evaluation of Space Force capabilities. More specifically, respective STARCOM Space Deltas perform the following missions:

- Develop Guardians through a career-long continuum of innovative basic military, initial skills, and advanced training courses as well as Space Force and joint exercises
- Deliver realistic, threat-informed test and training environments through the provision of live, virtual, and constructive range and combat replication capability
- Develop Space Force doctrine and tactics, conduct the Space Force Lessons Learned Program, and execute and support wargames
- Deliver institutional developmental education
- Develop Space Force officer accessions
- Execute advanced education programs in order to prepare Space Force forces and designated joint and allied partners
- Conduct independent test and evaluation of Space Force capabilities and delivery of timely, accurate, and expert information in support of space capability acquisition, operational acceptance, and readiness decisions

Other Department of Defense (DOD) Organizations

In addition to those within the Space Force, a number of other organizations fulfill roles that contribute to the sustainment of space capabilities.

a. **Air Force Materiel Command (AFMC).** In order to implement the vision of a light, lean, and agile force focused on space operations; reduce costs; and avoid duplication of effort, the Space Force obtains the majority of its enabling functions from the US Air Force. AFMC, as the designated servicing MAJCOM, is the primary source for infrastructure, logistics, base operating support, security, medical services, and a host of other common capabilities. This support relationship varies dependent upon whether the unit is located on a Space Force or Air Force installation. For Space Force units on Space Force installations, AFMC coordinates directly with OCSO and provides logistics support to the Space Base Delta or Space Launch Delta. For Space Force units on Air Force installations, the host wing supports those units through the base Mission Support Group.

b. **Air Force Research Laboratories (AFRL).** AFRL leads the discovery, development and integration of affordable warfighting technologies for DOD air, space, and cyberspace forces. In addition, AFRL coordinates and collaborates with academia and industry. AFRL enables the Space Force to leverage emerging and future technologies to define current and future space sustainment efforts. Space Force performs these through existing relationships and forums with program offices and staff in SSC and SpOC.

Intelligence Community, Other US Government Agencies, Allies, and Commercial Partners

The 2018 National Military Strategy acknowledges the unique contributions of allies and partners, a strategic source of strength for the joint force. Building strong, agile, and resilient sustainment abilities requires better interoperability to enhance the combat lethality and survivability of our allied and partner space capabilities. Our allies and partners provide complementary capabilities and forces along with unique perspectives, regional relationships, and information that improve our understanding of the environment and expand our options. Allies and partners also provide access to critical regions, supporting a widespread basing and logistics system that underpins global reach. The Space Force should integrate and synchronize sustainment with operations at every level, to include those of our joint and multinational partners. Sustainment depends on joint and multinational strategic links for strategic airlift, sealift, intra-theater airlift, rail systems, ports of debarkation/embarkation (sea and air), and strategic and theater-level supply support. Sustainment also depends on host-nation partners to provide infrastructure and logistics support necessary to deliver both maneuver forces and follow-on sustainment to the right place, at the right time, and in an operable condition. Where appropriate, military space sustainment efforts should be coordinated with the Intelligence Community, civil, and commercial space programs. These can include the National Reconnaissance Office, National Aeronautics and Space Administration, and a host of commercial space systems developers. The Space Force benefits from government and commercial partnerships to enhance capabilities in space launch and space sustainment. The In-Space Servicing, Assembly, and Manufacturing (ISAM) National Strategy exemplifies the coordination of several US Government entities in developing current strategy relevant to space systems sustainment. This strategy outlines how the US will support and stimulate the US Government academic and commercial ISAM capability development. It provides strategic goals to advance ISAM capability development discussed in the US Space Priorities Framework.

Appendix A: Acronym Listing

AFMC	Air Force Materiel Command
AFRL	Air Force Research Lab
AOR	area of responsibility
DAF	Department of the Air Force
DOD	Department of Defense
GPS	Global Positioning System
HDLD	high demand, low density
HN	host nation
HNS	host-nation support
ISAM	in-space servicing assembly and manufacturing
JFC	joint force commander
MAJCOM	Major Command
MTA	middle tier of acquisition
O&M	Operations and Maintenance
OCSO	Office of the Chief of Space Operations
ODMSP	Orbital Debris Mitigation Standard Practices
OE	operational environment
POL	petroleum, oil, and lubricant
RAM	reliability, availability, and maintainability
RCO	Rapid Capabilities Office
SAML	space access, mobility, and logistics
SDP	Space Doctrine Publication
SF/S4O	Space Force Mission Sustainment Directorate
SF/S7O	Space Force Global Force Management and Readiness Directorate
SFB	Space Force Base
SWAC	Space Warfighting Analysis Center
SpOC	Space Operations Command

SSC	Space Systems Command
STARCOM	Space Training and Readiness Command
TT&C	telemetry, tracking, and commanding
US	United States
USSF	United States Space Force

Appendix B: Applicable Strategic and Planning Guidance, Policy, and Doctrine

1. **Interim National Security Strategic Guidance, March 2021** – Identifies National Security Priorities as an obligation to protecting the security of the American people, enduring interest in expanding economic prosperity and opportunity, and a commitment to realizing and defending the democratic values at the heart of the American way of life. Promotes doing this, in part, by reinvigorating and modernizing alliances and partnerships around the world.
2. **Fact Sheet: 2022 National Defense Strategy** – Consistent with the President's Interim National Security Strategic Guidance, the classified National Defense Strategy sets out how the DOD will contribute to advancing and safeguarding vital U.S. national interests – protecting the American people, expanding America's prosperity, and realizing and defending our democratic values.
3. **2018 National Military Strategy** – Provides the Joint Force a framework for protecting and advancing US national interests. Pursuant to statute, it reflects a comprehensive review conducted by the Chairman with the other members of the Joint Chiefs of Staff and the unified combatant commanders.
4. **Defense Space Strategy Summary, June 2020** – Identifies how DOD will advance spacepower to enable the DOD to compete, deter, and win in a complex security environment characterized by great power competition.
5. **National Space Strategy Fact Sheet, 2018** – The National Space Strategy prioritizes American interests, ensuring a strategy that will make America strong, competitive, and great. The strategy features four "essential pillars" that constitute a whole-of-government approach to United States leadership in space, in close partnership with the private sector and our allies.
6. **United States Space Priorities Framework, December 2021** – The Space Priorities Framework outlines the White House's space policy priorities, including addressing growing military threats and supporting "a rules-based international order for space." It guides the National Space Council's efforts to develop and implement national space policy and strategy.
7. **Space Capstone Publication, 10 August 2020** – The capstone doctrine for the United States Space Force and represents the Service's first articulation of an independent theory of spacepower. This publication answers why spacepower is vital for our Nation, how military spacepower is employed, who military space forces are, and what military space forces value.
8. **Chief of Space Operations' Planning Guidance, 2020** – Provides foundational direction for the Space Force to advance National and DOD strategic objectives. This authoritative Service-level planning guidance supersedes previous guidance and provides the context and outline for our new Service design.
9. **Joint Publication 3-14, Space Operations** – This publication provides fundamental principles and guidance to plan, execute, and assess joint space operations. It sets forth joint

doctrine to govern the activities and performance of the Armed Forces of the United States in joint operations, and it provides considerations for military interaction with governmental and nongovernmental agencies, multinational forces, and other interorganizational partners. It provides military guidance for the exercise of authority by combatant commanders and other JFCs, and prescribes joint doctrine for operations and training.

10. **DOD Guide for Achieving Reliability, Availability, and Maintainability (August 3, 2005) –** This guide addresses RAM as essential elements of mission capability. It focuses on what can be done to achieve satisfactory levels of RAM and how to assess RAM.

11. **Orbital Debris Mitigation Standard Practices (November 2019 Update)** – The US Government Orbital Debris Mitigation Standard Practices (ODMSP) were established in 2001 to address the increase in orbital debris in the near-Earth space environment. The goal of the ODMSP was to limit the generation of new, long-lived debris by the control of debris released during normal operations, minimizing debris generated by accidental explosions, the selection of safe flight profile and operational configuration to minimize accidental collisions, and post-mission disposal of space structures. This 2019 update includes improvements to the original objectives as well as clarification and additional standard practices for certain classes of space operations.

12. **DODI 5000.80, Operation of the Middle Tier of Acquisition –** This issuance describes the responsibilities of principal acquisition officials and the purpose and key characteristics of the middle tier of acquisition (MTA) acquisition pathway. The MTA pathway is intended to fill a gap in the defense acquisition system for those capabilities that have a level of maturity to allow them to be rapidly prototyped within an acquisition program or fielded, within five years of MTA program start. The MTA pathway may be used to accelerate capability maturation before transitioning to another acquisition pathway or may be used to minimally develop a capability before rapidly fielding.

13. **DODI 5000.81, Urgent Capability Acquisition –** This supplement provides AF guidance for the acquisition of capabilities fulfilling Joint Urgent Operational Needs, Joint Emergent Operational Needs, and Urgent Operational Needs.

14. **DODD 5000.71, Rapid Fulfillment of Combatant Commander Urgent Operational Needs** – Establishes the Warfighter Senior Integration Group as a standing DOD-wide forum to: (1) Lead and facilitate agile and rapid responses to combatant commander urgent operational needs, and to recognize, respond to, and mitigate the risk of operational surprise associated with ongoing or anticipated near-term contingency operations. These urgent operational needs include joint urgent operational needs , and joint emergent operational needs identified by combatant command. (2) Facilitate the resolution of other urgent warfighter issues as identified by the Co-Chairs of the Warfighter Senior Integration Group.

15. **In-Space Servicing, Assembly, and Manufacturing National Strategy (April 2022)** – This document provides an interagency strategy to guide US Government direction for ISAM. The Office of Science and Technology Policy formed an interagency working group, in collaboration with the National Space Council, for which this is the product. This ISAM National Strategy directly supports the US Space Priorities Framework, with a focus on

scientific and technological innovation, economic growth, commercial development, the rule of law, open markets, freedom of navigation, and fair trade.

Appendix C: Glossary

Adversary — A party acknowledged as potentially hostile to a friendly party and against which the use of force may be envisaged. (JP 3-0)

Alliance — The relationship that results from a formal agreement between two or more nations for broad, long-term objectives that further the common interests of the members. (JP 3-0)

Area of Responsibility — The geographical area associated with a combatant command within which a geographic combatant commander has authority to plan and conduct operations. (JP 1)

Armed Conflict — Situations in which joint forces take actions against a strategic actor in pursuit of policy objectives in which law and policy permit the employment of military force in ways commonly employed in declared war or hostilities. (JDN 1-19)

Competition Below Armed Conflict — Situations in which joint forces take actions outside of armed conflict against a strategic actor in pursuit of policy objectives. These actions are typically nonviolent and conducted under greater legal or policy constraints than in armed conflict but can include violent action by the joint force or sponsorship of surrogates or proxies. (JDN 1-19)

Competition Continuum — A world of enduring competition conducted through a mixture of cooperation, competition below armed conflict, and armed conflict. (JDN 1-19)

Cooperation — Situations in which joint forces take actions with another strategic actor in pursuit of policy objectives. (JDN 1-19)

Debris — For space, refers to any spacecraft or artificial satellite (e.g., a rocket body) in orbit that no longer serves a useful purpose. (SCP)

Host Nation — A nation which receives forces and/or supplies from allied nations and/or North Atlantic Treaty Organization to be located on, to operate in, or to transit through its territory. (JP 3-57)

Joint — Connotes activities, operations, organizations, etc., in which elements of two or more Military Departments participate. (JP 1)

Link Segment — Comprises the signals in the electromagnetic spectrum that connect the terrestrial segment and the orbital segment. (SCP)

Logistics — Planning and executing the movement and support of forces. (JP 4-0)

Maintenance — 1. All action, including inspection, testing, servicing, classification as to serviceability, repair, rebuilding, and reclamation, taken to retain materiel in a serviceable condition or to restore it to serviceability. 2. All supply and repair action taken to keep a force in condition to carry out its mission. 3. The routine recurring work required to keep a facility in such condition that it may be continuously used at its original or designed capacity and efficiency for its intended purpose. (JP 4-0)

Multinational — Between two or more forces or agencies of two or more nations or coalition partners. (JP 5-0)

Operational Environment — A composite of the conditions, circumstances, and influences that affect the employment of capabilities and bear on the decisions of the commander. Also called **OE.** (JP 3-0)

Orbit — Any path through space an object follows based on the pull of gravity. While orbits are commonly depicted as circular or elliptical paths, orbits can be repeating or non-repeating. (SCP)

Orbital Segment — Consists of a spacecraft in orbit beyond Earth's atmosphere. Depending on the application, spacecraft can be remotely piloted, crewed, or autonomous. (SCP)

Partner Nation — 1. A nation that the United States works with in a specific situation or operation. (JP 1) 2. In security cooperation, a nation with which the DOD conducts security cooperation activities. (JP 3-20)

Reconstitution — Actions taken to rapidly restore functionality to an acceptable level for a particular mission, operation, or contingency after severe degradation. (JP 3-14)

Resources — The forces, materiel, and other assets or capabilities apportioned or allocated to the commander of a unified or specified command. (JP 1)

Space Capability — 1. The ability of a space asset to accomplish a mission. 2. The ability of a terrestrial-based asset to accomplish a mission in or through space. 3. The ability of a space asset to contribute to a mission from seabed to the space domain. (JP 3-14)

Spacecraft — An object which has been engineered to be controlled and deliberately employed in order to perform a useful purpose while traveling in, from, and to the space domain. (SCP)

Sustainment — The provision of logistics and personnel services required to maintain and prolong operations until successful mission accomplishment. (JP 3-0)

Terrestrial Segment — Encompasses all the equipment within the terrestrial domains required to operate or exploit a spacecraft. This includes control stations, antennas, tracking stations, launch sites, launch platforms, and user equipment. (SCP)