Falcon 9 rocket carrying Starlink 4-37 payload launches from Space Launch Complex 39A at Kennedy Space Center, Florida, December 17, 2022 (U.S. Space Force/Joshua Conti)

A Framework for Mission Analysis in the Space Planning Process

By Nicholas R. Shaw

The U.S. Space Force (USSF) has a joint integration problem. It provides capabilities that give the military and its partners decisive advantages in combat. In this way, many USSF missions are inherently "joint." However, the Space Force is unprepared to contribute to planning for true joint operations—operations with a significant space nexus where the main effort could easily transition between space and other domains. In such an environment, adversary space systems will be high-value targets that drive action, and friendly space systems will be critical assets that require

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protection. Although the Space Force has made significant progress toward establishing Service components at the combatant commands, putting Guardians in a position to support joint force commanders (JFCs), the Service has not yet armed those Guardians with a process to bring space system considerations into joint planning.

Space component commands will have to feed the joint planning process (JPP) and may need to plan and execute independent or joint operations on behalf of a JFC.[1] The Service owes its members doctrine that guides space professionals on how to communicate space planning factors related to the operational environment (OE). Without such doctrine, Guardians will struggle to translate their technical and mission expertise into a format that is easily understood by members of other Services.

The Doctrine Picture

In his *Chief of Space Operations' Planning Guidance*, General John W. Raymond, the Service's first commander, directed the Space Force to use joint planning methodology, in part to prepare Guardians for integration with joint forces.[2] And when the Service published Space Doctrine Publication (SDP) 5-0, *Planning*, in December 2021, that document reinforced the intent to mesh with the joint force by using the JPP, plus an additional step pulled from Air Force doctrine, as a guide for Guardians to follow.[3]

Unfortunately, the JPP baseline, now captured in SDP 5-0 as the "Space Planning Process" (SPP), will not meet the future needs of the space domain. Pre-established mission analysis processes and products are geared toward terrestrial operations within well-defined physical boundaries. Even when specifically addressing the space domain, joint planning documents generally fail to look beyond the space segment (the portion of space systems in space), ignoring the terrestrial (Earth-based) and link (electromagnetic spectrum) elements that enable space operations. SDP 5-0 acknowledges the problem, stating, "Spacepower planners should be wary of only considering space-based solutions to problems," and cites terrestrial and link factors as areas of consideration.[4] However, the Service doctrine does not give its planners any tools for analyzing and incorporating those factors. Most seriously, neither the joint nor the Service doctrine gives space professionals the responsibility for analyzing the full space systems that are relevant to their OE, regardless of whether segments of those systems are in a JFC's battlespace.

Previous models have been sufficient for an environment with little risk of contested space operations. Moving forward, though, the SPP must contain a unique mission analysis framework to capture the information relevant to space systems and portray it in a usable way to the joint command. Without adjustments to the SDP 5-0 doctrine, Guardians are limited in their approach to mission analysis and will be handicapped in their operations.

The Space Force has the challenge of updating its planning methodology to allow Guardians to fully portray the space common operating picture and analyze space domain threats and opportunities. But the Service must do so while still easily integrating its methodology into joint planning, effects, and intelligence processes.

Moving Beyond the Operational Area

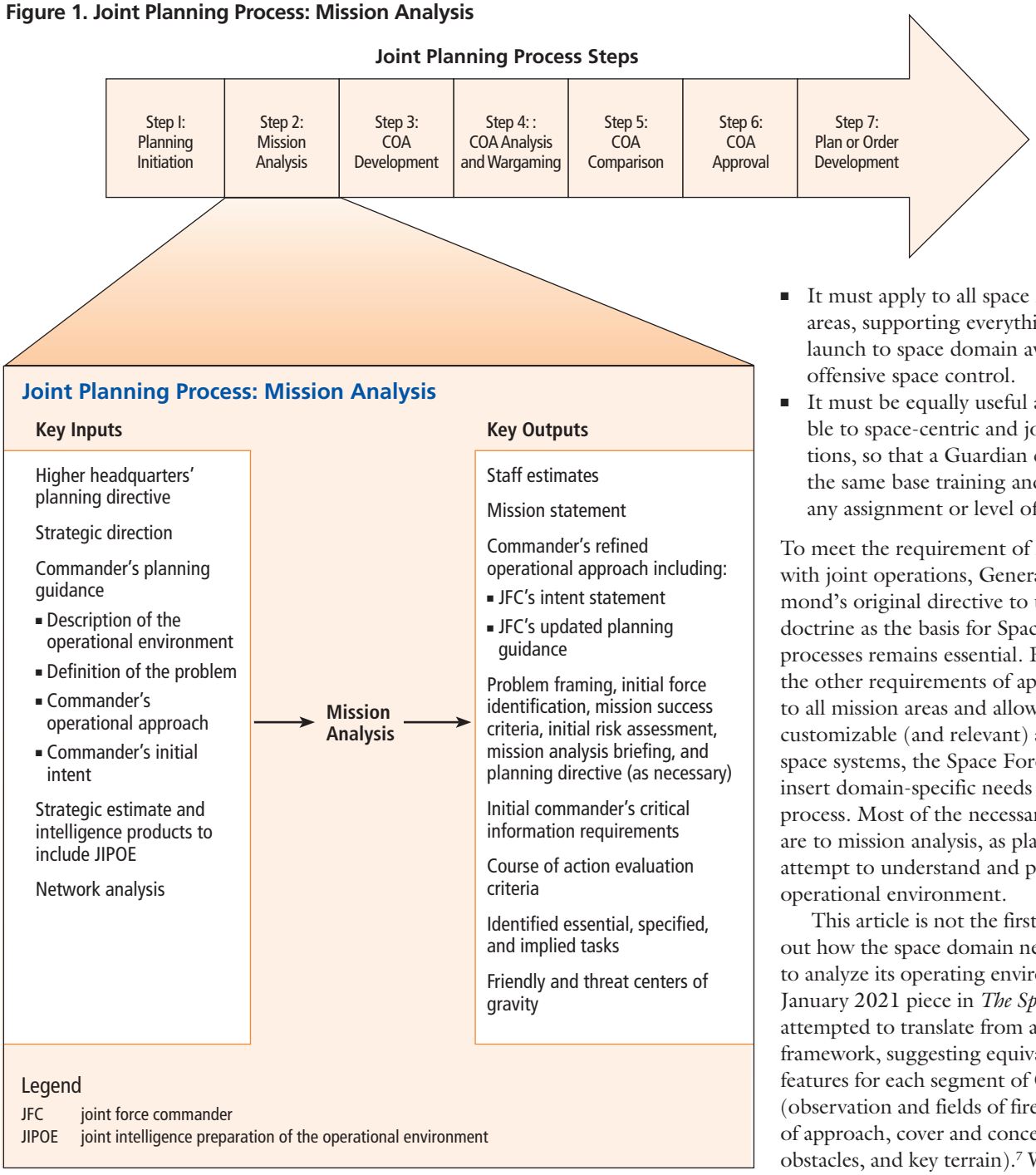
A doctrine that fully accounts for space must break with past norms by addressing the fact that space transcends commanders' boundaries. Planners and analysts must look at space from a systems perspective, ignoring the traditional focus on operational areas. If a threat to operations can be eliminated by targeting a ground station on another continent, that fact is relevant to the local command and should be a part of the mission analysis and decisionmaking process. It is not only U.S. Space Command's role to consider the full space system. Guardians will leverage assets from U.S. Space Command, U.S. Cyber Command, and other resources to examine the total extent of the space domain: terrestrial, link, and orbital segments of all friendly and adversary systems that bring effects to their battlespace, wherever elements of the architecture happen to be.

This approach is not an extreme position. For the air domain, an Army analyst may note the presence of an airfield, its length, and general capabilities, but an Air Force operator or analyst will understand the importance of that airfield relative to other sites and the enemy's overall air strategy. An Air Force expert is also the right person to prioritize targeting related to the airfield, rather than the Army expert who "owns" the domain. Similarly, in the maritime domain, a shipyard may be noted on the land component's modified combined obstacle overlay (MCOO), but the Navy should lead on providing an understanding of how that infrastructure fits into friendly or adversary capabilities and the need for action related to it.

For space systems, the ground and link segments—such as a satellite control station and its associated communications frequency to control a space-based asset—may be more accessible or more vulnerable than the space systems they support. Also, it may be acceptable for the Space Force to prioritize targeting the ground and link segments over the space segment, to avoid space debris and to establish precedent for responsible space operations. To do so, the space component commands need full authority to analyze and prioritize the terrestrial and electromagnetic portions of space systems that affect their JFCs.

But even if the right authorities were granted today, the Space Force would remain ill-equipped to deliver the analysis that commanders need. Existing methods of examining, defining, and analyzing the space OE are poorly developed. For example, the joint intelligence preparation of the operational environment (JIPOE) manual contains an example of a space MCOO layer that is woefully inadequate.[5] This doctrinal layer ignores the worldwide nature of space systems, essentially omits the electromagnetic aspects of space operations, and fails to consider most space operations and their effects on the battlefield. And the Service's own

Figure 1. Joint Planning Process: Mission Analysis



planning doctrine, firmly rooted in joint techniques, lists several space-centric factors (such as orbital hazards and terrestrial sites) but provides no guidance on how to assess those factors.[6]

Guardians at the new component commands will struggle to integrate with the other services and the JFC's staff as they try to follow the SPP. The Space Force must update the SPP to enable its personnel to analyze the space domain, feeding operations and the joint force's mission analysis.

A Space Planning Process

A new SPP has three main requirements:

- It must be tailorable, allowing planners to customize their analysis to meet the current mission need.
- It must apply to all space mission areas, supporting everything from launch to space domain awareness to offensive space control.
- It must be equally useful and applicable to space-centric and joint operations, so that a Guardian can apply the same base training and skills to any assignment or level of planning.

To meet the requirement of integrating with joint operations, General Raymond's original directive to use joint doctrine as the basis for Space Force processes remains essential. But to meet the other requirements of applying to all mission areas and allowing for customizable (and relevant) analysis of space systems, the Space Force must insert domain-specific needs into the process. Most of the necessary changes are to mission analysis, as planners attempt to understand and portray the operational environment.

This article is not the first to point out how the space domain needs a way to analyze its operating environment. A January 2021 piece in *The Space Review* attempted to translate from a land framework, suggesting equivalent space features for each segment of OACOK (observation and fields of fire, avenues of approach, cover and concealment, obstacles, and key terrain).[7] Whereas some elements of OACOK, such as key terrain, do translate, others do not. A prime example of the latter is observation and fields of fire, which the author assesses are "almost limitless" in space operations. This analysis is limited and unhelpful but is the natural result of the OACOK framework, which does not guide planners through the detailed on-orbit factors and considerations of space system capabilities that would lead

U.S. Space Force 1st Lieutenant Laura Drapinski, 2nd Space Warning Squadron, front, and Specialist 4 Ariana Gonzalez, 11th Space Warning Squadron, use Space-Based Infrared System Simulator to monitor missile indications during simulated combat operations in U.S. European Command during Space Flag 23-1, at Schriever Space Force Base, Colorado, December 13, 2022 (U.S. Space Force/Judi Tomich)

to true OE analysis. Also, the OACOK model—like other existing models—assumes proximity of elements on the battlefield. It does not account for the distributed systems, remote effects, and reliance on links that define the space domain. Overall, the output from this framework is unusable and is an example of why space analysis must differ from the traditional approach to land, maritime, or air domains.

The Space Force's model to analyze the OE, providing mission analysis and options to JFCs, must consider all three segments: space, link, and ground. It must look beyond the borders of the physical space domain and beyond the traditional borders of the commands that space forces support. Ultimately, it must provide in-depth assessments of friendly and adversary space systems—on the ground, at sea, in the air, in space, in cyberspace, or within the electromagnetic spectrum.

A traditional approach to OE assessment starts by addressing the environment separately from the forces employed in it. For example, an Army intelligence analyst would begin by analyzing the battlespace terrain. That Soldier would then set the terrain analysis aside and assess the adversary's capabilities, purely because of knowledge of the order of battle, assessed objectives, and doctrine. Finally, the analyst would "overlay" the enemy's likely actions on the terrain, developing courses of action that utilize the terrain features where the operation will take place.

Mission analysis of the space OE cannot follow this pattern, where the environment is examined before considering the forces. Space is *supraglobal* (a term coined by Lieutenant General John E. Shaw, deputy commander, U.S. Space Command, to capture the immense physical area and scope of impact of space operations), and there is no way to start with the local terrain or climate.[8] Instead, the actual or ideal locations of segments of space systems determine which terrain or weather elements are factors to a space professional. Therefore, analysis of the space OE is a combined process in which the environment and space systems are considered concurrently.

In the JPP, the mission analysis step has a few inputs and outputs, building

Loadmasters from 60th Air Mobility Wing and Lockheed Martin Space unload sixth Geosynchronous Earth Orbit Space Based Infrared System satellite from C-5M Super Galaxy, at Cape Canaveral Space Force Station, Florida, June 2, 2022 (U.S. Space Force/Walter Talens)

the knowledge necessary for development of courses of action and informed decisionmaking by the commander. The figure, derived from Figure III-5 in Joint Publication 5-0, *Joint Planning*, outlines those inputs and outputs.

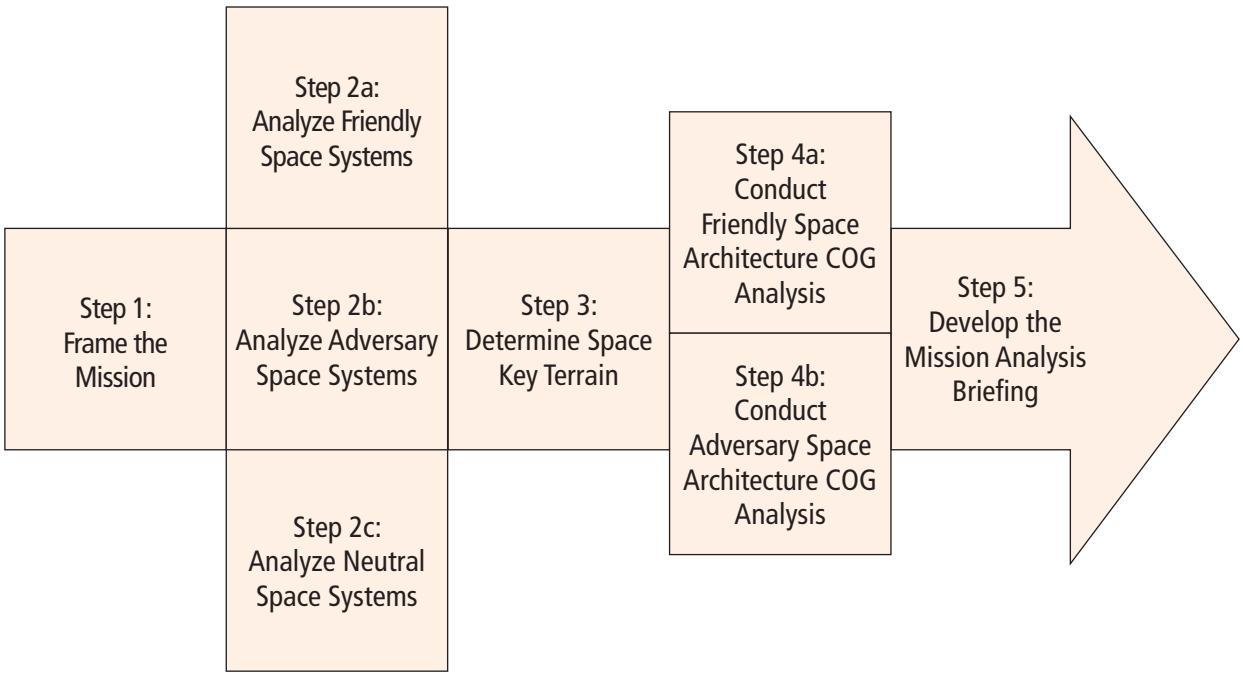
To integrate with the JPP, the SPP needs to provide the same range of planning outputs from mission analysis. This article proposes the following five-part mission analysis approach in the SPP:

1. frame the mission
2. analyze space systems
3. determine space key terrain
4. conduct space architecture center-of-gravity (COG) analyses
5. develop the mission analysis briefing.

Step 1: Frame the Mission. Upon receipt of instructions from a higher headquarters or guidance from the commander, the planning staff conducts initial framing of the mission. Guardians identify the specified, implied, and essential tasks and validate that they have a clear understanding of the commander's intent for the operation. They also begin to develop staff estimates, capturing assets available, constraints, restraints, limitations, facts, assumptions, and other key details from the initial guidance. With these facts, leaders can make informed decisions on which elements of the space domain to analyze and leverage in their planning.

Step 2: Analyze Space Systems. Analysis of space systems determines the scope of the space operational area—the range of effects and architectures relevant to a commander. The ideal way to visualize space systems is through a global, scalable space MCOO with layers of elements.

Figure 2. Space Planning Process Mission Analysis Steps



Layers for consideration in a space MCOO are identified in the table. Development of these layers will feed the assessment of the environment and friendly, adversary, and neutral capabilities in this step and will provide the information needed to complete steps 3 through 5. The specific layers incorporated, analyzed, and provided to the commander's common operating picture are dependent on the operation, allowing it to be tailored to the space mission area or commander's objectives.

Note that for mission planning, specific mission orbits (space segment); the locations of ground stations, spacelift facilities, space observation sites, directed energy systems, or jammers (ground segment); or specific electromagnetic frequencies (link segment) may be notional/ideal to help with the later identification of key terrain for a specific mission. This structure for analyzing the segments of space systems gives space planners a framework for their mission analysis. It is a baseline of training that all members of the Service should receive to contribute to USSF and joint operations. Leaders guide their teams in the execution of planning for specific missions by using the information provided to them in step 1 of the JPP (planning initiation), together with information from step 1 of the mission analysis process proposed in this article (frame the mission), to identify which layers are needed to shape decisions for the operation at hand. For example, planning for a spacelift mission might require all the layers in the space and link segments but need to look only at the weather and ground station layers of the ground segment. This scalability makes the format tailorable to any situation.

Step 2a: Analyze friendly space systems. Analysis of friendly space systems provides a commander with awareness of current capabilities and limitations. It provides the information necessary for an assessment of the force's own space COG and associated critical capabilities, requirements, and vulnerabilities. Planners conduct analysis of friendly space systems by working through the space MCOO layers, analyzing the environment and friendly capabilities relevant to the operation. Space operations personnel lead the analysis of friendly space systems via cross-functional teams with expertise in all relevant space mission areas.

Step 2b: Analyze adversary space systems. Analysis of adversary space systems provides a commander with awareness of the enemy's capabilities and limitations. It enables an assessment of the adversary's space COG factors. Commercial or other national systems (spacelift; satellite communications; intelligence, surveillance, and reconnaissance; navigation and timing; other capabilities) known to be used by the adversary should be considered in this step as well. A planner will accomplish analysis of the adversary systems by going through the relevant space MCOO layers with a focus on the adversary's capabilities. Intelligence personnel should lead the examination of the adversary systems. Operations personnel with expertise in each space mission area support the effort.

Step 2c: Analyze neutral space systems. Many commercial entities, nonbelligerent countries, and international partnerships conduct space activities for business, scientific, tourism, or other purposes. As an example of relevant neutral space systems: commercial remote-sensing or satellite communications platforms represent additional capabilities that could be leveraged by friendly or adversary forces. Other satellites may also use critical segments of the electromagnetic spectrum in the commander's battlespace. Analysis of the space OE is incomplete without

Two members of 216th Space Control Squadron set up antennas as part of "Honey Badger System" during Black Skies 22, designed to rehearse command and control of multiple joint electronic warfare fires, at Vandenberg Space Force Base, California, September 20, 2022 (U.S. Space Force/Luke Kitterman)

consideration of these systems. As in assessment of friendly and adversary systems, space planners use the space MCOO layers to complete this step, focusing on neutral space systems that affect the OE. This assessment is led by space operations personnel with expertise from each space mission area.

Step 3: Determine Space Key Terrain. Key terrain is a subset of terrain that provides a distinct military advantage to the side that controls it. Key terrain is dependent on the operation being conducted. Identification of key terrain shapes the development of courses of action (COAs) in future steps of the JPP and SPP and influences the commander's decision on which COA will best support the endstate.

Space key terrain is determined by a set of terrain characteristics (based on relative locations and access via space system links) that, at a specific time, provide a distinct military advantage in an operation to the force in control of that terrain. Space planners determine which sets of characteristics should be considered space key terrain through analysis of the operation and their assessments of friendly, enemy, and neutral space architectures.

Key terrain must be controlled to provide an advantage. In space operations, that control requires placement of a space system object in the right location, at the right time, with an unobstructed path to the target location for desired effects, and the ability to use the portions of the electromagnetic spectrum relevant to the specific mission. If any of these factors is denied, the key terrain is no longer controlled, and there are no advantages to the combatant.

With the identification of specific space key terrain, planners help the commander visualize the critical factors that will influence the outcome of space operations. Identification of the key terrain will also support future requests

Table. Space MCOO Layers

Space Segment ("WeGOTO")	
We: Space Weather	Space weather/climate impacts on on-orbit systems (does not include uplink/downlink/crosslink or terrestrial comms)
G: Gravity	Gravity "slope" plot, showing changes in potential energy and interactions between celestial bodies
O: Orbit Profiles	Mission orbit(s), characterization, and operational status, as operationally relevant—could include ground tracks and field of view for information, surveillance, reconnaissance satellites; the health of a constellation; or effects of satellite geometry from global navigation satellite system distribution
T: Space Terrain	Space terrain features, such as debris, micrometeorites, and the Van Allen radiation belts. Terrain is captured in mission analysis when the terrain will come within a certain proximity of or overlap with mission orbits
O: Orbit Threats	Co-orbital threats, such as rendezvous proximity operations–capable platforms or other potential adversary capabilities within a certain proximity of mission orbits
Ground Segment ("WeGrASSpED")	
We: Terrestrial Weather	Terrestrial weather/climate impacts on ground segments
Gr: Ground Stations	Locations of ground stations that enable command and control, uplink/downlink, or other space mission capabilities
A: Anti-Satellite Weapons	Location and characterization of anti-satellite weapons systems
S: Space Observation Sites	Radar or optical sensor sites used by space surveillance networks, and their assessed capabilities (threat fan and detection threshold)
Sp: Spacelift	Locations of spacelift facilities (space access and sustainment sites) that enable delivery of space systems to orbit, and projected spacelift operations (timeline, payload, and destination) from each site
E: Electronic Warfare	Locations of electronic warfare systems, such as jammers or spoofing systems, and their assessed capabilities (frequencies, power, and likely area of effects)
D: Directed Energy Weapons	Directed energy sites for space control, and their assessed capabilities (threat fan and potential impacts)
Link Segment ("WeFI")	
We: Weather	Space or terrestrial weather/climate impacts on uplink/downlink/crosslink signals (location, duration, and anticipated effects)
F: Frequencies	Link electromagnetic factors for space systems (frequency and vector, for both control and payload mission)
I: Interference	Any known friendly, enemy, or neutral systems operating on the same frequencies that could result in intentional or unintentional jamming

for collection, targeting, or protection related to these terrain features.

Step 4: Conduct Space Architecture COG Analyses. Using the data now available from analysis of the space systems and assessment of key terrain, planners utilize traditional methods to determine the COG and associated critical capabilities, requirements, and vulnerabilities of the friendly and adversary space architectures. No new system is needed for this mission analysis step; Guardians can utilize joint processes to support interoperability with the rest of the force.

Step 4a: Conduct friendly space architecture center of gravity analysis. Space operations planners perform a self-assessment of the friendly space architecture. The COG, critical capabilities, critical requirements, and critical vulnerabilities identified during this step help the commander to shape the friendly force information requirements and essential elements of friendly information and to consider investments in protection or redundancy in critical elements of the space systems.

Step 4b: Conduct adversary space architecture COG analysis. The adversary's space architecture receives the same attention, with planners identifying the adversary's space COG, critical capabilities, requirements, and vulnerabilities for exploitation. Assessment of the adversary's COG is led by the intelligence staff. These items will shape the development of COAs, support prioritization of targets, and contribute to the development of priority intelligence requirements.

Step 5: Develop the Mission Analysis Briefing. The previous SPP mission analysis steps generate the extensive data needed to update and refine the initial JIPOE product and complete drafts of staff estimates. The products are translated into the mission analysis briefing, continuing the dialogue between the staff and the commander. In this step, the other JPP mission outputs that were not covered in previous SPP mission analysis steps, such as development of a proposed mission statement, initial risk assessment, and COA consideration criteria, are completed and incorporated into the briefing.

SpaceX Falcon 9 reusable, two-stage rocket from Vandenberg Space Force Base, California, launches first set of Space Development Agency's Tranche 0 of Proliferated Warfighter Space Architecture satellites, April 2, 2023 (SpaceX)

Up until this point in the SPP mission analysis framework, the planning staff has collaborated in the development of a single MCOO, a combined list of proposed space key terrain, and mutually assessed COGs. Now, all members of the space planning staff have the information they need to tailor their sections' own products. The core mission analysis products serve as a launching point for the development of sustainment plans, the drafting of COAs, the maintenance of running estimates, and other actions by the staff.

With the employment of this adjustment to the SPP, the elements unique to space planning have been addressed and planners can merge with the traditional process, continuing with JPP step 3 (COA development). Following this series of steps and guidance satisfies the three requirements (tailorable, applicable to all space missions, and universally applicable to space-centric or joint operations) identified at the beginning of this section and enables space planners to meet their domain-specific needs.

Overall, the products that result from this five-step SPP mission analysis process will provide a picture that spreads far beyond a single operational area, potentially hitting multiple combatant commands and orbital regimes. But through its execution, space planners and analysts will obtain the data they need to present a complete picture to the commander for assessment of friendly and adversary capabilities and COGs, decisions on targeting or protection of space system segments, selection of a COA, and initiation of necessary coordination with supporting or supported commands.

Calls to Action

The process as outlined above would meet the needs of the growing Service, but there are three major prerequisites for the Space Force to successfully adopt this model as an update to its SDP 5-0 doctrine. Those prerequisites involve process validation, data management, and training integration. No new process can be adopted with confidence unless it has been questioned and tested by experts from across the space mission areas. Space planners should critically validate this SPP recommendation, testing it against their mission areas to identify gaps and confirm its utility. Where possible, they should provide feedback to simplify the framework, making it easier for Guardians to learn and implement.

The framework outlined in this article involves the processing and display of a huge amount of data. The three-dimensional nature of space systems makes it even more difficult to accomplish. Visualization tools to display the space MCOO are not available yet; space planners will have to utilize local innovation and alternative products to portray their analysis until the optimal resources are fielded. The Space Force's vision of a digital service is needed here, and quickly, to turn these immense requirements into a user-friendly interface that allows for rapid, customizable presentation of the relevant data. The systems that display this information must communicate with the mission command systems used in the joint community, allowing Guardians to seamlessly shift their products into a joint display of the OE for mission planning purposes. Without that essential step by the Service's innovation teams, it will be virtually impossible for a space planner to convey analysis to a decisionmaker.

Finally, capturing this planning model in Service doctrine (SDP 5-0, SDP 2-0, and associated implementation documents) is only one part of the transition. The Space Force must train Guardians in its use for application at the combatant commands and in core space mission assignments. Only by integrating this methodology into the Service's beginning education, reinforcing the process in later schools, and leveraging the SPP for space planning in all organizations can the Space Force build a cadre of planners capable of supporting joint operations.

The USSF's transition from a traditional role, with space operations focused on "space for others," to a component role in joint operations requires an investment in personnel and processes. The mission analysis framework proposed here will support the establishment of the Space Force as an equal member of the joint planning team. Testing of this process, followed by its inclusion in Service doctrine and education and the development of supporting visualization aids, is necessary for the Space Force's growth and ownership of the domain. The Space Force is approaching an exciting milestone with its establishment of component commands. It is imperative that Guardians across the force have the knowledge and tools to succeed in their new roles. **JFQ**

Notes

[1] Joint Publication (JP) 3-0, *Joint Operations* (Washington, DC: The Joint Staff, January 17, 2017), VIII-21.

[2] John W. Raymond, *Chief of Space Operations' Planning Guidance* (November 9, 2020), 9, available at <https://media.defense.gov/2020/nov/09/2002531998/-1/-1/0/cso%20planning%20guidance.pdf>.

[3] Space Doctrine Publication (SDP) 5-0, *Planning* (Peterson Space Force Base, CO: Space Training and Readiness Command, December 2021), 12.

[4] Ibid., 9.

[5] JP 2-01.3, *Joint Intelligence Preparation of the Operational Environment* (Washington, DC: The Joint Staff, May 21, 2014), III-20, available at <https://irp.fas.org/doddir/dod/jp2-01-3.pdf>.

[6] SDP 5-0, *Planning*, 16–18.

[7] D. Grant Greffey, "Terrain Analysis for Space Warfare," *The Space Review*, January 25, 2021, available at <https://www.thespacereview.com/article/4111/1>.

[8] John E. Shaw, Jean Purgason, and Amy Soileau, "Sailing the New Wine-Dark Sea: Space as a Military Area of Responsibility," *AEther* 1, no. 1 (Spring 2022), available at <https://www.airuniversity.af.edu/Portals/10/AEtherJournal/Journals/Volume-1_Issue-1/06-Shaw.pdf>.