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MONOGRAPH

Future Military Space

From Procurement to the Tactical Fight

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General Issue

Current space acquisition, vehicle processing, and operations are too cumbersome and expensive to meet future emerging war fighter needs. The cost associated with placing assets into orbit has been the greatest problem to the United States (US) fully recognizing its potential in space. With the emergence of commercially available reusable launch vehicles, the military must consider the possibility of building an internal space lift capability as a core competency. Also, the military must develop and integrate new capabilities from space that will enable strategic capabilities, down to tactical war fighter implementation.

Launch costs currently represent a third to half the cost of fielding a space system.[1] Additionally, the current bureaucratic model for the Department of Defense (DOD) space architecture does not enable a rapid approach to space for the US to gain space supremacy and prevent further loss of space superiority. Key hurdles must be removed and new methods utilized to accomplish this goal. This process requires a change in acquisitions, operations, doctrine, and organizational structure.

Requirements for space systems are developed on a five to ten-year time horizon, which does not allow the development of systems that can be utilized on demand in an area of responsibility (AOR). New systems must be developed that can be deployed on demand to AORs and utilized by ground, sea, air, cyber, and space forces.

Problem Statement

Space access and capabilities are rapidly evolving, and the US military must posture itself to utilize these capabilities to protect and defend US national security.

Research Objectives

This research seeks an end-to-end approach for developing new space capabilities, fielding the capability on demand, and utilizing that capability across all domains (land, sea, air, cyber, and space) of military power. To meet the objective of a new end-to-end approach for space, a new methodology will be developed in five parts. The first part is to develop and analyze the current state of acquisitions, launch, and payload operations, and how space capabilities are utilized today. This part will set the baseline from which to build a future end-to-end approach for future space mission sets.

The second objective of this research will utilize various approaches to develop a desired future state of space. This objective will include developing a new end-to-end architectural view that incorporates requirements development, acquisitions, launch operations, payload command and control, and tactical war fighter implementation of space capabilities.

The third objective will utilize this new architecture and contrast it against the current conditions of space to find gaps in military capabilities, processes, and doctrine. This objective includes looking at how space supports terrestrial domains and how space will be required to defend itself and project offensive capabilities in the future.

The fourth and final objective will recommend new processes, organizations, and capabilities. These processes, organizations, and capabilities will be in the form of recommended technological investment, changes to processes, changes to organizations, and updates to doctrine and tactical war-fighting approaches.

Methodology

The primary methodology for this research is to research best practice systems and processes and overlay them into a new approach for rapid space acquisition, fielding, and operations. Figure 1 provides an outline of how the research will flow into the future desired end state.

The top row of figure 1 lays out the building blocks for this research that include: defining user and system requirements process; acquisition approaches; satellite processing, launch, and checkout; and on-orbit operations and end-user interaction. The literature review in chapter 2 looks at analogous systems and processes that apply to the research building blocks. The literature review focuses on best and worse practices, a technology that has been demonstrated, and planned future technology. From the literature review, the desired end state is derived in chapter 3. Finally, utilizing the current state and the desired state, this research

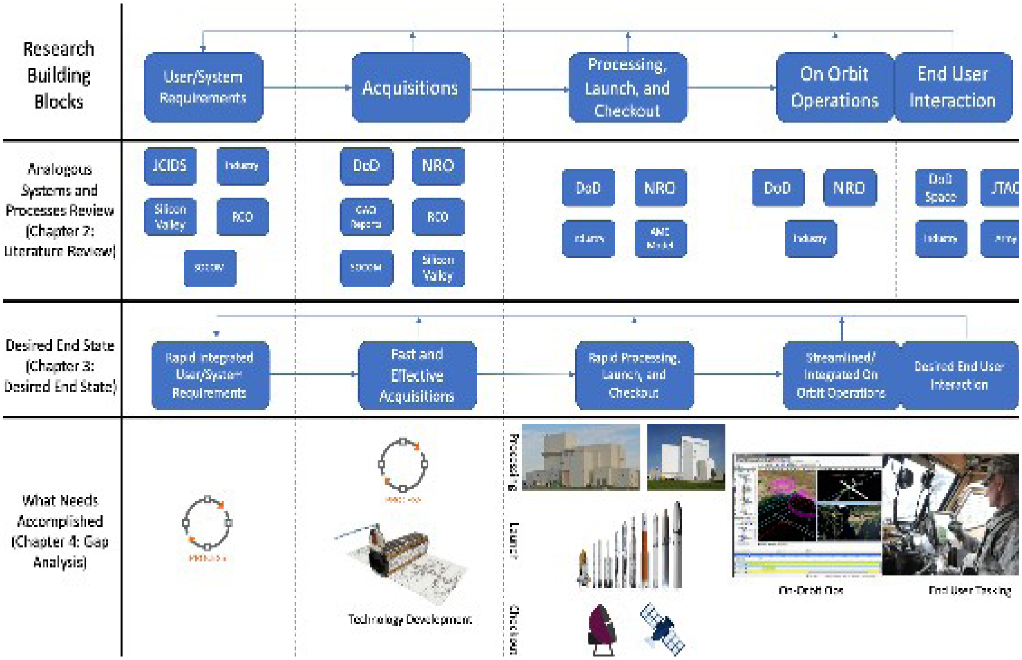


Figure 1. Research methodology road map

discusses the gaps in chapter 4 that need to be filled both in processing, technologies, and war-fighter integration that need to be filled.

Research Focus

This research will focus on developing and generating a new end-to-end approach for space capability implementation. In general, this research will:

- Define in general terms the current state of how space approaches end-to-end capability.
- Develop a new architecture for end-to-end capability implementation.
- Analyze future space technologies and capabilities for future war fighters in all domains of operation.
- Develop a concept of operations (CONOPS) for the new end-to-end space approach.
- Analyze technological, process, and doctrine gaps that must be addressed to enable this new architecture and CONOPS.

Investigative Questions

To meet the research objectives, the following questions will be answered to help build a new end-to-end approach for space operations.

- What is the current landscape for end-to-end space operations?
- What should the future architecture for an end-to-end approach for space operations be?
- What gaps will the US military need to fill to enable this new architecture?
- How should the US military organize to enable this new architecture?
- What technology should the US military invest in to enable this new architecture?
- What new military doctrine should be created to allow the implementation of this new architecture and CONOPS?

Assumptions and Limitations

This research paper is written in the context of developing a new end-to-end architecture for space. The following forms the key assumptions and limitations of this research:

- A time horizon of 2030 for this new architecture to be in place.
- The cost will not be factored into this effort.
- This article will assume that capabilities discussed (launch, satellite and ground processing) will mature at a rate that will enable this future architecture.

Implications

This research defines future end-to-end architecture for space capabilities. It has the potential to improve the responsiveness of space to better support terrestrial users, as well as provide a means for space to defend space, and project offensive capabilities.

Document Overview

This thesis is organized into six chapters. Chapter 1 provides a general overview of the research and problem set. Chapter 2 provides a foundation of literature reviewed and a summary of that literature, setting the baseline for the current state of space.

Chapter 3 provides a desired end state architecture for a future end-to-end space capability. Chapter 4 will describe gaps in technology, processes, and doctrine that must be overcome to enable this new end state. Chapter 5 develops key recommendations to include recommended requirements, changes to organizations, new processes, and key investment areas. Finally, Chapter 6 provides conclusions and areas for further research.

Background and Literature Review

Chapter Overview

The literature review covers the topics that are the foundation for this research. Each topic provides key insight into a specific area essential to the development of this research. The first key area will be a review of the state of space acquisitions. Next will be a review of space vehicle processing and launch operations. The third area reviewed is end-to-end on-orbit satellite operations, which includes a discussion on Kestrel Eye.

Kestrel Eye is an Army program that demonstrated end-to-end imagery collection to real-time downlinking of those images to troops on the ground. Following this, a review of potential analogues models that could be used in the future for space operations will be revised. Next is a general review of how government satellites are tasked for use.

Finally, a comprehensive review of current space technology and technology that is likely to be available by 2030.

Space Requirements Development

Joint Capabilities Integration and Development System (JCIDS)

The JCIDS process in the formal DOD process to define requirements for acquisition programs. JCIDS' main purpose is to enable the JROC to execute its statutory duties to access joint military capabilities and identify, approve, and prioritize gaps in these capabilities.[2] The JCIDS process starts with a robust assessment of missions, functions, and tasks in the context of threat and environment to identify and quantify capability requirements.[3] These capability requirements are service, solution, and cost-agnostic. Therefore, these requirements are thought of as "what needs to be done and to what level" without taking into account cost or schedule. The process then further flows by assessing these requirements against current capabilities across the force. After a capability gap is identified an Analysis of Alternatives (AoA) is performed to assess options for filling the gap. The AoA is then utilized to make decisions on the best path forward for a capability solution, including capability requirements, measures of performance, and required resourcing to develop the proposed capability solution.[4]JCIDS is a very deliberate process that was developed to integrate the requirements process of all four branches of the military. The intent was this process would be informed by combatant commanders to procure capabilities required to fight ongoing contingency operations, anticipated contingency operations, and further out operations.

Figure 2 provides a depiction from JCIDS on how these needs correlate to timelines and what documents are created.

JCIDS Lanes	Operational Timeline	JCIDS Documents	JCIDS Staffing Timeline
Ongoing Contingency Lane	Urgent Need (<2 Years)	JUON	15 days
Anticipated Contingency Lane	Emergent Need (<2 Years)	JEON	31 days
Deliberate Lane	Future Need (>2 Years)	ICD CDD	97 days 103 days

Figure 2. JCIDS process lanes

Source: JCS, JCIDS, B-A-2

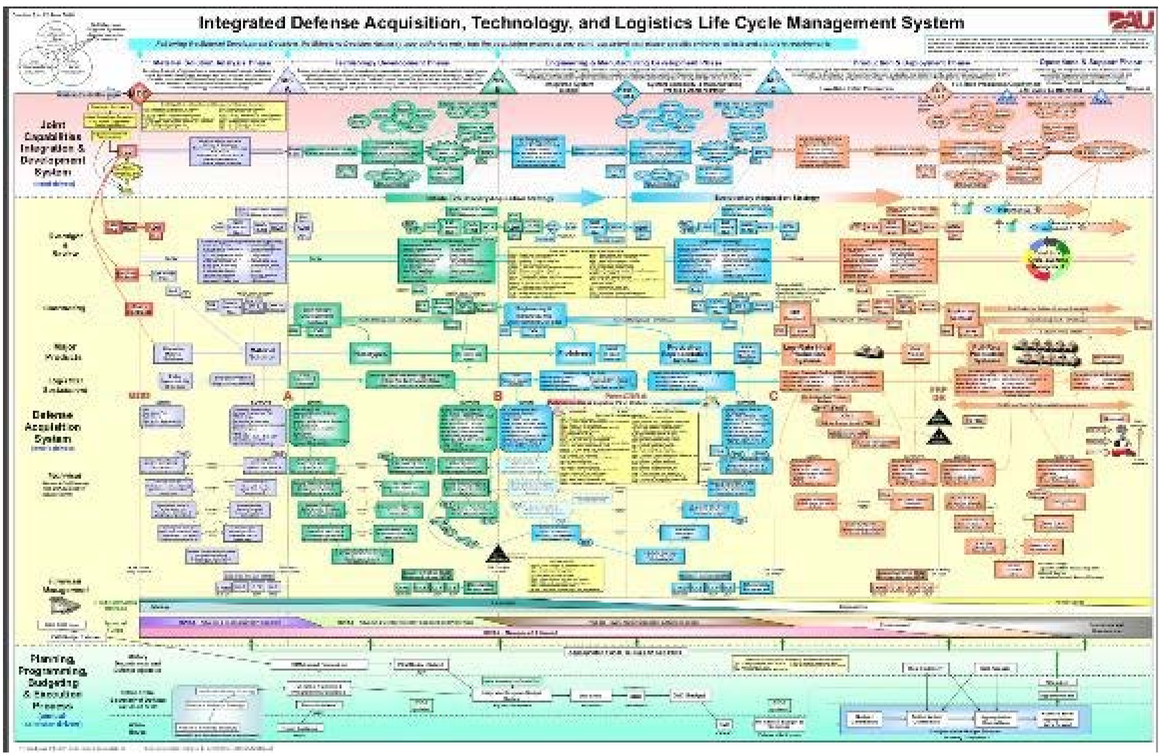


Figure 3. Integrated Defense AT&L Life Cycle Management Process

The overall JCIDS process flows in parallel with the standard DOD acquisition process. Figure 3 shows how the two processes flow and are interconnected. On the top is JCIDS, in the middle is the Defense Acquisition System (DAS) and the bottom of the chart depicts the Planning, Programming, Budgeting and Execution process.

From figure 3, it is easy to see how complex the process for requirements, acquisition, and budgeting is within the DOD. The complexity of JCIDS and DAS typically leads to long acquisition timelines for large programs. The benefits are that all services have a chance to provide input into the requirements to these systems.

Air Force Rapid Capability Office (RCO)

The Air Force RCO was formed in 2003 to expedite important, often classified programs while keeping them on budget.[5] The RCO has a streamlined flat structure that is seen as critical to its success, as is the office's ability to keep requirements stable and work alongside operators.[6] This organization reports directly to a board of directors with members that include the Secretary of the Air Force, Air Force chief of staff, and the assistant secretary of the Air Force for acquisition. The office directly responds to Combat Air Force and combatant command requirements.[7]

Commercial Industry

Commercial industry approaches requirements different than a typical government satellite acquisition. After the JCIDS process, an initial capability document (ICD) is developed which contain the high-level production requirements. This document is then further refined into multiple system level specific documents and further refined into subsystem specification documents in a Systems Program Office. On the other hand, the commercial company procuring a system typically keeps requirements at a higher level and allows the satellite vendor to distill the requirements to more effectively make trades.[8] These trades include balance cost, schedule, and satellite performance more effectively against a risk tolerance level. At the same time, the commercial company procuring the satellite loses insight into the program progress and mission assurance associated with the build. Additionally, commercial companies rely on mature technologies to be inserted on satellites, whereas the DOD will take the additional risk for less mature capabilities that potentially will bring greater user capability.

One example of commercial vendor procurement is IntelSat. IntelSat succinctly notes this and states:

> Intelsat must assess and predict future customer and market demands and pursue rapid capability evolution in our satellite systems and networks to meet those demands and stay ahead of our competitors. We enable rapid system development through streamlined organizations and processes. We also rely on mature technologies, when possible, to reduce risks and to increase the speed to market. When necessary, we use market leverage to drive technology innovation through our manufacturing base, in order to bring transformational capabilities to bear against new market opportunities.[9]

This example from IntelSat shows the flexibility of commercial companies to procure satellites fast to meet customer requirements. To do this IntelSat relies on procuring proven technologies to reduce risk to the program. As discussed before the DOD typically takes on greater developmental risk versus commercial companies to bring on new capabilities for the war fighter. Each approach has pros and cons that must be weighed during an acquisition program.

Space Acquisitions

General

Over the past 20 years, multiple reports, publications, and recommendations have been generated related to the issues within space acquisitions. Over this course of time, a few major organizational and process changes occurred in space acquisitions.

The first change came on 1 October 2001 when space acquisition authority was transferred from Air Force Materiel Command to Air Force Space Command. The goal was to provide "cradle-to-grave" management from concept through development, acquisition, sustainment, and final disposal of space systems."[10] The next major change was the guidance for DOD Space Systems Acquisitions, which was implemented on 27 December 2004. The goal of the National Security Space (NSS) acquisition process was to emphasize the decision needs for "high-tech" small quantity NSS programs, versus the DOD 5000 model, which focused on making the best large quantity production decision.[11] In 2009, the decision was made to move space acquisitions back under the standard DOD 5000 instruction for all acquisition's programs.

A RAND Study from 2015 listed the key factors contributing to space acquisition difficulties as space programs implementing a high-risk acquisition approach contributing to difficulties and inefficiencies in space acquisition programs.[12]

These reports continue to be generated, and the DOD recently stood up two organizations to address rapidly developing future space capability. The first was directed by Congress and is the 2018 National Defense Authorization Act (NDAA). The NDAA directed the DOD to develop a Space Rapid Capabilities Office (RCO). In response, the Air Force is transitioning the Operationally Responsive Space Office into a new Space RCO. In testimony to Congress in 2018, General Raymond (AFSPC/CC) discussed the new Space RCO by stating,

> The SRCO must have the same rapid acquisition capabilities as the existing Air Force RCO. We are working hard on an implementation plan that will expand the former ORS office portfolio to include highly-classified, hand-picked, game-changing, space programs, that will move at an accelerated pace while not losing the demonstration, experimentation, warfighter-focus and Joint Capabilities Integration and Development System (JCIDS) exemptions covered in ORS statutory guidance. This will not be just a name change, AFSPC will look to broaden the scope and scale of this office to deliver real results.[13]

The second organization that was formally designated by the DOD in April 2019 is the Space Development Agency (SDA). In a presentation to the Space Symposium, the new director of SDA, Fred Kennedy, briefed that the new organization will: "Do business in a way that is radically different from the way the military currently develops and acquires space systems."[14] Director Kennedy also believes that disruption is long overdue, and will be drafting an architecture that leverages commercial capabilities coming online to churn out hundreds and thousands of satellites such as OneWeb and SpaceX that will begin deployment in low-Earth orbit (LEO).[15] SDA has plans to leverage these commercial companies to develop an accelerated acquisition cycle that will develop hundreds of satellites for DOD use in a streamlined manner to meet new emerging operational needs.

Finally, the main acquisition of the DOD space enterprise remains the Space and Missile Systems Center (SMC). The SMC has long been criticized due to the slowness and cost overruns associated with acquisitions of major DOD satellite systems, including GPS, the Space-Based Infrared System (SBIRS), Advanced Extremely High Frequency (AEHF), and other satellite programs. In response, the SMC begins an overhaul of the organization in 2017 under the leadership of Lt Gen John F. Thompson. This overhaul is known as SMC 2.0. Recent reports have noted that SMC 2.0 will work to acquire future capabilities in a more streamlined manner. The plan is to turn vertical stovepipe focused mission areas into horizontal "enterprise" mission areas.[16] As reported by *SpaceNews*, these new four horizontal organizations will be a Development Corps (for innovation and prototyping), a Production Corps (for system procurement), an Enterprise Corps (for product support and launch services), and finally an Atlas Corps (for workforce talent and culture management.)[17]

Constellation Design Overview

Satellites come in various sizes, depending on mission requirements and mission design. For example, satellites placed in medium-Earth orbit (MEO) at 20,200 kilometers (km) provide an orbital period of 12 hours. This provides the benefit of a longer dwell over a point on the ground when compared to LEO systems. But this longer dwell comes at the expense of larger aperture requirements for transmitting or receiving signals. Also, MEO satellites at 20,200 km operate in the Van Allen Belt, which requires additional shielding to protect key components, thus adding weight to the vehicle. This example showcases various trades that need to occur between mission requirements, mission design, and size, weight, and power (SWaP) of the satellite. Figure 4 provides a depiction of the orbital period versus satellite altitude.

Satellites in LEO operate with an orbital period of approximately two hours or less. This period means a satellite will orbit the same spot on the earth 12 or more times per day. In contrast, a satellite operating in GEO dwells on a single location for the life of the satellite by having an orbital period equal to the rotation of the earth. (Note: Geosynchronous satellites can have various inclinations and will appear to make a figure eight pattern over a location but still has constant dwell.)

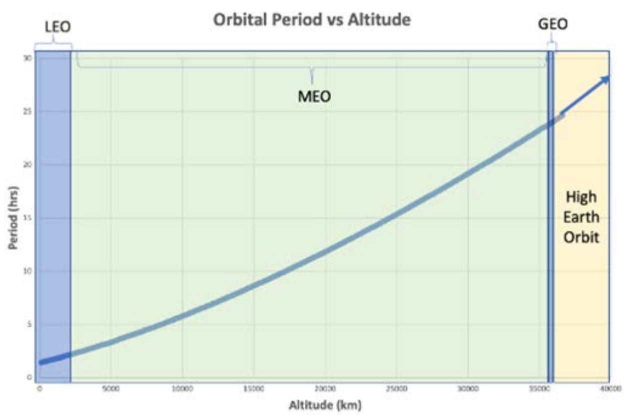


Figure 4. Orbital Period vs Altitude (km) (See Appendix A for derivation)

Additionally, when considering mission requirements and design for a constellation, desired intended effects must be taken into consideration. For instance, if the desired effect is to provide constant imagery to a ground user, the trade between resolution required, size of the satellite, and the required orbit must be considered. This trade is where requirements become of vital importance to the design of a system. For example, if the requirement is to provide a signal strength on the ground of - 125 dBm, it is possible to analyze how this might impact a satellite constellation design. Table 1 provides the required effective isotropic radiated power (EIRP) from a satellite at various orbits (assumes signal of 2000 MHz and free space propagation loss modeling). Therefore, a satellite in LEO would need to produce an EIRP of 9 watts, in MEO, 900 watts, and in GEO, 2,900 watts. Logically one would want to choose the LEO satellite the requires far less power, but if a secondary requirement exists to dwell over a target for long periods of time, LEO may not be a feasible choice.

Table 1. EIRP for desired signal strength on ground (See Appendix B)

Satellite Altitdte (km)	EIRP at Satellite to Achieve -125 dBm on Ground (W)
2000	9
20000	900
36000	2900

From the discussion above, it is easy to see many trades must occur when designing a constellation of satellites to perform the desired task. SWaP and orbit determination are key factors that help determine how a mission is designed. Other factors that are considered include design life, launch vehicle selection, on-orbit maneuver requirements, point accuracy, and more.

The above analysis shows that solution sets have multiple variables when it comes to satellite constellation design. Therefore, it is not as simple as dictating solutions to constellation designs. Careful trades between cost, schedule, performance, risk, and mission design should occur to ensure the correct satellite constellation is developed to meet end-user requirements. Therefore, well-defined requirements up-front are essential in enabling a program to best meet end-user needs.

Launch Vehicles

The launch market is rapidly evolving. In the past, one of the greatest expenses in placing a satellite in orbit was launch. Today, the commercialization of launch is creating new competition that is reducing the cost of placing payloads on orbit. In the past launch, vehicles were full expendable, which means the launch vehicle was lost after every mission. This loss is extremely costly and requires the constant production of new launch vehicles. The Fast Space Report discusses leveraging Ultra Low-Cost Access to Space (ULCATS), as a means to bolster strategic stability is space.[18] The report notes the benefits of rocket reusability and increasing launch rate to reduce the cost of launch from more than $7000 per kilogram to less than $1000 per kilogram (fig. 5).[19] Reductions in the cost of launch of this magnitude are significant and will bring new space vehicle companies and technology into the space market, creating new opportunities for satellite companies.

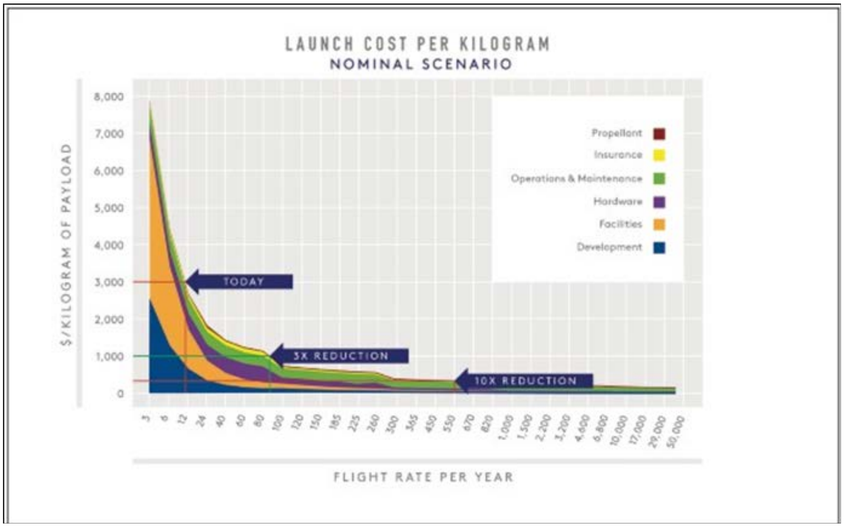


Figure 5. Launch cost per kilogram

In the case of spacelift, the US currently has the capability to launch 14,500 lbs of mass directly into a geostationary orbit with the Delta IV Heavy launch vehicle. A significant issue with this capability is cost, which by some accounts is estimated to be around $400M (~$60,000 per kilogram to directly injected GEO orbit).[20] The result is the cost of "heavy" launch is nearly unaffordable and deprives budgets from focusing on actual space capability. Therefore, the current gap in technology is not due entirely to technology not being able to meet requirements; but rather, technologies costing too much to reasonably meet requirements.

Based on the Fast acquisition report, company plans from SpaceX, Blue Origin, and ULA are continuing to seed the commercial market to develop new and innovate spacelift capabilities. Currently, SpaceX plans to develop a rocket known as the Big Falcon Rocket capable of launching 150,000 kilograms into LEO in a 9 meter fairing.[21] Blue Origin plans to develop the capability to lift almost 45,000 kilograms into LEO in a 7 meter fairing.[22] The SMC recently awarded other transaction authority (OTAs) to ULA, Blue Origin, and Northrup Grumman to support these development activities in December 2018.[23]

The launch vehicle is also moving toward an "aircraft" model, where launch vehicles are launched, landed, refueled, and reused. This capability has been demonstrated by both Blue Origin and SpaceX who have both successfully landed launch vehicles. The FAST Space study notes that the reuse of launch vehicles has the potential to increase access to space, reduce the cost of launch significantly, and allow rapid deployment of systems.[24]

Timeline for Developing and Launching Government Satellites

The perception is that it takes almost 10 years to develop and launch a government satellite system. This perception is due in part to the government acquisition process, which includes a lengthy pre-Milestone A and B phase to develop and mature the concept and requirements, as well as achieve funding and advocacy for a new system.[25] Research shows that it takes roughly seven and a half years to develop and launch a first article space vehicle, but that subsequent vehicles take approximately three years to assemble and launch.[26] This is comparable to the two to three-year duration for typical commercial satellite development. Figure 6 provides the typical satellite production time for commercial and DOD systems by minimum, average, and maximum time. From figure 6, we can see that satellite development time is comparable between commercial and DOD launches for non-first article vehicles.

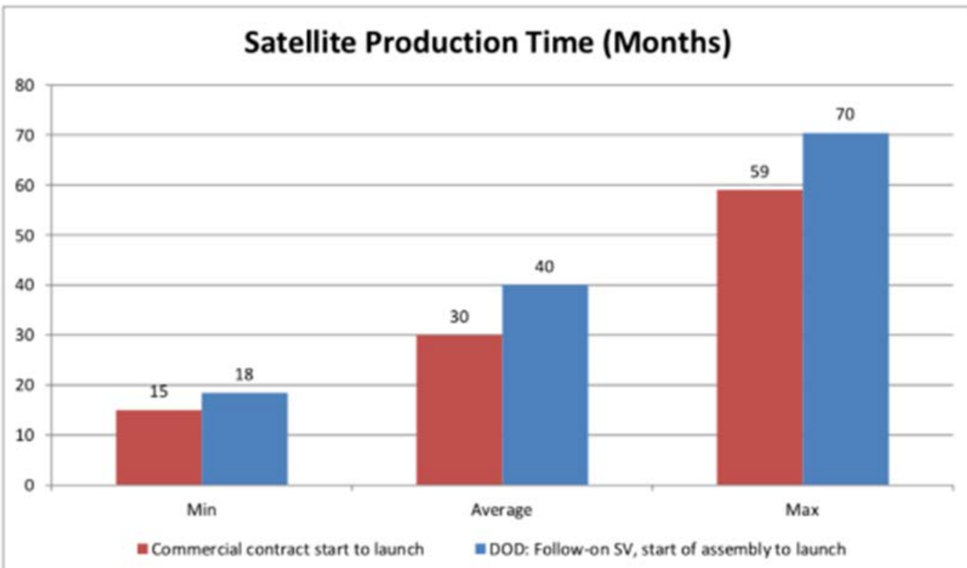


Figure 6. Satellite production time

Source: Lorrie A. Davis and Lucien Filip, "How Long Does it Take to Develop and Launch Government Satellite Systems," The Aerospace Corporation, 12 March 2015, 1.

Figure 6 may seem counterintuitive to many who believe that DOD acquisitions take far longer than commercial acquisitions, but the data shows that similar scale commercial acquisitions take only slightly longer for the DOD. Therefore, it is feasible that procuring smaller commercial satellites in the DOD would be relatively fast as is seen in the commercial industry.

Space Vehicle Processing and Launch Operations

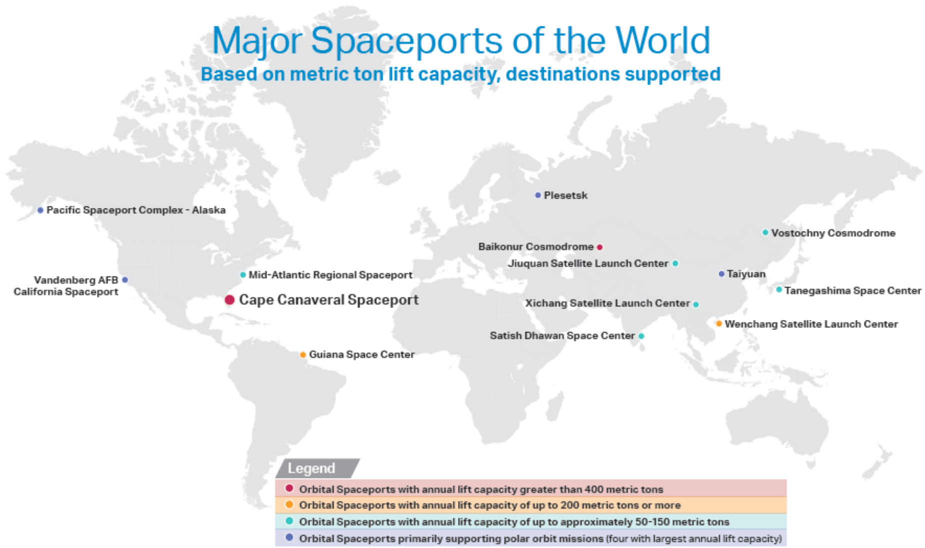
Air Mobility Command Space Concepts

Air Mobility Command's (AMC) mission is to provide rapid, global mobility, and sustainment of American's armed forces. They also provide humanitarian support around the globe. AMC utilizes a mix of intrinsic military capabilities such as the C-5, C-17, and C-130 aircraft. In addition to military capability, the US Transportation Command aircraft supports airlift requirements and transports military forces and material in times of crisis.[27]

(Source: Space Florida)

Figure 7. US spaceport locations

With the recent launch of reusable launch vehicles by commercial companies, AMC has begun to discuss the feasibility of utilizing these systems to transport military equipment and personnel.[28] The capabilities of future rockets such as the Big Falcon Rocket could potentially launch 150 metric tons in 30 minutes or less to any point on the globe and at a cost less than that of a C-5.[29] Additionally, these future reusable launch systems have the potential to place supplies on orbit, that could be rapidly deployed to AORs; as well as, rapidly transport US forces to a battlefield.



(Source: Space Florida)

Figure 8. Major world space ports

Spaceports

All end-user markets for space-based products and services depend on the availability of reliable and affordable access to space.[30] Additionally, they require a higher level of responsive to meet the needs of customers. Figure 7 showcases the United States' Federal Aviation Administration's current inventory of spaceports includes 19 active launch sites. Ten are licensed sites that are operated by state established entities and local airport authorities. Eight are US government operated sites, and some of these are available for commercial operations.[31]

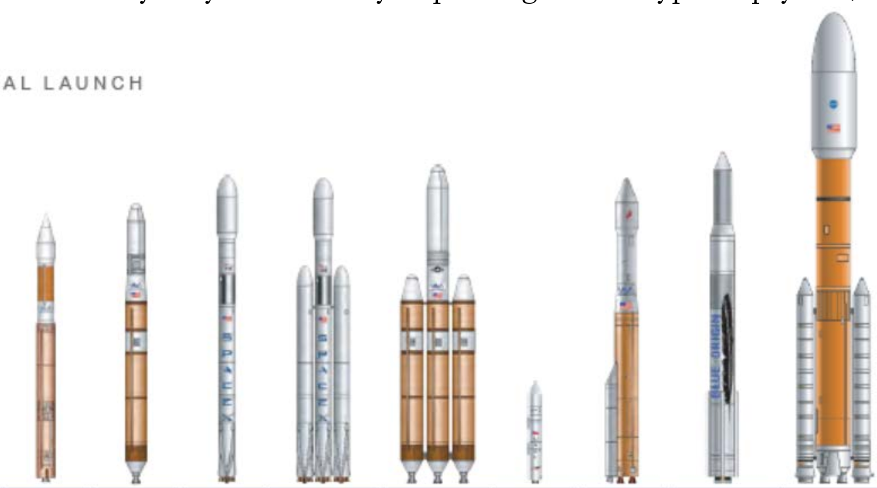
Figure 8 shows the major spaceports of the world.[32] From a DOD standpoint, the more launch sites, the better as this provides additional access points to space outside of Vandenberg Air Force Base and Cape Canaveral Air Force Station

(AFS), Florida. Additionally, such disaggregation prevents adversaries from only having to target two locations to impact American access to space.

Launch and Space Vehicle Processing

The process of preparing both launch and satellite vehicles for their mission is crucial to mission success but is often overlooked in the overall process of getting a satellite into orbit. Payload processing facilities are an essential component of a spaceport system.[33] Payload processing may happen at facilities on-site at spaceports like Cape Canaveral AFS or a separate location.[34] Processing timelines and requirements may vary considerably depending on the type of payload, launch

VERTICAL LAUNCH



Vehicle	Atlas V	Delta IV	Falcon 9	Falcon Heavy	Delta IV Heavy	Minotaur IV	Vulcan	New Glenn	SLS
Lift Class	Medium	Medium	Medium	Heavy	Heavy	Small	Medium	Medium-Heavy	Super Heavy
Operator	ULA	ULA	SpaceX	SpaceX	ULA	Orbital ATK	ULA	Blue Origin	NASA

Expected 2017-2020

HORIZONTAL LAUNCH

Vehicle	Pegasus XL	GOLauncher-2	LauncherOne
Lift Class	Small	Small	Small
Operator	Hortsontal ATK	Generation Orbit	Virain Galactic

(Source: Space Florida)

Figure 9. US launch vehicles

vehicle and mission. Figure 9 shows the current launch vehicles utilized within the US,[35] each of which may have unique mission requirements to add to the vehicle processing process. The significance is that current infrastructure must be in place to meet the unique mission requirements of each launch vehicle.

As seen in figure 10, there are numerous moving parts and this only accounts for launching a United Launch Alliance (ULA) Atlas-V rocket. The process will vary between launch vehicles. The illustration below demonstrates all that goes into bringing all to bear for mission success. First, the launch vehicle and satellite vehicle should be transported to the launch facility. In most cases, ULA will transport both their centaur (upper stage rocket) and its lower stage rocket body and engines by the sea in the Mariner. It will transport the vehicles from Decatur, Alabama to Cape Canaveral AFS that can take 7–10 days to travel the 2,100 miles. Next, the vehicles will be offloaded and sent to a processing facility to prepare them for launch and then brought to the vertical integration facility where it will wait to be mated with the spacecraft/satellite.

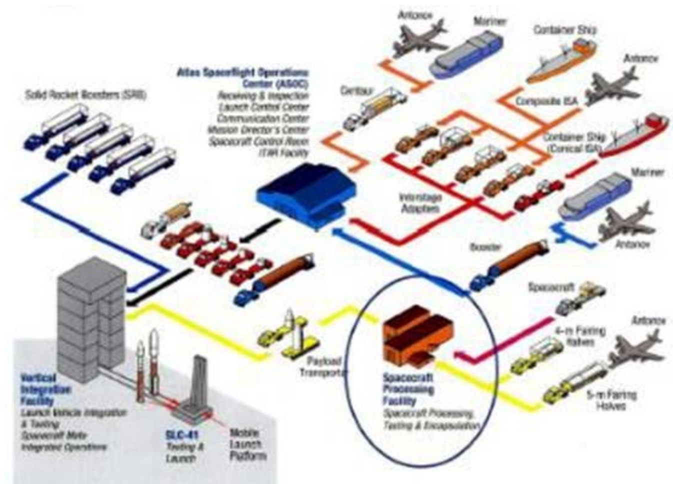


Figure 10. "Typical" mission processing flow

The spacecraft will also be shipped from its factory that can come from a variety of locations within the US and depends on where the manufacturer is located. Often the spacecraft is transported by air because there are significant limitations to traveling with spacecraft over the road, such as speed limitations to ensure spacecraft safety and environmental conditions. Additionally, over-the-road travel requires coordination with all local authorities and government bodies to ensure roadways are cleared and obstacles are removed. Once the spacecraft arrives at Cape Canaveral AFS, it will be brought into a spacecraft processing facility to prepare it for launch. Nominally, this is a 60–90-day process. That process will encompass testing and integration of its electrical and mechanical parts, ground station compatibility testing, fueling, encapsulation, transport, and mate to the booster. It will then be transported to the launch site where it will be mated atop the launch vehicle and ready for launch.

The National Reconnaissance Office (NRO) utilizes its own designated processing facility called the Eastern Processing Facility (EPF). The EPF is a state-of-the-art processing facility and enables the NRO to process its dedicated satellites and not have to rely on contracting out to privately owned processing facility like Astrotech. The EPF is unique in the capabilities it provides. It has four processing bays, two transfer aisles, an equipment air lock (area designated for equipment to be cleaned before going into the clean rooms), and each bay is a designated clean room. The EPF is also protected against hurricanes that can generate 155 mph winds. It demonstrated the level of its hurricane protection during Hurricanes Michael and Irma in 2016 and 2017.

The typical process for satellite processing for the NRO at the EPF starts with the spacecraft arriving at the EAL where its shipping container will be cleaned. Next, the satellite will be removed from its shipping container within one of the transfer aisles and floated into its appropriate processing bay. At this point, work can begin on the satellite to prepare it for launch. Satellite checkout will include mechanical inspections, electrical testing, propellent load, and encapsulation. All these steps are significant, but the most dangerous to the vehicle and personnel is propellent loading. Most satellites utilize hydrazine as a propellent, and it is deadly to breathe in.

Therefore, the EPF provides trained personnel to conduct the fueling while in full protective equipment that resembles hazardous materials and astronaut suits. Additionally, safety personnel monitor the 8- to 12-hour fueling operation from a safe location to ensure procedures are adhered too and respond to any anomalous conditions. Upon the completion of fueling, the satellite is ready for encapsulation and transport to the launch site.

What the illustration and NRO process above does not show is how painstakingly long operations surrounding the launch and satellite vehicles can be. For example, while transporting the prepared spacecraft to the launch site to mate with the launch vehicle the allowed speed limit is 5 miles per hour and is conducted during the night, which typically lasts several hours. Additionally, removing a spacecraft from the transport aircraft it arrived on typically takes three to five hours and requires a large footprint of support personnel to get the spacecraft off the plane. Due to the fact, that moving the spacecraft off the aircraft is going an inch at a time. Additionally, fueling operations can take 8–12 hours and last for up to three days. Air Force missions typically take one day to run through the procedure, another day to load oxidizer if necessary, and a final day to load propellant.

For the US to become more responsive in space, it must begin looking into process improvements to reduce the burdensome processes in place.

However, that is significantly easier said than done. Most spacecraft contain sensitive instruments that can be easily damaged and thus require gentle handling.

Therefore, for processes to improve, spacecraft may need to be more robust and be required to handle harsher conditions. The need for clean rooms is often due to the sensitivities of optical components. Obstruction of said components will decrease signal throughput and can scatter the signal beyond the diffraction design and thus decrease the performance of an optical satellite.[36] Additionally, on thermal control surfaces alteration of absorptance and emittance ratios can change thermal balances. Finally, contamination or foreign object debris can decrease power output on solar arrays and mechanical failure on moving parts. Therefore, the current construction of satellites requires the need for clean rooms.

Currently, Cape Canaveral AFS has the following payload processing facilities:

Armstrong Operations and Checkout (O&C) Building, Orbiter Processing Facility 1 and 2, Commercial Crew and Cargo Processing Facility, Multi-Payload Processing Facility, Orbiter Processing Facilities (OPF), Payload Hazardous Servicing Facility, Space Station Processing Facility, SpaceX Payload Encapsulation and Integration Facility, Large Processing Facility, Eastern Processing Facility (EPF), CCAFS Satellite Processing and Storage Area, and Space Life Sciences Laboratory.[37]

The O&C building was originally used for the integration of the Apollo spacecraft. In 2005, it began building renovations to receive and assemble the Orion Spacecraft.[38] The MPPF is being utilized for processing several payloads at once within a clean room environment and has also been renovated to accommodate Orion processing.[39] The OPF is home to the Boeing Starliner program, but OPF 1 and 2 have been utilized to support the processing of the Air Force's X-37B program.[40] The Payload Hazardous Servicing Facility is used for the integration of payloads with solid motors and liquid fueling. It is used for processing National Aeronautics and Space Administration (NASA) payloads.[41] The large processing facility was built in 1964 for the Air Force to assemble solid motor sections of DOD military rockets and is currently licensed to SpaceX and is used for large payload processing.[42] The EPF is a recently completed NRO facility that is utilized to prepare its satellites for launch. Finally, the Space Life Sciences Laboratory is the primary gateway for life science payloads bound for the International

Space Station, and it will enable testing and development of small payloads for launch on all Cape Canaveral-based launch vehicles.[43]

The significance in listing all these facilities out is to showcase that there are currently 12 processing facilities on Cape Canaveral AFS and not a single one is dedicated to the Air Force or the DOD. With the exception of a few select mission areas that the NRO has allowed to be processed at the EPF and the OPF, all Air Force and DOD mission process through the Astrotechs Space Operations facility. It is the only major processing company in Florida that is not located on Cape Canaveral.[44] In comparison to the EPF, it does not offer the same level of capabilities and is much more cramped as it was not designed to accommodate all DOD missions, unlike the EPF which was designed with NRO current and future mission needs in mind.

On-Orbit Satellite Operations

Spacecraft Checkout

On-orbit checkout and verification of the satellite occurs after launch and deployment of a satellite. The process for checkout is a deliberate process that takes anywhere from days to months. The checkout process and timeline are dependent on the complexity of the payload, characterization of sensors, testing of onboard systems, and exercising flight software. First of a kind satellites can take upward of six months to fully check out and characterize. Similar payloads can be checked out and verified in less a week. Continued reduction of on-orbit checkout times is a priority of both commercial and military providers; due to the fact, shorter timelines enable the payload to be placed into operations sooner, and extend the usable life of satellites.

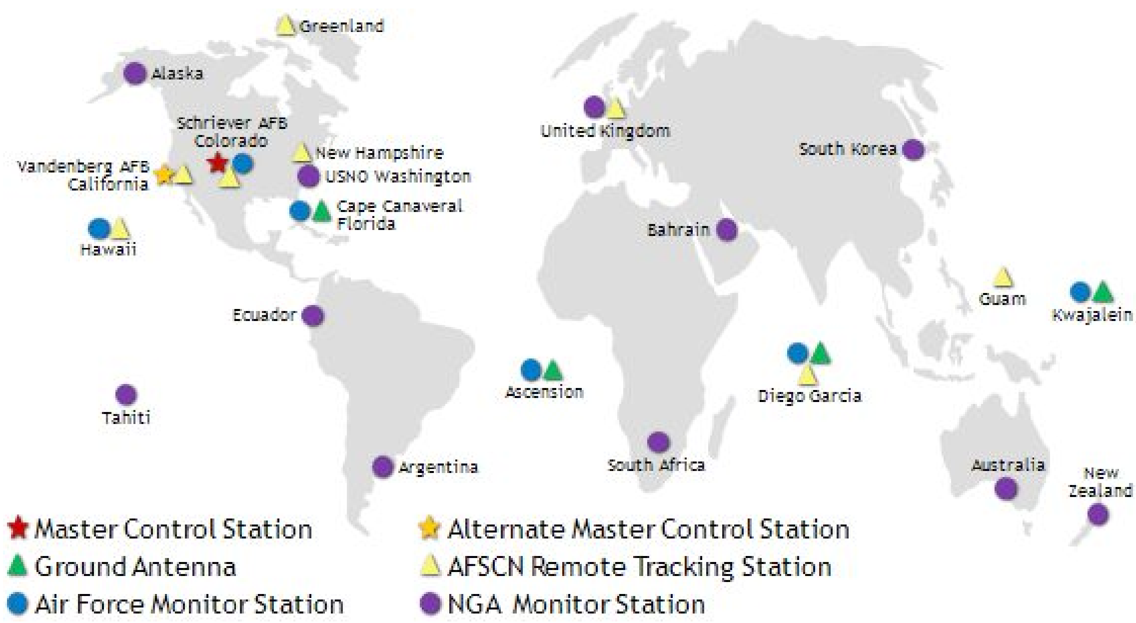
A study by the Joint Airpower Competence Center (JAPCC) notes that the idea of short notice, especially for military reasons or requirements, is to react quickly to developing situations. Process-wise, classical Space launch campaigns last from several weeks to even months, and conclude with the on-orbit checkout phase of the satellite, which satellite operators also must reduce significantly. A responsive launch capability requires already produced and preassembled Space Launch Vehicles, either produced or at least in assembly sets, and preproduced satellites, all kept in stock and ready to deploy. If a critical satellite is disabled, either due to technical reasons or due to an opponent's counterspace activities, it provides a quick way to react to restore the mission.[45]

In other words, the system should be able to be deployed and checked out quickly to respond quickly to user requirements.

Spacecraft Operations

Spacecraft operations consists of commanding and controlling satellites to perform station-keeping operations, checking the status of health, operating payload operations, and managing the day-to-day operations of the system. In the Air Force, most satellites are operated at Schriever Air Force Base (AFB) outside of Colorado Springs. To accomplish on-orbit operations, the satellite operator first must connect to the satellite.

The majority of Air Force satellites connect through the Air Force Satellite Control Network (AFSCN). Other satellites, such as GPS, utilize AFSCN and system dedicated ground sites.



(National Coordination Office image)

Figure 11. GPS control segment

Figure 11 provides an overview of the GPS control segment. To have worldwide coverage and access to the on-orbit operational constellation of 31 satellites (currently), GPS utilizes a mixture of the seven AFSCN and four dedicated ground antennas for commanding and controlling the constellation. Also, sites around the global constantly monitor signals from the GPS satellites that are relayed back to the Master Control Segment at Schriever AFB. This monitoring allows the operators to know if any issues are occurring even when the satellite is on the other side of the earth.

After a satellite operator connects to a satellite via AFSCN or other dedicated ground antennas, they can then command the satellite. These commands can vary from repositioning the satellite, performing software updates, turning on or off payload functions, and more. The operator utilizes ground-based software to accomplish these tasks at Schriever AFB. DOD space operations continue to evolve in tactics and techniques. Space was once a sanctuary where the US was free to deliver effects to the war fighter without worrying about the actions of advisories. China recognized the US success in leveraging the space domain and has taken steps to remove the US advantage in space. In 2007 the Chinese launched a ballistic missile with a direct ascent antisatellite (kinetic kill vehicle, destroying a defunct Chinese weather satellite.[46] This test illustrated that space was no longer a benign domain where the US is free to operate without the intervention of foreign advisories. Space has now become a new war-fighting domain with a unique character. This new domain has created a situation where space operators must learn to react in real time to preserve on-orbit capability.

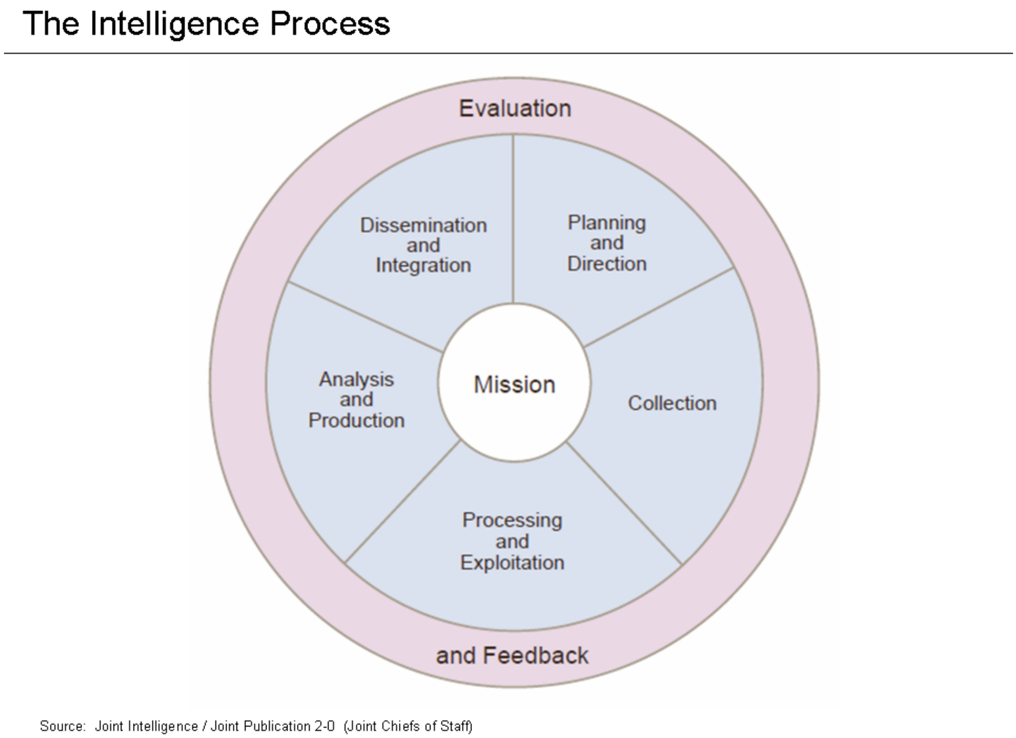


Figure 12. Task, collect, process, exploit, demonstrate (TCPED) process

Spacecraft Tasking

One example of space tasking is the intelligence model. Figure 12 provides the process as depicted by Joint Publication 2-0 (JP 2-0). This process starts at the top right where planning and direction is provided by an end-user to collect on the desired target. Next, the asset is prioritized to collect against the desired target.

Prioritization is predefined by standard operating procedures and may or may not elevate a user's requirement to the collection deck depending on sensor requirements. After collection of the data, the collection agency processes and exploits the received data. The functional manager of the data will then analyze the exploited data and process products for the user. This data is finally disseminated to the user for use in operations.

The TCPED process is further explained by JP 2-0 in Figure 13 by explaining how the operational environment filtered through a lens down to data, further refined into information, then finally into end-user intelligence.

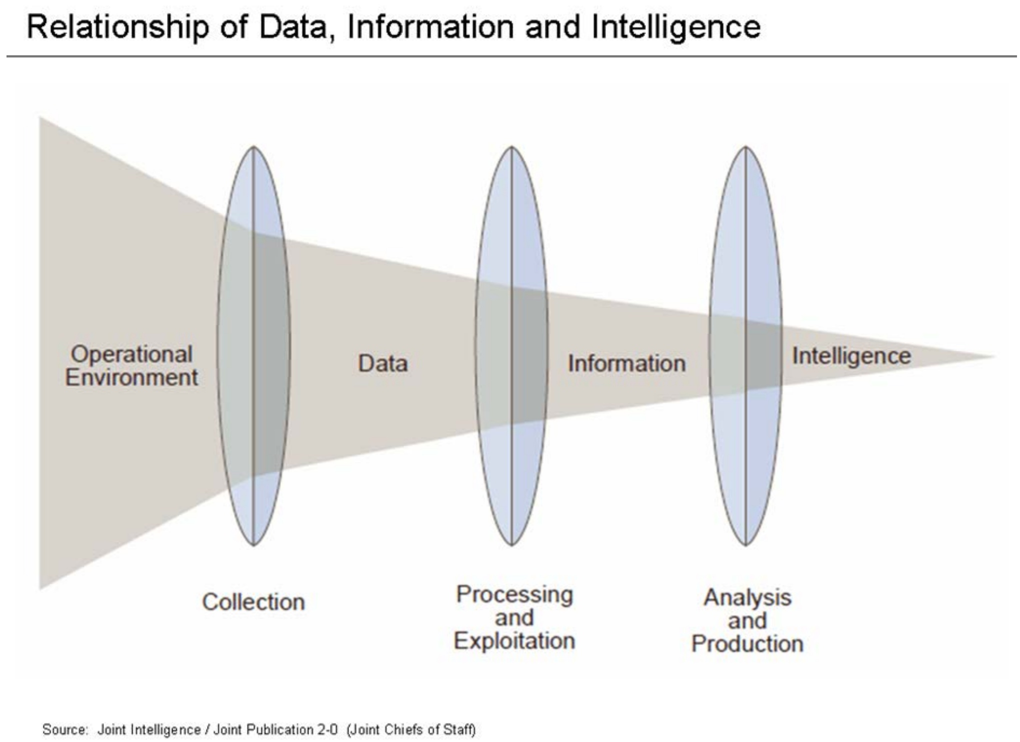
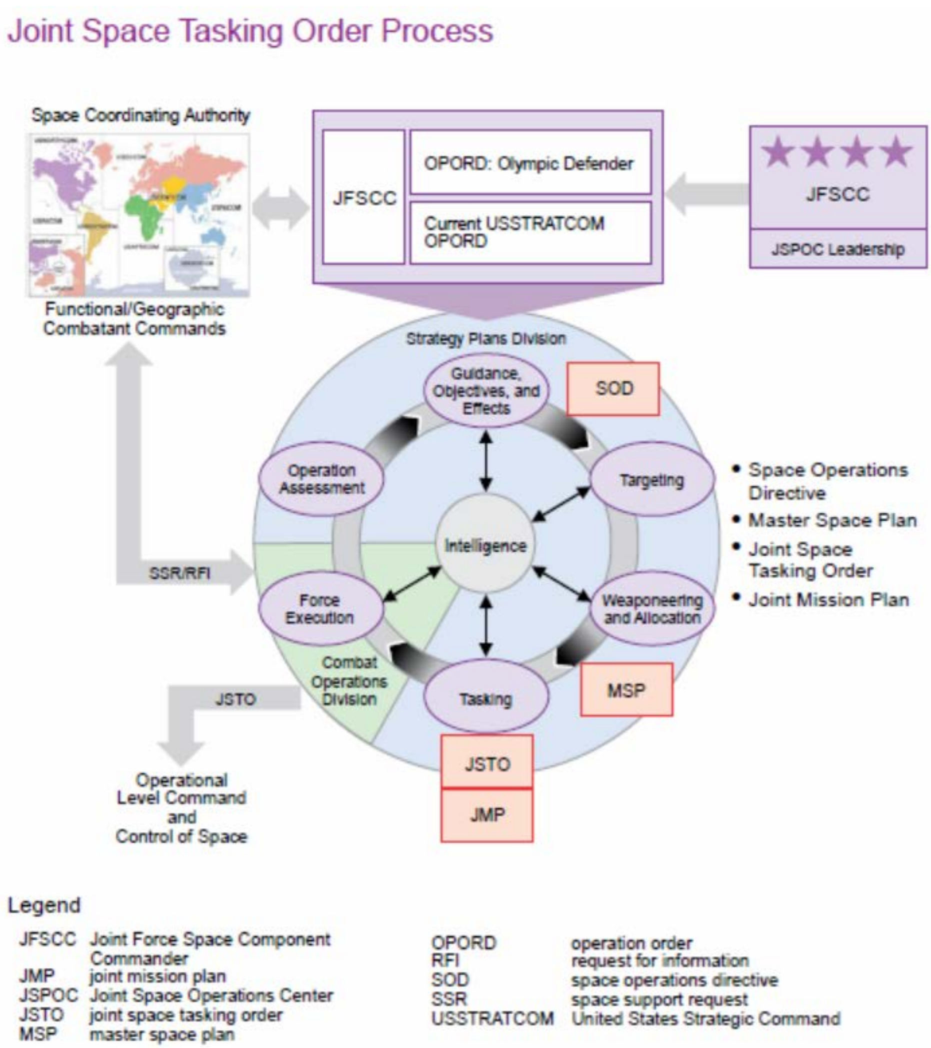


Figure 13. Data refinement process

The data refinement process is one example of how on-orbit assets are tasked by an end user in the field to receive final intelligence. While tried and true, this process lacks the immediate raw intelligence some users require to accomplish missions at the speed of relevance.

The second example of current DOD space vehicle tasking is the Joint Space Tasking Order (JSTO) process defined in JP 3-14, and figure 14 provides a pictorial representation of how the JSTO process is accomplished to meet requirements for the JFSCC and functional and geographic commands.



(Source: JP 3-14: Space Operations)

Figure 14. JSTO Process

JP 3-14 discusses the JSTO process transmits the JFSCC's guidance and priorities for a timeframe, assigns tasks to meet operational objectives, and, when required, synchronizes and integrates JFSCC activities with other combatant command elements. The JSTO process can be sped up or slowed down, depending on the urgency of the requested space effect.

Future End-User Interaction

Typical User Interaction with Satellites

Interaction between end users (i.e., combatant commanders down to theater units) is typically a passive experience. For instance, a GPS user simply turns on a device, and the signal from several overhead GPS satellites is received, correlated to, and a position is calculated and displayed on the user's device. Similarly, satellite communication occurs in much the same way. A user transmits or receives data to or from a satellite that is then received and processed. Additionally, COCOMs are typically not presented space assets as forces to be utilized in the planning and execution of theater operations. Space assets reside under the commander of Strategic Command and effects are produced through the JSTO process.

Army Program Kestrel Eye Program

The Kestrel Eye program was an Army initiative to prove a small, low-cost, visible-imagery satellite capable of providing images rapidly to the tactical-level ground war fighter.[47] Kestrel Eye was a prime example of how within a future space architecture, ground users will be able to receive tactically relevant data nearly real time. Kestrel Eye was a microsatellite with a weight of only 50 kg. The small size provides the advantage of being more affordable than larger satellites and therefore the ability to propagate a larger number of these satellites on orbit for better persistence of presence. The program manager noted:

> The chief item we learned from Kestrel Eye is that the concept to provide the Warfighter with rapid situational awareness at a reasonable cost has validity. Heeding lessons learned from the Kestrel Eye demonstrator will enable other SMDC small-satellite science and technology efforts to have an increased chance of success. The demonstrator has been a trailblazer for Army imaging from a microsatellite. It has shown beneficial tactical capabilities from space, which could represent a new tool for the tactical commander.[48]

The Kestrel Eye program is an emerging example of how future satellites may be tasked directly by ground users in the theater. This program has the possibility of pushing the use of satellites from the strategic level down to the operational and tactical level. Once this occurs, new doctrine, tactics, and procedure will rapidly evolve to deal with these changes.

Space Capabilities

Current Space Capabilities and Architectures

The current US space architecture includes capabilities across the DOD, intelligence community (IC), NASA, National Oceanic and Atmospheric Administration (NOAA), and commercial entities. Within the DOD, Air Force Space Command (AFSPC) provides the vast majority of current space capability. DOD capabilities include global positioning and timing, space-based communications, space-based infrared, space-based weather systems, and space-based surveillance systems. Inside the IC, the NRO provides the vast majority of capability, which includes signals intelligence, geospatial intelligence, and special communications. NASA is the focal point for US civilian space activities and conducts various space exploration missions, deep space imaging, and international space station occupation. NOAA operates geostationary operational environmental satellites. Also, US commercial entities operate various communications, imagery, and remote sensing satellites.

To implement the capabilities discussed above these organizations typically utilize a three-segment architecture approach. The first segment is the space segment and consists of a satellite on-orbit that contains mission payloads, hosted payloads, TT&C systems, station-keeping systems, flight software, and power systems. This segment requires launch vehicles to lift the satellite into specific orbits to meet mission requirements.

The second segment is the ground segment. This segment is responsible for the commanding and controlling of the satellite. In recent years, the ground segments have become extremely complex and one area of constant concern. As an example, in the Air Force, the Next Generation Operational Control Segment (OCX) for GPS has been under development since 2010 and has still not been fielded for operations. OCX has also faced numerous program breaches for both cost and schedule.[49] Issues and delays in field ground segment capabilities directly impact both the satellite and user segments. Since satellites are designed to last 10–15 years, capabilities are developed in the space segment and launched awaiting the ground segment to catch up with the proper software to command and control the new capabilities. In the case of GPS, OCX will bring on capabilities for a new military code (M-Code), as well as deliver the capability to turn on a signal that is compatible with allied Global Navigation Satellite System known as Galileo.

Ground systems are also responsible for receiving, processing, and, in many cases disseminating data, to users. Processing data in space is a costly task due to the required computing power required to convert data output from a sensor into the desired end product. For this reason, satellites typically transmit raw data down to the ground segment to be processed by server farms on the ground.

The final segment is the user segment. This is the segment that utilizes the on-orbit capability for the desired effect. In the case of communications satellites, the user segment could be a satellite phone; for GPS, it could be a smartphone; for weather satellites, it might be a military weather officer. The user segment must have the requisite equipment capable of receiving and processing the signal.

Capabilities on the Horizon

Multiple capabilities are on the horizon that is already beginning to revolutionize the space domain. First is the reduced cost to access space through the reduction in the cost of space launch. The decreased cost to orbit is leading companies to development proliferated constellations of small satellites. Next, is the development of extremely large launch vehicles capable of moving more mass to orbit in a single launch. Finally, artificial intelligence and machine learning will quickly revolutionize both space and ground segments.

The reduced cost to access space has been discussed earlier. Reducing access costs is rapidly changing the space marketplace from one where only large wealthy companies and countries have access to space, to a market where college students now have the ability to launch satellites into orbit. The reduction in cost to orbit has created a market for new technological solutions that include developing smaller proliferated architectures, that can rapidly be developed and launched.

The first example of a proliferated constellation design is OneWeb and Starlink.

OneWeb plans to build a constellation of 650 satellites in LEO to provide high-speed space-based internet.[50] Similarly, Starlink plans to develop a constellation in LEO of 4,425 satellites to provide broadband services.[51] Assuming one of these two companies comes to fruition, vast manufacturing lines of satellites will be developed that can be leveraged by both commercial and military markets.

Currently, SpaceX plans to develop a rocket known as the Big Falcon Rocket capable of launching 150,000 kg into LEO in a 9 meter fairing, and Blue Origin plans to develop the capability to lift nearly 45,000 kg into LEO in a 7 meter fairing. Additionally, the SMC plans to award other transaction authority to some of these companies to support these development activities in September 2018.[52] Future fairing of 9–11 meters will open up the engineering trade space in the design. Providing engineering flexibility to payload size will allow rapid development of technology that vastly increases performance and capability. For instance, larger payloads will be able to carry larger apertures into orbit. Larger apertures will enable new capabilities due to the fact they can collect more light and RF signals. This will increase the ability to accomplish both space intelligence, surveillance, and reconnaissance (ISR), communications, and situational awareness missions. In addition to receiving more and lower power signals, larger apertures allow energy to be transmitted more effectively. Therefore, large rockets have the potential to expand space capabilities tremendously.

Finally, artificial intelligence and machine learning are technologies on the horizon that will change space in the future. Artificial intelligence has the potential to change the space ISR enterprise by finding and tracking targets from satellites without user intervention. Also, as satellites architectures become more complex, satellites will utilize machine learning to fly without space operator intervention. These technologies are being researched by research institutes within the DOD and IC. IARPA discusses one program known as the Space-based Machine Automated Recognition Technique (SMART) that has the objective to develop tools and techniques to automatically and dynamically execute a broad-area search over the diverse environment to detect construction and other anthropogenic activities using time-series spectral imagery.[53]

Current Command Support Relationships to Combatant Commands

This section provides the background of space operations command support relationships to COCOMs. This background is important to understand to develop new command support relationships in the future.

Currently, space operations and the associated units deployed (either in-place or forward deployed) to a combatant command (COCOM) have clearly defined command and support relationships. Daily operations and the various staffs that work within the COCOM often misinterpret these command and support relationships. The common misunderstanding results in frustration and leads to discounting the integration of space effects that support the COCOM's theater campaign plan.

Joint doctrine and associated authorities place the command authority of all DOD space personnel, assets, and capabilities with the commander, United States Strategic Command (CDR USSTRATCOM).[54] When the US Strategic

Command (USSTRATCOM) presents these space units to a COCOM, the CDR USSTRATCOM delegates tactical control (TACON) of these space units to the Joint Force space component commander (JFSCC) who is dual-hatted as the commander. Ultimately, the JFSCC "coordinates, plans, integrates, synchronizes, executes, and assesses space operations, as directed by CDR USSTRATCOM, and facilitates unified action for joint space operations."[55]

Critical in maintaining the ability to command and control, synchronize multidomain effects, execute, and assess space operations is having a staff of professionals that maintains the technical, tactical, operational, and strategic understanding of the operating environment. The operation center that exercises TACON of STMF units and is responsible for command and control theater space operations is the Combined Space Operations Center (CSpOC). The CSpOC has various functions, but when the CDR USSTRATCOM presents forces to a COCOM, the CSpOC provides "reach back to facilitate coordination and support to theater SCAs."[56]

A restructuring and force structure review could occur for an organization like the CSpOC to address the monumental task of taking in requirements from the COCOMs and prioritizing their effects for execution. The missions assigned to the CSpOC may be attainable in peacetime or gray zone conflict but will eventually overwhelm the current structure of the CSpOC when engaging in near-peer conflict. During a force structure review, the CSpOC should address doctrine, organization, training, material, leadership, personnel, and facilities solutions to the required mission sets assigned to the CSpOC. There are numerous solutions that could be pursued that include a proposed change to the command and support relationships for SMTF units assigned to COCOMs.

Space forces, when deployed under the SMTF, should have the ability to conduct their mission with a clear and concise set of mission orders and tasks. Their operational support to COCOMs may take place in their home-station locations or in a forward deployed capacity physically located within a COCOM. However, a specific COCOM may use these space forces in a manner of their choosing to accomplish the COCOMs mission.[57] Under the current command and support relationships, space forces that are forward deployed must maintain numerous command and support relationships from USSTRATCOM to the operational unit they may be supporting. These relationships become complex when dealing with the ground, link, and space segments that include potential operations and impacts spanning multiple COCOMs.

COCOMs should request space forces within the SMTF for a period that they assess is required to meet the end state. Furthermore, these forces may be required for a JTF within a COCOM which adds another layer of complexity to the organizational chart, command and support relationships, and execution authorities. If a JFC requests TACON or operational control (OPCON) of space forces in their AOR, this process will be denied under the current construct because those authorities are held at USSTRATCOM. However, if requested OPCON or TACON of SMTF units can be coordinated by the CDR USSTRATCOM and the JFC with final approval usually from the secretary of defense.[58]

When considering how to integrate SMTF units and effects into the COCOM theater campaign plans or contingency plans, command and support relationships that reduce redundant staffing and coordination should be paramount. Joint Publication 3-09 dictates that units conducting joint fire support, whether lethal or nonlethal must be coordinated with adjacent units. This requirement to coordinate joint fires implies a level of coordination between the Joint Staff, COCOMs, service components, and operational units. Additionally, this reduction in staffing efforts and focused operational support to the COCOMs will be essential to consider and require coordination to procure, request, launch, checkout, and operational support to provide an economy of force and concentrate efforts within the SMTF.

To enable this coordination, the space coordinating authority (SCA) is a special type of authority that gives a specific individual the ability to coordinate space functions, missions, effects, and activities. This authority can be delegated to any individual from the CDR USSTRATCOM, but historically has been delegated to the air component commander (ACC).[59] This authority should not be confused with TACON or OPCON authorities but rather specific coordination between joint space forces within a specific ACC in the COCOM. Historically, SCA has been delegated to the director of space forces (DS4). The DS4, exercising SCA should integrate multidomain effects and ensure the proper level of coordination required for joint fire support for specific COCOM missions. The individual with SCA uses the staff functions to plan and present space effects based on the objectives of the operation for the joint force.[60] The DS4 does not have any authority to employ or direct space forces, but rather coordinate their requested effects from the COCOM to USSTRATCOM and JFSCC. This becomes complex when dealing with multiple requests from subordinate units within the COCOM that may be located in different areas of responsibility or regions throughout the COCOM.

Summary

Chapter 2 provides an overview of current requirements processes, acquisitions processes and organization, launch market summary, satellite tasking process, satellite operations, and current and future capabilities on the horizon. Understanding each of these elements is essential to have an informed conversation about where space will be moving in the 2030 timeframe. The next chapter will look at the desired end states for space architectures in the future.

Desired End-to-End Space Architecture

Chapter Overview

The primary goal of this research is to provide a future space architecture, that can be used as a vision to align priorities. Building on the literature review conducted in Chapter 2, Chapter 3 creates a future end-to-end architecture for space in 2030. The ultimate desired end state is a rapid process for developing space capability, processing the satellite, launching the satellite, and providing effects to the end user.

Architecture

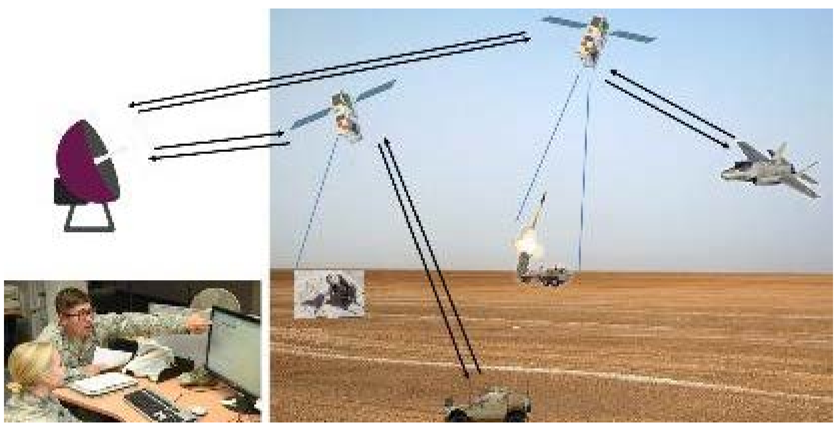


Figure 15. High-level operational concept graphic

Figure 15 provides a high-level operation concept for the desired system. The first step is to develop systems that end users can utilize for operational and tactical fights. Most satellites today are strategic assets utilized for strategic missions, and data produced from these systems is flowed slowly down to the operational and tactical levels. The architecture depicted in figure 15 will allow end users (i.e., forces on the ground, planes in the air, or ships at sea) to utilize satellites real-time to provide intelligence, reconnaissance, and surveillance (ISR) data real-time from rapidly deployable space-based assets. Additionally, data received from on-orbit sensors will be able to fuse data real-time with end users platforms to generate a synergy of effects from those platforms to target adversary forces. Day-to-day operations of the satellites, to include station keeping, the status of health checks will occur by space operators at CONUS or OCONUS locations.

To enable this future space capability for operational and tactical users, multiple items should be accomplished. First, requirements for systems that need to be designed. Next, the systems must be designed, built, and fielded. Fielding requires rapidly processing, launching, and certifying the system as ready for operations. Finally, the satellites will have to be command and controlled. This command and control will first occur between satellite operators who will provide satellite check-out, the status of health, and daily maintenance. The second type of command and control will occur between the operational and tactical user and the satellite.

Future Space CONOPS

Requirements and Acquisitions

It is envisioned that forces on the ground will require immediate tactical and operational space assets upon entering a theater of operations. To accomplish this task, these new systems must be ready to be deployed before entering a campaign. This preparation will require changes to the requirements and acquisition process. These processes must move to rapidly acquire systems capable of accomplishing the desired function of providing tactical and operational level ISR from space and fuse that data with end-user systems.

First, the requirements process must be set up in such a way that users provide direct input into the development of requirements. Similar to JCIDS, the end user would define capabilities required to enhance mission effectiveness. In parallel, a Joint Systems Program Office (JSPO) would be established. This office will analyze what is in the realm of the possible through a technology maturation office that will conduct market surveys, broad-area announcements, and fund basic research. The technology maturation office will be responsible for accessing options that meet end-user requirements, as well as determining areas for investment to bring new technologies required online. The JSPO will also have a systems office, required for procuring space and ground system to meet end-user requirements. This entire JSPO and requirements process will be overseen by a relatively small board of directors. This board will be responsible for making decisions on which requirements to fund and guiding the JSPO through acquisition decisions.

As requirements are developed, the program office will work to rapidly procure technology demonstration satellites to test requirements and determine updates to requirements required for seamless end-user interaction with the satellite systems. This will involve taking high-level capability requirements and distilling them into system level requirements for both satellite vehicles and ground software. To streamline this approach, it is recommended that the acquisition office be flat, similar to the RCO or NRO acquisition offices. This means that one program executive officer (PEO) is over the office with the authority to make acquisition decisions. This PEO will report to a board of directors, who will also have oversight of the requirements process. This board will comprise of five executives representing the four branches and US Space Command. Figure 16 provides a recommended PEO structure for decision-making for high-level requirements and program decisions.

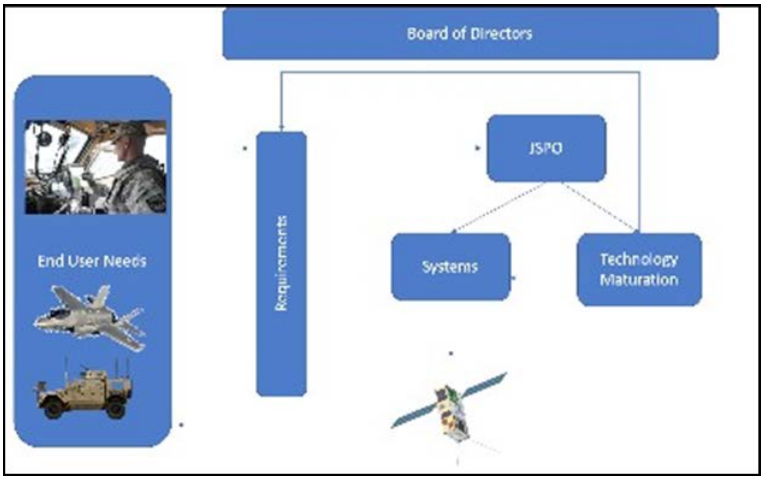


Figure 16. Streamlined requirements definition process

Processing Operations

With a renewed commercial interest in the launch mission, the DOD should begin seeking to benefit from achievements made by commercial parties. The US government should begin building partnerships with US commercial firms to pursue ultra-low-cost access to space.[61] Figure 17 demonstrates how the market has grown and should further motivate the DOD to begin developing partnerships.[62]

Additionally, the introduction of reusable launch vehicles (RLV) will likely generate a significant increase in the number of suborbital and orbital launches as it has the potential to significantly reduce the cost of gaining access to space.[63] For example, RLVs typically have a smaller footprint, require less infrastructure, and

	TOTAL NUMBER OF NON-COMMERCIAL ORBITAL LAUNCHES CONDUCTED FROM 2006-2015	TOTAL NUMBER OF COMMERCIAL ORBITAL LAUNCHES CONDUCTED FROM 2006-2015
Russia	225	93
USA	208	151
China	198	14
Europe	55	64
Japan	39	2
India	41	4
Iran	8	0
Israel	4	0
South Korea	4	0
North Korea	4	0
Multinational	0	23
Argentina	0	3
Canada	2	2
Singapore	5	1
Indonesia	2	0
Philippines	1	0
TOTAL	800	357

Source: FAA, Commercial Space Transportation Year in Review (2006 to 2017); AECOM compilation

Figure 17. Total launches by country (2006–17)

can often utilize the mobile infrastructure.[64] Figure 18 shows the percent of sub-orbital RLV launches which are currently being dominated by the commercial human space flight market.[65] This is yet again another opportunity for the DOD to benefit from the commercial sector.

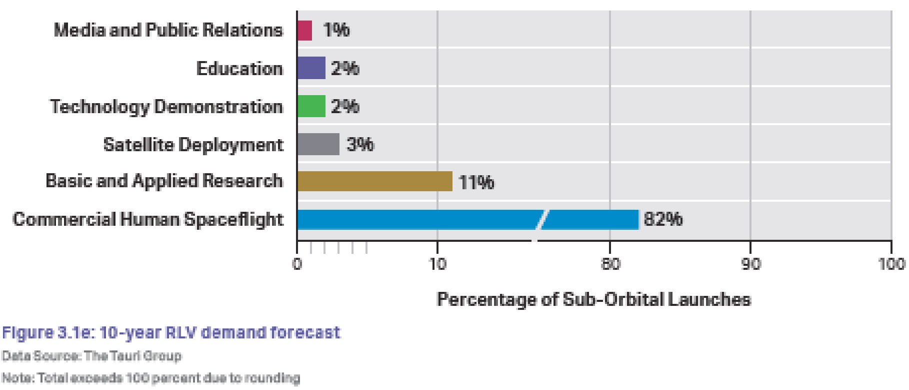


Figure 18. 10-year launch vehicle demand

Future demands from the commercial sector will likely drive the requirement for future processing centers similar to Astrotech. Additionally, commercial operators processing smaller satellites and cube satellites will likely be only willing to pay smaller fees to process through a facility.[66] Both large and small satellites will require clean rooms, thermal vacuums, vibration tables, acoustic chambers, radio frequency chambers, and an electronic bench.[67] The difference will be the size and scale.

Smaller satellites will likely be able to utilize mobile processing centers which will reduce the needed infrastructure that larger satellites require.[68] Therefore, the US government, specifically, the DOD should begin investing in infrastructure that provides processing capabilities for DOD specific satellite mission areas. The construction of a processing facility along the lines of the EPF but dedicated to the Air Force and the DOD could eliminate processing timelines and reduce the potential bottlenecks if the DOD begins realizing the capability of launching on demand. As stated earlier, Astrotech is not located on Cape Canaveral AFS, and thus transportation timelines are longer for DOD satellites. Additionally, the transportation infrastructure can pose issues as their bridges and roadways that fall on local government to maintain and thus put the DOD mission at risk if local governments do not deem infrastructure maintenance as a priority. Finally, a DOD-dedicated facility allows for more flexible and responsive access to space as it eliminates reliance on commercial entities, can ensure for future growth, and provide for storage of satellites. This final point provides for the storage of satellites and will be a requirement for the US to enable rapid constellation replenishment and enable rocket initial supply or resupply downrange into the theater.

Launch Operations

In the desired future, architecture launch operations should be seamless and rapid. With the advent of reusable launch vehicles that act similar to aircraft, with the capability to transport payloads to a desired orbital location, it is envisioned the future of space launch will evolve into an Air Mobility Command model. A future Space Mobility Command would be responsible for rapid deployment of forces and material to a battlefield. In the future, battlefields will also include space orbits; therefore, a Space Mobility Command would assume responsibility for launching and deploying satellites on-orbit.

Similar to AMC, who has in-house capability and utilizes commercial services, a future Space Mobility Command would have both intrinsic capabilities and the capability to procure commercial launch services.

Proposed Command Support Relationships to COCOMs

Concepts put forward in this article require an assessment of current command support relationships when requesting space assets as needed within a COCOM. Historically, the space assets have been organized, trained, and equipped within the joint services and presented to USSTRATCOM as the COCOM authority. USSTRATCOM has retained COCOM authorities and OPCON of space assets within the space operations squadrons and TACON within the JFSCC at the CSpOC. Also, the Air Component Command within a geographical COCOM has been delegated SCA from CDR USSTRATCOM and generally further delegates this authority to their director of space forces (DS4). The current command and support relationships as outlined above will be challenging to manage with the standard ATO and JSTO cycles when presented with robust capabilities from a proliferated LEO constellation and the evolution of complex threats.

In the proposed solution to the current command and support relationship, COCOMs can identify gaps or requirements that are not fulfilled to achieve their theater campaign plans or during times of crisis. The COCOMs must have the ability to request, task, and integrate space effects that can create redundancy and resiliency within all war-fighting domains within their COCOM. This process could begin with a formal request from the COCOM to the CDR USSTRATCOM for a specific effect or unit.

Furthermore, assuming concepts such as a proliferated LEO constellation as outlined in this article come to fruition, the COCOM could request space assets from USSTRATCOM for use to mitigate risks from identifying gaps. For example, if United States Africa Command (AFRICOM) has identified a gap in their ISR collection plan due to higher level national priorities and their inability to collect with organic means, they could request in-theater ISR augmentation to enable their collection plan and support preplanned or ongoing operations. The CDR USSTRATCOM at that time could allocate space-based assets within a proliferated LEO constellation, SMTF units or elements, and delegate authorities to AFRICOM. Once the CDR USSTRATCOM concurs with the request from the COCOM, multiple authorities could be delegated to streamline the ATO/JSTO process within the COCOM resulting in the delivery of space effects for the COCOM's subordinate units.

First, space crew units that are trained, certified, and assigned to the SMTF fall under the OPCON authorities of USSTRATCOM. Their daily operations are to ensure the health and safety of the satellite (bus) and payload (sensor). These SMTF space operating squadrons that operate the bus and payload are currently under OPCON of USSTRATCOM even though their satellites may be supporting various COCOMs.

Currently, their daily tasking and operations are dictated and prioritized by the CSpOC based off requirements and requests from the COCOMs through the JSTO process.

If USSTRATCOM were to delegate OPCON to a requesting COCOM, the subordinate units could leverage proliferated LEO constellations in a more dynamic and rapid tasking methodology. Under this restructuring, OPCON of the SMTF space operating squadrons that ensures the health and safety of the bus will more than likely not need to forward deploy from the ground site previously used for operations under USSTRATCOM. As an example, AFRICOM may not require the SMTF unit to physically be within the COCOM to conduct operations to ensure the health and safety of the bus but still retain OPCON of the space operating squadron that USSTRACOM delegated OPCON to the COCOM.

Second, OPCON of the sensor operators assigned to the SMTF space operating squadrons may or may not be required to forward deploy to the COCOM. If required to colocate within the COCOM, the SMTF would have the ability to dynamically task dedicated space assets during operations without delaying operations due to the ATO/JSTO cycles. For instance, AFRICOM may request a deployable space crew sensor operators from the SMTF space operating squadrons home station to colocate within COCOM C2 nodes to enable operations. If required to be an expeditionary unit within the SMTF, they must maintain a trained and ready force capable of providing space effects to the requested COCOM and their subordinate units. The ability of an expeditionary SMTF element to forward deploy and integrate space effects will be a requirement within the next decade.

Third, SCA should continue to be delegated to the COCOM as this delegation has been historically exercised in COCOMs. However, SCA may require further delegation to ensure the requirements and effects when conducting operations in, from, and through the space domain. This will ensure that multidomain effects are synchronized from the tactical level to the COCOM. There are various units that are in existence today from the Army and Air Force to provide such integration at the tactical to operational levels such as Army space coordination elements and Air Force weapons officers. However, SCA has not traditionally been delegated below the DS4 who has traditionally integrated and working within the Combined Air Operation Center on behalf of the ACC.

Additionally, if the SMTF establishes an expeditionary element within the unit, they could be delegated SCA for their specific mission set forward deployed in the COCOM. As outlined in this article, this individual could be trained, certified, and placed on the SMTF as a space master gunner. As an example, SCA may be delegated from USSTRATCOM to AFRICOM, who further delegates SCA to the ACC/DS4. If and when mission requirements or COCOM request is submitted, SCA may be further delegated to a designated SMTF space crew servicemember that is deeply familiar with the satellite capabilities and architecture. More importantly, this individual must maintain a high level of operational planning and understanding of the operating environment to support the overall ground scheme of maneuver. This individual can be the liaison on behalf of all space entities, understand multidomain integrations points, and provide the best military advice to multiple echelons of commanders within the COCOM. They can also remain synchronized with the DS4 and their home-station SMTF unit conducting the bus and payload operations that enable COCOM mission success.

Gap Analysis

Chapter Overview

To reach the desired architecture, multiple items need to be accomplished. These include developing and integrating new technologies, streamlining processes for both requirements and acquisitions, and finally taking a fresh look at military doctrine on how to incorporate the new capabilities.

Technology

Multiple technologic gaps exist to achieve the capability to operate extremely large constellations of satellites and nearly instantaneously provide that data to ground users within the theater. First, satellites must be able to be produced at large scale. Also, it will be required to rapidly deploy these satellites on a large scale. Next, it must be possible to command and control large constellations of satellites. Finally, data must be processed on board the satellite and downlinked to end users with extremely low latency to ensure the data is timely and accurate.

Satellite Production

Currently, satellites are produced in very small numbers. Within the DOD, the largest current manufacturing line for satellites is the GPS III and IIIF production line in Waterton, Colorado operated by Lockheed Martin. This production line is projected to produce a total of 32 satellites, with production starting in 2012 and anticipated to complete in 2036.[69] This is approximately 1.5 satellites produced per year. In the future, it is anticipated that the DOD will have constellations of hundreds of satellites operating in various orbits. To produce hundreds of satellites on a rapid timeline will require rethinking how satellites are developed and built.

Additionally, it is envisioned proliferated constellations will provide numerous capabilities. These capabilities include localized PNT, GEOINT, SIGINT, communications, space situation awareness, and space-based offensive and defensive services. Therefore, to effectively leverage large-scale production lines, flexible payload integration options must also be produced. This will require the development of standard satellite bus to payload interfaces. These interfaces will allow payloads to be developed that can simply plug into satellite buses. A standard interface will provide the flexibility to develop specific payloads required for specific tasks and allow for rapid integration of these payloads to buses in large-scale production.

Large-Scale Rapid Satellite Deployment

Currently, there is no existing infrastructure to process or store DOD assets at a launch site. The launch on-demand capability will drive increased processing needs in addition to clean room storage. If the DOD is to recognize a more agile launch capability for its existing satellite assets large dedicated infrastructures will need to be created.

One significant issue currently facing spaceports is the ability to store spacecraft before launch. Storability allows for increased launch opportunities and launch on demand.[70] There is currently no location at Cape Canaveral AFS to store satellites outside their launch processing window. This is due to the current acquisition process for satellites that launches on order not on demand. Space domain capabilities can be further expanded through smaller launch on-demand systems when rapid and responsive effects are necessary.[71] Currently, as showcased above such capabilities do not exist for the DOD. The current American space launch system is based on a policy that is focused on launching on schedule, not on demand.[72] Operationally responsive launch is one vital component of an operationally responsive space architecture.[73] It will require acquisition and production capabilities that allow for rapid satellite and launch vehicle procurement.[74] Additionally, it will require streamlined processing procedures and satellites that utilize components that are the same to reduce the need for unique mission requirements.

However, a lack of processing facilities may result in spaceports like Cape Canaveral AFS acting as chokepoints to space mission areas. Therefore, the Air Force and the DOD as a whole must work to adapt to the changing marketplace and begin seeking opportunities to better support more capable ranges, mobile clean rooms, flexible satellite transportation, and spacecraft processing infrastructure.[75] Such a process should focus on incorporating lessons learned from NASA and other space organizations transportation operations to improve existing transportation concept of operations and inventory.[76]

Key Recommendations

Chapter Overview

This chapter provides the key recommendations derived from the research of a future end-to-end vision for the future of DOD space. These include recommendations in the areas of requirements development, organizational constructs and relationships, processes, and finally technology.

Requirements

It is recommended that the US streamline future requirements processes and provide more crosstalk between the user and acquisition organizations for systems that can be utilized by theater commanders. Experienced acquisition professionals should be embedded in COCOMs to a greater level and act as direct liaisons to space program offices. This will enable SDA, Space RCO, SMC, and the Air Force Research Lab to conduct more focused research through broad-area announcements, small business innovate requirements, and studies with vendors to rapidly mature technologies that meet end-user needs. Also, the requirements process should be flattened to enable disruptive space technology to deploy at a more rapid rate.

In addition, it is recommended current global and strategic systems such as GPS remain on the deliberate requirements approach defined in JCIDS, with appropriate oversight. The importance of specific DOD strategic systems requires deliberate development and mission assurance that results in longer requirements cycles.

Organizations

As discussed in Chapter 2, the DOD is moving forward with three key organizational changes in space acquisitions. These are the development of the SDA, Space RCO, and a redefined SMC. Effectively integrating and deconflicting the roles and responsibilities of these organizations will be essential to developing a streamline and coherent space acquisition capability within the DOD. This will require deconflicting roles and responsibilities, effectively integrating the acquisitions into a coherent enterprise, and leveraging developments across the organizations.

The second organizational recommendation is to further research the development of a SMC. The benefits of having an intrinsic military capability, manned by members of the military to process, launch, and deploy military forces, military and capability in the future cannot be underestimated. In conflict commercial entities may not be able to take the same risk as the military concerning reusable launch vehicles. Therefore, the military must consider possessing its capability through the procurement of launch vehicles, and development of military launch organizations that own reusable launch vehicles and launch those vehicles.

The final organizational recommendation is to rethink how some satellite constellations are utilized to present forces to a COCOM. With the vision of future satellite proliferation, it is feasible that capabilities could be presented to a COCOM when assets are above the theater. These assets could be tasked by the COCOM to meet theater level requirements, without the approval or coordination with STRATCOM or a future USSPACECOM.

Infrastructure

As stated above the US must begin developing infrastructure that supports the growing commercial space capabilities. Specifically, the DOD should move away from the current model that focuses solely on commercial provided space craft processing.

The ability to launch on-demand as opposed to on-schedule will require space craft to be stored and at the ready with its required flight hardware. The current infrastructure in use is not sufficient.

Technology

It is recommended that the DOD begin to invest in companies planning to do large-scale satellite development. These companies need to mature the capability of producing satellites at scale. In addition, these companies will need to develop methods for controlling large constellations of hundreds of satellites. By leveraging the work of these commercial companies, the DOD can save significantly on research and development costs, while bringing significant capability to the fight.

Conclusion

Conclusions of Research

This research provides a concept for future end-to-end space architecture for US national security space. It looks at requirement, acquisitions, processing and launching space vehicles, on-orbit operations, and constructs for how these future forces could be employed by COCOMs. This research concludes that by 2030, new capabilities will be readily available that allow larger proliferated architectures to conduct numerous theater activities from space. Moving forward it will be important to develop requirements proliferated satellite systems. Also, it will be important to rethink how satellite processing and operations occur. Currently, our ground infrastructure to processing and launching satellites is vastly inadequate to meet emerging capabilities brought along with proliferated architectures.

Finally, this research recognizes the benefits of proliferated architectures, but still recognizes the importance of maintaining current capability with smaller constellations of large satellites that provide PNT, ISR, early missile warning, and communications. A proliferated architecture should be built in parallel to maintaining and modernizing existing capabilities.

Investigative Questions Answered

The following section answers the investigative questions presented in Chapter 1 of this article.

What is the current landscape for end-to-end space operations?

The current landscape is two parts. First, the DOD and IC must maintain current strategic assets held. These assets must continue to be procured and fielded to meet strategic needs. Second, the landscape is changing to include constellations of hundreds of satellites.

What should the future architecture for an end-to-end approach for space operations?

The future architecture should include a mixture of both proliferated satellite constellations and modernized legacy constellations. This end-to-end approach should maintain maintenance and status of health monitoring of satellites in CONUS, but also be able to present these satellites as in theater forces to COCOMs when the satellites are available in the AOR. Modernized legacy constellations will remain national assets with authority for tasking out of USSTRATCOM (or a future USSPACECOM).

What gaps will the US military need to fill to enable this new architecture?
The major gaps the US military needs to fill are both technological and bureaucratic. The technological gaps include determining how to procure, build, and operate extremely large constellations of satellites. Also, the DOD must fill the gap of processing and launching large constellations. This will involve developing new processing facilities, and potentially an intrinsic military capability for space mobility, such as an SMC.

Finally, multiple bureaucratic challenges need to be overcome organizationally. These include flattening the requirements and acquisitions process, developing a new space tasking concept that includes presenting space forces to COCOM.

How should the US military organize to enable this new architecture?

The US military is already moving forward with a USSPACECOM that will be in charge of DOD strategic space assets. In addition to USSPACECOM, the organizational methodology should be worked out so that COCOMs are presented assets for in-theater use. Satellites presented to COCOMs would fly over multiple commands in a single orbit, and therefore deconfliction, handing over assets between commands needs to be addressed organizationally.

What technology should the US military invest in to enable this new architecture?

The US military should invest in three key technologies to enable this future architecture. The first key technology includes methods to reduce the cost of placing satellites to orbit. Today, multiple companies are pursuing reusable launch vehicles as a means to reduce cost to orbit. In addition to the reusable launch, the US military should continue to search for other means of placing satellites in orbit at a low cost.

Next, the US military needs to invest in satellite processing and launch infrastructure. Today, only two sites exist for processing and launching satellites. These are at Cape Canaveral AFS and Vandenberg AFB. Limiting launch to these locations will limit the ability to meet the flexibility and rapidness of launch. Finally, the DOD should invest in companies who plan to mass produce satellites for commercial proliferated constellations.

What new military doctrine should be created to allow the implementation of this new architecture and CONOPs?

Doctrine should be reviewed and updated to work through tasking and presenting space forces to COCOMs. This update would likely be provided in JP 3-14 *Space Operations*. Also, manning should be reviewed to determine how to staff future organizations that are envisioned. These organizations include launch squadrons that can process and launch satellites; organizations within COCOMs who take control over satellite tasking while specific assets are in theater; and finally, how to embed acquisitions with COCOMs to produce better requirements. Finally, this research looked at one methodology based on the Army Master Gunner Concept for Space. Proposed doctrine language to leverage is located in Appendix B.

Recommendations for Future Research

This article identified a few areas for recommended future research. These include the following:

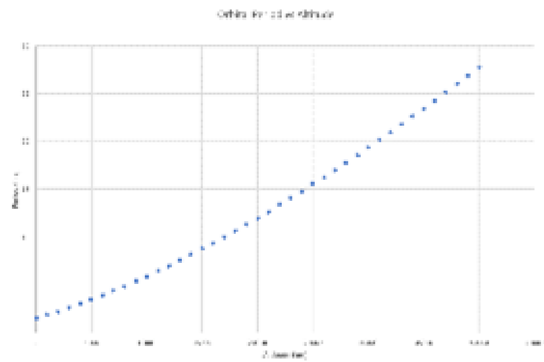
- How should space acquisition offices (i.e., SMC, Space RCO, and SDA) be organized, and what should each organization's roles and responsibilities be within the space enterprise?
- What would a detailed construct for a SMC? What infrastructure (launch and processing) will be required for rapid replenishment and launch on demand?
- How will assets in future proliferated LEO constellations be utilized by COCOMs, including how will these assets be transitioned as they fly through various COCOMs?

Appendix A: Orbital Period vs Altitude Derivation

Equation for Orbital Period (P_o)

$$P_o = 2\pi(\sqrt{\frac{a^3}{GM}})$$

Altitude (km)	Semi Major Axis (km)	Period (seconds)	Period (Hrs)
100	6480	5191.266962	1.4420186
1100	7480	6438.182024	1.7883839
2100	8480	7771.496088	2.15874891
3100	9480	9185.934838	2.55164857
4100	10480	10677.08692	2.96585748
5100	11480	12241.19134	3.40033093
6100	12480	13874.99171	3.85416436
7100	13480	15575.63254	4.32656459
8100	14480	17340.5831	4.81682864
9100	15480	19167.58019	5.32432783
10100	16480	21054.58402	5.84849556
11100	17480	22999.74372	6.3888177
12100	18480	25001.36985	6.94482496
13100	19480	27057.9122	7.51608672
14100	20480	29167.94167	8.10220602
15100	21480	31330.13526	8.70281535
16100	22480	33543.26357	9.31757321
17100	23480	35806.18022	9.94616117
18100	24480	38117.81295	10.5882814
19100	25480	40477.15593	11.2436544
20100	26480	42883.26319	11.9120176
21100	27480	45335.2429	12.593123
22100	28480	47832.25237	13.2867368
23100	29480	50373.49374	13.9926371
24100	30480	52958.21011	14.7106139
25100	31480	55585.68217	15.4404673
26100	32480	58255.22516	16.182007
27100	33480	60966.18622	16.9350517
28100	34480	63717.94197	17.6994283
29100	35480	66509.89636	18.4749712
30100	36480	69341.47872	19.2615219
31100	37480	72212.14203	20.0589283
32100	38480	75121.36131	20.8670448
33100	39480	78068.63219	21.6857312
34100	40480	81053.46959	22.5148527
35100	41480	84075.40653	23.3542796
36100	42480	87133.993	24.2038869
37100	43480	90228.79501	25.0635542
38100	44480	93359.39361	25.9331649
39100	45480	96525.38408	26.8126067
40100	46480	99726.37511	27.7017709



Constants	
GM (m^3*s^-2)	3.986E+14
Earth Radius (km)	6380

Appendix B: Space Master Gunner Concept

The US Army's Master Gunner's primary duty description is to be the subject matter expert for their assigned weapon system and to assist the commander in the planning, development, execution, and evaluation of all individual, crew, and collective combat training.[77]

The United States Army establishes 11 principles of unit training listed in figure 19.[78] For the purposes of this article, we will analyze principles of unit training and their application to either individual training, collective training, or ongoing during the unit training cycle.

- Commanders and other leaders are responsible for training.
- Noncommissioned officers train individuals, crews, and small teams.
- Train to standard.
- Train as you will fight.
- Train while operating.
- Train fundamentals first.
- Train to develop adaptability.
- Understand the operational environment.
- Train to sustain.
- Train to maintain.
- Conduct multiechelon and concurrent training.

Figure 19. US Army 11 principles of training

With the lack of established and fundamental doctrine, the US Air Force must look to other organizations to establish doctrinal principles to enable the space master gunner to develop, plan, execute, and assess training for space crews. Furthermore, these principles could provide rough guidelines and priorities for unit commanders, leaders, and master gunners to emphasize during individual and collective training events. The 11 principles discussed in Chapter 2, figure 4 can be used within the individual and collective training phases of the space crew certification before their assignment to the SMTF. For this article, we will analyze principles of unit training and their application to either individual training, collective training, or ongoing during the unit training cycle. It is imperative that the commander, unit leadership, and the proposed space master gunner(s) take an active role and are invested in the unit training pipeline.

The unit commander is ultimately responsible for their space crews mission execution; they must delegate authorities within the unit, understand the all facets of the unit training, they themselves must observe training management processes, and develop leaders that are capable of executing decentralized operations if required.[79] Furthermore, these standards and space crew certifications are certified by the command authority for the unit. To enable organic training and evaluation opportunities, the space master gunner, on behalf of the unit commander, can oversee and evaluate the certification training events for the unit.

During this process, the space master gunner should implement training that is sustainable within the available time and resources allocated to the unit during the training cycle. The space master gunner, with the execution and oversight authority from the unit commander, incorporates training that takes into consideration unit maintenance for space systems and their requisite equipment. Space crew operators must understand their equipment and reinforce fundamentals at all levels of training proficiency. This understanding also must be clearly and deliberately outlined in the unit training plan. All these training principles are primarily ongoing throughout the unit training cycle and varying levels of attention and application will occur during unit training.

Individual training must incorporate initial entry training and unit level training opportunities that ultimately provide trained and ready space crews. When understanding the fundamentals of training, "Units proficient in fundamentals are more capable of accomplishing a higher level, more complex collective tasks that support the unit's mission-essential task list—the fundamental, doctrinal tasks that units should be prepared to execute during any assigned mission."[80] In the current USAF Squadron construct, it is difficult to grasp and understand the big picture and support to multidomain operations without working on the staff before gaining operational experience on a space crew.

The USAF must utilize its noncommissioned officers to provide training oversight on behalf of the commander and train and develop junior leaders in the unit. In the US Army, noncommissioned officers (NCO) train subordinates within the direction and guidance of the commanders unit training plan.[81] Ideally, in our proposed space master gunner concept, the unit training would be led by them with overall direction and guidance from the commander.

It is important to stress the importance that as the space master gunner, this must be their only job within the unit. Pending recent developments at the Space Weapons School, NCOs may indeed be able to execute this concept. This would require a culture shift within the USAF to utilize their NCOs differently than historically used. But if the culture change is overcome, it may enable the assignment of space master gunners at all flight levels due to availability of personnel trained as space master gunners. The shift from individual to collective training requires that all space crew members be proficient in their individual tasks. Space crews must train as a crew and is introduced to the ever-changing operational environment and changing variables dictated by the unit commander and space master gunner. These inputs and variables are chosen from space crews that are operational under the SMTF, captured through formal and informal feedback mechanisms. Enabling the communication and training objectives proposed by

SMTF space crews helps collective training objects they would see in the operating environment.

Space crews must be presented with realistic and demanding training during the collective training phase. To enable realistic and demanding training, space crews must train as they fight, or they must "establish in training what the unit can expect during operations to include the culture of an operational environment."[82] Collective training that forces space crews to react to varying scenarios that required adaptability as they would as a member of the SMTF. This training can also help the space crews understand important reporting requirements that are often time-sensitive and complex authorities to execute and report.

Space crews must train in multiechelon and multidomain operating environments for their final space crew certification. Space crews could "train to improve performance and address changes in tactics, techniques, and procedures that affect the operation."[83] This final step must be the commander's certification of the crews before their transition to operational space crews as part of the SMTF. This final certification would exercise the request process for space support and effects through multiple commands, certify approval authorities at varying echelons of command, and display the ability of a space crew to transition custody of the spacecraft from a launch squadron to a command and control squadron.

Upon completion and certification of the training requirements under the RSP or modified concept stated above, the space crew will become a certified crew available for operations in the Space Mission Task Force (SMTF). Once designated certified for operational use, the space crew is part of the SMTF that allocates personnel, equipment, and capabilities to a variety of commands and applications either within a garrison or in a forward deployed capacity.[84] If able to streamline SMF concepts, unit training management, and implement principles of training, the space crews that are operational as part of the SMTF will be more prepared to operate in a complex and changing environment that can provide support and effects to the Joint Force in support of the multidomain operation.

To effectively take custody of a launched vehicle under the current SMF construct, organizational structure and training oversight must ensure readiness for the space crew to take an on-orbit spacecraft through checkout, operations, and taskable support to the Joint Force. First, the organizational structure must adopt a subject matter expert into organizations that bring effectiveness to the command and the Joint Force.

Second, training must be managed by these subject matter experts at all unit levels from crew to squadron to ensure operational readiness and effectiveness for the SMF. In the following paragraphs, we will use the US Army's master gunner concept as an example of how the SMF could provide the impacts as outlined at conception, referred to as the space master gunner.

Gen John E. Hyten's vision in 2016 for the SMF highlighted the need for a cultural transformation that would emphasize the need for a "force capable of achieving space superiority" and one that could "provide vital space capabilities for the Joint Force now and in the future.[85]" To produce a force that is capable of achieving space superiority to the greater Joint Force, effective training becomes paramount to operational readiness. To establish a culture that supports General Hyten's vision, space crews must be exposed to varying complexities during individual and collective training events. For the SMF to be successful, the training, evaluation, and certification process must impart specific lessons learned from the operating environment today and those perceived threats in the future.

Commanders of operational units within SMF can leverage the concept of a space master gunner and bring an expert into their organizations that have the technical and tactical knowledge to maintain high levels of readiness to the Joint Force. It is important to identify a potential master gunner as one of the most competent individuals from the unit, send them to training and retain them within the master gunner billet to ensure continuity within the unit. This may require the US Air Force to extend or curtail assignments based on high-demand skillsets within the force

The space master gunner could have several responsibilities for the operational units, but, most importantly, they must be used primarily in the capacity for what they are intended. First, the master gunner at any level should be the subject matter expert for the assigned weapon system. These weapon systems will vary depending on the mission area, but they should understand the complexities of the system, subsystems, sensors, architecture, and capabilities of the weapon system large. Second, the squadron master gunner in conjunction with the flight master gunners should manage individual, crew, and collective training events. As subject matter experts, they understand the doctrinal application of the weapons systems and therefore are most qualified to train individuals and crews. Lastly, the master gunner, at all levels, should coordinate and forecast changes in crew decertification for various reasons. Actively managing this process results in a streamlined process to ensure onboarding of new crews in the most efficient manner and redundancy for unforecasted decertification.

Training, evaluation, and certification are important for the US Air Force if its space crews pursue a role in the acquisition, launch, and operational control of a spacecraft that supports the overall Joint Force. The Ready Spacecrew Program (RSP) is the name of the training mechanism that was identified in SMF that would manage individual and collective training requirements of crews and would require commander certification before assuming operations.[86] The RSP is the umbrella program of different mission areas within the space domain. This program should not only focus on the training, evaluation, and certifications of space crews but also stress the importance of retaining certified crews and personnel within operational units as part of the SMF.

Vital to the success of the RSP is the execution of individual and collective training that represents the rapid evolution in the space operating environment.

Underpinning this training as an operational unit is continuation training that maintains space crew proficiency as well as the advanced training required for space crews that focus the advancement of the space crew in an observed and projected contested domain environment.[87] As a crew transitions out of the Space Mission Task Force (SMTF) as an operational unit and into a period of reset, continuation training could be utilized to maintain the certification for various reasons. The space crew can maintain its cohesion and effectiveness, springboarding them into the next SMTF operational cycle as the crew that can mentor newly formed space crews or maintain certification to reduce risk and supplement operations in times of extremes due to unforeseen circumstances.

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FEATURE

COVID-19: China's Chernobyl, China's Berlin Airlift, or Neither?

Dr. Ian C. Forsyth

Contemporary history shows a pattern of crises such as wars or pandemics leading to a shift in global power politics and realignment of power centers. Crises result in opportunities for countries to climb or fall on the global power scale.

The current Coronavirus 19 (COVID-19) pandemic has presented just such an opportunity for China. As the source of the outbreak, China initially faced a situation similar to the Soviet Union's 1986 Chernobyl nuclear power plant explosion: an authoritarian state's lies, cover-ups, and utter lack of openness and transparency leading to unnecessary loss of life domestically and internationally. Chernobyl—by some accounts—was the first step of the collapse of the Soviet Union.[1] Could the COVID-19 pandemic be China's Chernobyl?[2]

Yet, this is not the only potential outcome. China's comprehensive lockdown of Wuhan, in Hubei Province, (the source of the outbreak) allowed Beijing to control the scope and scale of the outbreak to the point where China currently has a lower infection rate and lower lethality rate than does the United States (US). China followed up its lockdown by delivering vast numbers of personal protective equipment (PPE) to suffering countries. China could frame itself as performing a Berlin Airlift of sorts; using its knowledge, abilities, and largesse to provide much-needed relief to grateful populations. The Berlin Airlift provided immeasurable global esteem to the United States, and Washington's soft power has been high ever since.[3] Is this China's path?

Reality is rarely that binary or simple, however. China committed sins of censorship and control that turned a problem into a crisis. Yet, there is no denying that Beijing's draconian controls afforded China the luxury of providing aid to suffering countries due to its success in domestic contagion control. However, for China to turn the COVID-19 pandemic into a Berlin Airlift victory, Beijing needed to deliver reliable products with a positive and humble narrative, and reports are that China generally failed in that regard. It often delivered faulty or defective PPE wrapped in an arrogant and defensive tone, which defeats the purpose of aid.

More broadly, this crisis could reveal that China's rise is independent of the United States and whether Washington's power is declining; China cannot effortlessly fill a void that the United States might leave. If the Washington suffers a loss to its soft power due to mishandling of this crisis, that does not directly help China. The end result could be a world looking at a post-World War I (WWI) void with no obvious benign hegemon leading a liberal international order, unlike the post-World War II (WWII) era. As such, perhaps no post-WWII/Cold War metaphor is appropriate for this crisis.

Background

An excellent chronology of China's actions at the beginning of the outbreak was published by the Congressional Research Service.[4] This is a truncated account:

Late December 2019: Hospitals in Wuhan, China, identify cases of pneumonia of unknown origin.

30 December 2019: The Wuhan Municipal Health Commission issues "urgent notices" to city hospitals about cases of atypical pneumonia linked to the city's Huanan Seafood Wholesale Market. The notices leak online. Wuhan medical workers, including ophthalmologist Li Wenliang, trade messages about the cases in online chat groups.

31 December 2019: A machine translation of a Chinese media report about the outbreak is posted to ProMED, a US-based open-access platform for early intelligence about infectious disease outbreaks. World Health Organization (WHO) headquarters in Geneva sees the ProMED post and instructs the WHO China Country Office to request verification of the outbreak from China's government. The Wuhan Municipal Health Commission issues its first public statement on the outbreak, saying it has identified 27 cases.

1 January 2020: Wuhan authorities shut down the city's Huanan Seafood Wholesale Market.

3 January 2020: Local Wuhan police reprimand Dr. Li Wenliang for spreading allegedly false statements about the outbreak online. Chinese Center for Disease Control and Prevention (China CDC) Director-General Gao Fu tells US Centers for Disease Control and Prevention (US CDC) Director Robert Redfield about a pneumonia outbreak in Wuhan.

4 January 2020: In its first public statement on the outbreak, the WHO tweets, "China has reported to WHO a cluster of pneumonia cases—with no deaths—in Wuhan, Hubei Province."

6 January 2020: US Department of Health and Human Services Secretary Alex M. Azar II and US CDC Director Redfield offer to send US CDC experts to China. US CDC issues a "Watch Level 1 Alert" for Wuhan and advises travelers to Wuhan to avoid animals, animal markets, and animal products.

11 January 2020: A team led by Prof. Yong-zhen Zhang of Fudan University in Shanghai posts the genetic sequence of the virus on an open-access platform, sharing it with the world. China CDC and two other Chinese teams subsequently also post genetic sequences of the virus on an open-access platform. China shares the virus' genomic sequence with WHO.
12 January 2020: Dr. Li Wenliang is hospitalized with symptoms of the novel coronavirus.
14 January 2020: In an internal meeting, China's national health officials warn that China faces a "severe and complex public health event," adding that "the risk of transmission and spread is high" but not disclosing this publicly.
20 January 2020: China officially confirms person-to-person transmission of the novel coronavirus and infections among medical workers.
21 January 2020: The US CDC announces the first novel coronavirus case in the United States, in a patient who returned from Wuhan on 15 January 2020.
23 January 2020: Wuhan suspends public transportation and bars residents from leaving the city.
28 January 2020: Chinese leader Xi Jinping and WHO Director-General Tedros Adhanom Ghebreyesus meet in Beijing.
30 January 2020: WHO Director-General Tedros declares the epidemic a Public Health Emergency of International Concern.

Chernobyl?

The Chernobyl nuclear reactor disaster of 26 April 1986 was marked by several distinguishing characteristics: a flaw in the design of a system that can go undetected but is not unforeseeable; a heroic localized response to a disaster that is much worse than initially realized; a cover-up via draconian information control; a reassigning of blame and ducking of responsibility; impressive efforts to contain the disaster and mitigate its effects; and revelations about the flaws of governance and disaster preparedness.[5] China's COVID-19 outbreak possesses each of these qualities but to varying degrees.

The timeline in the prior section tracks crucial events in the first two months of the outbreak, but the story does not end there. Dr. Li Wenliang—the hero who first brought attention to the virus and was silenced for it—died of COVID-19 on 7 February 2020. This sparked a massive outpouring of grief and rage on Chinese social media. The proliferation of online tributes after his death overwhelmed censors. The public expression of anxiety and dissatisfaction with government responses was a nightmare for Chinese Communist Party (CCP) leadership, yet Beijing denied there was a problem. The responses of the Hubei authorities to the first cases of COVID-19 was not an anomaly but instead part and parcel of the

Chinese system of regionally decentralized authoritarianism. The provincial authorities reacted with hesitation—and even denial—because they did not want to create an impression of lack of control or of poor management. They relayed as little information as possible to the center about the mysterious infections, even as the seeds of the pandemic were sown. Meanwhile, the Hubei local government took pains to silence any whistleblowers. "Internet police" were mobilized to threaten people criticizing the CCP and its handling of the virus online. Essentially, local Chinese officials tried their best to cover up the coronavirus outbreak from the outset of the epidemic, which delayed effective responses and allowed the virus to spread unabated.

(US Department of State illustration, D. Thompson)

Figure 1. Chinese censorship. "China has one of the most social media–savvy and active online populations in the world, with more than 800 million internet users. However, because of the Chinese government's oppressive internet censorship, everything Chinese citizens see is restricted and controlled." (Leigh Hartman, "In China, You Can't Say These Words," *ShareAmerica*, 3 June 2020, https://share.america.gov/.)

Beijing's statements in late December and early January denied that human-to-human transmission was possible. Crucially, Beijing waited six days—14 to 20 January—to issue a public warning that China was facing a pandemic from a new coronavirus.[6] Beijing even allowed the residents of Wuhan to circulate inside the country and abroad to celebrate the Chinese New Year. In February, the primary newspapers and the most widespread Western media were talking about a Chinese Chernobyl, as if the coronavirus was the death knell of the Chinese system, prompting China watchers to speculate on President Xi's political vulnerability.[7]

Only when the problem was too obvious to conceal was the truth allowed to climb uphill. At that point, China's central government responded with an efficiency and professionalism that made up for some lost ground. China's centralized power structure, resource management, and surveillance state capabilities proved to be very useful in containing the domestic spread of COVID-19. China was able to direct resources in an authoritarian manner and shift assets—including human assets—to where they were most needed. The construction of ~1,000 bed hospitals in Wuhan in a week was an impressive example of this. The end result was containment: Shanghai, a city of 24 million persons, experienced coronavirus deaths only in double-digits, just three months after its quarantine was imposed. China essentially approached the COVID-19 outbreak as a domestic security threat, not just as a public health emergency. It mobilized every unit of state and societal control. Once they received Beijing's signal to clamp down at all cost, local governments organized quickly. Citizens were told to monitor their neighbors. Chinese tech companies supplied the police with data from health apps that determined whether citizens should be quarantined. Like the Chernobyl explosion, this was an unmitigated disaster that actually could have been much worse for all involved.

However, there is deep suspicion that Chinese authorities throughout the provinces were systematically underreporting coronavirus cases. For example, it is now widely known that the Chinese government did not include asymptomatic cases in its statistics before 31 March 2020. On 17 April, China revised its domestic fatality rate upward by 30 percent; thus, tacitly admitting errors, if not outright deception. Perhaps most damning to China is the US intelligence analysis that alleges China covered up the extent of the COVID-19 outbreak—and how contagious the disease is—to stock up on medical supplies needed to respond to it.[8]

China's global standing suffered a major blow as a result. Beijing's relations with Sweden and the Czech Republic were already deteriorating, but this exacerbated it.[9] Even Russia and Iran have criticized China's hiding the extent of the outbreak.[10] This is reflected in certain polls: a large majority of Germans thinks China bears some blame for the COVID-19 pandemic and believes Beijing has been dishonest about its infection numbers. The online poll of 1,500 adults, carried out by London-based Redfield & Wilton Strategies on 7 May, showed that 77 percent of respondents said China was at least somewhat to blame for the virus. Some 34 percent of respondents said China was significantly to blame.[11] Meanwhile, 74 percent said China has dishonestly reported its infection figures. More generally, the pandemic has fed arguments that countries should not rely on China for crucial goods and services, from ventilators to 5G networks. However, China can potentially improve its image if and when it allows the WHO to conduct a review of the COVID-19 outbreak.[12]

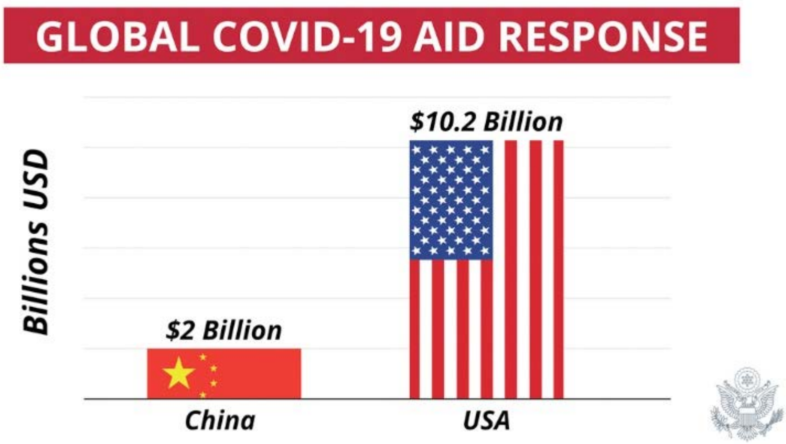
Like the Chernobyl disaster, the political effects of COVID-19—both domestic and international—will take more than a year to fully realize. Still, there is no denying that China's handling of the COVID-19 outbreak makes referring to it as "China's Chernobyl" not unfair.[13] However, that does not mean that is all it is.

Berlin Airlift?

The Berlin blockade and airlift was an international crisis that arose from an attempt by the Soviet Union in 1948 to force the Western Allied powers (the United States, the United Kingdom, and France) to abandon their post-WWII jurisdictions in West Berlin. The Soviet Union sealed all road, rail, and river links into Berlin. Millions of German citizens under the protection of American, British, and French forces faced starvation. The Western Allies organized the Berlin Airlift (26 June 1948–30 September 1949) to fly supplies to the people of West Berlin. At its height, there was an American or British airplane landing or taking off every 90 seconds, 24 hours a day. This act of Allied heroism and coordinated resolve yielded immeasurable amounts of credibility and "soft power" for the West, particularly for the United States. China hopes that providing medical PPE and financial aid (combined with proper messaging) to needy countries will engender similar soft power and goodwill to that the United States enjoyed from the Berlin Airlift. Has it been successful thus far?

After the outbreak was becoming a full-fledged pandemic, President Xi made a flurry of phone calls with world leaders to promise aid. By 31 March, China had provided 120 countries and four international organizations with surgical masks, N95 respirators, protective suits, nucleic acid test kits, ventilators, and other assistance, including loans. More than 170 Chinese medical experts were dispatched to Europe, Southeast Asia, and Africa. At the subnational level, Chinese local governments sent medical items to their sister cities in more than 50 countries, and Chinese provinces dispatched medical teams to neighbors in need, including Guangxi to Cambodia, Yunnan to Laos and Myanmar, Xinjiang to Pakistan, and Fujian to the Philippines. China used video conferencing to share experiences and provide expertise on testing methods, contact tracing, prevention and control measures, clinical treatment, and asymptomatic cases in partnership with the ASEAN Secretariat, the Arab League, and individual countries including India, Malaysia, and Russia. Even the Chinese private sector such as the Jack Ma Foundation was part of this aid effort.[14] Overall, China delivered 30 tons of equipment to Italy and 500,000 surgical masks to Spain, two EU countries that were hardest hit by COVID-19.[15] The aid to Italy was especially notable because Rome had expressed feelings of abandonment from its EU neighbors in its time of need.[16]

To capitalize on this aid, Beijing crafted a narrative through official and unofficial channels so that China received the soft power it felt was due.[17] President Xi engaged with foreign leaders on a daily basis to express support as outbreaks appeared there.[18] Among the recipients were the leaders of Finland, Kyrgyzstan, Serbia, and the Philippines. Chinese state media outlets flooded the Internet with photos of Chinese PPE arriving in more than 100 countries.[19] Ambassadors inundated international newspapers with op-eds hailing the sacrifices Beijing made to buy time for other countries, while ignoring the source of the pandemic.



(US Department of State graphic)

Figure 2. Comparison of US and China COVID-19 aid response. Despite providing far more aid to countries struggling with the virus, America has lagged behind China in driving the narrative of that fact, with Beijing aggressively promoting China's largesse.

China's medical aid has borne soft-power fruit, at least in Italy. The SWG research institute conducted a poll on 7 April that asked, "Who should Italy look more to develop their international alliances outside of Europe?"; 36 percent of Italians indicated China, while only 30 percent chose the United States.[20] Italian international relations scholar Francesca Ghiretti captured this sentiment:

> In these uncertain times, prompt and decisive responses are needed and expected. One can argue on the circumstances, the hidden motivations and the numbers, but nobody can deny that China has provided prompt and direct support to Italy in its time of need. In return, Italians' have been grateful, perhaps not as much as some Chinese media would like their home audience to believe, but China's effort has indeed been appreciated. Following Italy's request, China sent medical

> supplies and staff, receiving much media and political attention in Italy. Two elements have contributed to the success of the Chinese aid campaign: the lack of alternative support in the early stages of the crisis and a savvy media promotion strategy.[21]

The Chinese embassy in Rome embraced the hashtag #ForzaCinaeItalia ("Let's Go, China and Italy"), though Italian scholars discovered it was heavily amplified by a network of bots on Twitter.[22] Specifically, nearly half the tweets featuring the hashtag "#ForzaCinaeItalia" and more than one-third of tweets featuring the hashtag "#GrazieCina" ("Thank You, China") sprang from bots that averaged more than 50 tweets per day.[23]

The leaders of Hungary, Pakistan, Cambodia, and Serbia also sang China's praises: "We should thank them with all our hearts, they have proven to be great friends of Serbia and Serbs," declared Serbia's President Aleksandar Vucic on 21 March, after China delivered medical equipment to the country. "I am waiting for Xi to visit Serbia and hundreds of thousands of people will welcome him."[24]

However, some countries have brought attention to China's substandard PPE and overbearing propaganda. For instance, some of the tests Beijing gave to European countries did not work.[25] In Spain, the Czech Republic, and the Netherlands, governments announced recalls of Chinese masks and testing kits after large batches were found to be defective, undercutting what China sought to portray as goodwill gestures.[26] Spanish scientists have found that testing devices from the Chinese firm Shenzhen Bioeasy Biotechnology correctly identify a positive case only 30 percent of the time.[27] That has not cultivated a Berlin Airlift-type soft power for China in Europe. In the United Kingdom, a parliamentary committee on foreign relations urged the government to fight a surge in Chinese disinformation. Officials in Germany exposed subtle outreach attempts from Chinese officials hoping to persuade them to publicly praise China.[28] Delivering substandard aid defeats the purpose of providing aid in the first place. Furthermore, there are arguments that China should be exporting even more PPE, considering its production levels.[29]

Despite these blowbacks, Beijing is still striving to maintain a narrative that is well-captured by former Singapore diplomat Kishore Mahbubani:

> After its initial missteps in Wuhan (which were clearly disastrous), China firmly deployed good science and robust public policy measures to break the back of the problem. It responsibly released the genetic data as soon as Chinese scientists sequenced the genome of the virus on January 12th. A half century ago, had a similar global pandemic broken out, the West would have handled it well and the developing countries of East Asia would have suffered. Today the quality of governance in East Asia sets the global standard . . . the post-covid-19 world will see

> China accelerate both for the public's benefit—and the balance of strong markets and good governance will be an appealing model for other countries. . . . The world after the crisis may see a hobbled West and a bolder China. We can expect that China will use its power."[30]

Furthermore, by one metric at least, the Berlin Airlift parallel is applicable: when one looks at it in terms of domestic consumption. The Berlin Airlift generated pride among the US population, and China's foreign medical donations have generated the same type of domestic pride, regardless of any negative commentary by the recipient countries.[31]

Neither

By many metrics COVID-19 has proved to be China's Chernobyl. It was a preventable disaster that was made worse by the information control of an authoritarian government that refused to seem ill-prepared or in over its head. Yet, like Chernobyl, it took quickly unified efforts to contain the damage of the disaster. Chernobyl was both a disaster and a triumph. Will the COVID-19 pandemic bring down the CCP? Though the Party—notably Xi—suffered a major loss of face and China's economy is severely wounded, it is premature to declare that it is a mortal wound to the CCP. On the contrary, Xi seems to be weathering the storm thus far.

By fewer metrics COVID-19 is China's Berlin Airlift. Like the United States in 1948–49, China provided much-needed supplies to a desperate population, which yielded no small amount of goodwill. It could have yielded more had Beijing played its cards right. However, its substandard PPE made China look second-rate at the least and deceptive at the most. The heavy-handed propaganda—coined as "Wolf Warrior Diplomacy"[32]—and demands for praise undermined the charitable nature to the donations. If allegations that China is using cyberespionage to pilfer vaccine research are true, then China's standing will take a large hit.[33] China had the opportunity to rise but has fumbled its chances. China's medical aid was welcomed with open arms, but numerous shipments, including those to Spain, Turkey, and the Czech Republic, were filled with thousands of faulty and unusable devices. The accompanying propaganda has done little to erase the memory of Beijing's Chernobyl-like cover-ups that helped enable the global pandemic in the first place. Tellingly, an alleged internal report by the Ministry of State Security's China Institute of Contemporary International Relations reveals a fear of a world turning against China in the wake of COVID-19.[34] If China's Berlin Airlift-type aid was successful, Beijing would not allegedly fear a global backlash to it. China could still make a net improvement in its standing in the Middle East and Africa, but much of that depends on how it handles its One-Belt-One-Road loans during this economic crisis. Furthermore, should China be the first country to develop a COVID-19 vaccine and share it generously, then its Berlin Airlift could become a Noah's Ark moment.[35]

However, one way this was successful is the domestic Chinese reaction. It is very likely that much of China's soft-power narrative efforts have been for domestic consumption as well; Beijing can distract from cover-ups and crackdowns and instead bolster the populace's sense that China is a global leader in rebuilding and aiding the world in a time of crisis—a Berlin Airlift in other words.

But perhaps it is misguided to apply post-WWII and Cold War parallels to China's COVID-19 actions. This assumes a framework that is fading and may have suffered a fatal wound with this pandemic. Perhaps neither parallel is applicable, because the world is staring at a post-WWI setting, more than a post-WWII setting.

The sobering reality is that a post-COVID order is more likely to resemble the post-WWI world than the post-WWII world. With the right leadership, international institutions and norms could be renewed with a spirit of unity, as was seen in the 1940s. Could international cooperation over nontraditional security threats flower? This seems unlikely. The United States' role as a benign hegemon with shaping power is fading. For example, in 2019, about twice as many Germans prioritized their country's relationship with the United States over China (50 percent vs. 24 percent). Since then, however, the share of Germans who value a close relationship with the United States has fallen 13 percentage points, while the share who prioritize a close relationship with China has increased by 12 points.[36] However, China is not filling that role; so, neither a new Chinese benign hegemon nor a renewed US benign hegemon will emerge victorious, barring one being the first to develop and share a COVID-19 vaccine. Rather, both powers will be weakened. In the words of Professor Ashley Tellis: "The absence of the United States in leading the international response to the pandemic has strengthened the perception, now commonplace even among its own allies and partners, that Washington can no longer be relied on to uphold the international order that it once created."[37] Consequently, the global environment is not conducive for shaping. The distribution of power is more diffuse; resembling the 1920s more than the 1940s. Agendas among global powers are conflicting. As after WWI, leaders are more concerned with assigning blame than finding common cause and solving problems—or at least creating and/or strengthening institutions that can solve problems. Global inequality is increasing, as is global unilateralism. The drive to constrict globalization is accelerating. Consensus is fading fast, as is cooperation;[38] it would be nearly impossible to craft a post-COVID19 version of the Atlantic Charter.[39] The post-WWII alliance structure is at its weakest point in its 75-year history. Emerging technologies and their unique challenges have outpaced the collective ability to contend with them. Ominously, the International Monetary Fund predicts that the economic effects of COVID-19 will force the global economy to ebb and flow for up to three years.

Another disconcerting signal that the world is headed toward a post-WWI atmosphere is the rise of populism and nationalism across the globe. In their excellent piece, Alexander Cooley and Daniel Nexon make the argument that,

> Despite important regional, cultural, and political differences, many contemporary populists embrace multipolarity—an international system composed of multiple great powers rather than one or two superpowers. They do so as a rhetorical aspiration, a vision of a global order that privileges national sovereignty over liberal rights and values, and as a tool to increase their freedom of action by playing alternative suppliers of international and private goods against one another. . . . The global impact of the COVID-19 pandemic, at first glance, strengthens and fuels these dynamics. The closing of borders and the curtailment of international economic exchange increase the appeal of national fortress narratives conjured by populists about the perils of globalism…this politico-economic shift is not new. During the 1930s—after the Great Depression—economic deprivation and rising unemployment rates fueled the rise of authoritarian leadership across the world. . . . Whether, in a post-pandemic scenario, a revival of political populism leads to a transition in greater government control, or change in a nation-state's economic preferences, is yet to be seen. What is clear is that the social, political and economic landscape of the post-COVID-19 world will be very different.[40]

Pre-COVID underlying pressures such as China-US tensions could exacerbate, fueled by authoritarian ambition and nationalist populism. Overall, these dynamics resemble the post-WWI world more than the post-WWII world, ultimately making post-WWII metaphors like the Chernobyl disaster and Berlin Airlift inapplicable.

Summary

COVID-19 has presented the global community with a challenge to livelihood, security, and stability at a level not seen since WWII. The challenge was unique to China, given its role as the ultimate source of the contagion.

Was the pandemic China's Chernobyl? By many metrics, yes it was. It was a crisis that could have been better contained had Chinese health officials and medical personnel been allowed to better disseminate their information. Yet, like Chernobyl, China performed impressive feats of control over the spread, even if it was via draconian lockdown measures. As bad as Chernobyl was in 1986, it could have been globally catastrophic but was not, and much of the credit to that must go to the efforts of certain Soviet scientists and officials; such is the case with COVID-19 in China proper. Is COVID-19 the beginning of Xi's or the PRC's end, the way Chernobyl was the harbinger of doom for the Soviet Union? Many analysts thought so, but this seems unlikely at this point.

Has China been able to turn this into a Berlin Airlift and parlay that to a role of global provider in a time of need? Perhaps it could have at one point, but the negatives have outweighed the positives. Too many of China's PPE have been defective. Beijing's demand for a certain type of gratitude is souring the otherwise positive sentiment. Perhaps if China is the first to discover a vaccine and accompanying treatment, then it will obtain massive amounts of global esteem, but that has not happened yet.[41] Countries—despite China's largesse —are not inclined to adopt a China model. China's attempts to influence the WHO and EU are done via subtle pressure, not earned soft power.

What COVID-19 is revealing is that, unlike in the post-WWII era, no country is able to provide comprehensive leadership. Since WWII, the United States has played this role, but Washington has stumbled out of the gate during the COVID-19 pandemic. The United States has the lowest testing rate of any Organisation for Economic Co-operation and Development country, and its fumbled responses and political immaturity have only tarnished its global image as a the richest, most powerful country in the world with a cutting edge in scientific expertise. China's fall, rise, then subsequent fall on the leadership scale is not affecting the US image. Nor has Washington's amateurism in handling this crisis boosted China's quest for global elite status.

In sum it seems Beijing's response to the crisis has been neither a boon nor a bust for China. More worryingly, it seems that without global leadership to establish cooperation and consensus, the world could be looking at a post-WWI dynamic—an absence of global leadership—with uncertainty followed by tension.

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FEATURE

So Just What Is a Killer Robot?

Detailing the Ongoing Debate around Defining Lethal Autonomous Weapon Systems

Austin Wyatt, PhD

Developing a definition for a complete lethal autonomous weapon system (LAWS) is arguably one of the major stumbling blocks to developing an effective international response to the emergence of increasingly autonomous military technology, whether regulation or a developmental ban. As a result of political and practical issues, the international group of experts convened by the United Nations has been unable to generate a definition of autonomous weapon systems that would be universally agreed or operate as the basis for a preemptive development ban. In this gap, various actors from states to arms companies to scholars have developed competing definitions for what they would consider LAWSs.

This article will compare some of these competing definitions, presenting them for consideration of their merits and differences. Whether a given definition would be considered "prominent" in this respect is largely dependent on the extent to which it was cited in the scholarly literature. It would also depend on whether the definition was referred to in the official statements issued after each meeting of the Group of Governmental Experts on LAWSs, and the extent of the author's broader contribution to military diffusion studies or Autonomous Weapon Systems (AWS) research. This article will draw together elements of competing definitions from scholars, including Ariel Conn, Chris Jenks, and Michael C. Horowitz.[1]

Overall, this article is to present the current state of understanding that underpins the ongoing international debate of AWSs. The core purposes of this article are (1) to present a succinct picture of what AWSs are to demonstrate the importance of differing definitions of this emerging technology; and (2) to present an argument in favor of refocusing the international community on developing objective, commonly held, and function-based understandings of autonomy in the military context.

Distinguishing Autonomous Weapon Systems, Unmanned Platforms, and Artificial Intelligence

Regardless of the specific definition, it is important to note at the outset that it is not realistic to consider autonomy in the robotics field in binary terms; instead, it is much more analytically effective to consider autonomy as a function-based spectrum where human interaction remains present at some point, even if it is limited to the production or strategic deployment stages.[2]

At the time of writing, there have been no publicly acknowledged deployments of fully AWSs. This deficiency is largely due to the ongoing legal and definitional uncertainty. However, a genuine question remains about the feasibility of imbuing a weapon system with capabilities that could be objectively classed as *autonomous*.[3] While there have been deployments of weapon systems that can operate in a manner independent from human supervision (the DoDaam Super aEgis II is an example),[4] a division must be drawn between weapon systems that are truly "autonomous" weapons and those that are merely "highly automated."[5]

It is also important to note that direct military applications of artificial intelligence and other related technologies comprise only a comparatively minor section of the broader research efforts in these fields. In a reverse of the traditional development burden of an emerging major military innovation, development is primarily occurring outside of the security space. Instead, commercial and university-based research has been principally intended to contribute to civilian projects, such as self-driving cars and home automation. As dual-use technologies, advances in related enabling components are still relevant in outlining our progress toward a future demonstration point of LAWSs. However, in addition to the fact that artificial intelligence software requires task-specific data, military co-option of these technologies would require far more robustness and resistance to interference than is generally present in civilian-designed systems.

Definitions of Autonomous Weapon Systems Put Forward by States

The most common definition of LAWSs originated in a 2012 US Department of Defense (DOD) directive on autonomous weapon systems.[6] This directive outlined the DOD's view on developing an autonomous capability for weapon systems and the required level of human involvement. This document defines a weapon as fully autonomous if, when activated, it "can select and engage targets without further intervention by a human operator."[7] Interestingly, DOD Directive 3000.09 lists a requirement for sufficient training for human operators, which indicates a recognition that human operators would have to retain some level of oversight over any use of force decisions. The concern of how to balance the need to achieve effectiveness in a battlespace characterized by an operational tempo potentially beyond the capacity of human reaction time while also maintaining sufficiently effective human oversight to guard against unintended engagements is apparent in this directive.[8] Finally, DOD Directive 3000.09 also contained a built-in process for obtaining waivers for development, deployment, or even the transfer of LAWSs in situations that potentially contravene the policy.[9] Despite being due to expire at the end of 2017, DOD Directive 3000.09 was still in effect at the time of writing and features prominently in the developing discourse on LAWSs. As the most commonly cited state definition for autonomous weapon systems, the DOD Directive 3000.09 definition has been used as the starting point for the definitions used by multiple other actors, including nongovernmental organizations such as the Campaign to Stop Killer Robots.[10] While this definition has found traction amongst scholars, it has largely been received critically. For example, Heather Roff criticized the DOD definition because the terms *select* and *engage* are open to interpretation.[11] Notwithstanding scholarly critique, the DOD definition is arguably the natural starting point for developing a working definition of AWSs.

Despite its flaws, the DOD definition does represent a more realistic, if nonspecific, view of autonomy in weapon systems than the definitions adopted by some other states. In 2011, for example, the UK Ministry of Defence definition referred to autonomous systems having the capability to understand "higher level intent and direction" and that individual actions "may not be" predictable.[12] This definition seems to indicate that a platform or military system must possess artificial intelligence with a level of self-awareness that bleeds into the field of general artificial intelligence (AI). It is highly unlikely that any state actor would countenance the development of weapons that they could not predict, even if it were technologically possible to create LAWSs with the capacity to interpret higher-level intent. The concept of this level of full autonomy has been justifiably dismissed as a distraction in the literature,[13] as an approach driven by this definition simply does not account for the weapon systems that are actually in development.

On 14 April 2018, China became the first permanent member of the Security Council to publicly endorse a ban on the use of LAWSs.[14] This surprise announcement was initially seized on as a victory by the Campaign to Stop Killer Robots and covered extensively in the media, but closer analysis identifies this announcement as an important example of how states can utilize definitional factors to gain influence over the development of LAWSs.

The Chinese definition of LAWSs is based around five characteristics, which serve to exclude other forms of increasingly autonomous military technologies from the discourse. The first characteristic is that a device must carry a "sufficient payload" and be intended to employ lethal force.[15] While this would obviously cover LAWSs that are designed to directly participate in combat, it would exclude those that carried a less-than-lethal munitions package (such as the remote-operated "Skunkcopter" unmanned aerial vehicle [UAV]), or are designed for an antivehicle/munitions primary function. The second characteristic is an unusually high autonomy barrier, stating that a LAWS would have an "absence of human intervention and control" for the "entire process of executing a task."[16] China's statement was vague about what it considers a "task"; this document could refer to a single use of force decision, the acquisition of a target, or an entire deployed mission. Thirdly, and closely linked, the device should have no method of termination once activated to be considered a LAWS.[17] This statement would discount weapon systems that operate autonomously but can be overridden by a human overseer, such as the Phalanx Close-in Weapons System. It is also highly unlikely that a state would deploy a weapon they had no way of deactivating or assuming control over, especially given the comparatively nascent state of AI technology.

The fourth characteristic is that the device must have an indiscriminate effect, that the device would "execute the task of killing and maiming regardless of conditions, scenarios and targets."[18] This characteristic is an interesting inclusion because international humanitarian law already forbids the use of weapon and weapon platforms that are incapable of being operated in a discriminate manner. The inclusion of this characteristic is complemented by the latter statement in the same announcement that a fully autonomous weapon system would be incapable of satisfying the legal requirement of discriminate use of force. The question of whether a fully autonomous platform could abide international law in the use of discriminate force is central to the debate surrounding LAWSs and has been at the forefront of publicly visible developments in the space. As an example, the Super aEgis II is capable of distinguishing between uniforms and offers clear warnings before engaging to reduce the chances of using lethal force against civilians. Finally, the Chinese definition includes the characteristic that LAWSs could evolve and learn through interaction with the environment they are deployed into in such a way that they "expand its functions and capabilities in a way exceeding human expectations."[19] This final characteristic leans closer to the UK's definition of fully autonomous weapons and is effectively arguing that the presence of an actively evolving artificial intelligence is necessary for a weapon system to be considered a LAWS. The concept that LAWSs are being developed with high level AI has been widely criticized by scholars and defense personnel but is a common point raised by concerned nongovernmental organizations (NGO) and smaller states. While it is possible, it is beyond the realm of current technology and whether states would even be interested in a learning autonomous weapon has been criticized as unrealistic.

There are many reasons that the Chinese definition of *lethal autonomous weapons* is particularly important. Aside from their obvious influence as a permanent member of the security council, autonomous military technology is emerging as a key force multiplier, a factor that is of obvious importance in the context of the Sino-American rivalry and Chinese military modernization. Furthermore, China has a proven track record of using and then ignoring international law as a tactic for advancing its interests, for example, consider China's reaction to being ruled against by the UN permanent court of arbitration in its case against the Philippines over territorial disputes in 2016.[20] Finally, China has already emerged as a major exporter of UAVs (armed and unarmed) to both state and nonstate actors.[21] Indeed, the 2017 decision to reduce export restrictions on US companies was partially motivated by a desire to counterbalance the market dominance achieved by China in the UAV export market. While China's decision to support a ban on the development and use of AWSs seems to be a victory for those opposed to LAWSs, the actual content of their announcement reveals the importance of definitional agreement.

The Chinese announcement clearly excludes large aspects of the developing autonomous military market; however, it has proven quite common in the definitional debate for state and scholarly actors to put forward definitions that have additions that limit the scope of their application. The inclusion of "lethal" in LAWSs excludes weapon platforms that are designed to utilize less-than-lethal ammunition or guide other munitions while the requirement of "higher level" autonomy excludes the plethora of human supervised weapon systems that are already deployed or in development. As encountered by the UN-sponsored Group of Governmental Experts on LAWSs, this disagreement on a common definition hampers efforts to develop either a ban or effective regulatory controls.[22]

Part of the problem is that, while most commonly cited definitions are broadly similar in their top-level language, when one attempts to apply these definitions or questions their underlying assumptions discrepancies emerge. Given the regulatory and discursive power of definitions in this debate,[23] there is a clear political and strategic incentive for states to adopt distinct discursive frames for understanding *autonomy* in this sense. This understanding implies that, among states as a minimum, definition discrepancies are likely to remain,[24] at least while the debate remains focused on the question of a ban.

The complex definitional debate surrounding the term *lethal autonomous weapon system* is one of the key reasons that international efforts to implement a preemptive ban have stalled. Seven states are publicly believed to be developing lethal autonomous weapon systems: the US, South Korea, China, Russia, India, the United Kingdom, and Israel, though none has admitted to possessing a functioning fully AWS.[25] Only 19 countries publicly support an outright developmental ban; however, this support is based on divergent conceptual understandings of "fully autonomous weapons." The clear majority of the 63 other states that have publicly stated a position support the continuation of governmental discussions.[26] This support shows that, while the majority of states do not support a preemptive ban, they are concerned and willing to continue high-level discussions toward generating a normative and legal framework to control the impact of LAWSs. Outside the land of government press releases, the 2017 intergovernmental meeting of experts was cancelled, ostensibly due to a lack of funds. The "discussion" advocated by the majority of states in 2019 has therefore been largely organized by NGOs, scholarly communities and regional interstate bodies.

Identifying Commonalities in the Focus of Nonstate Definitions of LAWS

Despite emerging as the principle vehicle for pushing forward discussion on the challenges presented by the emergence of increasingly autonomous weapon systems, there remains definitional disagreement among civil society and scholars, nor has there been any concrete steps taken toward developing an universally agreed set of functional standards for determining whether a given weapon system would fall under the proposed ban.

The majority of actively participating NGOs, including the International Committee for Robot Arms Control, Article 36, Human Rights Watch, and the International Committee of the Red Cross (ICRC), subscribe to functionally similar definitions. This is unsurprising given that these organizations are members of the Campaign to Stop Killer Robots (CSKR), which has been the leading advocate in this space since 2012. Another member of the CSKR—Reaching Critical Will (a Women's International League for Peace and Freedom program)—defines fully *autonomous weapon systems* as follows:

> "*Killer robots* are fully autonomous weapon systems. These are weapons that operate without meaningful human control, meaning that the weapon itself can take decisions about where and how it is used; what or whom it is used against; and the effects of use."[27]

There are three elements from this definition that can be commonly identified in the published literature and discussion papers produced by NGOs on this issue.

Lethality

The first element is that this definition explicitly states that fully autonomous weapons are Killer Robots. As part of the campaign's name, this is obviously, a central element of the CSKR's perspective. The term *killer robot* is a dysphemism that has been consistently used to focus the discourse on the capability of lethal aspect of LAWSs, particularly in media appearances and published materials, as well as in the central questions of the public surveys commissioned by CSKR over the past three years. While a legitimate and important concern, the lethal use of AWSs is the most controversial potential use of the underlying technologies and arguably distracts from the rapid progress that states are making on systems that are not designed primarily for the use of lethal force. Ajey Lele has argued that focusing on lethality makes it impossible to come to a "foolproof" definition because sometimes the lethality of an autonomous system will depend on the purpose of its deployment.[28] Heather Harrison Dinniss also argued that the purpose of deployment, target justification, and user intention were more important than the weapon's inherent nature.[29]

While Lele referred specifically to cyberwarfare, other problematic autonomous systems could include AI-enabled battlefield decision-making aides, cyber warfare agents, and "support" unmanned ground vehicles whose stated purpose is for battlefield resupply, none of which would necessarily be covered by a ban that followed this definition, yet could be used in a manner that leads to death and injury.

"Full" Autonomy and Critical Functions

Secondly, it is problematic to focus on whether a hypothetical system having full autonomy. While distinguishing fully autonomous systems from platforms that clearly operate under human supervision or within functional constraints has clear utility (at least from a policymaking perspective), autonomy is not a binary characteristic that can be easily identified, separated and measured. Jenks argues that it is more effective to consider autonomy as the "capability of the larger system enabled by the integration of human and machine abilities" and that autonomy (even in weapon systems) is inherently bounded by the interaction between human and machine.[30] Alternatively, Horowitz has argued that AI (the most important underlying technology for autonomous systems) is better conceptualized as a disruptive enabling technology rather than a distinct weapon system, maintaining that AI is conceptually closer to the combustion engine than the aircraft carrier.[31]

It is therefore important to focus on the extent to which a system has control over its *critical functions* independent of human intervention or supervision, which is reflected in the *Reaching Critical Will* definition. The critical functions of a weapon system are the processes used to select, acquire, track and attack targets.[32] These processes are considered critical because they become the core of the kill chain once human supervision is removed.[33] The *kill chain* is a commonly used term within the US military and in the relevant academic literature. The level of control over these functions is central to the ICRC definition of autonomous weapon systems.[34] Similarly for Anderson, it is the capacity of autonomous weapons to "undertake" the process of identification, rather than merely to respond to a particular stimulus that is their primary characteristic.[35] By focusing on the *critical functions* of the weapon system, advocates of a ban took a step toward the functional benchmarks that would be required for effective international regulation of LAWSs.

Meaningful Human Control

The final commonly seen element that can be extracted from the *Reaching Critical Will* definition is the importance placed on retaining a *Meaningful Human Control* standard. The concept of *Meaningful Human Control* arose as a response to the perceived "accountability gap" with autonomous weapon systems and has been a major talking point at each meeting of experts.[36] The Campaign to Stop Killer Robots, and affiliated groups, have enthusiastically embraced Meaningful Human Control as a vital standard that, employed alongside a ban on fully autonomous weapons, would arguably prevent the transfer of the decision to use lethal force to those robotic systems that are not prohibited. However, despite this prominence, there remains no universal agreement on the limits of its meaning or how to ensure that it is maintained. For example, Christof Heyns has written that autonomous law enforcement weapons would still be under meaningful human control if a human authorised that specific target and instance of force, even if the weapons did not engage immediately.[37] The literature has begun to push back against this lack of definitional clarity, as well as the murkiness surrounding definitions of autonomy in the military context.[38] As a prominent example, R. Crootof has challenged the blind acceptance of Meaningful Human Control.[39] Instead, her work explores how the concept of Meaningful Human Control would interact with inconsistent domestic state laws as well as international humanitarian law.[40]

Furthermore, tragic historical examples with semiautonomous weapon systems, including the downing of Iran Air Flight 655, demonstrated that Meaningful Human Control must be paired with robust verification procedures and organizational modifications, including comprehensive operator and commander training. Without these measures, there is a danger that human supervisors would operate on the basis of overly enthusiastic interpretations of the platform's capability, even where "meaningful human control" is theoretically maintained.[41]

So, What is an Autonomous Weapon System?

Attempting to present an authoritative single definition of LAWSs in the midst of the ongoing international debate would be a hubristic goal for this article. As with terrorism, the broad strokes of a definition have been admirably outlined by others and are generally agreed, the continued international debate centers on the specifics and is sustained by discursive differences that are primarily political in nature. However, by drawing on the positions explained above, and a selection of definitions developed by prominent scholars, it is possible to synthesize a working definition that would be sufficient to facilitate discussion separate from the politicized CCW process.

At its most simplistic an AWS could be thought of as a computer that is analyzing data inputted from multiple conventional sensors to inform its actions without direct human involvement. While insufficiently detailed, this kind of definition is useful for scholars whose analysis is focused on the ethical, moral, strategic, or legal issues raised by LAWSs. For example, Maya Brehm adopted a basic definition of AWSs as "a weapon system with sensors, algorithms and effectors," with the explicit acknowledgement that this approach sidestepped the ongoing debate while providing a sufficient descriptive picture for the reader. However, for regulation to be effective, it would require a more operationalizable and detailed approach.

At the core of this approach should be a consideration of the level of independent control that a system exercises over its critical functions.[42] Setting aside those weapon systems that are either inert (requiring human operation) or automated (such as landmines),[43] this approach would help identify whether a system is operationally semiautonomous, supervised by a human operator, or exercises operationally full autonomy over its critical functions. Interestingly, existing definitions have placed emphasis on different critical functions in their approach to autonomous weapon systems. For example, Crootof emphasized the weapon's ability to process information to make targeting decisions,[44] while Horowitz emphasized the ability to select a target that was not preselected by an operator.[45]

Furthermore, given the goal is to create a definition suitable for the development of technical standards among states that are currently pursuing AWSs, as well as potential future importers, it is better to focus the definition on autonomy at the platform level, rather than disposable munitions or systems where autonomous agents completely replace humans in the planning of military action.[46]

Based on these features, consider the following as an early example of such a working definition for LAWSs:

> "A fully autonomous Lethal Autonomous Weapon System (LAWS) is a weapon delivery platform that is able to independently analyze its environment and make an active decision whether to fire without human supervision or guidance."[47]

This is just one definition for your review. As Jenks noted, shifting international discussion away from calls for and against a preemptive ban toward discussing measurable technical standards around these critical functions is unlikely to resolve the currently stalled process at the CCW.[48] However, it is now approaching seven years into the CCW meeting of experts discussions without any agreement on objective standards for measuring autonomy or even a definition around which regulation could be meaningfully discussed. The development of autonomous military technology has not comparably slowed during this process, bringing us closer to the introduction of fully autonomous military technology without a common definitional basis from which a governing framework could be effectively developed.

Conclusion

In conclusion, the continued debate surrounding the challenge of defining AWSs highlights the need to reconsider the international community's current approach. Instead, the scholarly community should refocus on exploring and defining the line that must be drawn between true functional autonomy and mere sophisticated automation within the current paradigm of conflict. This line can sometimes be difficult for policymakers, academics, and even practitioners to see; however, it is vital that we distinguish such systems, as well as the use of AI-enabled technologies for logistics purposes from the term *lethal autonomous weapon system*. As Horowitz has argued elsewhere,[49] definitions have power and political significance. The international community cannot continue to focus debate solely around the question of a ban under international law. Instead, scholars and policymakers need to take a step back and take the time to develop objective, replicable, and agreeable standards for determining whether a weapon system is autonomous, merely automated, or falls into a different category.

If the current trajectory continues, the general understanding of autonomous weapon systems risks following the example of terrorism, which is still lacking a universal definition almost 20 years after 9/11. Without this agreement, any international regulation would be vulnerable from its inception. If this discussion cannot effectively take place in the forum of the United Nations, whether due to continued resistance from certain states or otherwise; it is time that regional security organizations step up to meet this gap. A concrete, function-based definition, agreed to between regional middle power states, would be an applaudable first step, and perhaps regional organizations could lead the way.[50]

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VIEW

The Case for Missile Defense and an Efficient Defense of the US Homeland

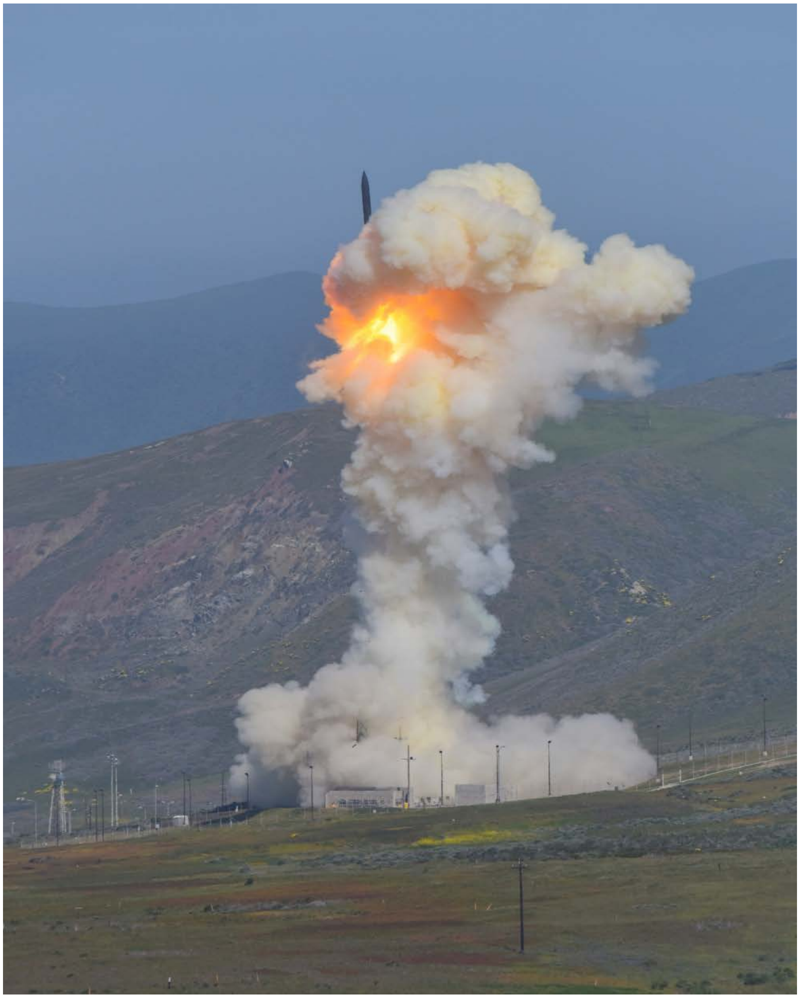
Michael Unbehauen

In May 2019, the Pentagon first announced a pause on the years-long troubled efforts to redesign the Exoatmospheric Kill Vehicle (EKV) of the Ground-based Midcourse Defense (GMD) system's interceptors.[1] Since 2004, the GMD system's mission is to defend the United States from ballistic missile threats. The EKV is a sensor-propulsion package that uses the kinetic energy from a direct collision with an enemy's missile warhead to destroy its target.[2] By August 2019, the Pentagon made the surprise decision to completely cancel the so-called Redesigned Kill Vehicle program of the GMD system.[3] For many, the decision represented an inflection point for homeland missile defense in its entirety.[4]

Since its inception, the GMD system had been under scrutiny for being too expensive and, according to its critics, ineffective.[5] More recently, with the emergence of hypersonic glide vehicles, continuing investment into the GMD system, which according to pundits could now become obsolete, was questioned.[6] Alternative missile defense systems like Aegis Ashore or Terminal High Altitude Area Defense (THAAD) were contemplated and presented with the goal to fill the role of GMD or at least complement its capability.[7] In addition, some believed to have identified a current gap in the homeland defense abilities of the GMD system; supposedly, the US East Coast could not be adequately defended with the current US missile defense capabilities.[8]

With this background, it must be the more surprising to those who believe that GMD is not sufficiently equipped to offer an efficient defense of the entire US homeland, that the Pentagon tasked the Missile Defense Agency in April 2020 to release a request for proposal to build America's next GMD interceptor, confirming the continued relevance of GMD.[9] This Next-Generation Interceptor will become the core of GMD and America's continued cornerstone of homeland missile defense going forward.

Over the last several months, multiple publications have described the evolving Iranian missile threat and attempted to highlight gaps in US defenses, particularly along the eastern seaboard.[10] Most certainly, the Iranian missile program is an important topic, and Americans should be concerned. The Iranian Islamic Revolutionary Guard Corps recently launched its first satellite into space. The launch dramatically revealed Iran's secret military space program and emphasized their continued ballistic missile development, underscoring the potential threat for the United States.



(US Air Force photo by SrA Clayton Wear)

Figure 1. Ground-based Midcourse Defense. A test of the nation's Ground-based Midcourse Defense system was conducted from Vandenberg AFB, California, 25 March 2019 by 30th Space Wing officials, the US Missile Defense Agency, and US Northern Command.

Ground-based Midcourse Defense

Nevertheless, in the interest of providing clarity on a critically important defense concern, there are a few aspects that must be considered in greater detail. First, recent articles in US media paint a rather grim picture of the capabilities of the GMD system, especially for the protection of the American East Coast.[11] It is true that GMD is mainly focused on the missile threat emerging out of Asia.

Such missile threats fly on a trajectory over the Pacific Ocean toward the United States. However, this does not mean that the American East Coast is undefended or severely under defended by GMD, as it is implied.[12] When the GMD system was anticipated, it was done so mainly with the upcoming missile capabilities of North Korea in mind. GMD was designed as a defense against a limited intercontinental ballistic missile (ICBM) threat that could potentially emanate from rogue states.

For North Korea, it was evident that the ultimate missile development goal was the capability to eventually reach the United States with nuclear warheads. Still, in 2004, when GMD became operational, many contested the decision to field the missile defense system, reasoning that North Korea did not have ICBMs at the time nor would it be able to have such a capability anytime soon. Today, the North Korean threat is real, and Pyongyang can potentially reach the American mainland with ICBMs and nuclear warheads.

Knowing today's reality, the establishment of GMD over 15 years ago proved to be farsighted. It must also be argued that, despite widespread criticism about the reliability and excessive cost of this missile defense system (the only defense system in the world designed to counter ICBMs), GMD has already proven its tremendous security value. Without such a system in place, the US defense establishment would likely have viewed a preemptive military strike on North Korea as a necessity had Pyongyang obtained a nuclear ICBM capability. It is hardly conceivable that an undefended United States would have tolerated a nuclear armed, ICBM-capable North Korea. This preemptive strike may have resulted in a war on the Korean peninsula, with clear global implications.

Ground-based Interceptors

Arguably, the Iranian missile program is very similar to that of North Korea. It must be expected that there are Iranian plans to follow in North Korea's ICBM footsteps. Although *optimized* for a limited threat out of North Korea, GMD planners also took a future Iranian threat to the East Coast into consideration when GMD was established. To further improve East Coast missile engagements, a data terminal at Fort Drum, New York, is an operational part of the In-Flight Interceptor Communications System (IFICS). The IFICS consists of a set of data terminals and antennas that are placed in specific geographic locations to support communications with an in-flight GMD interceptor.[13]

GMD's Ground-based Interceptors (GBI) in Alaska are capable of intercepting incoming ICBM threats from Iran. Fort Greely, Alaska, proves to be a formidable location for the GMD interceptors, because it enables GBIs to defend against limited threats aimed at both the East and West coasts. Unquestionably, an additional interceptor site for GMD on the East Coast would provide redundancy and give additional advantage in a potential Iranian ICBM attack scenario. GBIs travel with a speed of over 7 kilometers per second, exceeding 27,500 km/h, toward their target and release the EKV, which destroys the warhead through kinetic energy in the midcourse phase of the threat missile's flight in space.[14] These intercepts ideally take place as far away as possible from US territory. The key for this to happen, which is often overlooked in the discussion, is the data about the missile threat provided by multiple sensors. The sooner and the more accurate that information is collected from sensors on incoming threats, the higher the probability of the defense's success. Early warning and data collection provide more time to engage the threat and require fewer interceptors that need to be used. It is primarily this critical sensor and radar architecture arena that must be analyzed when understanding the threat that a missile attack from Iran on the East Coast presents.

Sensor Architecture

Developing a more efficient sensor architecture is far more important and effective for the defense of the East Coast than building additional categories of shooter capability. There are two types of missile defense radars: classification radars and discrimination radars. Discrimination is more precise and is needed to identify the actual warhead of the missile, which is difficult to detect among decoys and several other parts that break off the missile. Currently, in contrast to the Pacific Ocean, there is no discrimination radar that could adequately detect an incoming warhead in midcourse over the Atlantic Ocean after the warhead has separated. As a result, more interceptors would have to be fired at more potential missile pieces and decoys because of the uncertainty as to which object was the actual warhead. Adding an additional category of interceptors to the arsenal when the actual defense weakness is based on sensor architecture would be like providing a near-sighted sniper a second rifle when he actually needs glasses.

Aegis Ashore in Fort Drum

Recently, it has been argued that our homeland defense architecture should incorporate the Aegis Ashore weapon system to provide ICBM defense of the East Coast.[15] An Aegis Ashore system at Fort Drum, in upstate New York, is contemplated and supported in the media. But such a system located at Fort Drum would most likely not achieve what the proponents of that idea project. It could neither provide coverage for the entire East Coast nor would it offer a better defense capability against ICBMs than the existing GBIs. Aegis Ashore is a theater defense system that was originally conceptualized to counter regional medium- and intermediate-range missile threats with its SM-3 interceptor missiles. Admittedly, the enhanced version of the SM-3, the SM-3 Block IIA, shows very promising capabilities that may also make it possible to engage ICBMs in a limited role. However, it should be emphasized that the system is designed to defend against a different class of missile entirely.

Although nearly all US missile defense systems were originally designed for other threats and eventually grew into their other roles, the new SM-3 Block IIA has not yet been tested to determine if it can engage an ICBM-class threat. The only interceptor in the US arsenal that has successfully intercepted an ICBM class threat is the GMD system's GBI. GMD is the only US missile defense system that was specifically designed to counter long-range ballistic missiles threatening the US homeland. GBIs use a three-stage booster, giving GMD the necessary ability and power to perform intercepts over great distances. This range gives GMD, by far, the greatest coverage area of any US missile defense system. GMD is a strategic defense system, whereas other missile defense systems, including Aegis and THAAD are generally classified as "regional" systems. They are mainly geared toward short- to intermediate-range ballistic missile threats. While they may have homeland defense applications in certain circumstances and may be equipped with enhanced interceptors in the future, they still have much smaller coverage areas as compared to GMD and, subsequently, much less capability against ICBMs.

Even if, as it is often pointed out, the GMD system only has a 60-percent success rate, that is still a 60 percent better rate against ICBMs than any other system.[16] In this context however, it also has to be understood that the reported 60-percent success rate is a cumulative result of all live fire tests and the number of intercepts combined. Contrary to popular belief, however, not every GMD test was designed to hit its target. Some tests were conducted to study the rocket engines, behavior during near misses, and so forth. Therefore, the 60-percent value is misleading.

The new SM-3 Block IIA missile's range is classified, but it is a significantly enhanced range compared to the original SM-3. The new Block IIA version has a 21-inch diameter along its entire length, compared to the older SM-3 versions, which have a 21-inch-diameter booster stage at the bottom, but are only 13.5 inches in diameter along the remainder of their lengths. The increase in diameter to a uniform 21 inches with the new SM-3 Block IIA provides more room for rocket fuel, permitting the Block IIA version to have a burnout velocity (a maximum velocity reached at the time the propulsion stack burns out) that is greater than that of the older SM-3 versions.[17] However, the uniform 21-inch diameter also represents the maximum possible diameter size expansion for the SM-3 interceptor missile, as it is constrained by the size of the launching platform. Regardless of range and fuel enhancements, with an incoming ICBM nuclear warhead flying 20 times the speed of sound, there would not be much time to achieve a successful engagement with a SM-3 out of Fort Drum, nor the chance to get multiple shots on the target (which is the standard procedure in missile defense to ensure the destruction of the threat).

An even further enhanced version of the SM-3 (SM-3 Block IIB) with a longer range is of course possible, but there are clearly design limitations for increased range. GBIs, on the other hand, are basically ICBMs without a warhead and have similar ranges as ICBMs. They are much bigger in size than the SM-3 and are launched out of refitted silos that were originally designed for the US Minuteman ICBMs. They use the same rocket stages that are used to launch satellites into space. A SM-3, however, could never carry enough fuel to have a similar range, due to its much smaller size, and could therefore never engage a threat in comparable distance as a GBI.

The current GMD architecture is sufficient, albeit not optimized, to defend the East Coast against a potential limited ICBM attack from Iran. Defense capabilities against an Iranian ICBM could be enhanced by establishing a *GBI site* (not an Aegis Ashore site) at Fort Drum and could even be made significantly more efficient by adding a discrimination radar midway en route between Iran and the East Coast. Possible locations for such a radar could be in Iceland or in Greenland for example, with both already having US military presence there. Further, the three AN/TPY-2 Forward-based Mode radars that are supporting regional missile defense in Europe and the Middle East should be integrated into the GMD architecture for the defense of the US homeland (currently they are not). Although these radars are capable of discrimination, in their present locations and orientations, they are geographically too close to Iran to apply this feature in the case of an Iranian ICBM launch and, therefore, could not detect a warhead that separates in the midcourse phase of the missile flight in outer space. A potential Iranian ICBM directed at North America would have left the field of view of those radars by the time of warhead separation. Nevertheless, the three forward-based AN/TPY-2 radars in the European and Middle Eastern theaters could play a similar role for Iranian missile threats as the two AN/TPY-2 Forward-based Mode radars in Japan for launches out of North Korea. The two American radars in Japan are integrated in the GMD architecture and provide early warning and sensor cueing for homeland defense for missile threats out of North Korea.

Aegis Ashore and Terminal High Altitude Area Defense in Hawaii

Similar assessments are being promulgated for an Aegis Ashore system in Hawaii, just as in Fort Drum. Although transforming the Aegis Ashore test site on Kauai into an operational asset is certainly cheaper than building the long-planned Homeland Defense Radar Hawaii, the defense value for Hawaii against ICBMs is greatly reduced without said radar. The Department of Defense recently dropped funding and plans to build the proposed missile defense radar in Hawaii.[18] However, construction of the highly capable Homeland Defense Radar Hawaii would considerably increase the time window and efficiency for GBI launches from Alaska or California. This additional time window and critical threat data would create more security for Hawaii from ICBMs than an Aegis Ashore system could, even under the most optimal circumstances.

Nevertheless, the transformation of the Aegis Ashore test site in Hawaii into an operational asset provides more defense value than the aforementioned hypothetical Aegis Ashore system in Fort Drum. Hawaii's island geography and the relatively small area to cover could give the Aegis Ashore system, under certain conditions, a role as last intercept option in case of a missed GMD engagement.

An additional defense layer potentially provided by an enhanced THAAD interceptor in case Aegis Ashore also misses its target, as is suggested by some reports, is not realistic.[19] The time for THAAD to engage the incoming warhead, which at this point would probably be starting (or at least be very close to) reentry into the Earth's atmosphere at extremely high speeds, would be exceptionally short. The terminal phase of an ICBM lasts only one to two minutes.[20] In this phase, the warhead is also being armed.[21] A successful THAAD engagement at this stage with a potentially armed nuclear warhead could be tantamount to a nuclear air burst in the vicinity of Hawaii. This may be viewed as preferred to a potential nuclear ground burst in Hawaii but is in no way an outcome that justifies integrating THAAD resources into the US homeland defense architecture in Hawaii. Rather, the alternative is to fully optimize a potential GMD engagement through more capable GBIs and the most effective sensor architecture possible, in combination with an Aegis Ashore system (which is also enhanced through an optimized radar architecture) as last resort for failed GBI intercepts. THAAD is a highly valuable defense resource on the theater level for countering short-, medium-, and intermediate-range ballistic missiles, which THAAD would not face in Hawaii, due to its geographic location. Instead, THAAD would potentially only contribute to homeland defense in Hawaii with unresolved and potentially marginal effectiveness. There seems little value in creating a supposed additional defense layer that, even under the best circumstances, may be liable to fail when two more capable and appropriate defense layers could be more profoundly optimized for the best possible defense solution.

Sea-Based X-Band Radar

As previously mentioned, discrimination of the actual warhead is of utmost importance to ensure a successful intercept. The Sea-based X-Band Radar (SBX) provides this discrimination capability for missile threats in midcourse over the Pacific Ocean for the GMD system. SBX is a highly capable discrimination radar that is mounted on a self-propelled former oil platform. Its ocean-spanning mobility allows it to be repositioned as needed to support homeland defense. However, this flexible support concept could also mean that SBX may end up being in an unfavorable location for the defense of Hawaii when needed. In addition, the system cannot achieve its full performance under heavy rain and other weather-related environments.[22] SBX can provide GMD with extremely valuable data; however, a complete reliance on this one sensor for discrimination seems problematic. The Homeland Defense Radar Hawaii, with its discrimination capability, would have been an extremely efficient and important addition to the present sensor architecture for Hawaii. Instead, GMD will rely on the Long-Range Discrimination Radar (LRDR) in Clear, Alaska, for homeland defense. LRDR is currently under construction, scheduled to be completed in the next two years, and will provide a permanent discrimination radar for the Pacific. The LRDR in Alaska will complement SBX and lessen the reliance on this one single asset. However, it is important to note that SBX is still moderately better equipped to produce relevant data, since it operates in the X-Band radar frequency and is therefore more precise in discriminating objects and a possible warhead than the LRDR, which operates in the S-Band frequency.

The Aegis Ashore test site in Kauai, Hawaii, is equipped with a SPY-1 radar. Its range will most likely not be sufficient to guarantee a distant enough ICBM engagement. Fortunately, the new SM-3 Block IIA interceptor has the capability to Launch on Remote (LoR) and Engage on Remote (EoR). This means that the interceptor could be launched based on data from a radar other than the organic SPY-1 radar and then guided into the target by the SPY-1 radar (LoR) or even be completely independent from its SPY-1 radar, relying totally on another radar, for the entire engagement (EoR). But unfortunately, there is currently no other radar that could provide discrimination data for Aegis Ashore if the Homeland Defense Radar Hawaii is not built. SBX is only supporting GMD. To use SBX data for remote SM-3 launches or engagements, its link architecture would have to be redone. When completed, LRDR's location in Alaska may not be ideal for the defense of Hawaii. An alternative will be to equip the Aegis Ashore site in Hawaii with a different radar. The highly capable SPY-6 or the SPY-7 radar (a scaled-down version of the LRDR), which will complement the upcoming Japanese Aegis Ashore sites, will be needed in Hawaii as well.

Is GMD Obsolete?

The idea of the entire GMD system facing technological obsolescence as was put forward in some media publications is based upon incorrect assumptions.[23] GMD, like THAAD, Aegis, and every missile defense system in the US arsenal, is designed to engage an incoming missile according to a predictable trajectory and according to a calculation of where an enemy missile will be at a certain time. Often, Russian and Chinese development of hypersonic glide vehicles, which do not travel on a predictable trajectory, is cited as a reason to limit investment into GMD and abandon the program. This perspective misses some key points that must be considered for a reasonable discussion.

GMD was never intended to defend against Russian or Chinese missile attacks. The sheer number of their ballistic missile arsenals would easily overwhelm GMD without the need for hypersonic weapons. Even decades-old technologies used by Russia and China, such as Maneuverable Reentry Vehicles (MaRV), Multiple Independently Targetable Reentry Vehicles (MIRV), and Multiple Reentry Vehicles (MRV), pose significant issues for GMD. The introduction of hypersonic glide vehicles by Russia and China does not change the balance in strategic missile defense (its impact on a regional theater missile defense is another matter). GMD's purpose has always been the prevention of a limited ICBM threat to the United States posed by rogue states. It is currently not anticipated that North Korea or Iran will be able to develop hypersonic glide capabilities, nor do they possess MaRV, MIRV or MRV capability, even though these technologies have been around since the 1970s and 1980s.

The United States must certainly invest into research and development of countermeasures to the upcoming threat of hypersonic glide vehicles, but this should not come at the cost of existing defenses against real ICBM threats from rogue states, which are likely to persist and even grow. Conflating investment in GMD due to the threat from near-peer state actors such as Russia and China is a distracting mistake. GMD must continue to serve its role as an ICBM defense system from rogue states and must continuously be evaluated for areas of improvement in support of this mission.

THAAD and Aegis Ashore and the Defense of the US Homeland

Within the arena of air and missile defense, regional or theater missile defense systems such as THAAD and Aegis Ashore are increasingly being discussed as assets that should be deployed domestically in the role of homeland defense. These systems are currently only deployed outside of the United States—in Europe, Asia, and the Middle East. The media commonly proposes these assets as supplements or replacements to the existing GMD framework.[24] Although these discussions are likely beneficial in that they bring new ideas that may lead to an ultimate improvement in the robustness of homeland defense, it should be emphasized that these regional/theater-level missile defense assets are currently not proven capable to sufficiently engage ICBMs. If these systems are modified or enhanced to a degree in which they are capable of doing so in the future, they will never offer the same North American continental coverage as GMD. This shortcoming is based on their inherent design limitations.

Aegis Ashore and THAAD could still play a vital role in the defense of the US homeland by providing what they have proven to do exceptionally well and what they are currently doing in Asia, Europe, and the Middle East—providing protection from medium- and intermediate-range ballistic missile threats. The ICBM threat from rogue states is real, but it is not the only potential missile threat the United States faces. There is growing concern that the destabilizing northern area of South America is seeing increased involvement from Russia, China, and Iran. A hostile military presence in this region would not require an ICBM class of missile to threaten the country. It is only a matter of time before a ballistic or cruise missile threat emerges from this part of the world. It would be naïve to think that hostile actors would not seize upon the destabilized region as an opportunity to pressure the United States in furtherance of their objectives. Domestically deploying regional missile defense systems, such as THAAD and Aegis Ashore, in anticipation of these threats is certainly worth discussing. Similar to the initial planning sessions on the North Korean threat in the 1990s, defense concerns coming from the south may be met with skepticism or even mockery. This initial reaction should not dissuade thought leaders and military planners from objectively reviewing the growing threat from this region and America's vulnerability to it. Upon consideration of this threat, it is likely that planners will determine THAAD and Aegis Ashore could effectively serve as the country's defensive response.

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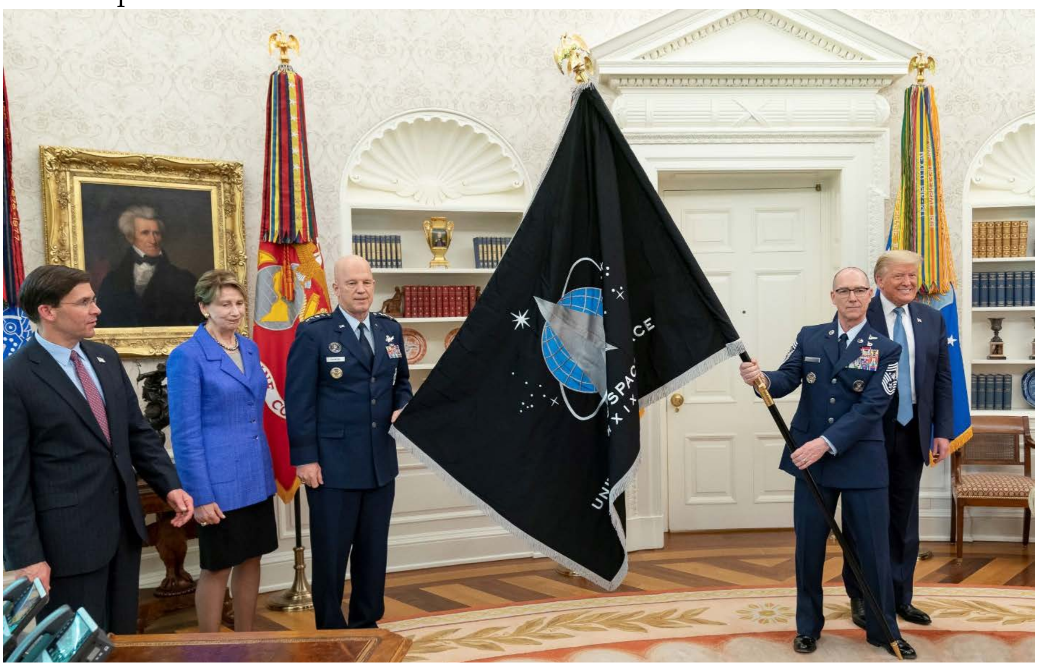
COMMENTARY

Space Legal Operations

Capt Bryant A. Mishima-Baker, USAF

In 2019, an out-of-cycle mission area working group funded by A3 in Colorado was assigned to collect expertise to accomplish an important task. That task was to develop policies defining what the US Space Force (USSF) definition of *aggression in space* would be, and to establish procedures for how to respond to aggressive acts. The group's leadership gathered operators from a wide variety of backgrounds, not just from within the space operator career field but also from the Air Force pilot and unmanned aircraft communities, and the space policy community, to set reliable policies for a possible future conflict in space.[1] Noticeably missing from this group of experts was any representation from public affairs, or more shockingly, from legal. Whether the decision to not involve the legal office in this study was purposeful or not, it highlights a gap in the United States' strategic approach to outer space, which, if not addressed, will lead to losing conflicts in space before shots are even fired.



(US Space Force photo by Shealah Craighead)

Figure 1. Space Force flag in the Oval Office of the White House. US Space Force Chief of Staff Gen John W. "Jay" Raymond and Senior Enlisted Advisor CMSgt Roger Towberman present Pres. Donald J. Trump with the Space Force flag in the Oval Office of the White House, 15 May 2020.

The newly formed USSF must adequately address this oversight to be successful in its mission to secure the space domain. The purpose of this writing is to propose that the USSF create a new Space Force Specialty Code (SFSC): *Space Legal Operations*. To explain this proposal, (1) China's "three-front" war will be described to illustrate the need for such an operator; (2) the challenges and requirements of the space domain will be described that the proposed SFSC would address; and (3) the article will give some details on the structure of the proposed specialty.

China's Three-Front War

In the space domain, China is the most prevalent threat to US security.[2] Although China's available space technology still lags well behind that of the US, its current rapid development and the growing ambition of China to become "the world's leading space power in the next two decades" has many concerned over possible ramifications. China has expressed that it intends to be the leading world superpower, not just in technology as a whole, but in space, specifically.[3] Among the specific targets that China has identified is (1) being the first nation to return to the moon since the 1960s Apollo program; (2) to be the first to begin extracting lunar resources for industrial use; and (3) to be the first to establish a permanent presence there. Its leaders believe all of these targets will be a part of the "national rejuvenation" of China.[4]

However, China has long since recognized that a purely technological approach to seizing world power is not in its favor. As China continues to gain steam in technological development, it has turned to what was labeled China's "Three Warfares" in a report sponsored by the Pentagon in 2014.[5] These "Three Warfares" are psychological, media, and legal operations.[6] *Psychological warfare* is defined as seeking to "influence and/or disrupt an opponent's decision-making capability, to create doubts, foment anti-leadership sentiments, to deceive opponents and to attempt to diminish the will to fight among opponents"; *media warfare* (or public opinion warfare) "aims to: preserve friendly morale; generate public support at home and abroad; weaken an enemy's will to fight and alter an enemy's situational assessment"; and finally *legal warfare* (often called "lawfare") "exploits the legal system to achieve political or commercial objectives." Dr. Stefan Halper includes several examples of the use of this strategy in his report explanations of the use of these three warfares in the South China Sea.[7]

Rather than openly attack nations in the South China Sea, China has stretched its definitions of the law by claiming sovereign control of the sea area, creating islands, and even just exerting economic and social pressures on states to recognize its claims to the maritime geography.[8]

Similar pressures have been used to claim continued ownership of Taiwan.[9] One such fascinating example has been China's use of propaganda maps and periodicals to show Taiwan as being a part of mainland China, or to demand that public and private entities only use maps that show the same.[10] With the growth rate of China, it makes sense for many international merchants to acquiesce to these seemingly small demands, but in so doing, they have permitted China to rely on these small acquiescences as historical proof of their claims to territory in international debates.[11]

Regardless of the validity of the claims and efforts by China in this example, the fact that they are making such claims, and that those claims are being steadily recognized in the international community, should give pause to those who could come into conflict with China, especially in space. What is further disturbing, is China's tendency to use these tactics to achieve military ends without an equivalent US unit with which to counteract these efforts.

Legal Regime of the Space Domain

But why is this trend especially concerning in the space domain? The reason lies in the ambiguity that exists in the law regarding outer space and the way in which international law is established. In outer space, as in all forms of international law, the law consists of two major sources: treaties and custom. The current legal structure of space law has within it four major international treaties which have been widely accepted amongst nations: the Outer Space Treaty of 1967, the Rescue and Return Treaty, the Liability Convention, and the Registration Convention. While the latter three agreements provide more details on their respective topics, the Outer Space Treaty is considered the foundation or constitution of outer space law. The difficulty lies in the fact that a great amount of ambiguity exists in its language that normally would be clarified via state practice and precedent but remains undefined due to the technical and slow pace of space advancement.

Among these fundamental, undefined legal concepts are the definition of a weapon in space, a framework for defining many of the basic principles of the law of war in the space domain (Humanity, Proportionality, or Distinction among others), or even the allowable role of the military as a whole in space. Currently, the only glimpse of agreed upon law on any of these topics comes from the Outer Space Treaty, articles III, IV, and IX. Article III explicitly incorporates principles of international law into the legal framework of space; this, of course, includes Geneva conventions on the law of war. However, Article IV then immediately addresses the concern for peace in space by prohibiting the placement of weapons of mass destruction in orbit around the earth and by stating that the moon and other celestial bodies are to be used exclusively for peaceful purposes. Finally, Article IX prohibits actions that could lead to harmful contamination of the earth or adverse changes to the space environment, as well as requires nations to consult with the international community if they were to plan to take actions that could result in harmful interference of the ability of other nations to use space.

The clear intent of all of these provisions is stated in the preamble of the Outer Space Treaty, that is, to recognize the "common interest of all mankind in . . . the exploration and use of outer space for peaceful purposes." Some have argued that thus any military involvement in space is inappropriate, a stance which is convenient for US adversaries. And whereas this argument is not one that the majority of nations have adopted, it nevertheless is one that needs to be actively fought against before wars in space are lost before shots are even fired.

The Space Legal Operator

To accomplish this, the USSF needs individuals with the technical skills and legal training to understand the needs of the military mission in space and the ability to best accomplish those needs in the legal environment; a space legal operator. Exactly how a space legal operator would accomplish the mission is beyond the scope of this article, however, it will help to understand what the mission of such operators is not. A space legal operator would not be the same or fill the same role as a standard space operator, and it would not be the same or fill the role as a judge advocate general (JAG) officer.

To understand the intricacies of the space environment and the needs of the space mission, it will be important for these space legal operators to have much of the same technical training as standard space operators. This training should include understanding of the various space platforms used by the USSF as well as the basics of orbital mechanics. It may even be prudent to either ultimately make the space legal operator a shred-out of the standard space operator after a certain amount of time in the latter SFSC or require a tour of duty in a standard space operator station to allow for mission familiarity. After this familiarization and training, however, the mission of the space legal operator would be completely separate. Far from handling the controls and equipment in space, as described above, the space legal operator would have two primary functions: (1) to use strategic planning to best understand the most advantageous legal construct for accomplishing the military mission in space; and (2) to use international lawfare to support this strategic vision and frustrate the strategic goals of US adversaries.

The space legal operator would also be different from and apart from the current JAG structure. Though similar to that of the standard space operator. the space legal operator could utilize many of the resources that are currently offered by the USAF JAG. The JAG is and would remain a vital part of the war-planning and execution processes in space. Unlike the JAG, however, it would not be the job of the space legal operator to review operational plans or advise space commanders on the legality of a given course of action. The JAG and the space legal operator would also contrast in their approach to the law. Where the JAG approach is largely passive, understanding and applying the law as synthesized from existing sources, cases and academia; it would be the job of the space legal operator to affect changes in and adherence to laws applied in space through advocating for the creation of laws, both in the US and with our international partners, as well as being active members of the space legal community.

Conclusion

By cultivating these skills, the USSF will be better prepared to train and equip its members with the tools necessary to fight the battles that will be had in the space domain. If the US remains inactive in this important endeavor, such a war has the potential to be lost before kinetic combat even enters the equation. By creating and training a specialized group of new space operators with the focused goal of fighting the legal and public wars that are already being waged by China and other nations, the USSF will protect the nation in this important newly recognized domain of war.

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COMMENTARY

If A2/AD Will Blot Out the Sun … Then We Will Fight in the Shade

300 Spartans and Information Warfare in the Twenty-first Century

Capt Jayson Warren, USAF

In 2019, the *National Interest* ran an article with the headline "A2/AD: The Phrase That Terrifies the U.S. Military (And China and Russia Love It)"—but rather than champion the term as helpful to the Department of Defense's operational lexicon, the author contends that the antiaccess/area denial (A2/AD) problem set can in fact be overcome through well-integrated countermeasures.[1] Receiving far less attention, however, is the information warfare implications of A2/AD discussions in a great-power competition environment, which is somewhat ironic considering the title's language regarding fear and love directly testifying to the power of ideas when they are incepted into the minds of an adversary. Thus, this article seeks not to confirm or deny the conclusions reached in the *National Interest* but rather to transcend its tactical and operational levels of analysis and address the strategic.

While the verb *incepted* is a deliberate nod to the 2010 Christopher Nolan film *Inception*, it is not a tongue-and-cheek pop culture reference but instead a mechanism to frame critical thought and introspection—after all, to borrow a line from the film, "if you're going to perform inception, you need imagination. . . . You need the simplest version of the idea in order for it to grow naturally in your subject's mind." What must first be realized is that A2/AD "is a Western [term] and its approximation in the Chinese strategic concept is China's active strategic counterattacks on exterior lines."[2] Second, not only is it a Western term but it is also a generally unproductive term, because it essentially applies to every modern country with an integrated air defense system just on varying degrees of maturation and sophistication (i.e., "states with the ability to use a combination of sensors and long-range missiles to prevent adversaries from operating in an exclusion zone, or 'bubble,' adjacent to their territory are said to possess anti-access/area denial capabilities"[3]).

So, what does this mean? It means that the defense enterprise's imagination has taken an ancient, yet simple, idea (i.e., combined arms defense of the homeland) and allowed it to grow unchecked into the notion that A2/AD is a revolutionary new concept and anyone who employs it possesses an impenetrable fortress: "A2/AD is an overhyped buzzword leveraged to create an excessive sense of vulnerability—intimidating potential adversaries before the match even begins."[4] Which then begs the question: What do we do about it?

(Kentucky Historical Society image)

Figure 1. King Leonidas at Thermopylae. The Battle of Thermopylae was fought between an alliance of Greek city-states, led by King Leonidas of Sparta, and the Persian Achaemenid Empire over the course of three days, during the second Persian invasion of Greece. Leonidas was a master of what we now recognize as information warfare.

The answer is simple—follow the archetype example of Spartan King Leonidas and engage directly through full-spectrum information warfare! Sparta's actions leading up to and during the Battle of Thermopylae can be analyzed through three distinct, but interconnected, efforts: generating insights, competing below the threshold of armed conflict, and preparing for escalation.

- Generating Insights. Xerxes of Persia wielded an army so massive that the ancient historian Herodotus asserted "whole rivers ran dry" when it stopped for water.[5] Xerxes was also a self-absorbed megalomaniac, believing himself to be a god with a divine right to crush anyone standing in the way of his authoritarian expansionism. This equipped the Persian Empire with a coercively compelling strategic narrative that it was in everyone's best interest to surrender rather than fight. Leonidas, however, was informationally resilient—succumbing not to the Persian narrative of invincibility but rather studying his opponent's cult of personality; his adversary's strength, tactics, and mobilization methods; and the topography of the battlespace. In short, Leonidas generated insights that served as the foundation for calculated and informed decision making.

- Competing Below the Threshold of Armed Conflict. The Spartan nation did not wait for war to breakout to engage the Persians but instead continually competed and seized the initiative where able. When the Persian emissary came demanding "earth and water" as a sign of surrender; Sparta threw him down a well. When the Persian army amassed its troops, the Spartans were found unafraid and could be seen exercising and tending to their hair. And when the Persians implied that their onslaught of arrows would "blot out the sun," the Spartan response identified the pragmatic benefit by countering with "then we will fight in the shade!" The Spartan resolve and honor were so regionally renown that when Persian intelligence sources indicated there would be resistance to his army, Xerxes exclaimed, "How is it possible that a thousand, or ten thousand, or fifty thousand, should stand up to an army as big as mine, especially if they were not under a single master, but all perfectly free to do as they pleased?"[6]
- Preparing for Escalation. King Leonidas recognized that war with the Persians was inevitable, thus he aligned his forces in a multi-domain environment—realizing the naval forces sent by other Grecian city-states required supplementation from a land force to secure their borders against the Persian invasion.[7] Moreover, Leonidas prepared his nation for battle while respecting the rule of law at home and abroad. Two key reasons for the size of the Greek fighting force was a Spartan religious festival that legally prevented all soldiers other than the 300 royal bodyguards from travelling[8] and the ongoing Olympic Games, a customarily peaceful time.[9] Nevertheless, Leonidas mobilized what he could, brokered a coalition of partner states, and led them to a strategically superior battleground that would serve as a force multiplier and cause Xerxes, while watching the battle, to thrice leap "from the throne on which he sat, in terror for his army."[10]

Information's power is timeless—as seen in the aforementioned case study from antiquity and the Department of Defense's recent designation of "Information" as the seventh Joint Function. The Air Force is actively moving out on operationalizing information warfare by establishing 16th Air Force—a component numbered air force (NAF) dedicated entirely to information warfare and its core tenants of intelligence, surveillance, and reconnaissance (ISR); cyber operations (CO); electromagnetic warfare (EW); information operations (IO); and weather (Wx). As Lt Gen Timothy Haugh, commander of 16th Air Force, stated, "We will expose [adversary] actions that undermine international norms and take the conflict in the information environment back to them."[11]

Chinese (and other) A2/AD initiatives are a prime example of a problem set already being cracked by the new NAF—and it is being tackled via Lt Gen Haugh's three lines of effort: Generate Insights, Compete Now, and Prepare for Escalation.

Generate Insights. Responsible for the USAF's entire ISR portfolio, 16 AF is leveraging all-source intelligence operations to analyze and characterize adversary arsenals to ensure US decision advantage by fostering an informed and informationally resilient air component. Furthermore, the invaluable intelligence collected is used to drive kinetic, nonkinetic, and cyberspace weaponeering strategies to provide commanders options that lead to effective outcomes across the continuum of conflict. And, like Leonidas, the intelligence categorizes and prioritizes key terrain—physical, cognitive, and digital—that will be critical power-projection platforms and force multipliers for Joint and coalition operations.

- Compete Now. Instead of fearing the very thought of A2/AD, as described above, the response to Chinese assertions that missiles will blot out the sun along the First Island Chain must be "Then we will fight in the shade!" While the threat should by all means be respected, it is equally necessary that challenge not be attributed a supernatural status that makes people believe it is an impenetrable fortress. 16 AF's problem-centric, multi-domain operations (e.g. cyberspace operations, sensitive reconnaissance operations, etc.) are actively generating insights regarding Chinese capabilities and Beijing's global activities (e.g., 5G technology, space, artificial intelligence, etc.) to provide tailored options for Joint Force Commanders to compete now below the threshold of conflict.

- Prepare for Escalation. Unlike the situation between the Persians and Greeks, war is not inevitable, and the current tensions are far from a Thucydides Trap. However, 16 AF is preparing for escalation on the basis that information at the speed of relevance is paramount to maintaining stability within the community of nations and unimpeded access to the global commons. Russian-built surface-to-air missile systems (of which China has bought many and reverse engineered many more) have increasingly been involved in identification mishaps, targeting civilian airliners as seen in Iran and even more recently in Syria—the point of engaging in the information domain is not to drive an arms race but, to the contrary, eliminate plausible deniability for destabilizing actors and encourage responsible statesmanship via accountability. Similar to Leonidas, 16 AF is also tackling problems such as A2/AD through coalition partnerships and the fostering of new multilateral relationships. Finally, as in Sparta, above all, 16 AF is performing the critical information warfare mission with respect and reverence for the rule of law—protecting the civil liberties of Americans in the information and cyberspace domains and counter malign influence against the 2020 elections. That said, with regards to the rule of law, there is one key point of departure from Sparta. As 16 AF prepares for escalation in steady-state operations, it can identify means of engaging the legislative and executive branches at the state and federal levels to identify possible changes to laws that would better enable the defense of the homeland while preserving liberty for all (ex. an Emergency Management Assistance Compact (EMAC) that could allow Air National Guardsmen to defend infrastructure across statelines without having to mobilize from a Title 32 to Title 10 status).

Ending this where it began, "A2/AD is an overhyped buzzword leveraged to create an excessive sense of vulnerability—intimidating potential adversaries before the match even begins". . . in the manner of the timeless writings of Sun Tzu: "To win one hundred victories in one hundred battles is not the acme of skill. To subdue the enemy without fighting is the acme of skill."[12] Fostering an informed and informationally resilient air component will drive agile basing and other US Indo-Pacific Command (INDOPACOM) initiatives that complicate China's targeting apparatus and enable the Joint Force and its coalition partners to say: "Then we will fight in the shade!"

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