Midterm Report

United States Transportation Command
And
Space Exploration Technologies dba SpaceX
Cooperative Research and Development Agreement
20-002

Space Transportation Capability for the Joint Force

12/31/2020

Executive Summary

U.S. Transportation Command (USTRANSCOM) exists to project and sustain combat power at a time and place of the Nation's choosing. The Command seeks opportunities to evolve for tomorrow by testing new concepts and making wise investments in innovative, transformational capabilities. This allows USTRANSCOM to position the Joint Deployment and Distribution Enterprise (JDDE) to create multiple options for national leadership and multiple dilemmas for potential adversaries.

The traditional distance-driven challenge of on-time worldwide delivery is increasingly complicated by the urgent pace of warfare in an era of contested environments and instantaneous sophisticated cyber threats. The Command has identified that common-user commercial point to point (PTP) space transportation may provide a unique and disruptive capability that allows it to better support global deployment, employment, and sustainment of forces.

USTRANSCOM Cooperative Research and Development Agreement (CRADA) 20-002 was established between the Command and Space Exploration Technologies Corporation (SpaceX) for the parties to collaboratively investigate commercial space transportation capabilities as a transportation mode to expedite global delivery of Department of Defense (DOD) material and personnel. The CRADA explores seven objectives:

- Investigate the technical feasibility of using SpaceX's Starship launch system in the next five years to support DOD global logistics transportation requirements.
- Investigate the use cases, criteria for choosing space transportation over other modes, responsiveness, supply chain integration principles, military advantages and risks of using SpaceX's Starship to meet DOD global transportation requirements.
- Project the costs of using the SpaceX Starship to deliver DOD cargo and personnel over the next 5 to 10 years and compare to current transportation capabilities.
- Investigate the viability of and innovations for the government and SpaceX entering into an agreement for surge space transportation capacity with similarities to the Civil Reserve Air Fleet.
- Predict industry space transportation capabilities for the next 5, 10, and 15-year future timeframes.
- Develop concepts for command and control of space transportation capabilities and implications for space traffic management and domestic/international space use policies and protocols.
- Deliver a roadmap to demonstrate the configuration, loading, launch and recovery of DOD cargo on a SpaceX Starship.

In addition to this CRADA, USTRANSCOM is collaborating research efforts with USSPACECOM, Air Force Warfighting Integration Capability (AFWIC), and the Air Force Research Laboratory (AFRL).

A synopsis of the current state of research to address stated research objectives are listed below.

- SpaceX's Starship vehicle and Super Heavy booster (collectively known as "Starship") are still in development. [redacted]

- The selection of space transportation will likely be chosen through consideration of strategic messaging, priority of movement, and speed. Additionally, standardization may be required across airlift and space transportation modes to enable shippers to obtain mode-neutral rapid delivery.

- [redacted]. Additionally, normalization of PTP space transportation provides an opportunity to enter an agreement for surge space transportation capacity similar to the CRAF. Commercial and government demand for space transportation enables higher launch rates that reduce costs. Foreign demand for launch services, to include satellite launches may drive overseas infrastructure development that can enable global PTP space transportation. USTRANSCOM's existing transportation service models that utilize the set rates and the Transportation Working Capital Fund (TWCF) provides a basis for space transportation as a new mode and method of transportation.

- The current set of space law and arms control agreements were formed from the treaties and international customs devised during the Cold War in order to define the legal boundaries of general space activities, attempts to prohibit the weaponization of space, and regulate ballistic missile development and testing. The current set of space laws and arms control agreements are applicable to commercial PTP space transportation and may require revision to address commercial PTP space transportation.

- [redacted]

Research continues with a final CRADA report in June 2021.

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1. [redacted] (b)(3) and (b)(4)

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Greater detail on site types and loading concepts is provided in the Proprietary Annex.

2. Use cases, criteria for choosing space transportation over other modes, responsiveness, supply chain integration principles, military advantages and risks of using SpaceX's Starship to meet DOD global transportation requirements

The selection of space transportation over other modes will likely be chosen as a result of consideration to strategic messaging, priority of movement, and speed. The choice of mode becomes simpler in a mature scenario with multiple commercial nodes accepting scheduled space transportation service. Additionally, standardization may be required across airlift and space transportation modes to enable flexibility for shippers to utilize rapid modes of delivery eases the mode selection process.

2.1 Transportation modes selection

2.2 Joint Operational Planning and Execution System (JOPES) / Defense Travel Regulation (DTR)

The DOD utilizes JOPES to plan and execute joint military operations. JOPES is a combination of joint policies and procedures designed to provide joint commanders and planners with a capability to plan and conduct joint military operations. An input into JOPES is the time phased force and deployment data (TPFDD).

The TPFDD identifies the types of forces and actual units required to support a plan or operation, contains estimates of logistics support, and designates ports for embarkation and debarkation. The TPFDD, based on planner input, establishes the time-phased sequence for forces into the Area of Operations. The time-phased forces, and their associated cargo and passenger movement requirements, are used as the basis for actual transportation scheduling.[1] USTRANSCOM and supported commands identify requirements, assess feasibility, validate requirements to transport personnel and cargo. This process begins approximately 6 to 24 months prior to execution (Figure 2-1).

[1] CJCS, *User's Guide for JOPES*, 1 May 1995

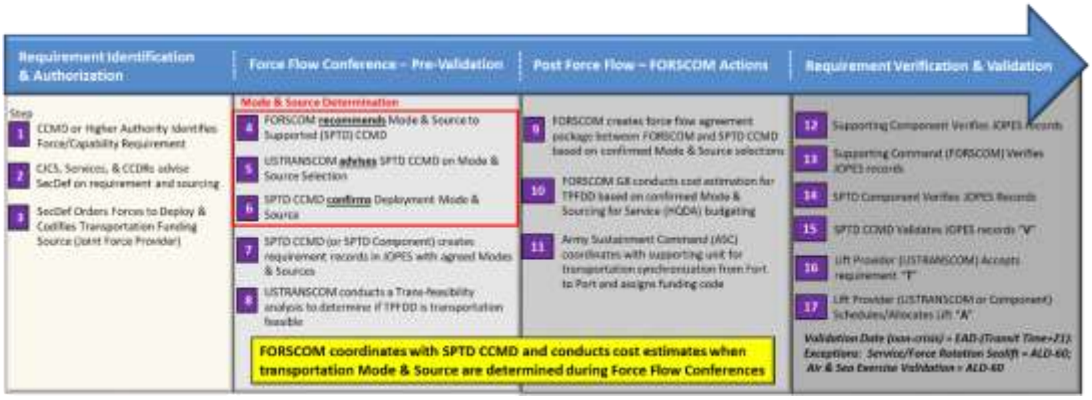

Figure 2-1 JOPES Requirement Process Flow[2]

USTRANSCOM advises supported commands on transportation mode and source alternatives in pre-validation coordination with the supported command while the supported commander has the final mode approval authority.[3]

At the tactical level, determining the mode and method of shipment is the responsibility of the shipper. Mode refers to the general category of movement (e.g., air or surface) while method refers to the specific means of transportation, (e.g., motor, rail, air freight, parcel post). The mode and method of transportation selected will be that which will meet DOD requirements satisfactorily using the best value to the Government from the origin to the final known destination in the CONUS or OCONUS.

The shipper also determines the level of transportation priority (TP): TP-1, TP-2, or routine transportation (TP-3). The TP is determined by the shipment content and the assigned required delivery date.[4] The Defense Transportation Regulation (DTR) outlines the DOD policy for selecting the mode of transportation (Table 2-1).

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[2] USTRANSCOM J38, *JOPES Requirement Process Flow*
[3] CJCSM 3122.02E
[4] DTR – Part II Chapter 203, *Shipper, Transshipper, and Receiver Requirement and Procedures*

Table 2-1 Application of Transportation Mode/Priorities[5]

TP Code	Recommended Shipment Mode	Type of Shipment Other Than Mail
1	Air	TDD Category 1 requisitions with priority designators 01–03 with or without RDDs except when the RDD starts with an "X" or "S". If "X" or "S" use TP-3
2	Air	DoD cargo shipments or TDD Category 2 requisitions with priority designators 04-15 with RDDs of 444, 555, 777, N__, E__, and specific Julian dates less than 8 days for CONUS or 21 days for OCONUS customers.
3	Surface	DoD cargo shipments or TDD Category 3 requisitions with priority designators 04-15 and those RDDs that are blank or greater than 8 days for CONUS or 21 days for OCONUS from Julian dates when the requisition and shipment(s) are being processed. Personal Property NAF.
4	AMC uncommitted space	TP-3.

2.2.1 Special assignment transportation

A mechanism to select and request rapid transportation is available through USTRANSCOM's Special Assignment Airlift Mission (SAAM) request process. The SAAM Request System allows Service or theater validators submit requests. When the request system is unavailable, validators may fax USTRANSCOM the manual DD Form 1249, SAAM or JCS Exercise – Airlift Request. SAAM requirements submitted within 96 hours of the available load date are considered rapid reaction or emergency. The individual declaring the rapid reaction or emergency requirement will be at least a general officer, civilian equivalent, or designated representative.[6]

Modification of the current SAAM request process to incorporate PTP space transportation provides an existing mechanism to select and utilize a more rapid method of movement. A modified special assignment mission for commercial PTP space transportation does not necessarily require on-demand commercial vehicles. Available commercial PTP space transportation at frequent rates with the ability to replace scheduled cargo with prioritized requirements (analogous to in-system-select for organic airlift) may provide an avenue for rapid transport without standing alert launch vehicles; however, further study of launch rates to support high priority DOD requirements and business case analysis is required.

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[5] Ibid.

[6] Defense Travel Regulation – Part II Appendix Q, *Format for Special Assignment Airlift Missions (SAAM) Request*

2.3 DOD use cases for point to point space transportation

Air Mobility Command (AMC) previously studied concepts of employment for space transportation under USTRANSCOM CRADA 19-001. The collaborative study identified three scenarios where PTP space transportation may provide force projection capabilities.

Table 2-2 Uses Cases Studied through USTRANSCOM CRADA 19-001[7]

Scenario	Description
TPFDD support for Pacific OPLANs	• PTP space transportation provides an alternative method for logistics delivery to support adaptive basing operations by enabling theater direct delivery. • Additional detail on impacts of PTP space transportation on force closure for operational plans is not provided.
Deployable Air Base System (DABS)	• PTP space transportation of DABS from the Continental United States to an Aerial Point of Debarkation Europe or the Pacific may provide faster response times than intra/inter-theater airlift and could drive leaner logistics infrastructure with fewer supporting bases as anti-access capabilities increase. • DABS is a collection of shelters, vehicles, construction equipment and other gear that can be prepositioned around the globe and moved to any place the USAF needs to stand-up air operations.
Embassy Support	• A rapid theater direct delivery capability from the U.S. to an African bare base would prove extremely important in supporting the Department of State's mission in Africa. • The ability to demonstrate PTP space transportation could deter non-state actors from aggressive acts toward the United States. • Additional details on cost per launch, range of permissible weather conditions for Quick Reaction Force utilization, and ability to redeploy a PTP space transportation vehicle were not studied.

USTRANSCOM continues to explore other uses for PTP space transportation via [redacted]

[7] USTRANSCOM-VOX Space, *Final Report: Researching Opportunities for Responsive Spacelift Serving Department of Defense Mobility Operations*, 15 November 2019

3. Costs of using the SpaceX Starship to deliver DOD cargo and personnel over the next 5 to 10 years and compare to current transportation capabilities.

(b)(3) and (b)(4) [redacted]

(b)(3) and (b)(4) [redacted][8]

The USTRANSCOM Annex provides independent cost analysis of the SpaceX Starship across multiple business closure cases.

[8] Air University, *Fast Space: Leveraging Ultra Low-Cost Space Access for 21st Century Challenges*, 22 December 2016

4. Viability of and innovations for the government and SpaceX entering into an agreement for surge space transportation capacity with similarities to the Civil Reserve Air Fleet

Normalization of PTP space transportation provides an opportunity to enter an agreement for surge space transportation capacity similar to the Civil Reserve Air Fleet (CRAF). Commercial and government demand for space transportation will enable higher launch rates that reduce costs. Foreign demand for launch services, to include satellite launches, may drive overseas infrastructure development that can enable global PTP space transportation. USTRANSCOM's existing transportation service models that utilize the set rates and the Transportation Working Capital Fund (TWCF) provides a basis for space transportation as a new mode and method of transportation.

4.1 USTRANSCOM Commercial Transportation Agreements

USTRANSCOM is responsible for the development and maintenance of relationships between the DOD and the commercial transportation industry to include concepts, requirements, and procedures to implement readiness programs.[9] This responsibility includes relationships with industry through the CRAF program, the Voluntary Intermodal Sealift Agreement (VISA), and Maritime Security Program (MSP).

Table 4-1 USTRANSCOM Commercial Transportation Agreements Summary

Program	Mode	Incentive
CRAF	Air	Business Preference
VISA	Sea	Cargo Preference
MSP	Sea	Stipend

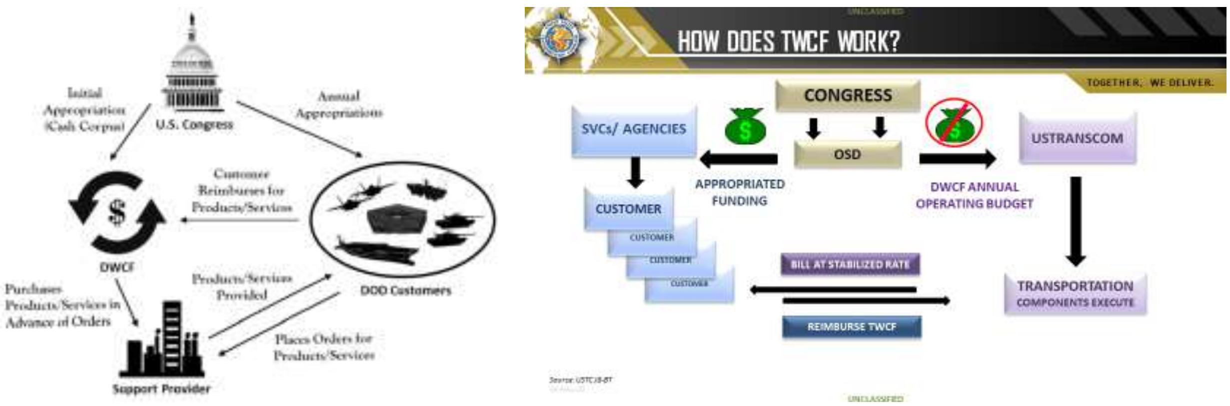
CRAF, VISA, and MSP are Emergency Preparedness Programs founded on the Defense Production Act (DPA) of 1950. The DPA gives broad authorities to the President for prioritization and allocation of industrial base resources and required national preparedness programs to respond to both domestic emergencies and international threats to national security. These programs provide the nation necessary power projection capacity during contingencies. Each program is structured differently to ensure readiness of commercial partners to support DOD operations and are operated collaboratively with the Department of Transportation (DOT).

[9] DODI 5158.06

4.1.1 Transportation Working Capital Fund (TWCF) Agreements

The TWCF is a type of Working Capital Fund (WCF). WCFs have shown to be an effective method for cost recovery in organizations with decentralized decision authority by allocating resources in a way that is beneficial to the enterprise as a whole. WCFs do this by providing a market-based structure through which independent parts of an overarching organization can exchange goods or services.[10]

More specifically, TWCF is a Defense Working Capital Fund (DWCF) that is intended to operate as a self-supporting entity to fund business-like activities for the DOD. DWCFs offer benefits and flexibility to DOD procurement and generally operate without fiscal year limitations. Additionally, they facilitate the aggregation of orders, allowing the DOD to leverage its purchasing power.



a. DWCF[11] **b. TWCF[12]**

Figure 4-1 How a DWCF and TWCF Operates

The Air Force Deputy Assistant Secretary for Budget (SAF/FMB) is the Executive Agent for TWCF while USTRANSCOM manages the day-to-day operations of the fund. The TWCF is used to fund the operation of aircraft and vessels in the CRAF, VISA, and MSP programs when performing missions on behalf of DOD. Customers pay for transportation provided by TWCF-funded activities at established DOD rates for the particular mode and type of provided. Rates are set annually and are based on transportation workload and cost forecasting accomplished by USTRANSCOM. This forecasting also influences service transportation budget requests.

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[10] RAND, *Aligning Incentives in the Transportation Working Capital Fund*, 2019

[11] Congressional Research Service, *Defense Primer: Defense Working Capital Funds*, 17 July 2020

[12] USTRANSCOM, *USTRANSCOM-SpaceX (CRADA 20-002) Service Models Brief*, 15 May 2020

4.1.2 Civil Reserve Air Fleet (CRAF)

The CRAF was created in February 1951. DOD and the DOT work collaboratively to manage the CRAF program to meet DOD airlift requirements in emergencies when the need for airlift exceeds the capability of the military aircraft fleet. All CRAF participants must be U.S. air carriers certificated by the Federal Aviation Administration (FAA).

The National Airlift Policy directs the balanced use of the commercial capacity provided by the CRAF with the capacity provided by military resources. The policy also defines national defense airlift objectives to ensure military and commercial airlift resources can meet defense mobilization and deployment requirements. The policy recognizes that military and commercial resources are equally important and interdependent to national defense and that CRAF provides capacity beyond the organic military airlift fleet. To provide incentives for commercial carriers and to assure the effectiveness of airlift reserves, participating CRAF carriers are given preference in carrying commercial peacetime cargo and passenger traffic for DOD.[13]

4.1.3 Voluntary Intermodal Sealift Agreement (VISA)

The VISA program was created in January 1997. Similar to CRAF, it is a partnership between the Maritime Administration (MARAD) and the commercial maritime carriers to provide DOD with assured access to commercial sealift and intermodal capacity to support the emergency deployment and sustainment of U.S. military forces.

Participants provide a variety of specialized U.S.-flag vessels and agree to volunteer their time and intermodal capacity during wartime in exchange for Cargo Preference during peacetime. Though enrollment in VISA is voluntary, participation when DOD activates vessel(s) is mandatory. To provide incentives for commercial carriers, enrolled vessels are offered peacetime DOD business under Cargo Preference laws.[14]

4.1.4 Maritime Security Program (MSP)

Established in October 1996 as part of the Maritime Security Act, the MSP provides military access to a fleet of government-owned/controlled and privately-owned U.S.-flag vessels to meet national defense and support a global intermodal transportation network of terminals, facilities, logistic management services and U.S. citizen merchant mariners.

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[13] National Security Decision Directive 280, *National Airlift Policy*, 24 June 1987

[14] https://www.maritime.dot.gov/national-security/strategic-sealift/voluntary-intermodal-sealift-agreement-visa

Similar to VISA, MSP provides an incentive to vessels in exchange for their availability during times of need. Additionally, vessels are U.S. flagged and must make their ships and commercial transportation resources available upon request by the Secretary of Defense during times of war or national emergency.

Unlike VISA, the MSP incentive is explicitly financial, in the form of an annual stipend. Vessels operating in compliance with their Operating Agreement with MARAD for 320 or more days of the year receive the full annual payment in 12 monthly installments. In addition, once in MSP a vessel owner may not withdraw vessels without Congressional approval.[15]

4.2 United States Space Force (USSF) Commercial Space Launch Agreements

Major USSF commercial space launch agreements are the National Security Space Launch (NSSL) and Orbital Services Program-4 (OSP-4).

Figure 4-2 Space and Missile Systems Center (SMC) Launch Enterprise[16]

4.2.1 National Security Space Launch (NSSL)

The NSSL enables acquisition of commercial launch services to ensure access to space for critical national security missions. The USSF is responsible for the military space launch mission. The NSSL program is managed by the Launch Enterprise Systems Directorate of the

[15] https://www.maritime.dot.gov/national-security/strategic-sealift/maritime-security-program-msp

[16] USTRANSCOM, *Service Models Brief*, 15 May 2020

Space and Missile Systems Center (SMC). The NSSL program consists of four launch systems: Atlas V and Delta IV Heavy (provided by United Launch Alliance [ULA]) and Falcon 9 and Falcon Heavy (provided by SpaceX).

NSS launches support the DOD and National Reconnaissance Office (NRO) owned spacecraft, and support the entire domain of military service space requirements. All four operational vehicle systems in the NSSL program have launched commercial, civil, and NSS satellites into orbit, including commercial and military communications satellites, lunar and other planetary orbiters and probes, earth observation and military research satellites, weather satellites, missile warning and NRO reconnaissance satellites, a tracking and data relay satellite, and numerous other classified systems.

Competition and significant private investment have significantly driven down program costs. Notably, the U.S. Government saved $7 billion as a result of commercial competition since NSSL transitioned from traditional providers. The NSSL offers block buys of launch vehicles and competition between certified providers. Competitions are conducted through either the Launch Services Agreements (LSA) or Launch Services Procurement (LSP) programs. USSF recently awarded launch contracts to SpaceX and ULA for NSSL missions over the next five years.

Through these service contracts, the NSSL provides launch capability for defense community satellite launches. Since payloads supported by NSSL are smaller in size and weight, the launch vehicles under this program do not provide useful capacity for terrestrial logistics. The normalization of PTP space transportation may drive the inclusion of NSS launches as a mode of transportation supported through USTRANSCOM contracts. Additionally, the use of a CRAF-like contract may reduce acquisition complexity for NSS launches.

4.2.2 Orbital Services Program-4 (OSP-4)

OSP-4 allows for the rapid acquisition of launch services to meet mission requirements for payloads greater than 400 pounds, enabling launch to any orbit within 12-24 months from task order award. The USSF expects to procure approximately 20 missions over the nine-year ordering period. The Rocket Systems Launch Program (RSLP) office will compete each mission among awardees. The contract supports small satellite and test launch mission to a variety of customers. OSP-4 is a follow-on to the very successful Orbital/Suborbital Program-3 (OSP-3) contract.

OSP-4 is part of USSF's Rapid Space Launch Initiative to provide responsive launch capability within 24 hours (Figure 4-3). The payload size and weight delivered through OSP-4 is likely not useful to support DOD terrestrial logistics; however, USTRANSCOM may find synergies with processes implemented through the Rapid Space Launch Initiative to inform commercial PTP space transportation operations.

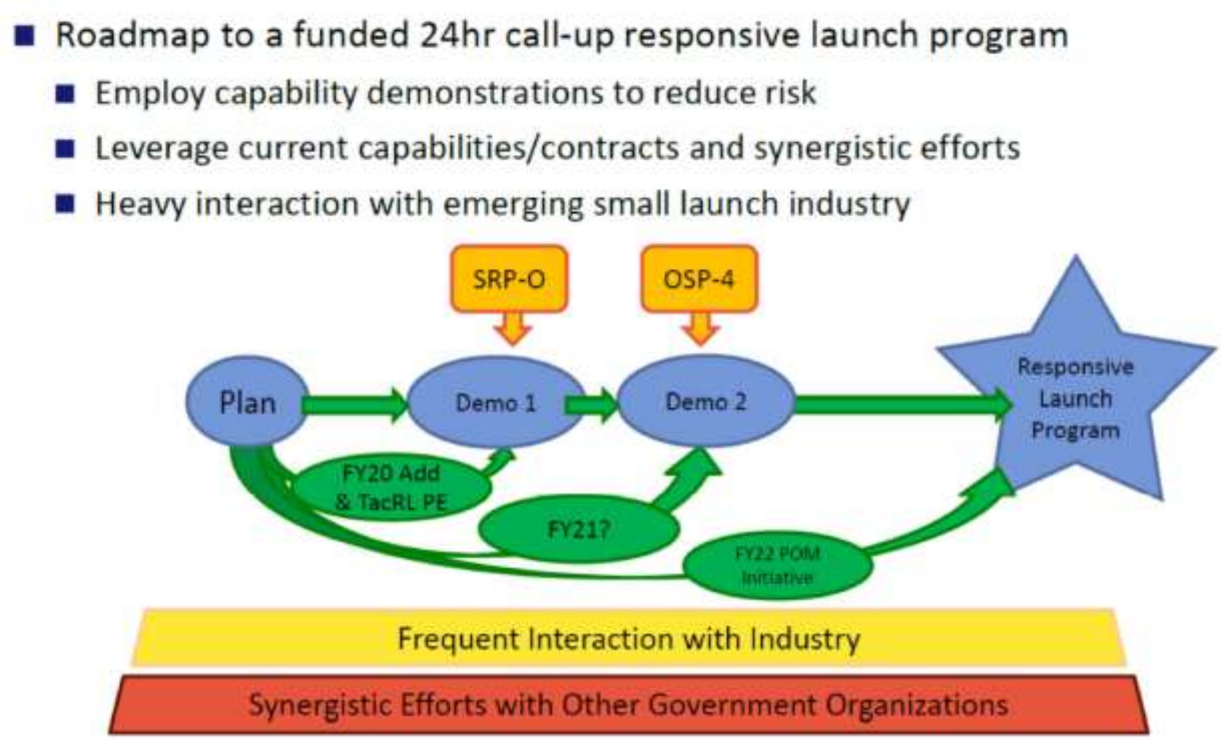

Figure 4-3 Rapid Space Launch Initiative[17]

4.3 National Aeronautics and Space Administration (NASA) Commercial Space Launch Agreements

NASA has recently placed growing emphasis on procuring services from the commercial space industry. While NASA previously used NASA-owned space shuttles to carry cargo and crews to the International Space Station, it now buys crew and cargo transport as a commercial service on commercially owned spacecraft.[18] Additionally, NASA has long utilized competitive commercial launch services managed by the LSP to send its spacecraft to orbit and beyond. The agency has not operated a U.S. Government-owned launch system since the retirement of the Space Shuttle in 2011.

[17] USTRANSCOM, *Service Models Brief*, 15 May 2020

[18] Congressional Research Service, *Artemis: NASA's Program to Return Humans to the Moon*, 8 September 2020

Additionally, Artemis NASA's program for a return to the Moon by American astronauts by 2024. Artemis has evolved from plans articulated in the NASA Authorization Act of 2010 that established a statutory goal to "expand permanent human presence beyond low-Earth orbit" and mandated the development of a crew capsule and a heavy-lift rocket to accomplish that goal.

Artemis lunar surface missions requires astronauts to utilize to a spacecraft, known as the Human Landing System (HLS), for lunar descent and ascent.[19] In April 2020, NASA awarded fixed-price contracts for the first phase of HLS design and development to three companies:

- Blue Origin – Developing the Integrated Lander Vehicle (ILV) – a three-stage lander to be launched on its own New Glenn Rocket System and ULA Vulcan launch system.

- Dynetics – Developing the Dynetics Human Landing System (DHLS) – a single structure providing the ascent and descent capabilities that will launch on the ULA Vulcan launch system.

  SpaceX – Developing the Starship – a fully integrated, reusable launch and landing system capable of delivering up to 100 tons to the Moon and Mars.

Not all companies will necessarily be selected for subsequent development and demonstration contracts. To facilitate lunar landings and other missions, NASA is developing a modular platform, known as Gateway, to be placed in a permanent orbit around the Moon. The first two Gateway modules—the Power and Propulsion Element and the Habitation and Logistics Outpost (a pressurized habitat for astronauts)—are currently in development, with launch planned in 2023.[20] SpaceX has been selected to provide cargo logistics services in support of the Gateway. Overall, development for NASA's Artemis provides synergies for PTP space transportation due to similar requirements to support logistics.

[19] Congressional Research Service, *Artemis: NASA's Program to Return Humans to the Moon*, 8 September 2020
[20] https://www.nasa.gov/press-release/nasa-names-companies-to-develop-human-landers-for-artemis-moon-missions

5. Industry space transportation capabilities for the next 5, 10, and 15-year future timeframes

Future capabilities over a 5 to 10-year time horizon are provided via the satellite launch market and niche PTP space travel market. These markets do not provide USTRANSCOM with substantial force projection capabilities; however, increased commercial expenditure and research in these sectors provides an opportunity for required ground support and infrastructure that enables rapid deployment and distribution capabilities via the space domain.

5.1 Current spacelift market

The global space economy consists of private industry revenues and government budgets totaling $345B in 2016. Approximately 76% of space industry revenue comes from television communications, ground systems, and global positioning services with governmental budgets providing 24% of revenue. Commercial launch services only comprised 1.5% of the 2016 space economy[21] and provided the satellite launch capability.[22]

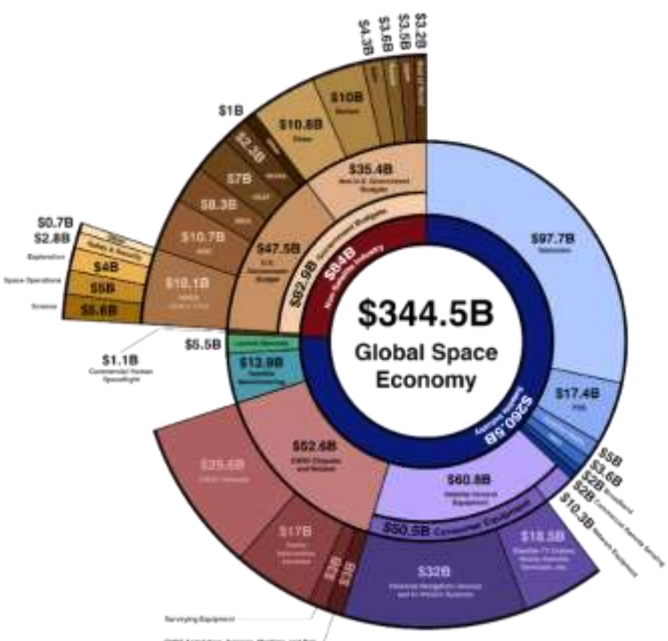

Figure 5-1. 2016 Space Industry Revenue[23]

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[21] Federal Aviation Administration, *The Annual Compendium of Commercial Space Transportation: 2018*

[22] The Federal Aviation Administration ceased publication of its commercial space transportation compendium in 2018.

[23] Ibid.

5.2 Future market (10 years)

UBS Group AG estimates a niche market ($20B) for a commercial PTP space travel market that competes with long-distance air travel by 2028.[24] For comparison, the commercial airline passenger revenues totaled $561B in 2018.[25]

5.3 Space vehicle costs and capabilities.

Until recently, most launch platforms have been single use (expendable) which results in the inability to reduce costs through vehicle reuse. Currently, SpaceX is the only company providing partially reusable launch systems.[26] Blue Origin is also seeking to develop a partially reusable launch capability. Of these companies, only SpaceX is pursuing a PTP space transportation capability for heavy cargo (Table 5-1).

Table 5-1. Publically Available Space Vehicle Comparison[27]

Organization	Vehicle	Metric Tons to LEO	Price Per Launch
SpaceX	Starship	150[28]	(b)(3) and (b)(4) [redacted]
U.S. Government	Saturn V	137	$2.1B[29]
SpaceX	Falcon Heavy	64	$90M
Blue Origin	New Glenn	45	Undisclosed
VKS/GK	Soyuz 5	26	$50M
United Launch Alliance	Atlas V	19	$110M-$220M
SpaceX	Falcon 9	13	$61.2M
VOX Space	Launcher 1	0.5	$10M

(b)(3) and (b)(4) [redacted].[30] Increases in space vehicle launch frequency and reusability provide exponential cost reductions

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[24] https://www.cnbc.com/2019/03/18/ubs-space-travel-and-space-tourism-a-23-billion-business-in-a-decade.html
[25] IATA, *Industry Statistics Fact Sheet*, December 2019
[26] As of 29 October 2020, SpaceX has landed 63 Falcon rocket boosters and conducted 45 reflights of previously flown boosters.
[27] From FAA *The Annual Compendium of Commercial Space Transportation: 2018* unless otherwise noted
[28] SpaceX, *USTRANSCOM CRADA Kickoff Presentation*, 9 March 2020
[29] Congressional Budget Office, *Alternatives for Future U.S. Space-Launch Capabilities*, 2016
(b)(3) and (b)(4) [redacted]

It is not expected that launch frequencies increase in excess of 3,000 launches per year to reduce price per kilogram within range of commercial airlift. Independent DOD analysis of launch costs for Starship is discussed in the USTRANSCOM Annex.

6. Concepts for command and control of space transportation capabilities and implications for space traffic management and domestic/international space use policies and protocols

Laws, treaties, and policies impact command and control (C2) concepts for space transportation capabilities.

6.1 Laws, Treaties, and Policies

Current international space law consists of treaties and customary international law arising from state behavior during the Cold War. The focus of efforts to establish this area of law in the 1960s and 1970s was to define a legal regime governing space activities, attempts to prohibit the weaponization of space, and to regulate ballistic missile development, testing, and deployment. For the potential development of normalized PTP space transportation, it is necessary to understand not only the space law implications, but also the legal intersection between the jurisdictions of air law, space law, and international custom for operating such a capability.

6.1.1 Delineation of Air and Space

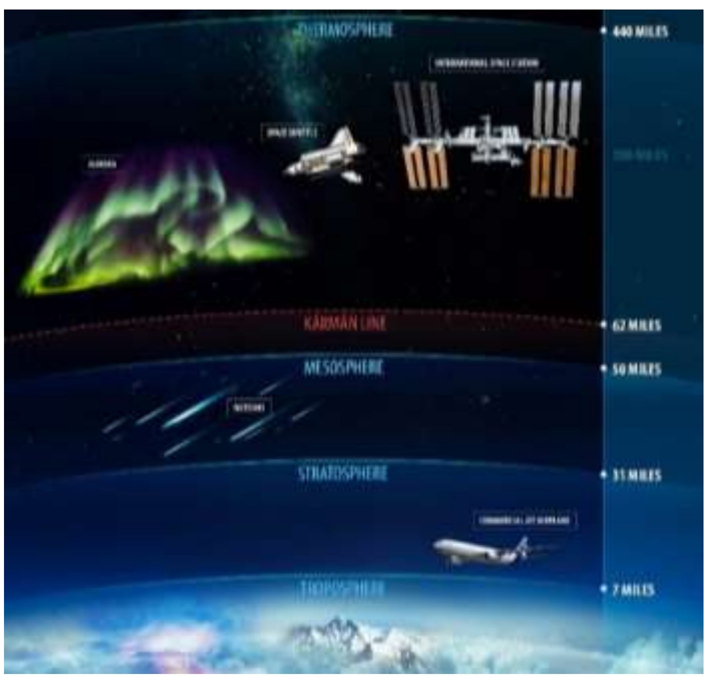

Figure 6-1 Delineations of Regions in Earth's Atmosphere[31]

[31] https://www.nesdis.noaa.gov/content/where-space

Although various proposals have been discussed over the years, international law relating to outer space does not define or specify the boundary between air and space. This boundary is of less importance when the purpose of a launch is to place an object into orbit. However, the lack of a definite boundary between air and space, as well as vague definitions for aircraft and space objects, creates potential issues and gaps regarding the applicability of laws governing objects traversing air and space as it applies to PTP space transportation. In practice, a common delineation between air and space is the Kármán Line at 100 kilometers (62 miles) above mean sea level (MSL) (Figure 6-1). For example, the Fédération Aéronautique Internationale, the world governing body for aeronautic and astronautic records, uses the Kármán Line to determine when space flight has been achieved. Theoretically, once the Kármán Line is crossed the atmosphere becomes too thin to provide sufficient lift for conventional aircraft to maintain flight and would need to reach orbital velocity or risk falling back to Earth.[32]

6.1.2 Air and Space Law

Laws governing air and space present different legal regimes. The airspace above a country is considered part of its territory and consequently subject to its domestic laws and regulations relating to aviation activities. This includes space launch and recovery activities through the country's airspace. International airspace for civil aviation is governed by the standards and recommended practices (SARPs) promulgated by the International Civil Aviation Organization (ICAO) under the Convention on International Civil Aviation of 1944 (known as the Chicago Convention). The SARPs and other international agreements address issues such as liability, security, navigation and air traffic management. Bilateral air transport agreements regulate commercial aviation activities between countries. Few of these agreements or ICAO SARPs contemplate or address the passage of vehicles in the launch or recovery phase that would be characteristic of PTP space transportation. In contrast to aviation law, the law relating to outer space is far less well developed. Space law does not, for example, adequately address commercial activities in space since at the time all major space treaties were adopted in the 1967-1975 timeframe, most space launches were by government entities. While commercial activities are allowed under this legal regime, governments are responsible and liable for those activities.

It remains unclear whether and how vehicles are subject to established aviation laws and to what extent, if any, these laws follow them into space for PTP space transportation. Moreover, the lack of a legal definition of the boundary between air and space creates an issue of where the application of aviation law ends and space law begins[33] Under existing legal regimes, PTP space transportation will likely fall under both domestic and international aviation law, as well

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[32] https://www.nesdis.noaa.gov/content/where-space

[33] Space Safety Law & Regulation Committee of the IAASS, *Suborbital flights and the delimitation of air space vis-à-vis outer space: functionalism, spatialism and state sovereignty*, 20 April 2018

as international space law for different phases of an operation (e.g. launch, ascent, descent, recovery, etc.). Note that the FAA takes a functionalist approach, where space launches are subject to space law and aviation law does not apply. Other countries may differ, and indeed the FAA may need to adapt its approach if PTP space transportation entails significant time and maneuvering in US controlled or managed airspace. Seeking an international consensus on the status and legal regime applicable to PTP space transportation would increase the viability of such transportation.

Table 6-1 Major Differences between International Air and Space Laws[34]

Air Law	Space Law
Applies to "air space"	Applies primarily to "outer space"
Applies to "aircraft"	Applies to "space objects"
States enjoy "complete and exclusive sovereignty" over their territorial air space	State sovereignty over outer space is prohibited
Imposes liability on the airline, or the aircraft operator	Imposes liability and oversight responsibility upon the State
Requires States to certify and register aircraft	Creates an international registration regime
Requires States to regulate safety, navigation, and security	No universal safety, navigation or security standards, but states are required to conduct activities with "due regard" for the activities of others and avoid harmful interference with those activities
Requires States to regulate noise and emissions	Environmental harm is to be avoided, but obligations are ill-defined

6.1.2.1 Aircraft versus Space objects

The construction of a vehicle in and of itself does not determine whether it is an aircraft, a space object, or both, let alone the legal regime that will apply to its operation. The Chicago Convention vaguely defines an aircraft as "any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface."[35] This potentially applies to space objects, particularly those capable of maneuvering in air space during the launch and recovery phases.

The FAA does provide definitions for types of rockets, expendable launch vehicles, and reusable launch vehicles as part of its licensing and safety oversight to U.S. commercial space programs. For example, a suborbital rocket is a vehicle, rocket-propelled in whole or in part, intended for flight on a suborbital trajectory, and the thrust of which is greater than its lift for the majority of

[34] Ibid.
[35] Chicago Convention, Annex 7

the rocket-powered portion of its ascent.[36] As noted earlier, the FAA takes a functionalist approach where space launches are subject to space law and aviation law does not apply. The advent of PTP space transportation may necessitate reconsideration of this approach.

6.1.2.2 Overflight Restrictions and Considerations

International law recognizes that there are no overflight restrictions for spacecraft in outer space since international law does not extend a nation's territorial boundaries into space.[37] However, as the United Nations' International Association for the Advancement of Space Safety (IAASS) notes the "right of innocent passage through territorial airspace for ascending or descending space objects has not been established under either conventional or customary international law. The U.S. Space Shuttle usually ascended and descended over U.S. airspace or over the oceans…on relatively few occasions has a space object flown over the territorial airspace of a State other than the launching State."[38]

Assuming that both aviation and space law apply to commercial PTP space transportation as the vehicle accomplishes reentry over non-U.S. airspace, overflight clearances may present some limitations to operations. In part, this depends on whether the vehicle being used is a state aircraft (government-owned or operated) or a civil aircraft. International law classifies aircraft as either state or civil, and prohibits the overflight of a country's territory by state aircraft of another country without the overflown country's permission.[39] In addition, civil aircraft are subject to ICAO SARPs while in international air space, and the domestic legal regime of a country when in that country's airspace. Consequently, depending on the legal character of the vehicle and the international and domestic airspace it transits, overflight permission may be required, as well as compliance with international and domestic aviation laws and regulations. As a practical matter this may only impact portions of a flight occurring in controlled airspace, which generally stops at 60,000 feet. However, assertions of sovereignty by an overflown country above that height are likely since most countries view their territorial airspace as extending to at least 60 miles above the earth. [redacted] This recovery places the Starship outside of altitudes typically characterized as controlled airspace.[40] .\ However, to the extent a country insists on requiring advance coordination for transits above

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[36] 14 Code of Federal Regulations 401.5

[37] Article II, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (1967 (the "Outer Space Treaty")

[38] Space Safety Law & Regulation Committee of the IAASS, *Suborbital flights and the delimitation of air space vis-à-vis outer space: functionalism, spatialism and state sovereignty*, 20 April 2018

[39] Art 3, Chicago Convention

[40] Air Force Research Laboratory, *Point-to-Point Rocket Cargo Delivery Lessons & Observations Slides*, 2020

60,000 feet it may do so, at least up to the altitude most countries would recognize as the limit of territorial airspace.[41] The C2 responsibilities required for DOD contracted commercial PTP space transportation are unknown, and responsibility for the coordination of overflight clearances for portions of the flight may fall on USTRANSCOM.

The question of legal characterization of aircraft or spacecraft may become an issue as the DOD contracts for commercial PTP space transportation. Currently, U.S. Government policy is that aircraft under contract to the U.S. retain their civil status unless specifically designated to be state aircraft, and that the normal practice of the U.S. Government is to not make such designations. USTRANSCOM contracts reflect this, requiring air carriers to operate as civil aircraft.[42] The Command does have the authority to designate contracted aircraft as state aircraft if necessary. The primary advantage to operating as civil aircraft, and the stated reason for the U.S. Government policy, is that civil aircraft enjoy overflight and transit rights that state aircraft do not.

6.2 Space treaties

The current set of four space law treaties provide the basic legal regime applicable to operations in outer space. They were negotiated between 1965 and 1975 at the height of the Cold War, as the U.S. and the Soviet Union increasingly operated in space. For the potential development of normalized PTP space transportation, it is necessary to understand not only the space law implications, but also the legal intersection between aviation law and space law for operating such a capability.

6.2.1 Outer Space Treaty[43]

The Outer Space Treaty of 1967 establishes that space shall be free for exploration and use by all nations, but that no nation may claim sovereignty of outer space or any celestial body. The treaty does not ban military activities within space, military space forces, or the weaponization of space, with the exception of the placement of weapons of mass destruction in space. The treaty establishes the basic legal regime applicable to outer space, while the next three agreements address specific aspects of outer space operations.

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[41] Air Force Research Laboratory, *Point-to-Point Rocket Cargo Technical Background Treaty and Policy Implications Brief*, 2019

[42] USTRANSCOM Instruction 24-09, *Civil Airlift Programs*, 15 January 2016

[43] Treaty on Principles Governing the activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (1967), commonly referred to as the Outer Space Treaty.

6.2.2 Rescue and Return Agreement[44]

The 1968 Rescue and Return Agreement requires that any state party that becomes aware that the personnel of a spacecraft are in distress must notify the launching authority and take all possible steps in rescuing them, and promptly return them to the launching state. In the event that a space object's parts land in the territory of another state party, the state where the object lands is required, upon the request of the launching authority, to recover the space object and return it to the launching authority. The Rescue and Return Agreement provides that the launching state must then compensate the state for the costs it incurs in recovering, and returning space objects to the launching state.

6.2.3 Liability Convention[45]

The Liability Convention stipulates that states bear international responsibility for all space objects that are launched from within their territory that cause damage to other objects in outer space, or to persons and property on earth. Additionally, if two states work together to launch a space object, then both of those states are jointly and severally liable for the damage that object causes. This means that the injured party can file a claim against either of the two states for the full amount of damage. Finally, claims under convention must be brought by the state representing the injured party or parties against the launching state(s).

6.2.4 Registration Convention[46]

The Registration Convention requires states provide the United Nations (UN) details about each space object launched into earth orbit or beyond. Execution of PTP space transportation may require space vehicles to orbit prior to reentry and thus require submitting registration information to the UN.

6.3 Arms control agreements

While commercial space vehicles are not weapons, portion of existing arms controls agreements may be applicable due to export controls and restrictions (Table 2-1).

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[44] Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Space Objects Launched into Outer Space (1968), commonly referred to as the Rescue and Return Agreement.
[45] Convention on International Liability for Damage Caused by Space Objects (1972), commonly referred to as the Liability Convention.
[46] Convention Registration of Objects Launched into Outer Space (1975), commonly referred to as the Registration Convention.

Table 6-2 Arms Control Agreements applicable to commercial PTP space transportation

Treaty/Agreement	Applicable
HCOC	X
MTCR	X
PLNS MOU	X
INF Treaty	
New START	

6.3.1 Hague Code of Conduct (HCOC)

The International Code of Conduct against Ballistic Missile Proliferation, also known as HCOC, was established to regulate access to ballistic missiles which can potentially deliver weapons of mass destruction. The HCOC is the only multilateral code in the area of disarmament which has been adopted over recent years. It is the only normative instrument to verify the spread of ballistic missiles. The HCOC does not ban ballistic missiles, but it does call for restraint in their production, testing, and export. The HCOC is recognized by 138 signatories to include the U.S. and Russia. China has not subscribed to the HCOC. The HCOC may be applicable to commercial PTP space transportation.

6.3.2 Missile Technology Control Regime (MTCR)

MTCR is a multilateral export control regime. It is an informal political understanding among 35 member states that seek to limit the proliferation of missiles and missile technology. The MTCR seeks to limit the risks of proliferation of weapons of mass destruction by controlling exports of goods and technologies that could make a contribution to delivery systems (other than manned aircraft) for such weapons. In this context, the MTCR places particular focus on rockets and unmanned aerial vehicles capable of delivering a payload of at least 500 kg (1,100 lb) to a range of at least 300 km (190 miles) and on equipment, software, and technology for such systems.

The MTCR is not a treaty and does not impose any legally binding obligations on Partners (members). Rather, it is an informal political understanding among states that seek to limit the proliferation of missiles and missile technology. The HCOC supplements the MTCR. Similar to the HCOC, the U.S. and Russia are members. China applied for membership to MTCR but was denied because of concerns about its export control standards. The MTCR may be applicable to commercial PTP space transportation since it may limit who can build and operate space vehicles.

6.3.3 Memorandum of Understanding on Notifications of Missile Launches (PLNS MOU)

The PLNS MOU attempts to reduce the confusion of nuclear escalation by establishing a Pre- and Post-Launch Notification System (PLNS) for launches of ballistic missiles and space launch vehicles, and by providing for the voluntary notification of satellites forced from orbit and certain space experiments that could adversely affect the operation of early warning radars. This agreement involves the exchange of notifications on many more types of launches than is provided for under existing arms control agreements between the U.S. and Russia. The commitment to a notification system was renewed with New START, which also highly encouraged other HCOC members (e.g., France, Germany, and Japan) to participate, and even sought to include non-members with ballistic missile capabilities (e.g., India and Pakistan). Updates to the MOU PLNS system does not require pre-launch notification *per se*, just an annual report of launch activities. However, HCOC "urges subscribing States to commit themselves to pre-launch notifications of launches and test flights of not only their ballistic missiles, but also space launch vehicles." The PLNS MOU may be applicable to commercial PTP space transportation.

6.3.4 Intermediate Range Nuclear Forces (INF) Treaty

The INF treaty between the U.S. and Russia prohibits both parties from possessing, producing, or flight-testing ground-launched ballistic and cruise missiles with ranges of 500–5,000 km (310–3,110 mi). Possessing or producing ground-based launchers of those missiles was also prohibited. The ban extended to weapons with both nuclear and conventional warheads, but did not cover air-delivered or sea-based missiles. The U.S. officially renounced the INF treaty in 2018 due to reports of Russia violating the treaty with observed missile testing activity. The primary consequence of this action is that both countries now have an unrestrained ability to develop and test intermediate range, ground-launched missiles.

Starship-only launches are limited to sub-orbital operations and have ranges up to [redacted] (b)(3) and (b)(4) dependent on fuel load. This range may need to be addressed if the U.S. seeks to reenter the INF Treaty.

6.3.5 New Strategic Arms Reduction Treaty (New START)

New START is a nuclear arms reduction treaty between the U.S. and Russia with the formal name of Measures for the Further Reduction and Limitation of Strategic Offensive Arms. New START expires in February 2021 and has no impact on commercial PTP space transportation.

6.4 Operator licenses, and notifications

Launch and reentry licenses for commercial missions are vehicle specific and authorize the execution of one or more launches or reentries having the same operational parameters for one type of launch or reentry vehicle operating at one launch or reentry site. The license identifies, by name or mission, each activity authorized under the license. Authorization to operate terminates when all launches or reentries authorized by the license are complete or the expiration date stated in the license, whichever occurs first.

The FAA requires lead time for commercial space missions. For example, not less than 60 days before a mission, a licensee must provide the FAA with payload information as well as flight information, vehicle, launch site, planned launch and reentry flight path, and intended landing sites including contingency abort sites. Moreover, not later than 15 days before a mission, a licensee must notify the FAA, via the FAA/USSPACECOM Launch Notification Form, of the time and date of the intended launch and reentry or other landing on Earth of the vehicle.

The current process to launch commercial space vehicles inhibits the ability to perform on-demand PTP space transportation missions. However, a regular cadence of scheduled missions [redacted] coupled with FAA allowances for DOD to change cargo loads may continue to provide rapid delivery capabilities. Additionally, many commercially-conducted launches for the U.S. Government are not licensed by the FAA, includes those procured under the NSSL Program.

6.5 Command and Control (C2)

As with contracted airlift, USTRANSCOM contracted PTP space transportation would likely require the contractor to provide all personnel, training, supervision, fully operational equipment, facilities, supplies and any items and services necessary to perform transportation services utilizing space launch vehicles. Additionally, the contractor would be expected to utilize licensed space launch vehicles, operated and maintained in accordance with all applicable rules and regulations of the FAA.

DOD would require and direct the contractor to accomplish PTP space transportation via contractual mechanisms, with the contractor responsible for command and control during the mission between points of embarkation and debarkation. USTRANSCOM Operations Centers are primarily concerned with monitoring mission status; however, USTRANSCOM does provide direction/authorization for the departure of contracted missions. [redacted]

[redacted]

The overall process for de-confliction to meet regulatory and treaty mandates (Figure 6-2) requires further analysis that will occur during long range PTP space transportation demonstration.

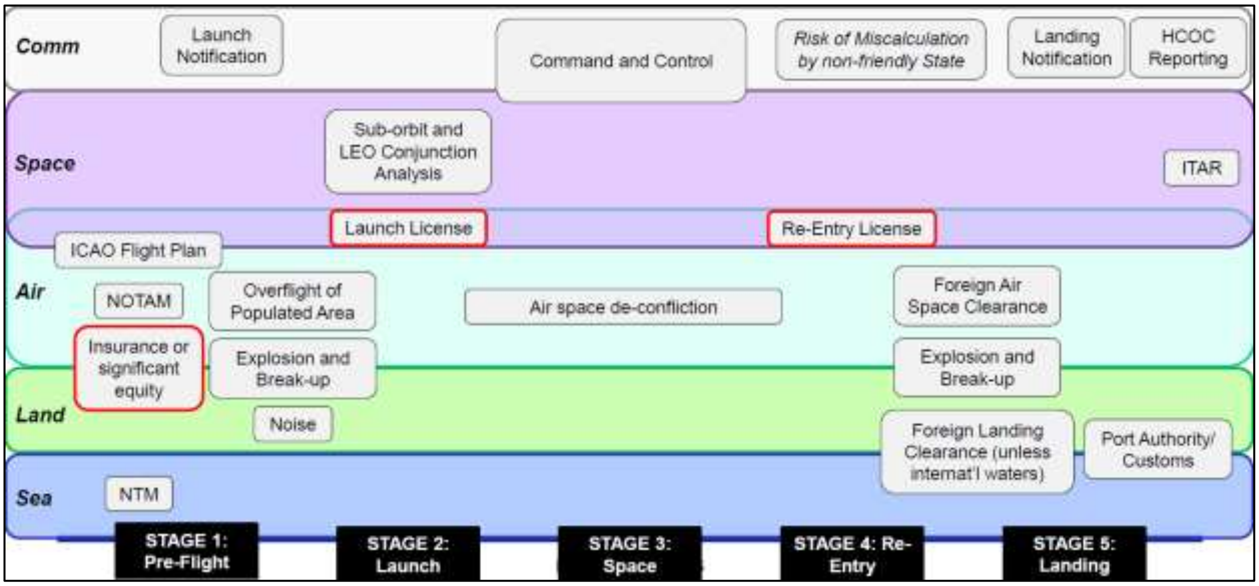

Figure 6-2 PTP Space Transportation Mission Stages[48]

[redacted]

[48] Maj Bettinger and 1Lt Shockley, *Policy and Geopolitical Considerations for Point to Point Mission Planning*, 12 June 2020

7. Roadmap to demonstrate the configuration, loading, launch and recovery of DOD cargo on a SpaceX Starship

[redacted] (b)(3) and (b)(4)

Annex A. Proprietary Annex (Intentionally Blank)

Annex B. USTRANSCOM Annex (Intentionally Blank)

Annex C. Glossary

C.1. Acronyms

ALD - Available load date
AMC – Air Mobility Command
C2 – Command and Control
CRADA – Cooperative Research and Development Agreement
CRAF – Civil Reserve Air Fleet
DABS – Deployable Air Base System
DPA – Defense Production Act
DTR – Defense Transportation Regulation
DWCF – Defense Working Capital Fund
ERIMP – Enroute Infrastructure Master Plan
GSE – Government Supported Equipment
HCOC – Hague Code of Conduct
HLS – Human Landing System
IAASS - International Association for the Advancement of Space Safety
ICAO – International Civil Aviation Organization
INF - Intermediate Range Nuclear Forces
JOPES – Joint Operational Planning and Execution System
LNG – Liquid Natural Gas
LOX – Liquid Oxygen
MSL – Mean Sea Level
MSP – Maritime Security Program
MTCR – Missile Technology Control Regime
NASA – National Aeronautics and Space Administration
NRE – Non-recurring Expenditure
NRO – National Reconnaissance Office
NSSL – National Security Space Launch
PLNS MOU – Memorandum of Understanding on Notifications of Missile Launches
RSLP - Rocket Systems Launch Program
SAAM – Special Assignment Airlift Mission
SARP – Standards and Recommended Practices
SMC – Space and Missile Systems Center
SpaceX – Space Exploration Technologies Corporation
START – Strategic Arms Reduction Treaty
TPFDD – Time Phased Force and Deployment Data
TWCF – Transportation Working Capital Fund
UN – United Nations

USSF – United States Space Force
USTRANSCOM – U.S. Transportation Command
VISA – Voluntary Intermodal Sealift Agreement
WCF – Working Capital Fund