POLICY IMPLICATIONS OF LAUNCH-ON-DEMAND EMPLOYMENT

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With the growing capability and frequency of spacecraft launch operations, as well as the accelerated research and development of high-altitude hypersonic vehicles, the prospect of rocket-based cargo mobility requires new legal and policy strategies to contend the implications of projecting air power to any global theater within one hour via a vehicle based in the continental U.S. This paper will explore the challenges posed by a sub-orbital "launch-on-demand" capability by not only air and space law, but also national policy and geopolitical perceptions. Citing contemporary legal and process-based requirements for space launch and atmospheric reentry operations, this paper will advocate an evolution of national policy to enable a launch-on-demand capability to deliver personnel and cargo to contested theaters of operation in support of U.S. core competencies of global reach and rapid global mobility.

INTRODUCTION

The twentieth century witnessed an unprecedented technological revolution which, among other things, resulted in the attainment of global mobility via heavy-lift cargo aircraft. Although naval shipping remained a mainstay for the transport of large-scale cargo and freight, advances in aeronautical, mechanical, and materials engineering spurred the development of aircraft which shortened transport timelines for smaller-scale cargo from weeks and days to hours. With the growing capability and frequency of spacecraft launch operations in the early twenty-first century, the concept of rocket-based mobility is becoming a reality as system designs for reusable space launch vehicles continue to evolve and mature [1,2]. The introduction of rockets flying exo-atmospheric ballistic trajectories into the global mobility construct will, therefore, enable a further reduction of intercontinental transportation timelines to less than one hour.

Once operational, the primary functions for rocket-based mobility will be passenger and cargo transport, similar to transoceanic airline and air-freight services in the air domain. The prospect of this new mode of mobility for cargo transport opens new possibilities for not only financial growth in the private sector, but also the realization of national defense and policy goals in the governmental sector. A rocket-based intercontinental delivery of personnel and/or cargo represents a capability enhancement that will dramatically shift the current mobility paradigm. It will very likely bring inherent challenges associated with both air and space law, as well as varied geopolitical perceptions to the use of ballistic, non-nuclear launch systems for governmental operations.

This paper will discuss the legal, policy, and geopolitical implications associated with the employment of a launch-on-demand system as a means to promote rapid global mobility [3]. In terms

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of structure, this paper will examine the thesis by first describing the launch-on-demand concept as featuring two possible modes of operation: (1) emergency mobility; and (2) routine mobility. Next, the paper will outline contemporary air and space law, as well as national and international policy considerations as applied to space launch systems. Subsequently, the challenges of introducing a launch-on-demand capability will be presented vis-à-vis the contemporary legal and policy framework. Finally, a potential pathway will be proffered for the non-commercial operation of launch-on-demand systems from U.S. territory. Since this paper's concern is the legal and international community's response to this capability, neither the feasibility of technology underpinning the launch-on-demand concept, nor costs associated with development or operations will be discussed.

LAUNCH-ON-DEMAND CONCEPT

For the purposes of this research, a notional launch-on-demand system is not based on any existing launch vehicle concept, but it is assumed to have a final stage that lands safely in a designated location. The vehicle is restricted to two stages based on its intercontinental mobility mission, in which injection into low Earth or higher Earth orbits with the use of three, or possibly four stages, is not required. In terms of classification, the vehicle is a vertical-takeoff, vertical-landing (VTVL) system [4]. The vehicle's first stage represents a "boost" or ascent stage that will be reusable rather than expendable. The vehicle's second stage, containing of the passenger and/or cargo payload compartment, features minimal aerodynamic properties, thereby restricting the landing profile to a powered vertical descent instead of an unpowered glide (e.g., Space Shuttle) [5]. The non-commercial implementation of a launch-on-demand system could occur in one of two modes: (1) emergency mobility; or, (2) routine mobility. For the "emergency mobility" mode, vehicle operation only occur in the event of a geopolitical situation necessitating a rapid deployment of personnel and/or cargo to a specified area of operation or theater.

Within this emergency-employment construct, the launch-on-demand systems would be owned and operated by a civilian contractor, with governmental operations conducted within the bounds of a pre-defined agreement with the contractor. Currently, the U.S. Government maintains two formal agreements for the temporary nationalization of civilian assets [6]. The first of these military-civilian contractual systems is the Civil Reserve Air Fleet (CRAF), managed by the U.S. Air Force (specifically, Air Mobility Command). Founded in 1952, the program now jointly exists under the Department of Transportation (DoT) and the Department of Defense (DoD). In order to ensure that the U.S. military retains the ability to rapidly move troops and their equipment, CRAF is renewed every year. Initially, an airline carrier signs a one-year contract with the CRAF program stating that the government is entitled to use a certain number of its aircraft if the CRAF program is activated. Activation of CRAF allows the DoD (via Air Mobility Command) to assume mission control including the ability to plan the mission, determine the type of aircraft required, and set times, locations, and cargo as needed. Within the CRAF arrangement, the airline retains operational control of the craft and crew [7].

The second contractual system, the Voluntary Intermodal Sealift Agreement (VISA), is managed by the U.S. Navy (specifically, Military Sealift Command). Founded in February 1997 via the approval of the Maritime Security Program, VISA is a cooperative program between the DoD and the DoT-Maritime Administration (MARAD). Fundamentally, VISA acts as a mechanism for the rapid deployment of U.S. cargo in the event that cargo shipment requirements outpace the capabilities of the U.S. Merchant Marine. Due to its relatively young status when compared with CRAF, VISA has yet to be activated in a real-world scenario, though biannual exercises test the program's readiness for activation via simulation [8]. Due to the scope of the present research, CRAF/VISA are only considered as historical examples of partnership. There does not currently exist a similar agreement with launch providers. The extent and nature of any legislative infrastructure to support

a government-civilian agreement similar to CRAF/VISA for use with the operation of a launch-on-demand system will not be assessed in this paper.

CONTEMPORARY AIR/SPACE LAW AND INTERNATIONAL CUSTOM

Despite the launch of Sputnik 1 and the subsequent initiation of the Space Race over six decades ago, the field of space law is still met with quizzical expressions when mentioned due to the general detachment of humanity from the very space-based architectures and systems that enable contemporary global society connectivity and function. For this reason, it is becoming increasingly recognizable that the cooperation of both engineers and lawyers is required as innovation and technological advancement continue to accelerate the opening of space beyond the governmental sector. In addition, such cooperation will enable novel uses of the space domain to include the present concept of launch-on-demand systems. For the potential development of launch-on-demand systems, however, 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.

The fundamental characteristic of a launch-on-demand capability is the use of a sub-orbital trajectory for Earth-to-Earth transportation. Although the system does not reach orbital speeds and, consequently, is unable to inject into a stable orbit, the system's trajectory still transcends the upper limit of the sensible atmosphere and traverses near-Earth outer space. Depicted in Figure 1, this trajectory encompasses both endo- and exo-atmospheric flight, thus necessitating a cursory exploration of the legal debate concerning the demarcation between air and space law, to include the application of such legal precepts to vehicles operating in both realms.

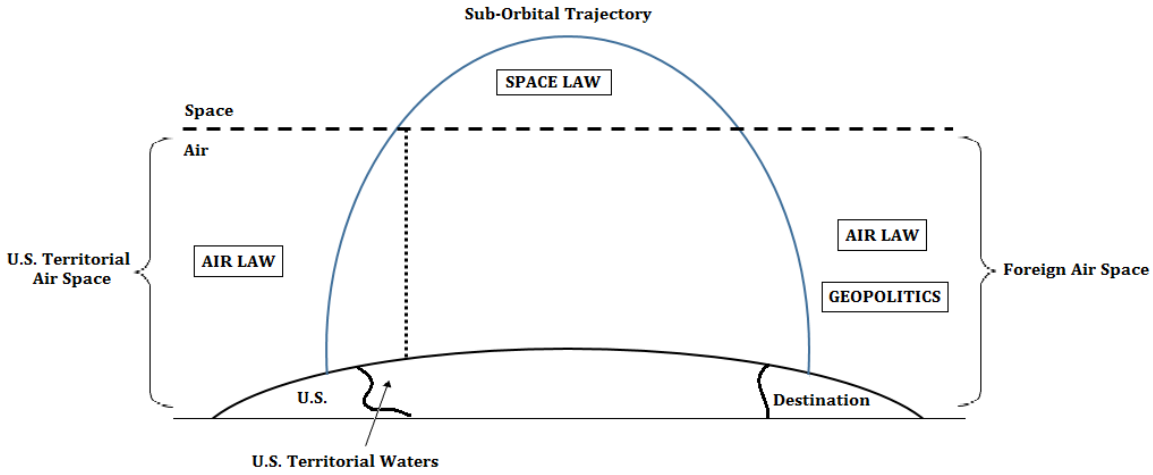

Figure 1. Jurisdictional Demarcation for Notional Launch-on-Demand Trajectory.

Not officially defined by international treaty, the demarcation between air space and outer space has created an extant legal debate concerning where air law ends and space law begins. As codified in Article I of the 1944 Convention on International Civil Aviation, air law grants each state "sovereignty and exclusive territorial jurisdiction" over its' respective air space, only to be infringed upon by prior formal agreement or treaty [9]. By contrast, Article II of the Outer Space Treaty (OST) declares outer space to be an international zone outside the realm of state sovereignty [10]. In an effort to define the transition between air and space law, two differing interpretations of air

space and outer space delimitation have arisen: spatialism and functionalism. For spatialists, the boundary between air and space is defined physically in terms of altitude, such as the von Kármán Line. Rather than an altitude boundary, the functionalist approach seeks to delimit air space and outer space according to the distinctive function of a given vehicle operating within the environment in question [10]. The long-standing policy of the U.S. Government regarding demarcation may be interpreted as aligning with the functionalist approach, and is absent a definable and recognized altitude-based boundary between air space and outer space.

Compounding the historical demarcation debate is the absence of any conventional or customary rule of international law addressing the passage of vehicles ascending to or descending from space on a reentry trajectory [11]. When viewed within the context of spatialism, sub-orbital trajectories transcend international attempts to delimit air space and outer space. Corresponding to an altitude of 100 km, the aforementioned von Kármán Line represents an approximate boundary above which aircraft cannot derive aerodynamic lift from the atmosphere and, as a result, must travel at speeds approaching orbital velocity so as to remain in flight [12]. As an alternative, Italy, in 1975, proposed a boundary at 90 km for it represented the median altitude between the assessed upper limit of aircraft flight (at 60 km) and the lowest possible satellite orbit (at 120 km). Later in the 1970s, Belgium and the Soviet Union continued the debate, with the former advocating a boundary at 100 km (à la the von Kármán Line), while the latter proposed an arbitrary boundary at 110 km [12].

Although the Italian delimitation proposal identifies the upper altitude limit of aircraft flight at 60 km, this corresponds to the approximate operating altitude of rocket-propelled aircraft, such as the North American X-15 [13]. In terms of conventional aircraft, the upper altitude limit is considerably lower with the Lockheed U-2 and Northrop Grumman RQ-4 reaching maximum ceilings of about 22 km and 19 km, respectively [14,15]. For lighter-than-air vehicles, such as NASA's "Big 60" balloon, the maximum ceiling is about 48 km [16]. By considering both the nominal ceiling of the X-15 and the limit defined by the von Kármán Line, in which sustained atmospheric flight is not feasible with current technology. Even with its operating limitations, this altitude regime is still considered sovereign air space as evidenced in several reports issued since the 1960s.

On the opposing, functionalism side of the historical demarcation debate, the question of legal jurisdiction is dependent on the function and design characteristics of a given vehicle. Outlined in the 1975 Convention on Registration of Objects Launched into Outer Space, a space launch vehicle and associated satellite payload(s) are acknowledged as "space objects" and, as a result, are governed by space law since they are intended to reach and operate within the space environment [17]. For vehicles intended to provide sub-orbital, Earth-to-Earth transportation, however, additional scrutiny is required. If such a vehicle is able to operate within the atmosphere without the generation of lift, or without requiring external oxygen to burn as part of its propulsion system, then one aspect of functionalism would categorize the vehicle as a "space object." With the case of a notional VTVL launch-on-demand system, the system does not "derive support in the atmosphere from the reactions of the air" and relies on internally-carried propellant for propulsion. Based on these design characteristics, then the launch-on-demand vehicle could ostensibly be assessed as being purely under the jurisdiction of space law throughout its entire sub-orbital trajectory, to include both launch and reentry.

A complicating factor with the functionalist approach to delimitation is the examination of a given vehicle's interactions with other systems, whether it is an air- or space vehicle. Specifically, the collision risks are evaluated and an assessment of legal jurisdiction is then made with respect to operating location [11]. In a 2005 working paper, the International Civil Aviation Organization (ICAO) – a specialized agency of the U.N. – argued that "air law would prevail" for sub-orbital

systems performing Earth-to-Earth transportation due to the potential for collision between such systems with air vehicles, and the judgement that any crossing of outer space was "brief and only incidental to flight" [11].

Space Law

At its core, space law originates from principally bilateral agreements between the U.S. and the former Soviet Union during the Space Race. In 1967, the U.N. became involved and the Outer Space Treaty (OST) was signed in Washington D.C. between the U.S., the Soviet Union, and Great Britain. On precisely the same day, the Apollo 1 crew perished in an electrical fire during a pre-launch test. The incident demonstrated the extreme consequences of space exploration and solidified the need for cohesive international cooperation. As of June 2019, OST has been ratified by 109 countries, with five related multilateral legally binding treaties, and many legal documents intended to guide practices for the international community [18].

On the State-level, several governmental organizations exist to regulate space activities, especially when such activities intersect the air domain. As an example, the Federal Aviation Administration (FAA) has its own dedicated Office of Commercial Space Transportation (AST) for the management of U.S. space activities. For the case of the U.S., there are more than nine agencies, including the FAA and the Federal Communications Commission (FCC), which issue clearance for space launches from U.S. territory according to Title 51 of the U.S. Code pertaining to space law.

Another consideration of the OST is its language on the usage of outer space for exclusively peaceful and scientific purposes. The Friendly Relations Declaration of 24 October 1970 reiterates this point that States "shall avoid any military use of or activity in outer space which may result in a threat to international peace and security" [19]. The militarization of space can be defined as the use of space systems for navigation; early warning; communications; and intelligence, surveillance, and reconnaissance (ISR) missions for the support of terrestrial military operations [19]. Alternatively, the term "weaponization" specifies that weapons have a target in space; by contrast, a system such as an intercontinental ballistic missile (ICBM) does not classify as a "space weapon" because it only passes through outer space during its transit to a terrestrial target [19]. Due to this distinction, only perceptions during the ballistic transit of a launch-on-demand system will be discussed further.

Language on Ballistic Missiles

A subset of ballistic missiles, ICBMs are traditionally assumed to feature at least three rocket stages, to include a post-boost stage for precise global reach and targeting. As previously described, a potential launch-on-demand system for Earth-to-Earth transportation will likely have two stages, thereby limiting its range, but not enough for the intended use. Also, the system will likely only be operated from above-surface locations rather than underground silo facilities traditionally used for ICBMs. The latter sites are open to Russian inspections, just as Russia's nuclear capable missiles and facilities are open to inspection by the U.S. The guiding documents of how these weapon systems are controlled are the Intermediate Range Nuclear Forces Treaty (INF), which is now withdrawn, the New Strategic Arms Reduction Treaty (New START), and the Hague Code of Conduct against Ballistic Missile Proliferation (HCOC). These multilateral treaties have been updated over time, including the establishment of limits on the development of certain missile technologies and the numbers of missile systems.

As of July 2019, the U.S. has officially pulled out of INF after a 6 month probationary period due to reports of Russia violating the treaty with observed missile testing activity [20]. The primary consequence of this action is that both countries now have an unrestrained ability to develop and test intermediate range, ground-launched missiles. The INF included conventional ground-

launched ballistic missiles, so negotiations in coming years could likely affect this technology if the language is expanded to include transportation in the category of "militarization" of space, rather than focusing on nuclear weapon employment and delivery.

HCOC, addresses ballistic missile technology development with concern to both ballistic missiles and space launch vehicles. The U.S. has been a subscribing state since the treaty's inception in November 2002 [21]. The formation of HCOC was fostered by members of the Missile Technology Control Regime (MCTR) and meant to supplement existing policies by outlining how States can commit to restraint in developing and testing nuclear-capable ballistic missiles [23]. To facilitate this effort, HCOC requires an annual reporting of all ballistic missile and space launch tests, along with encouragement of pre-launch notifications that contain the "generic class of the… Space Launch Vehicle, the planned launch notification window, the launch area and the planned direction" [21]. With vehicle and trajectory information, this further confuses the approach of both functionalists and spatialists.

Language on Notifications

Notification of a missile or space launch usually entails publishing the projected vehicle launch time and trajectory on a shared system for monitoring by subscribed States. This notification mechanism arose from agreements between the U.S. and the former Soviet Union to reduce the risk of miscalculation that could lead to a nuclear exchange. In 2000, The U.S. and the current Russian Federation signed a Memorandum of Understanding on Notifications of Missile Launches (PLNS MOU) that initialized a communication system and guidelines for both countries [23]. Later in 2010, this 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) [22]. For ICBMs, it requires notification and telemetry data within 5 days after launch [22]. Overall, 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" [24].

Due to HCOC and other treaties formulated in the post-Cold War geopolitical landscape, the U.S. will likely continue to comply with a form of launch notification to Russia via established communication channels. The extension of launch notification to States beyond Russia is a possibility if U.S. military forces operate in regions of heightened geopolitical tension. A 2004 study by Air Force Space Command states that, "particularly in the event of actual use, operational security would need to be the driver of the type of notification, its timing, and the level of detail" [25].

As implied by the functionalist argument, safety and, by extension, air traffic control motivates the necessity for pre-launch notifications. For space launch and reentry operations, such notifications (i.e., Notice to Airmen [NOTAMS]) clear air space in an effort to reduce the likelihood or air-to-air collisions. Currently, communication channels exist for organizations within the DoD to contact the FAA in order to rapidly deploy aircraft, as well as the AST for space launch activities. The nature of air space congestion is evolving, and managing the addition of launch-on-demand systems can be grounded in historical policy precedent.

As for arrival notification to a given destination State, it is assumed the launch-on-demand system must conduct a controlled touch-down on a pre-existing landing pad built specifically accommodate such vehicle operations. The destination State would either have an existing partnership for landing pad construction and be willing to accept a landing with appropriate coordination, or the technology must further evolve for the possibility of landing on unprepared surfaces. Notification to States that may experience high-altitude overflight is not required by existing law of treaty, whether for the air or space domain. Nevertheless, notification is

recommended to be considered on a case-by-case basis depending on the relationship with the overflight State(s).

LAUNCH-ON-DEMAND IMPLICATIONS

Air/Space Law and International Custom

Aspects of a launch-on-demand system that require examination include the use of potential launch sites, the prospect of overflying neighboring countries during the reentry and descent phases of the trajectory, and, ultimately, the potential confusion of launch-on-demand operations with nuclear weapon employment. As of 2019, spaceports in 15 U.S. States are at various stages of proposal in the process of attaining status as FAA Licensed Launch Sites. From the start of space launch operations in the mid-twentieth century, U.S. Air Force and FAA regulations limit trajectory azimuth for all launch sites (e.g., Vandenberg AFB, Cape Canaveral, and Wallops Island) in order to prevent any overflight of populated areas. For spaceports in development, and for a launch-on-demand capability, the concept of overflight must be revisited due to the restrictive nature of current azimuth and location limits. The key to expanding launch operations to both non-traditional coastal and inland launch sites is to illustrate a low expected casualty risk so as to enable greater latitude in risk handling and mitigation. Similar analysis of inland launch sites in the continental U.S. is pivotal for a launch-on-demand capability to fully come to fruition.

Following the initial launch and departure of a launch-on-demand system from U.S. territorial air space, the remaining trajectory will occur either in outer space or within the air space of a single or several foreign States. Overall, international air space – like international waters – is "a *res communis omnium* like outer space, and territorial jurisdiction is absent" [22]. Once outside of international air space, the issue of sovereign air space must be addressed either through a pre-launch dialogue to secure permission for overflight of a given State, or the pursuance of a non-notification approach of *fait accompli*. The occurrence of "unauthorized" overflights and infringement of sovereign State air space for the purpose of military operations a have occurred with a variety of ISR aircraft since the 1960s [26].

For launch-on-demand reentry operations, the trajectory will likely overfly and enter sovereign State air space at altitudes below any proposed demarcation of air and space, but above any altitude capable of sustaining aircraft flight (previously identified as approximately 60 km). Below this altitude, the decision for overflight notification is linked to the potential mode of launch-on-demand operation. If launch-on-demand is used in a mature "routine mobility" mode, then air space passage rights will almost certainly be attained prior to a given mission, with all flight plans provided to regional air traffic control authorities to ensure air space de-confliction. For the "routine mobility" mode, launch-on-demand operations are expected to resemble traditional cargo aircraft missions with the exception of a brief sub-orbital trajectory segment that will necessitate additional collision avoidance planning.

Geopolitical Perceptions

From a geopolitical perspective, the possibility exists for a launch-on-demand capability to be erroneously perceived as a nuclear weapon threat. Depending on the baseline anatomy of launch-on-demand employment, nominal (routine) operations will likely be conducted as a single launch of a single vehicle for a mission on a pre-determined and likely advertised flight-path. This is in direct contrast to the anticipated deployment of multiple launch vehicles from multiple locations either simultaneously or in quick-succession as expected for a coordinated nuclear strike. Even in the case of an emergency operation possibly without notification, a launch-on-demand system would only appear like a possible nuclear launch based on its ballistic, sub-orbital trajectory. Even here, the analog with nuclear operations deteriorates for two reasons. First, not all nuclear weapon

systems use a ballistic trajectory (e.g., nuclear cruise missile system); second, it is unlikely for States to initiate nuclear hostilities with a single weapon. A further difference that would discourage miscalculation of the mission's intent by potential adversary States are the reliance of a controlled, non-destructive landing for the vehicle payload. Although the launch of a single missile/launch vehicle does not constitute an active nuclear threat, factors such as the identity of the launching State and the geopolitical climate contemporary to the launch must be analyzed to raise the confidence of the assessment.

During the development of any potential partnership between the commercial space industry and the U.S. government on this capability, such interaction could be perceived as the governmental sponsorship of a new long- range missile, which would be in violation of HCOC. As mentioned previously, the INF is no longer valid, and the New START treaty only limits system numbers, not development. While potential adversary States would not necessarily call out the U.S. for such a development partnership so as to not draw attention to their own long-range missile programs, threats to pull out of arms control agreements could still be proffered due to the lack of pre-launch notification of this capability. The consequences of such actions would be a lack of international accountability on the further development of ballistic missile technologies, and the increased U.S. national security risk from more States boasting long-range ballistic missile capabilities.

PATHWAY TO OPERATION/NATIONAL POLICY

Based on current U.S. policy structures, space launches usually take on the order of months to plan, with requirements to not only clearing the air space around a given launch site, but also ensure the safety of the vehicle and launch pad, and enhance space object collision avoidance by establishing the correct launch window compatible with a desired injection orbit geometry. In addition to overcoming all potential technical obstacles associated with space launch operations, launch providers must conduct a series of administrative actions that, if not completed, will prevent launch from occurring. Specifically, a launch program must register for a launch license, secure insurance, and obtain licensing to use a requested signal frequency (or frequencies). Also, a notification of launch must be issued at the national-level to appropriate offices and, possibly, at the international-level depending on the sensitivity of the mission.

For the U.S., a principal logistical task of a space launch is for the FAA to issue NOTAMs to clear the air space local to the launch site and ascent trajectory of all civilian/commercial aircraft. With space launch currently only occurring from coastal locations, then Notices to Mariners (NOTMARs) will also be required to clear littoral waters of ships and other surface vessels in the vicinity of the launch site. For example, the inaugural Falcon Heavy launch in 2018 required the clearance of 1,300 nautical miles of air space extending from the Atlantic seaboard, along with the adjacent Atlantic littorals (which were patrolled by the U.S. Coast Guard), for more than three hours despite the launch only taking minutes [26]. The FAA is currently working to modernize its software to include future air space congestion predictions, and account for spacecraft occupying those areas to mitigate stress on air traffic controllers, especially in the case of weather delays for space launch [26]. However, this software will likely require frequent upgrades over the next decade to account for a growing frequency of space launches and high-altitude travel, potentially in non-traditional regions of spaceflight activity across the continental U.S.

The largest obstacle to any civilian/commercial and possible governmental/military operation of a launch-on-demand system will likely be the historical paradigm that all space launches shall not fly over populated areas and restricted air space. A demonstrated safety record could change this paradigm, but there is considerable bureaucratic inertia that may hamper such efforts. On the international-level, the FAA coordinates with the ICAO to manage international air space and the

transit between a given aircraft's departure and arrival locations. As mentioned previously, a launch-on-demand system will travel in the controlled air space of both the originating and destination States, to include the possibility of overflight and air space infringement of neighbouring States if warranted by the reentry and descent trajectory. In general, the flight of sub-orbital vehicles remains a "gray zone" in current air and space law development that must be resolved to facilitate both the initial testing and eventual establishment of global sub-orbital, launch-on-demand operations.

As part of its regulation of space transportation activities, the FAA also issues licenses for the launch or reentry of a space vehicle, as well as the operation of any launch or reentry site, by U.S. citizens both within and outside the U.S. Of note, FAA licenses are not required for the space activities conducted by the U.S. Government, to include the DoD and NASA. This absence of a licensing requirement for DoD launch and reentry operations streamlines potential activity timelines by eliminating the FAA's (at most) 180-day window to make a licensing determination [27]. Instead of licenses, the FAA may issue experimental permits for the commercial launch or reentry of reusable sub-orbital launch vehicles in order to conduct the active research and development of new design concepts and technologies. However, the use of experimental permits is prohibited for the use of suborbital launch vehicles to carry personnel and/or cargo "for compensation or hire" [27].

In terms of frequency allocation, the FCC works with the International Telecommunication Union (ITU) to ensure "space objects" are not communicating at the same frequencies and are not violating pre-established spectrum usage restrictions. Although a launch-on-demand system transits its space for a short duration, frequency permissions will still need to be granted for any on-board guidance and/or cargo communication requirements. Overall, the FCC approval timeline represents another obstacle for launch-on-demand operations, with modifications required to streamline licensing and reduce the approval window from potentially months to days (or even hours).

Finally, ICBMs and space launch vehicles are Category II MCTR-controlled items according to the International Traffic in Arms Regulations (ITAR), and any export of such technology is deemed a potential risk to national security [28]. Yet, there exists limited "sharing" of rocket technology around the world. For example, India allows other countries to fly on Geosynchronous Satellite Launch Vehicle (GSLV) launches in exchange for compensation [29]. While space launch vehicles tend to be launched from the country of origin, some exceptions do exist: Russia allows some Soyuz launches from the European Space Agency (ESA) launch site in French Guyana, and ESA conducts a majority of launch operations from French Guyana. The common theme throughout these examples is the ultimate control of the launch vehicle by the country of origin. As potential sub-orbital landing destinations and spaceports are proposed, export control increasingly needs more attention. If a launch-on-demand system is owned and operated by a U.S. business or governmental agency, then overseas operations could be met with protest; the foreign State could attempt to dictate the inclusion of local officials for safety verification, which opens up the possibility of industrial espionage on an ITAR-controlled asset. Legislation addressing the possibility of conducting space launch operations from locations external to the U.S. are a necessity before a launch-on-demand capability can take flight. Such legislation must parry both the benefits of such a capability with the consequences of potentially proliferating ballistic missile technology, which is contrary to the current security posture of the U.S. and international community.

CONCLUSION

This research sought to address the obstacles pertaining to a launch-on-demand capability in the modern geopolitical setting. As a means of examining these obstacles, two potential modes of system operation were considered: "emergency" and "routine" mobility. With space law forming at a slower rate than the evolution of technology, then a prudent and recommended approach is to adhere to the most restrictive of legal and policy guidelines when considering launch-on-demand operations. In the context of legal jurisdictional concerns for system operation, the U.S. Government aligns with a functionalist approach within the historical demarcation debate and, as a result, does not recognize a formal altitude-based boundary between air space and outer space. With sub-orbital vehicles only using outer space as a temporary medium of transportation as compared to the time-of-flight within the sensible atmosphere, then functionalism indicates that *air law* and the policy guidelines associated thereof *must* take priority due to considerations of air space safety and collision avoidance. For the limited exo-atmospheric segment of flight, launch-on-demand systems are legal in terms of space law because they do not weaponize space and only function as transport vehicles.

In the realm of geopolitics, the New START treaty will be expiring by 2021 with the option for extension, and the recently nullified INF will likely be renegotiated. Historically, these treaties have included language seeking to preclude the militarization of space with space-based weapons platforms, whether nuclear or non-nuclear in nature. While using outer space or the "gray zone" between controlled air space and outer space for sub-orbital military transport is not currently addressed by international treaty, such operational capabilities will need to be considered as derivative technologies developed in the civilian or commercial sector for the purpose of sub-orbital transportation. Finally, launch-on-demand systems will more than likely be export-controlled with a Category II ITAR status. Such classification could hinder any civilian sector business models for the extra-national commercial development and use of this technology. A distinction between sub-orbital vehicles used for transportation and ballistic missiles intended for weapon system employment is required as a means of overcoming current legal and geopolitical perception obstacles.

The concept of using space as a medium for Earth-to-Earth transportation is novel and serves to stress the current boundaries of technology, national policy, and the arenas of air and space law. The technology underpinning a launch-on-demand capability is advancing at an accelerating rate, with any likewise revision and/or expansion of the legal framework intended to govern such technology being noticeably outpaced. An expanding dialogue between the engineering and legal/policy disciplines is a necessity for launch-on-demand and similar capabilities to reach their full operating potential, as well as to infuse flexibility into emerging laws and policies as technology continue to evolve.

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