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Two Perspectives on Civil Space Traffic Management Implementation

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The Department of Defense (DoD) has been conducting a variety of space traffic management functions for six decades. As launches have become more frequent and re-entry and landing operations have become more routine, the FAA and DoD have developed highly effective processes for de-conflicting air and space traffic. Recognizing the potential impact on their mission, the FAA has published multiple in-depth studies on how US airspace would be impacted by routine point-to-point suborbital, or orbital-reentry, operations. These studies have resulted in several theoretical processes for conducting individual portions of space traffic management operations. At the end of 2017 space is a very dynamic, commercially-dominated domain that is in need of a robust US space traffic management capability. This has prompted politicians and operators to move forward to developing a FAA-managed Civil Space Traffic Management (CSTM) capability for US entities. To complete this effort, the DoD and FAA are still working through several items which require agreement before significant progress can be made. Clear authorities and responsibilities are the basis for deciding what a CSTM capability will be and has been the central issue of most discussions on this topic. Additionally, policy questions associated with the use of DOD data to support the US CSTM will have to be resolved. The allocation of observations, security, and further refinement of that data requires further discussion. Finally, the timeframe for each of the phases of implementation have not been agreed upon. To fully understand why these issues are contentious, a short synopsis of the background of a US CSTM capability is necessary.

Presidential Policy Directive - 4, *National Space Policy of the United States of America*, released on June 28, 2010, called upon the Secretary of Transportation to identify options, requirements, and potential implementing structures for providing space traffic management (STM) services. Seven months later, an interagency working group presented a paper to the National Security Staff that identified capabilities, authorities, and responsibilities for providing space traffic management services; offered definitions for Space Traffic and Space Traffic Management; identified associated challenges and risks; and identified three options for providing space traffic management services.

The DoT and the DoD further explored a US CSTM capability by including the concept in the commercial cells of multiple high-level international space-centric wargames led by former Deputy Secretary of Defense Robert Work. In these events, the FAA/AST carefully defined what a US CSTM capability is, what it can do, and what it canôt do. Al
a tertiary issue in a DoD event, it became evident to participants that there would be a significant growth in commercial activity in space by the epochs for these wargames. This

growth would change the battlefield as well as influence the tactics, techniques, and procedures required for operating in a contested space domain. Though not the central focus, the need for a well-developed US CSTM capability was very evident during these events.

During the time that the US CSTM capability was being examined in DoD wargames, observable real-world progress was being made in the Legislative and Executive Branches of the US government. One such advance was the Commercial Space Launch Competitive Act of 2015 which included this verbiage:

> *It is the sense of the Congress that an improved framework may be necessary for space traffic management of United States Government (USG) assets and United States private sector assets in outer space and orbital debris mitigation.*[i]

This verbiage precipitated three reports, Section 108, Section 109, and Section 110. The Section 108 report recommended implementation of legislation that gives the Secretary of Transportation the power to authorize missions into space. It also recommended the Secretary of Transportation, in coordination with the Secretary of Defense, be authorized to examine the planned and actual operational trajectories of space object and advise operators as appropriate to facilitate prevention of collisions.[ii]

The section 109 report concluded that ñ[It] is in interests to have an improved domestic space traffic safety governance framework that specifically aims to mitigate and reduce the risk of possible space traffic safety incidents, while at the same time protect the economic vitality of the space industry. Likewise it is important to enable the DoD to focus on its space protection[iii] and defen

In the section 110 report the reportôs authors determined that ñ specifically the Department of Transportation (DOT) acting through the FAA Office of Commercial Space Transportation (FAA/AST), to release safety-related SSA data...ò, ñStatutory authority would be required...ò and ñA civil lawsuits similar to the DoD immunity provision... necessary...ò[iv]

On 16 Nov 16, A National Security Council Deputies Committee approved the Space Safety Engagement Work Plan. This plan included a task that directed the FAA and the DoD to cooperatively create a civil space traffic system to support commercial and foreign entities. This work plan also stipulated that the DoT would require statutory authorization to share safety-related space situational awareness (SSA) information, immunity from lawsuits, and the necessary resources to accomplish the mission.

The initial step in meeting this task was to determine an end state on which to focus the efforts of the stake holders. Articulating a single objective for multiple organizations with very different cultures and missions is a complex task. Different entities have defined space traffic management in different ways for decades and even when sitting in the same room and stating the same phrases, words from the same definitions tend to have different meanings to different people. Still one of the most quoted definitions for space traffic management is from the International Academy of Astronautics, 2006 COSMIC Study on Space Traffic Management:

> *.. the set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space, and return from outer space to Earth free of physical or radio-frequency interference*[v]

Even though this definition describes the concept it does not provide enough specific information for a multi-agency working group to plan and begin implementation efforts. The capability presented by the FAA/AST during the DoD wargames had a stated goal of providing ñSafety of space operations and protection of t FAA/AST further determined that in order to meet this goal a CSTM Center must:

- provide reliable, secure, automated, efficient sharing of data critical to the safety and integrity of the space environment and the radio frequency spectrum
- provide physical conjunction management including planned maneuvers
- provide radio frequency interference mitigation support
- provide access to space weather data
- assist with satellite identification
- provide oversight for rendezvous proximity operations
- provide risk and advisory services during catastrophic debris events
- have regulatory authority to:
    - ¶ determine the safety of flight parameters that guides commercial space activities
    - ¶ establish and enforce norms for safe conduct in space for US commercial operators
    - ¶ provide orbital safety advisory services and support to US commercial operators as well as foreign and civil space operators
    - ¶ provide zone regulation for smallsats

- be operated in a manner that protects US national security concerns, foreign policy and international obligations.
- protect sensitive US space operations and establish norms for handling orbit information for sensitive US government spacecraft not currently included in the public space catalog maintained by JFCC SPACE (Space-Track.org)
- fulfil international agreements authorizing space operations, notification, controlling debris, etc.
- have oversight over bidirectional SSA data sharing agreements between FAA and commercial organizations providing STM services
- be indemnified, along with commercial SSA providers to the CSTM system, from lawsuits under the act of Congress that established the CSTM system.

The details above are not considered contentious. However, some included issues do make warfighters want to dig deeper into a term or concept. For instance, if a rendezvous proximity operation is required for military purposes and a civil entity is observing and reporting on those operations, the military benefit could be negated. Additionally, the protection of observation data that is not available to entities outside of national security organizations is critical to operations that could have a significant impact on the ability of the United States to defend itself. A much more robust coordination effort would be required between the DoD and a CSTM Office than exists in other domains where the military operates alongside civil and commercial operators.

There are also benefits to military operations derived from a more organized space domain where civil and commercial norms evolve and are codified by a civil agency. As the CSTM Center begins to observe and track normal behavior of orbital object owner/operators, it makes it easier and faster for a military organization
to, or even during, a conflict. Norms in other domains tend to evolve as economic factors and dictate actions instead of being imposed be a regulatory entity. If these norms evolve in a manner contrary to existing military operational norms they could create the potential to alter current DoD operational concepts. A balance between allowing normal behaviors to develop and molding that development over time will depend on the regulatory and moral authority the US uses during the initial operation of a CSTM Center.

Without clearly defined authorities and responsibilities, the difficulty in working together to optimize benefits to commercial, civil, and military operators will overcome the capability of a newly-formed entity. What FAA/AST has proposed is an excellent basis from which to build a consensus among owner/operators. Once an agreement is reached on authorities and responsibilities, further work must be done on how to gather data to conduct the operational activities of a CSTM Center.

The DoD began tracking and cataloging satellites at Hanscom Field in 1957 at what would become the National Space Surveillance Control Center. As more man-made objects were placed into Earth orbit the system of surveillance resources grew more wide-spread and complex. These resources fed an Air Force Major Command catalog as well as a separate DoD Combatant Command catalog maintained by what is now Air Force Space Command and Space and Naval Warfare Systems Command respectively. By 2001 the number of objects in these catalogs was nearing 20,000. A number of assumptions were required to simplify the general perturbation theories used to produce these catalogs. For example, third-body influences and resonance effects were sphere is only partia
modeled as a spherical density field with consistent decay. Changes in the models used to predict orbital object locations can produce statistically different conjunction predictions which complicate already difficult owner/operator maneuver decisions. Additionally, data collection resources that can be confirmed to be maintained and calibrated are less likely to produce erroneous observations. Because of these concerns, some stakeholders in this conversation are resolute that a single catalog, produced by verified, secured data sources be the single source of producing conjunction messages to owner/operators.

At odds with this concern is the thought that the
that these are also sources that have not kept up with advances in technology and therefore the results achieved through this process would not have the accuracy or the precision to meet the requirements of the 2020s era with mega constellations of hundreds or thousands of satellites and commercial crewed missions in orbit. Advances in computing methods and in the development of commercial observation networks makes the creation of a civil SSA architecture operating in a data-rich environment that can meet the needs of the 2020 environment a reachable goal for a reasonable amount of funding. This architecture would generate a database of RSOs using owner/operator-produced ephemeris and use models that minimize assumptions and more accurately incorporate perturbations such as third-body influences or space weather effects. The safety advisories produced using this highly accurate RSO database could be more accurate and more precise and would avoid flooding the commercial operators with enormous numbers of conjunction warning messages.

Additionally, security concerns over the sharing of ñraw
among stake holders. In order to conduct the most effective conjunction assessments a catalog

should contain all available observations. However, balancing that need with the need to protect national security assets or operations requires protecting a small number of observations. A process for dealing with this disparity would need to be part of any future CSTM capability. The FAA and DoD are still working through concepts on how best to approach the development of the initial sharing concepts. As they work through this issue they also run into the concern of how quickly they need to reach an operational capability.

The DoD has been c ñspace situational awarenessò for decades and is v
interested in seeing that the future US CSTM system is compatible with national security interests. A very deliberative development process helps to ensure issues are identified prior to devolving into significant problems. This is the DoD preferred method of building a US CSTM capability. Gen John Raymond, now Commander of Air Force Space Command, suggested having FAA personnel in the Joint Space Operations Center working hand-in-hand with DoD personnel as a first step to the pilot program. This would provide the FAA with first-hand knowledge of why current tracking operations have evolved as they have and what capabilities and limitations the Air Force and USSTRATCOM currently work with every day. Additionally, the proximity creates a much closer working relationship on which the two organizations can build, and will speed up the process of developing, the final US CSTM capability.

Alternately, as with any effort, initial success leads to momentum that quickly dissipates without observable activity. Further support follows measurable success in almost any endeavor. That support is critical to reaching an eventual end state. In many instances this forward progress is personality-dependent. As people move, get promoted, or retire, comprehension of the originally-intended end state often gets lost or evolves into a different objective. These, among other reasons, have given the FAA/AST incentive to pursue a more short-term implementation of a US CSTM capability. The ñcrawl, walk, runò concept require
smaller tasks are owned by the FAA at an earlier
process before moving on to other tasks.

Regardless of the tempo of the tasks, the implementation can be broken down into three phases:

Phase 1 ï A Pilot Program, leading to development of Partial Mission Capability

Phase 2 ï Development of an Initial Operational Capability

Phase 3 ï Development of the Full Operational Capability

The ñcrawl, walk, runò philosophy helps to ensure the key stakeholders are comfortable with the approaches being used, with the progress that is being made, and with the products and services that are provided.

Phase I involves the establishment of a pilot program to demonstrate the ability of the FAA to provide orbital safety services, to define key technical details of the operational architecture, and to resolve the many policy questions associated with the operation of a civil STM system. The objective is to stand up the capability to accept observations, generate at least a partial catalog of space objects, and analyze potential conjunctions. Specific activities include the testing, selection, and test-bed operation of various hardware and software capabilities. Data produced by the program during this phase will be assessed against DoD data. At the end of this phase, once the basic technical capabilities have been developed, the system will have reached Partial Mission Capability (PMC).

In phase II, the CSTM center will develop an Initial Operational Capability (IOC). The CSTM Center will make products and services available to interested satellite operators in parallel with what is being provided by DoD operations. The success criteria for exiting this phase will be whether the products and services being provided are at least as complete, at least as accurate, and at least as timely as those being provided by the DoD.

During Phase III the CSTM center will reach Full Operational Capability (FOC). Once civil, commercial, and international users are satisfied with the space safety products and services being provided by the CSTM Center, the FAA will assume full responsibility for these activities, and the DoD can focus more resources on national security users.

The need for a US CSTM capability is no longer in question. The Legislative and Executive Branches have both made progress toward establishing this resource to ensure the sustainability of the space domain. Global economic and security concerns reliant on a sustainable space domain are creating the need for a shorter implementation timeframe while at the same time creating an environment much less forgiving of shallow learning curves. As the DoD and DoT work together to build an effective US CSTM capability they will have to be focused on a single end state with clearly defined roles and responsibilities that allow for sharing of verifiable information and supporting a safe, sustainable space domain.