National Space Society

Position Paper:

Space Guard: A New Organization to Facilitate Safe Space Activities

December 2017

Executive Summary

In a prior position paper, the National Space Society (NSS) identified the urgent need to control the growth of Earth orbiting debris.[1] Despite this growing threat, the number of Earth-orbiting satellites is on the verge of exponential growth. Most of these satellites will be commercial and launched into Low Earth Orbit (LEO). However, Medium Earth Orbit (MEO) will also face a sharp increase in its commercial satellite numbers. A key to minimizing the orbital debris threat while managing the space environment for the benefit of safety for spacecraft and persons is a vigorous Space Traffic Management (STM) system, which would take advantage of emerging technologies and techniques for Active Debris Removal (ADR) and enhanced Space Situational Awareness (SSA) to carry out its traffic management mission effectively.

NSS defines STM as activities taken to promote the safe use of Earth orbit, including measures to minimize or mitigate the negative impacts of the increasing physical congestion in space. Such safety of navigation measures include all systems and processes that assist spacecraft to safely orbit the Earth, including orbital assignment coordination, space situational awareness (SSA), collision warning, orbital debris mitigation, orbital debris remediation (cleanup) through Active Debris Removal (ADR),[2] and the regulation of launch and reentry. For such an upgraded and *comprehensive* STM system to be truly effective, it would need to be integrated into a larger management system of space activities and capabilities for Earth orbits and beyond.

Ensuring the safety of Earth orbiting spacecraft, in coordination with private industry and international stakeholders, is crucial to maintaining the satellite services that support our modern industrial societies. Such management is also crucial to facilitate human spaceflight within and beyond Earth orbit. Considering the growing threat of orbital debris to our current spacecraft and future plans for space and the lack of coordination among diverse space actors, our national space effort would benefit from an overall organizational structure to facilitate, integrate, and orchestrate activities in Earth orbit, including by commercial space entities.

On the international level, a separate but connected integrated entity is also needed to orchestrate and facilitate the safe use of Earth orbital space. However, no national or international umbrella organization exists to orchestrate and facilitate such activities. The National Space Society therefore recommends that the legislature of the United States seize world leadership by creating a national space entity to organize and enable safe public and private space activities related to "comprehensive STM," while promoting and coordinating with analogous entities internationally.

The Urgency of Comprehensive and Effective Space Traffic Management

The urgency for better Space Traffic Management (STM) comes from the dramatic increase expected in trackable and untrackable objects in space within the next decade. There are about 1500 functioning satellites in Earth orbit, sharing space with about 6,300 metric tons of orbital debris. About 800 of these working satellites are in Low Earth Orbit (LEO). Some of the altitude and inclination bands in LEO are becomingly perilously crowded with both functioning satellites and orbital debris. Most satellites currently in LEO are government owned and operated. However, commercial use of LEO (200 to 2000 km altitude) will grow drastically within a few years because private companies are planning to launch over 20,000 new commercial satellites, mostly into LEO.[3]

Space X alone (possibly under the trademark name Starlink) plans in 2019 to begin launching a constellation of 4,425 low-latency high-capacity broadband satellites at around 1,200 km altitude and proposes to launch another 7,500 satellites eventually at much lower altitudes.[4] OneWeb intends to launch 720 such satellites at around 1,200 km and another 1,280 satellites in Medium Earth Orbit (MEO). Boeing plans to launch 2,956 satellites into LEO, Samsung 4,600 satellites, Telesat 290 satellites, and Theia Holdings 112 satellites. There are other companies with such plans as well.[5] All of these constellations may not be implemented, but regardless of the details, we are poised for a dramatic growth in the usage of space for a variety of beneficial purposes, mainly broadband data communications and Earth observation. **This dramatic growth in the number of satellites is critical to providing the orbital traffic that will enable companies to further reduce the cost of reaching space. Thus, the success of this next phase of space development is critical to our future in space.**

Several orbital bands in LEO between 600 km and 1020 km are already dangerously crowded with both working satellites and orbital debris (see Fig. 1 below). The altitudes from 460 to 660 km, while not yet so crowded, are seeing a growth in tracked objects. Note also that Figure 1 only indicates the mass and number of *tracked* objects.[6] However, the largest number of debris objects are *not tracked* because they are too small to be spotted by heritage tracking systems, which typically only track objects larger than 10 cm in diameter.

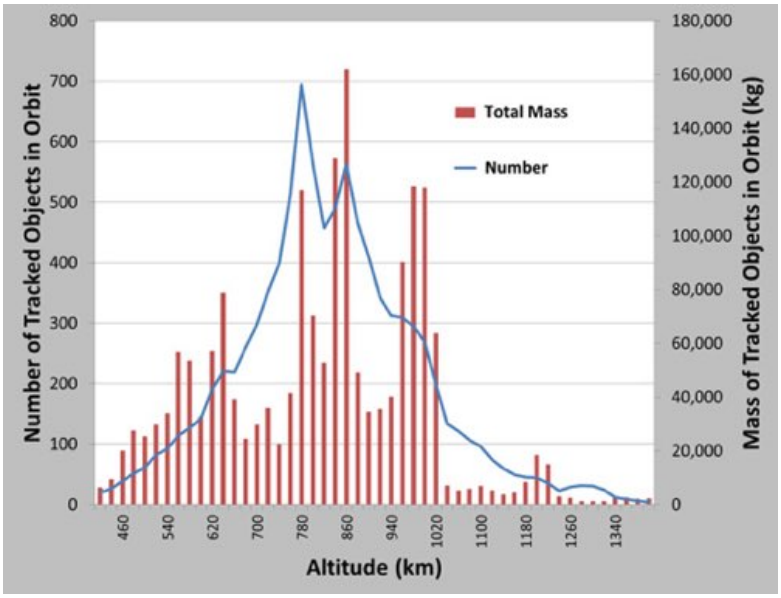

Figure 1. Number of tracked objects in LEO (larger than 10 cm in diameter) and their total mass as a function of altitude. Image credit: Darren McKnight and Patrick Dingman (2012).

There are an estimated 700,000 untracked debris objects from 1 to 10 cm in Earth orbit, dangerous to spacecraft and people, but which cannot practically be shielded against. Yet even 1 cm-sized shrapnel (size of a playing marble), with relative impact velocities in Low Earth Orbit (LEO) approaching 35,000 mph, can completely disable a multi-ton satellite, damage the International Space Station (ISS), or kill humans carrying out extravehicular activities (EVAs). A 100-gram bolt striking the ISS crew chamber would certainly be a lethal event.[7]

Because these smaller objects are produced when larger spacecraft and debris breaks up or suffers from collisions, the altitudes in Figure 1 that show the highest mass represent the altitudes that will produce the greatest amount of future debris. Without active intervention, these masses will produce more orbital shrapnel *even if we never launch another spacecraft*. Without active Space Traffic Management (STM), the 20,000 or more new satellites will therefore make the current orbital debris and satellite situation much more dangerous and complicated. It is therefore urgent that modern societies worldwide plan for comprehensive STM, much like human societies did when airplanes began to proliferate.

Our Modern Way of Life and Future Space Plans Are Threatened

Space X, OneWeb, and Samsung together are planning for their mega-constellations of satellites to be around an altitude 1,200-1,400 km, albeit at different inclinations. Just one of these LEO mega-constellations is expected to incur 2,000 to 3,000 conjunction warnings *per day*, with two to three within 50 meters. If there is just one collision among these satellites or their corresponding upper stages, the number of events to actively deconflict drastically climbs, and a runaway cascade of collisions could be produced.[8] If such a catastrophic "Kessler Syndrome," were to occur in other crowded orbits as well, global communications, navigation,

weather reporting, timing-synchronization, and other satellite services could eventually become disabled.

Medium Earth Orbit (MEO), which currently contains only 96 satellites,[9] is relatively free of debris.[10] However, OneWeb wants another 1,280 satellites in MEO at a (so far) publicly undeclared altitude.[11] Viasat and O3b also plan to launch satellites into the MEO altitude of 8,200 km.[12] Because our Global Positioning Satellites orbit in MEO at an altitude of 20,200 km, there is currently little danger of collisions from the newly planned commercial satellites or their upper stages. However, markets and industries rely on Global Positioning System (GPS) satellites in MEO to provide not only navigation services, but also precise timing information for financial transactions. For these reasons, new satellites to be launched into MEO need a watchful eye.[13] Traffic in Geostationary Earth Orbit (GEO) is also becoming congested, but radio interference considerations and the finite number of available orbital slots limits growth in number of new satellites.[14]

In sum, orbital debris potentially threatens our modern way of life and our plans for future human spaceflight. The longer we ignore the 6,300 metric tons of debris already in orbit, while making no new provisions to manage the more than 20,000 new commercial satellites and upper stages to be launched in the next few years, the more vulnerable we will become.

Space Traffic Management with Space Situational Awareness and Orbital Debris Cleanup Require a Dedicated Agency

The broadest meaning of the term STM, which we will call "comprehensive STM," encompasses SSA, orbital debris mitigation, ADR, and the designation of orbital altitudes, inclinations and other characteristics to keep launched objects from collisions, as well as all other management activities to promote the safety of persons and property in Earth orbit. Despite this broader meaning of STM, in this paper we will also speak of SSA, ADR, and other elements of comprehensive STM separately.

Consistent with our prior position, the National Space Society recommends, as part of an energetic effort for comprehensive STM, major campaigns to enhance SSA and carry out vigorous ADR. The enhancement of SSA should be to the point where orbital debris objects as small as 1 cm in diameter are tracked and conjunction reports for collision avoidance become much more frequent and accurate.[15] The ADR effort should make use of emerging public and private technologies[16] and commercial salvors to clear away debris.[17]

STM is a thorny public policy problem that involves balancing technical, legal, and economic variables; stakeholder conflicting interests and worldviews; and complex political/geopolitical environments with diffuse responsibilities and authorities.[18] Any effort to enhance the safety of navigation in space cannot succeed without the active involvement and support of our military, the commercial satellite industry, and space stakeholders worldwide. In this latter

regard, the Department of State's Office of Space and Advanced Technology (DoS/OES/SAT) plays a central role in coordinating with space stakeholders internationally.

Organized U.S. action to reach any space-environment sustainability goal will also require adherence to the 1967 Outer Space Treaty (OST). In that connection, a "watchdog" civil agency could ensure U.S. compliance with its obligations under Article VI of the OST:

> Article VI
> States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, **shall require authorization and continuing supervision by the appropriate State Party to the Treaty**.[19] (Emphasis ours.)

This international treaty provision requires the U.S. to track and keep custody of every object it launches from the time it is launched until it is deorbited. Moreover, as a national priority, we need comprehensive, persistent, timely space domain awareness, and this is in keeping with the 1967 OST.

NSS believes that a new, properly constructed, dedicated civil agency with connections to other U.S. government agencies, the commercial satellite community, and international space stakeholders worldwide could provide an effectively integrated "action nexus" to secure the space environment for safely expanding commercial use of orbital space, human spaceflight, lunar development, and Mars settlement. NSS further believes that comprehensive STM should be at the core of this nexus. For the sake of convenience, but also to invoke the desired purpose, we will call this new agency "Space Guard."

Through multiple, mostly unconnected players, the United States pursues a wide range of largely successful activities in space, including military, civil government, and commercial activities. An independent, civil-government Space Guard is needed to facilitate and coordinate action by private and public space actors as they carry out a diverse and growing set of actions related to comprehensive STM for defense and space development, leading to human spaceflight beyond Earth orbit.

Space Guard could be an independent agency at the subcabinet level, not attached to any other agency, or could be part of an existing Executive Branch department, with the capacity to coordinate with all relevant government and private entities, both nationally and internationally. Moreover, components of other government entities could be transferred separately or combined and transferred into Space Guard, while keeping ties to their parent agencies. For instance, to maintain and better utilize experienced government space personnel, NSS recommends that FAA's Office of Commercial Space Transportation (DoT/FAA/AST) be

incorporated into our proposed Space Guard. Likewise, NASA's Orbital Debris Program Office and NASA's Planetary Defense Coordination Office should be moved into Space Guard.

Other federal agencies and departments, as well as academic and commercial parties, while not necessarily incorporated into Space Guard, would still have the capacity to advise and coordinate closely with Space Guard's administration. For instance, NOAA, which manages Earth-observation satellites, would have a major input channel. FCC's Office of Engineering and Technology (FCC/OET) (which administers radio spectrum for non-Federal use) and DoC's National Telecommunications and Information Administration (DoC/NTIA) (which administers radio spectrum for Federal use) would also advise Space Guard as needed. Finally, the State Department's Office of Space and Advanced Technology, which works to ensure that U.S. space policies and multilateral science activities support U.S. foreign policy and enhance U.S. space and technological competitiveness, would play a crucial role as liaison for, and advisor to, Space Guard vis-a-vis international space entities and issues.

While a high-level federal executive committee to deal with comprehensive STM could be established by Executive order, NSS believes that a legislative process to establish Space Guard, although slower, would lead to a more stable and durable space agency. No matter how the proposed new federal entity is established, however, it should form and maintain strong connections to FAA, DoC, DoS, NASA, and DoD, and coordinate closely with relevant public and private stakeholders, both nationally and internationally. Such public and private stakeholders will necessarily include satellite companies, universities, insurance companies and other relevant parties.

The Potential FAA Role in Space Guard

NSS recommends that after the current moratorium on FAA safety regulations for human passengers on commercial spacecraft is lifted, the incorporated AST office should work from within the proposed Space Guard with other relevant outside agencies such as DoC, DoD, NASA, DoS, NOAA and with the commercial space industry, to continue evolving guidelines, rules, and finally industry-enabling regulations to protect both person and property, as part of the licensing process for all new launch and reentry vehicles. Any safety licensing should consider as relevant not only the spacecraft to be launched, but also the spacecraft and debris already in orbit.

FAA's Office of Commercial Space Transportation already has the authority to issue a non-mandatory "safety approval" for one or more of the following elements of navigation safety: a launch vehicle, a reentry vehicle, a safety system, process, service, or any identified component thereof, and qualified and trained personnel performing a process or function related to licensed launch activities. Although a safety approval document is not a license, it enables launch and reentry vehicle operators to use an approved safety *element* within the terms of the safety approval, without having to go through a re-examination of the element's fitness and suitability for a proposed launch or reentry operation. This allows commercial operators to

repeatedly use pre-approved safety elements to save time, effort, and money. We therefore also recommend that, even after safety licensing is required for persons and property, the incorporated AST office continue to allow *voluntary* safety approvals for specific safety elements to save operator time and money.

The Safety Licensing Process

As part of a safety licensing process to enhance orbital debris mitigation and remediation (cleanup),[20] NSS recommends that the incorporated AST Space Guard office continue to utilize the FAA's risk management approach using Expected Casualty Calculations for launch licensing[21] to evolve specific safety of navigation guidelines, standard practices, rules, and eventually enabling regulations, in consultation with industry and government. NSS recommends that safety licensing evolve from and build on the Payload Review and Policy Review processes which FAA already carries out for new launches. Space Guard should have a broad licensing mandate for all commercial missions and an open-to-all register to list resource claims or safety zones. Space Guard should also have specific contracting authority to enter into public-private partnerships (PPPs) to test, develop, and utilize technologies and techniques and to contract for services via Space Act Agreements.

To ensure a level playing field and synch with evolving industry-enabling regulations for national entities, the State Department's Office of Space and Advanced Technology should lead the effort to standardize such requirements internationally as well. In all cases of evolved national requirements, NSS strongly recommends that they be instituted as hard regulations only after Russia, China, ESA, India, Japan and other relevant space actors also agree to the same regulatory requirements. NSS also recommends that space entities responsible for any spacecraft already in orbit be grandfathered under the policies and rules and enabling regulations in existence at the time of their design and construction, so that they are not penalized by any new STM policy, rule, or regulation.

The Key Role DoD Could Play in Coordination with a Civilian Agency

Although other DoD entities have contributed to space development, since the 1950s the USAF has been the lead for military space activities.[22] Although the civilian Space Guard would organize the remediation of orbital debris in coordination with NASA and other agencies, the USAF could also play a key role. The USAF already has the capability to track assets and debris, operate communications globally, launch rockets, and operate assets in space. Thus the USAF could contribute to SSA enhancement, conjunction warnings, ADR, and other STM capabilities.

DoD capabilities and technology transfers to commercial space industry could benefit comprehensive STM. NSS believes that DoD space resources and capabilities could be integrated into the civilian Space Guard in a step-wise organized fashion, under the

watchful eyes of DoD and civilian observers, for the general benefit of the U.S. space effort. To assuage the fears of those who might suspect that a civilian Space Guard will only serve as cover for aggressive military plans, the processes, procedures, and safeguards for bringing DoD capabilities into Space Guard must be clear and reassuring to outside national and international observers.

Our recommendation is for Congress to establish the expectation or requirement that Space Guard would take over primary SSA capabilities (with extant SSA sensor capabilities) from DoD within two years of start-up. Within a further year, the Space Guard head should report to Congress to provide Space Guard's best value for an initial increment and follow-on increments toward a capability to have:

- near-real time (< 20 secs latency) capability to track all objects in LEO, MEO, GEO, L1/2/4/5 down to 1.0 cm.
- an ability to deorbit multi-ton objects, such as spent upper stages in polar orbit, at a rate of eight per year.
- an ability to deorbit small objects (1-10 cm) at a rate of no less than 200 per year.

Pay Now, or Pay MORE Later

The new LEO and MEO commercial satellites represent both a threat and an opportunity. As we face the task of managing the coming avalanche of new space traffic, while avoiding or cleaning the trash already in orbit, our situation is simply: pay now, or pay *(much more)* later. Even without launching another satellite, with time there will be more collisions between multi-ton bodies and more catastrophic breakups, and cleaning up the mess will cost us all more. Satellite service users (i.e. nearly all of us in modern industrial societies) will likely fault their political leaders and complain stridently to them. Under these non-optimum conditions, those same leaders will have to scramble to collect funds and organize the cleanup. It behooves us all to adequately fund comprehensive STM now (including SSA and ADR) to avoid this kind of situation.

In coordination with spacefaring entities worldwide, funding for comprehensive STM, including enhanced SSA and effective ADR, could come from general government revenues, minimal launch fees, and/or minimal orbital "parking" fees imposed on companies launching new satellites into Earth orbit.[23] Minimal orbital-use fees would also have the effect of inducing satellite companies to attach devices to their satellites to deorbit them shortly after end of mission or when they become disabled—without specific time-deadline regulation.

A fourth potential source of revenue, at least to help fund comprehensive STM *in orbital bands used by commercial satellites*, could come from the end-users of satellite services. Because the satellite service industry already generates more than $127 billion annually in gross, a 1 cent per dollar fee on end-user bills would hardly be noticed by consumers, yet would generate over $1 billion annually to help fund comprehensive STM for orbital bands used by commercial

satellites. Although commercial satellites are currently located primarily in GEO, soon 20,000 or so new commercial satellites will be launched into MEO and LEO to provide broadband services. Under these new conditions, a 1 penny per dollar fee on end-user bills would generate multiple billions annually to fund comprehensive STM for orbital bands used by commercial satellites in LEO, MEO, and GEO. NSS urges that fees collected in this fashion be dedicated to comprehensive STM, and not funneled to general revenue.

Currently, no single national or international entity exists to collect and allocate funds for space operations safety from any revenue source. Yet the need for such funds will only grow as public works involving infrastructure and safety enhancement in support of commercial and government activities in space become necessary. For this reason, NSS recommends that our Congress and the Administration work diligently with public and private stakeholders domestically and abroad to design and engage a collection and allocation mechanism to fund comprehensive STM worldwide.

International Action Also Needed

Various political and psychological factors have impeded our ability to deal effectively with cleaning up the space environment.[24] On the international stage, despite the need for overall international coordination to deal with space traffic and cleanup issues, perceived dual use technologies within a tense geopolitical context thwart urgently needed actions. The potential to interfere with others' satellites presents a geopolitical quagmire of suspicion.

Bilateral and multilateral agreements to transparently carry out ADR on mutually selected non-sensitive debris targets, such as defunct upper stages, could greatly ease geopolitical tensions while advancing debris cleanup technologies for those involved. At least equally important, such bilateral or multilateral debris remediation actions could establish new "customary international law" consistent with the Outer Space Treaty and "due regard" concepts of maritime and aviation law.[25]

At some point, however, there should be a global summit to organize comprehensive STM on a worldwide scale, similar to the situation when international aviation conferences led to the formation of the International Civil Aviation Organization (ICAO), which now publishes standards and recommendations widely adopted by civil air navigation authorities around the world. However, the U.S. should not wait for international cooperation to enhance space security and safeguards for persons and property, but instead should show leadership by establishing Space Guard and transparently forging national STM plans and projects, helping to induce such international cooperation by example.

Acronyms and Abbreviations

ADR: Active Debris Removal
AST: Historical acronym for what is now the Office of Commercial Space Transportation within the Federal Aviation Administration
DoD: Department of Defense
DoC: Department of Commerce
DoC/NOAA: National Oceanic and Atmospheric Administration in the U.S. Department of Commerce
DoS: Department of State
DoS/OES/SAT: Department of State/Bureau of Oceans and International Environmental and Scientific Affairs/Office of Space and Advanced Technology
DoT: Department of Transportation
DoT/FAA/AST: Department of Transportation/Federal Aviation Administration/Office of Commercial Space Transportation
EVAs: Extra-Vehicular Activities
FAA: Federal Aviation Administration within the Department of Transportation
FCC: Federal Communications Commission
FCC/OET: Federal Communications Commission/Office of Engineering and Technology
GEO: Geostationary Earth Orbit
GPS: Global Positioning System
ICAO: International Civil Aviation Organization
ISS: International Space Station
LEO: Low Earth Orbit
MEO: Medium Earth Orbit
NASA: National Aeronautics and Space Administration
NOAA: National Oceanic and Atmospheric Administration in the U.S. Department of Commerce
NSS: National Space Society
NTIA: National Telecommunications and Information Administration within the Department of Commerce
OES: Bureau of Oceans and International Environmental and Scientific Affairs within the U.S. Department of State
OET: Office of Engineering and Technology within the Federal Communications Commission
OST: Outer Space Treaty (Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 1967)
OOS: On-Orbit Servicing
PPPs: Public-Private Partnerships
SAA: Space Situational Awareness
SAT: Space and Advanced Technology (Office of)
STM: Space Traffic Management
USAF: United States Air Force

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[16] See the National Space Society 2016 policy paper, "Orbital Debris: Overcoming Challenges," pages 18 - 23 for information about ADR, which includes On-Orbit Servicing (OOS). http://www.nss.org/legislative/positions/NSS_Position_Paper_Orbital_Debris_2016.pdf.
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