SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

HEARING CHARTER

Space Situational Awareness: Key Issues in an Evolving Landscape
February 11, 2020
2:00 p.m.
2318 Rayburn House Office Building

PURPOSE

The purpose of the hearing is to examine issues related to Space Situational Awareness (SSA), how the changing space environment is challenging the current SSA system, and the factors anticipated to influence SSA in the future. The hearing will also explore approaches to addressing the challenges, including activities at the international level.

WITNESSES

- **Dr. Brian Weeden,** Director of Program Planning, Secure World Foundation
- **Mr. Daniel Oltrogge,** AIAA Space Traffic Management Space Governance Task Force Chair, Founder and Administrator, Space Safety Coalition, Official International Standards Organization (ISO) representative to the United Nations Committee for the Peaceful Use of Outer Space (UNCOPUOS)
- **Professor Joanne Gabrynowicz,** Professor Emerita of Space Law, University of Mississippi Law Center
- **Professor Danielle Wood,** Director of the Space Enabled Research Group, Assistant Professor of Media Arts & Sciences and Aeronautics & Astronautics, Massachusetts Institute of Technology
- **Dr. Ruth Stilwell,** Adjunct Professor, Norwich University, Senior Non-Resident Scholar, Space Policy Institute, George Washington University

OVERARCHING QUESTIONS

- *Why is SSA important and how is the SSA landscape changing? What factors are anticipated to influence SSA over the next 10 to 15 years?*
- *What is Space Traffic Management (STM) and how is it different from SSA?*
- *Who are the key SSA stakeholder, and how are they engaging to better understand and to more effectively protect the space environment?*
- *What is the current state of international collaboration on SSA issues?*

Background

Over the past decade, the space industry has grown and changed significantly, particularly with the rapid increase of commercial and private activity in low-Earth orbit (LEO). With the advent of megaconstellations, often involving thousands of satellites and new global players launching CubeSats and small satellites into Earth's orbit, operating in the space environment is becoming more complex. The locations and predicted positions of active satellites, defunct satellites, and space debris must be considered in order to avoid collisions and maintain safe operations. These and other emerging changes in the space environment are poised to overwhelm current space flight safety and operational processes.[1] Given this evolving landscape, space situational awareness (SSA) is becoming an essential means to ensuring the safety and sustainability of the space environment.

Defining SSA and STM

SSA encompasses collecting space object location data, processing space object data to characterize the space environment, and developing data products to support satellite owners and operators in decision-making (e.g., when there is potential for collision). SSA data and information inform plans, operations, and protection of space assets and U.S. government operations in space, and also help ensure the safety of the space environment for commercial and non-U.S. operators. A significant aspect of SSA refers to the location and projected location of space objects, including both operational satellites and orbital debris, the avoidance of potential collisions between objects, and the mitigation of collision risks to space assets and human spaceflight activities. The operating environment pertains not only to the location of objects with respect to potential collisions, but also radio frequency interference and the environmental effects of space weather on space objects and how they move through space. [2]

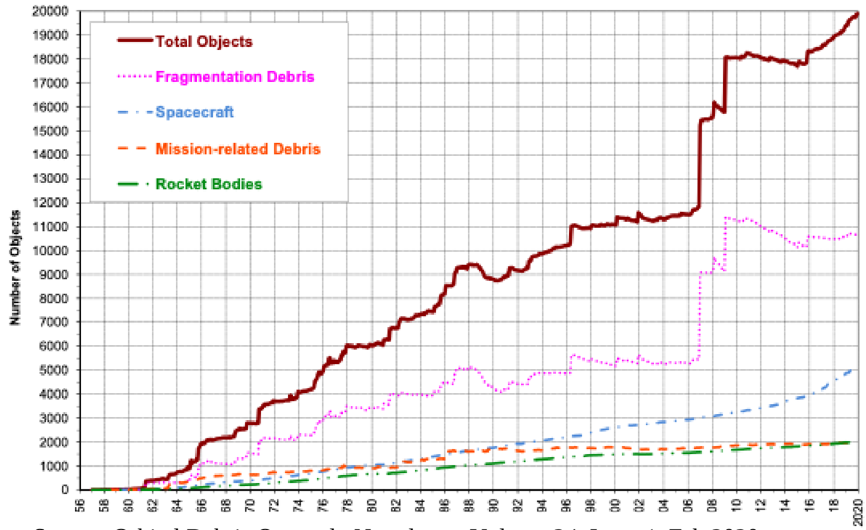
SSA is distinct from but related to what is referred to as space traffic management (STM). While there is no universally accepted definition of STM, many often refer to the International Academy of Astronautics' study on Space Traffic Management which states that STM is a "set of technical and regulatory provisions for promoting safe access into outer space, operations in outer space, and return from outer space to Earth free from physical or radiofrequency interference".[3] In other words, SSA results in data and information as input into safety decisions, while STM provides guidance about how those decisions should be made and implemented.

Changing Landscape

The population of active satellites and tracked debris has changed over the past two decades and is anticipated to change dramatically over the next several years. Of the nearly 9,000 payloads that have launched since 1957, about 5,370 are still in orbit (and are either active or defunct),

[1] Theodore J. Muelhaupt, Marlon E. Sorge, Jamie Morin, Robert S. Wilson, Space traffic management in the new space era, The Journal of Space Safety Engineering 6 (2019) 80–87
[2] Institute for Defense Analysis, Science and Technology Policy Institute, "Evaluating Options for Civil Space Situational Awareness (SSA)", August 2016
[3] International Academy of Astronautics. Space Traffic Management - Towards a Roadmap for Implementation. 2018

Figure 1. Number of Objects in Earth Orbit by Object Type



Source: Orbital Debris Quarterly Newsletter, Volume 24, Issue 1, Feb 2020
https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv24i1.pdf

while the rest have disintegrated upon reentry into the Earth's atmosphere. Forty-four percent of these payloads are U.S. payloads.[4] The Department of Defense's Combined Space Operations Center (CSpOC) uses radar and optical telescopes to track space objects and actively maintains a public catalogue of these objects. Figure 1 shows how the number of active payloads is dwarfed by a number of defunct objects, such as rocket bodies, debris from satellite breakups and collisions, and inactive satellites. At present, DoD's public catalogue reports over 20,000 space objects, of which nearly 15,000 objects are classified as debris objects and the remaining are classified as active and defunct payloads.[5,6,7] Statistical models estimate that there are about 34,000 space objects larger than 10 centimeters (cm) and 900,000 objects between 1cm and 10cm in orbit around the Earth, but it is challenging for current radar and optical systems to detect the smallest objects, particularly those below 10cm.[8]

Changing debris environment

Active satellites comprise only about 10 percent of all tracked objects in space.[9] The remaining objects comprise spent rocket bodies, defunct satellites, and debris from breakups or collisions. A study conducted in 2017 by NASA's Orbital Debris Program Office found that two major debris causing events, the 2007 Chinese anti-satellite missile test and the 2009 Iridium-Cosmos collision, accounted for about 25 percent of space debris objects.[10] Depending on the altitude and orbit of the object, some debris can enter Earth's atmosphere and burn up upon reentry while other debris will remain in orbit indefinitely.

Travelling at very high velocities, debris of any size can pose significant risk to active space systems and human spaceflight operations. Furthermore, when on-orbit collisions occur, more

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[4] Downloaded space-track.org data, accessed Feb 5, 2020.
[5] Orbital Debris Quarterly Newsletter, Volume 23, Issue 4, Nov 2019. https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv23i4.pdf
[6] However, other sources quote the number of objects tracked by DoD's Space Surveillance Network (SSN) as between 23,000 to 26,000
[7] https://www.npr.org/2020/01/29/800433686/space-traffic-is-surging-and-critics-worry-there-could-be-a-crash
[8] https://www.esa.int/Safety_Security/Space_Debris/Space_debris_by_the_numbers
[9] Institute for Defense Analysis, Science and Technology Policy Institute, "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)", April 2019
[10] Orbital Debris Quarterly Newsletter, Volume 21, Issue 2, May 2017. https://orbitaldebris.jsc.nasa.gov/quarterly-news/pdfs/odqnv21i2.pdf

debris is generated and can result in an increased risk of collisions. This phenomenon is known as the Kessler effect.[11] To address this issue, some nations and companies have committed to deorbiting satellites with 25 years of the end of their mission life through the Inter-Agency Space Debris Coordination Committee (IADC), a voluntary multilateral forum for nations to engage on facilitating cooperation on debris research and activities.[12] Active debris removal and other debris mitigation measures are also being explored to address the growing concern of debris and its effect on the space environment.[13]

Outlook for active satellites changing over time

Megaconstellations and small satellites are altering the future of the space environment. The extent of growth in the number of satellites involved and projected to be launched is challenging to predict. In 2018, market reports predicted the number of commercial satellites in orbit would reach between 10,000 - 12,000 by 2030.[14] A revised assessment published in June 2019 predicted more than 20,000 satellites would be launched into orbit by 2030, based on announcements of new planned commercial constellations and license applications filed by satellite companies with the Federal Communications Commission.[15] If all of the projected constellations are launched, the population of satellites in low Earth orbit (LEO) would rise by a factor of 10 over the next decade. Of these planned new entrants into LEO, three megaconstellations of communications satellites are anticipated to make up 82 percent of the total projected number of satellites.[16]

Increasing number of space actors

As of 2019, over 80 countries have had at least one spacecraft in orbit. [17] This number has grown from 2 countries in the 1950s to over 20 by the late 1970s. Commoditization of off-the-shelf satellite components and the introduction of CubeSats and small satellites are lowering the barrier for entry into space for previously non-space faring nations.[18] While the U.S., China, Russia, Japan, France, Germany and other European nation's satellites still make up the overwhelming majority of satellites launched into space, nations such as Rwanda and Ethiopia are now also launching satellites into space.[19] From Earth observation satellites that help nations modernize agriculture and mitigate against drought conditions to communication satellites that offer connectivity to rural areas, more nations are looking to space assets to help address terrestrial challenges and support domestic activities and infrastructure.

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[11] https://www.nasa.gov/centers/wstf/site_tour/remote_hypervelocity_test_laboratory/micrometeoroid_and_orbital_debris.html
[12] https://orbitaldebris.jsc.nasa.gov/library/iadc_mitigation_guidelines_rev_1_sep07.pdf
[13] https://www.esa.int/Safety_Security/Space_Debris/Active_debris_removal
[14] Frost Report. Small-satellite Launch Services Market, Quarterly Update Q1 2018, Forecast to 2030. https://go.frost.com/EU_PR_JHolmes_MDD2_SmallSatellite_May18
[15] Theodore J. Muelhaupt, Marlon E. Sorge, Jamie Morin, Robert S. Wilson, Space traffic management in the new space era, The Journal of Space Safety Engineering 6 (2019) 80–87
[16] Theodore J. Muelhaupt, Marlon E. Sorge, Jamie Morin, Robert S. Wilson, Space traffic management in the new space era, The Journal of Space Safety Engineering 6 (2019) 80–87
[17] Data downloaded from space-track.org, accessed Feb 5, 2020
[18] Institute for Defense Analyses, Science and Technology Policy Institute, "Global Trends in Small Satellites" July 2017
[19] https://listwand.com/ethiopia-joins-the-list-of-african-nations-with-satellites-in-space/

U.S. Government SSA Data Collection and Tracking System

The number of objects being tracked by the DoD is rising for several reasons including the increasing number of objects in space. The DoD's Space Surveillance Network is currently adding the new Space Fence ground-based S-band radar to its network of over 20 ground-based and space-based data collection sites. Space Fence (SF) is expected to collect data on objects smaller than 10 cm, though the exact minimum size of objects that can be tracked is not publicly known. The DoD's Office of the Director of Operational Test and Evaluation recently published an assessment of SF, which is expected to become operational in February 2020. The report states, "SF demonstrated the capability to find many small objects that had not previously been tracked or cataloged. Once SF becomes operational, the number of tracked objects confirmed orbiting the earth is expected to grow significantly". [20] Also, the DoD is regularly declassifying more and more objects that are being added to the public catalogue which is helpful to those governments and commercial entities relying on DoD SSA data.[21] With more objects in the catalogue, SSA and the process for detecting, processing and alerting operators of potential collisions becomes more complex.

Non-U.S. Government SSA Data Collection and Tracking Systems

Commercial and non-U.S. capabilities conducting SSA activities including tracking of objects, cataloguing, processing SSA information and developing collision warnings, are growing. While many countries continue to maintain data sharing agreements for SSA data with the DoD, a number of countries and regions including Japan, Germany, and France are developing their own SSA systems to augment the data they are receiving from the U.S. Furthermore, several commercial SSA companies have emerged to support government and private sector satellite owner/operators in identifying, tracking and supporting potential collision avoidance maneuvers.[22] Commercial and international data, when combined with DoD SSA data, provide more frequent observations than the DoD system alone and can improve the accuracy of SSA information for satellite operators.[23] Other commercial SSA vendors are looking to offer tailored information and SSA services to accommodate individual operator needs.

Technical factors changing the SSA landscape

Traditionally the behaviors of spacecraft on orbit have been fairly predictable and routine. Once at the correct inclination and altitude, most satellites maintain their orbit over the mission lifetime. However, new modes of operating in space including satellite servicing, active debris removal and rendezvous and proximity operations are adding complexity to the task of tracking and predicting the locations of active satellite. In many cases, when an on-orbit maneuver has been conducted, it has been planned, coordinated, and communicated within the SSA community. However, some commercial and government operators are planning to use artificial

[20] FY2019 Annual Report for the Office of the Director, Operational Test & Evaluation. https://www.dote.osd.mil/Publications/Annual-Reports/2019-Annual-Report/

[21] https://www.popularmechanics.com/space/satellites/a25562991/pentagon-declassifying-space-traffic-data/

[22] Institute for Defense Analysis, Science and Technology Policy Institute, "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)", April 2019

[23] Institute for Defense Analysis, Science and Technology Policy Institute, "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)", April 2019

intelligence for determining whether a satellite will autonomously maneuver in a potential collision situation.[24,25] How these unplanned maneuvers would be communicated and coordinated with the SSA community is not yet well understood.

Another challenge in tracking and predicting the location of active satellites is the use of on-board propulsion. Satellites that use chemical propulsion, which thrust at one time with a high impulse, are challenging to track unless the maneuver is planned and coordinated.[26] Satellites that use electric propulsion systems, which thrust over periods as long as months, may require more SSA observations in order to determine the spacecraft's new orbit and track and predict its future locations.[27] In both cases, coordinating and communicating maneuvers with the SSA community can help the fidelity of the ever growing and changing catalog of space objects.

International Cooperation

International cooperation in space dates back to 1959 when the United Nations established the Committee on the Peaceful Use of Outer Space (UNCOPUOS), a Committee mandated to strengthen the international legal regime governing outer space and to support national, regional and global efforts to maximize the benefits of the use of space science and technology and their applications. Since 2011, UNCOPUOS has been developing Long-Term Sustainability Guidelines to promote greater international cooperation in space security and sustainability. The long-term sustainability of outer space activities is defined as, "as the ability to maintain the conduct of space activities indefinitely into the future in a manner that realizes the objectives of equitable access to the benefits of the exploration and use of outer space for peaceful purposes, in order to meet the needs of the present generations while preserving the outer space environment for future generations."[28] In 2019, UNCOPUOS ratified 21 voluntary guidelines which fall into four major areas: policy and regulatory framework for space activities; safety of space operations; international cooperation, capacity-building and awareness; and scientific and technical research and development.[29]

In addition to the multilateral discussions that take place under UNCOPOUS and the Inter-Agency Space Debris Coordination Committee, the space community has self-assembled to address the challenges of maintaining a safe and sustainable safe environment. In 2019, the World Economic Forum chose a team of researchers, led by the Massachusetts Institute of Technology, to launch the Space Sustainability Rating (SSR) to foster global standards on debris mitigation. The press release for the initiative states, "similar to rating systems such as the LEED certification used by the construction industry, the SSR is designed to ensure long-term sustainability by encouraging more responsible behavior among countries and companies participating in space."[30] Also in 2019, a group of space-industry stakeholders established the

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[24] https://qz.com/1627570/how-autonomous-are-spacexs-starlink-satellites/
[25] https://www.thespacereview.com/article/3800/1
[26] Simon George, Andrew Ash, "Future On-Orbit Spacecraft Technologies and Associated Challenges for Space Situational Awareness" AMOS Conference, 2019. https://amostech.com/TechnicalPapers/2019/Space-Based-Assets/George.pdf
[27] Institute for Defense Analysis, Science and Technology Policy Institute, "Global Trends in Space Situational Awareness (SSA) and Space Traffic Management (STM)", April 2019
[28] https://www.unoosa.org/res/oosadoc/data/documents/2019/a/a7420_0_html/V1906077.pdf
[29] Daniel L. Oltrogge and Ian A. Christensen. Space Governance in the New Space Era. First Orbital Debris Conference. 2019. https://www.hou.usra.edu/meetings/orbitaldebris2019/orbital2019paper/pdf/6013.pdf
[30] https://news.mit.edu/2019/space-sustainability-rating-system-mitigate-debris-0506

Space Safety Coalition (SSC) and is building set of best practices for the sustainability of space operations. Other more enduring efforts have included the Consultative Committee for Space Data Systems (CCSDS), which is focuses on stakeholders developing standards and best practices for communications and data systems to enhance interoperability for satellite systems. Furthermore, the International Standards Organization (ISO) is an independent, non-governmental international organization that coordinates to develop voluntary, consensus-based standards to promote safe operations in space. Other issues being discussed in the international community include liability, and approaches to coordinating space traffic among space operators.