SSC24-V-01

Introduction to the Traffic Coordination System for Space (TraCSS)

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ABSTRACT

This paper presents an overview of the Department of Commerce's Traffic Coordination System for Space (TraCSS), its planned architecture, and the basic space situational awareness (SSA) and space traffic coordination (STC) services which it will provide.

In 2018, the White House's Space Policy Directive-3 identified the Department of Commerce (DOC) as the lead agency for civil SSA, directing transfer of that responsibility from the Department of Defense (DoD), which has historically offered that function to all space operators. This will allow the DoD to focus on its critical space domain awareness needs and mission, while DOC can drive spaceflight safety, space sustainability, and international coordination.

The National Oceanic and Atmospheric Administration's Office of Space Commerce (OSC) has been developing TraCSS to be a modern cloud-based IT system providing basic SSA and STC safety services to space operators free of direct user fee. The three main components of TraCSS are: the TraCSS-OASIS data repository; the TraCSS-SKYLINE application layer of SSA and STC services; and TraCSS-HORIZON, consisting of a modeling, simulation & research environment and a development and test environment. OSC is undertaking a phased development approach for TraCSS, coordinated with DoD and NASA, to minimize disruption to spaceflight safety services. TraCSS is being deliberately developed with commercial capabilities in mind; with multiple inputs and on-ramps for commercial data, services, software, and innovation.

BACKGROUND

In recent years, there has been a dramatic increase in space activity. Space operators have launched thousands of new satellites over the past few years and plan to launch tens of thousands more. There is an urgent need for better space situational awareness (SSA); as Earth's orbits are become increasingly congested, commercial, civil, and national space missions are put at risk. Today, the U.S. Department of Defense (DoD) is tracking over 45,400 space objects, including about 10,200 active spacecraft and about 18,700 pieces of debris over 10cm [1]. For years, the DoD has conducted regular conjunction screenings and provided warnings and unclassified SSA information to space operators via space-track.org. However, given the increase in space activity and the need for DoD to focus on its national security mission, the White House issued Space Policy Directive-3 (SPD-3) in 2018. SPD-3 identified the U.S. Department of Commerce (DOC) as the lead agency for civil SSA, directing a transfer of responsibility from DoD to DOC for providing basic SSA and space traffic coordination safety data and services. Such direction recognizes the pressing need for more accurate and timelier SSA data, and the need for DoD to concentrate resources on its own critical space domain awareness needs and mission.

DOC designated the National Oceanic and Atmospheric Administration's (NOAA's) Office of Space Commerce (OSC) to be the lead in this effort. In 2022, OSC unveiled a prototype SSA/STC system known as the "open architecture data repository." [2] In Fiscal Year 2023, with the support of Congress and the Executive Branch, NOAA reorganized, elevated, and expanded OSC to address the challenges of developing a civil SSA system at an operational scale. OSC is currently developing the Traffic Coordination System for Space (TraCSS) to blend government and commercial SSA data, which will provide actionable SSA/STC information at an operational scale to space operators for spaceflight safety.

TRACSS OVERVIEW

TraCSS is being developed as a modern, cloud-based IT system that will combine unclassified data from the DoD and commercial sources. The TraCSS program is

following an Agile development approach, incrementally building capabilities to provide on-orbit basic SSA/STC data and safety services in Phase 1, which is planned to last through September 2025. Phase 2 is planned to focus on launch collision avoidance services and Phase 3 is planned to focus on reentry assessment and management. The Phase 1.0 release of TraCSS, the program's minimum viable product, is slated for September 2024.

OSC is pursuing a phased development approach for TraCSS to build up capabilities and ensure a smooth offloading of SSA and STC responsibilities from the DOD. Over time and with each phase, more commercial data and commercial SSA services will be integrated as core capabilities.

Program Objectives

The TraCSS program is driven by a mission to support spaceflight safety, space sustainability, and international coordination. The program objectives are listed below:

- Relieve DoD of responsibility for SSA coordination for the burgeoning global commercial space industry;
- Provide "Basic SSA Services" in a manner that promotes safer space operations;
- Encourage US commercial SSA leadership and rely on commercial SSA providers to the greatest extent possible;
- Establish and maintain a resident space object data repository from which all basic services will be derived and utilized for international coordination purposes;
- Conduct R&D activities that will advance the science and technology of SSA; and
- Promote global SSA standards and best practices.

TraCSS High Level Architecture

TraCSS will consist of three main elements, which are depicted in Figure 1. TraCSS OASIS is the data repository within which data from diverse sources are stored. TraCSS SKYLINE is the SSA application services layer, wherein software applications will leverage the data in OASIS to provide basic SSA and STC data and safety service products. TraCSS HORIZON will be separated from the operational OASIS and SKYLINE elements and will consist of two partitions: a research, modeling & simulation environment to support R&D, and a development and test environment to test and validate new services before they are integrated into the operational system.

In the Phase 1.0 release, TraCSS will rely more heavily on unclassified data from the DoD that will be ingested into TraCSS. This information will be stored in OASIS and applications within TraCSS SKYLINE will leverage the data to generate ephemerides, if needed, and will run a conjunction screening process every four hours to produce conjunction data messages (CDMs) for a beta

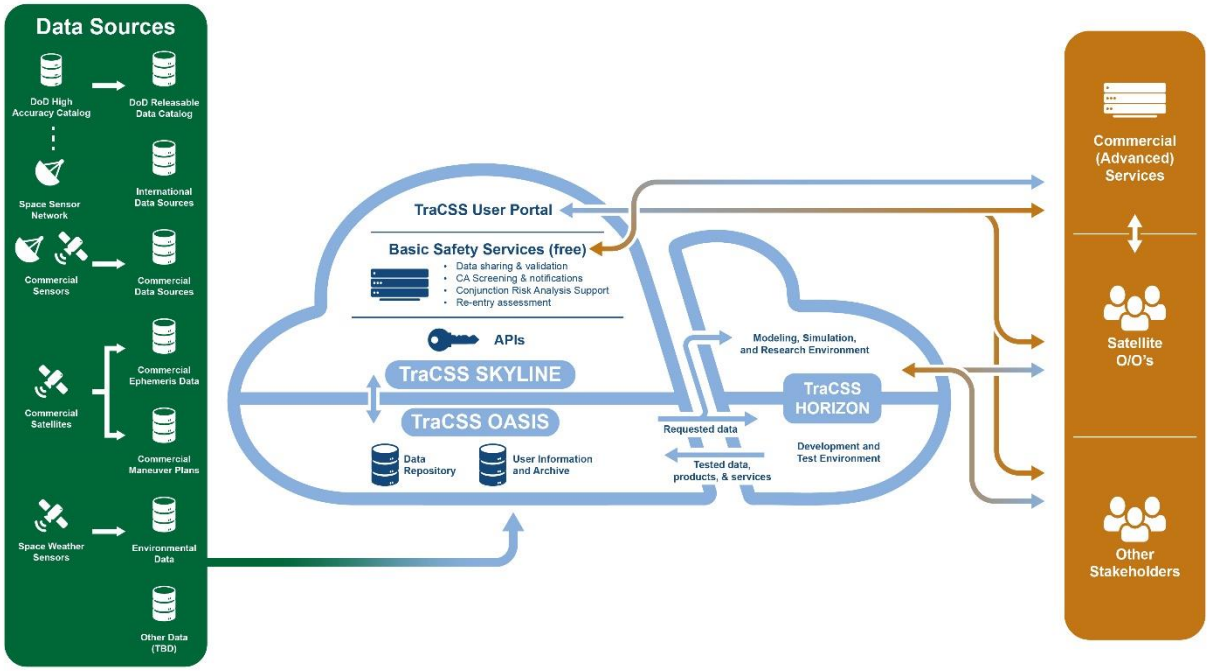

Figure 1. TraCSS High Level Architecture

set of users. As TraCSS further develops in capability across Phase 1, more diverse data sources will be ingested, new applications will be procured from the commercial SSA industry and integrated into SKYLINE, and the TraCSS user base will expand. TraCSS plans to ingest data procured from the commercial SSA industry, satellite owner/operators (O/Os), space weather information, and possibly international sources of data.

TraCSS users will interact with the system via a user interface. For some users, this engagement will consist of inputting and receiving information to and from TraCSS machine-to-machine via an API. Other users will likely interact with TraCSS via a web interface. The primary TraCSS users are envisioned to be satellite O/Os, but other stakeholders will also be able to interact with the relevant elements of the system.

Figure 2 demonstrates the planned information flows for the Phase 1.4 release at the end of Phase 1 in September 2025. Data is ingested from the unclassified portions of the DoD high accuracy catalog. Other data ingests include ephemerides from satellite O/Os. In cases where O/O cannot produce ephemerides to the quality and preciseness needed for actionable conjunction screening and assessment, OSC may procure the services of commercial SSA service providers to improve the quality of the ephemerides. A commercial CA screening tool will execute all vs. all screenings, screen O/O provided ephemerides, and produce CDMs. An SSA Mission Planning tool will analyze the CDM to determine whether additional tracking data on the secondary object should be gathered to increase the quality of the CDM. The tools will task commercial SSA data providers to provide the additional tracking information in the form of ephemerides, which will be routed back to the CA screening tool. Satellite O/Os will receive a notification of the additional tasking. Data quality monitoring tools will evaluate data ingests and product outputs to and from TraCSS. Satellite O/O interactions with the system will be via APIs or a web interface.

STAKEHOLDER ENGAGEMENT

Department of Defense Coordination

In September 2022, DoD and DOC signed a Memorandum of Agreement (MOA) formalizing the organizations' relationship for basic SSA and STC services and defines how the organizations will work cooperatively to implement SPD-3. [3] This MOA kicked off robust discussion on priorities and coordination. Multiple working groups have been established with focuses on technical and policy issues. Weekly working groups include data exchange specifications, machine-to-machine data transfer, data state management, operations coordination, roles and responsibilities, and strategic communications. The DoD and DOC teams also meet at least twice a year in-person for an STC Operations Coordination Workshop. As TraCSS moves to Phase 2 and beyond, some working groups will cease as new ones are stood up to address topics such as launch collision avoidance and large proliferated constellations. Beyond data, coordination topics also include the sharing of expertise in SSA analysis and spaceflight safety operations.

User Engagement

As TraCSS is being developed via an Agile approach, user engagement and feedback is an integral part of the process. The program has sought to engage with future TraCSS users and stakeholders in a variety of forums. OSC publishes video updates regarding program

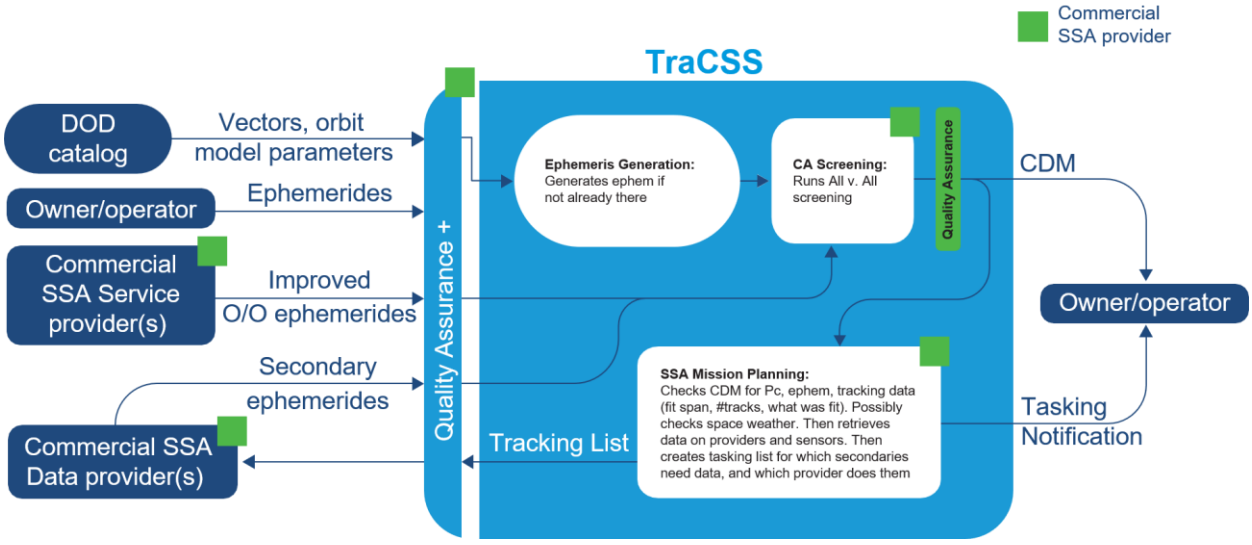

Figure 2. TraCSS Phase 1.4

planning and major updates [4]. OSC has hosted several virtual and in-person workshops with the satellite O/O and commercial SSA communities [5]. In December 2023, OSC began hosting regular virtual listening sessions on different policy, operations, and data standards-related topics [6]. These listening sessions provide an opportunity for OSC to brief a particular topic and pose questions for stakeholder feedback; responses are gathered either live during the listening session or via a written comment following the listening session. Feedback is directly passed to the technical development team for consideration in design decisions. Listening sessions occur on about a monthly basis. The TraCSS team also hosts briefings at different conferences, workshops, and public events when appropriate.

As users are onboarded to TraCSS, feedback will be integral to refining existing functions and developing new capabilities. OSC has initiated engagements with an initial set of beta users for Phase 1.0, who are experienced space operators with various fleet sizes across orbital regimes. OSC will proactively determine how additional beta users are onboarded across Phase 1.

Pathfinder Projects

Commercial SSA capabilities will provide critical functions to TraCSS across Phase 1 and onwards. The Government will procure and manage the minimum infrastructure for TraCSS – including the cloud layer, system integration, and the user interface – and software tools will be procured to provide services such as data quality monitoring, mission planning, additional SSA data, and CA screening. Utilizing diverse commercial applications from multiple sources requires diving into specific technical integration topics; developing metrics to guide how such services will be procured and how vendors will be held accountable to providing a level of service needed for spaceflight safety; and exploring various acquisition pathways.

Such challenges motivated the initiation of "pathfinder projects" within the TraCSS program. Pathfinder projects are limited term efforts designed to explore how specific commercial SSA capabilities can be tested and integrated by the Government. Findings and lessons learned from pathfinder projects can accelerate OSC's ability to procure and integrate sustained commercial SSA data and capabilities for the operational TraCSS system. OSC kicked off the first pathfinder project, the Consolidated Pathfinder, in January 2024 [7]. The Consolidated Pathfinder, focused on the low Earth orbit (LEO) regime, will inform buildout of the operational TraCSS. It will assess industry capabilities to maintain a space object catalog for a subset of LEO objects and provide follow-up tracking data on close approaches among those objects. The companies involved in the Consolidated Pathfinder project include COMSPOC (Exton, PA) for the provision of orbit determination services, LeoLabs (Menlo Park, CA) for SSA data and services in the LEO regime, Slingshot Aerospace (El Segundo, CA) for SSA data and services in the LEO regime, Kayhan Space (Broomfield, CO) for data quality monitoring services, and SpaceNav (Boulder, CO) for data quality monitoring services [8]. OSC is executing the Consolidated Pathfinder with The Aerospace Corporation, The MITRE Corporation, and MIT Lincoln Laboratory providing subject matter expertise.

Earlier this year, the Consolidated Pathfinder project team completed a preparation period and entered into a live data collection period. The preparation period involved: setting up a cloud-based, OSC-owned storage solution to support conduct in a test environment; setting up and confirming data flows from observation to the production of conjunction data messages (CDMs) across two LEO data providers with diverse phenomenologies and an orbit determination provider; collaboratively building a mission planning tool; and developing a set of metrics to be validated during the live data collection period. Since the live data collection period kicked off, the OSC team and participating companies confirmed regular data flows from observation to the production of CDMs, with follow-up tasking from the mission planning tool. To support the project objectives, the pathfinder companies have built and are maintaining a space object catalog encompassing a majority of the LEO regime. The pathfinder also integrates data quality monitoring service providers to conduct data evaluation. The live data collection period concludes at the end of June 2024 and will be followed by an evaluation phase.

The subsequent pathfinder project will be focused on improved O/O ephemerides and more pathfinder projects are planned to follow.

International Engagement [9]

As the United States is developing the TraCSS system, many other nations and organizations around the world are also developing or improving their own SSA capabilities. As these developments continue, OSC is committed to maintaining an open and transparent system that enables global coordination with other SSA providers and ensures reliable and efficient services to global spacecraft operators.

OSC envisions that in the future there will be a global, coordinated system of SSA providers, with a series of national or regional hubs providing SSA information and services to spacecraft operators. These centers will be supported by networks of international partnerships, and their services will be augmented by a robust global commercial SSA sector.

To enable this vision, OSC is examining SSA data standards, transparency and best practices for SSA data and information sharing, and opportunities for international coordination that can best support global spaceflight safety and space sustainability. OSC is also pursuing intergovernmental engagement to build support and connections with global SSA providers and global user engagement to raise awareness of TraCSS.

CONCLUSIONS

A robust civil SSA capability is essential for the safety and sustainability of Earth's orbit – and the innovation and vitality of our space sector. Orbits are becoming increasingly congested, putting space missions at risk. There is a growing need to better identify and track objects in space, and to deconflict (and eventually coordinate) orbital traffic. SPD-3 directs that DOC should be responsible for providing basic SSA services to commercial space operators – offloading those responsibilities from the DoD so that DoD can focus on its "protect and defend" mission. In partnership with industry, government, and academia, OSC is making great strides in implementing an operational public SSA and STC services system through the Traffic Coordination System for Space.

These efforts are improving SSA data interoperability and increasing SSA data sharing; coordination across the U.S. Government will help minimize any disruption to basic SSA safety services. This public-private collaboration will continue to evolve through ongoing research, integration, and testing to advance capabilities for civil SSA and STC.

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