Avanti's response to NOAA's RFI on Scope of Civil SSA Services

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Introduction

Scope and Purpose

This document is intended as Avanti's official response to the "*Request for Information on Scope of Civil Space Situational Awareness Services*" issued by the National Oceanic and Atmospheric Administration on January 26th, 2023.

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The purpose of this document is to provide comments and recommendations aimed at aiding the design of accurate and timely SSA services.

About Avanti

Avanti is a regional operator of a fleet of geostationary satellites used for civilian and military communication purposes.

Avanti owns and operates the following spacecraft:

- HYLAS 1 (37237 | 2010-065A)
- HYLAS 2 (38741 | 2012-043B)
- HYLAS 4 (43272 | 2018-033B)

Avanti holds a SSA Sharing Agreement with USSTRATCOM, and relies on the SSA products of the US Department of Defense for conjunction assessment.

Avanti also is a member of the Space Data Association (SDA), and a user of the Space Surveillance and Tracking service of the European Union (EUSST).

Avanti has acquired significant experience in contributing to the development of SSA services, by providing constructive feedback to both the SDA and EUSST, as well as the Monitor Your Satellite service of the UK Space Agency.

Avanti's Recommendations

Avanti welcomes the Department of Commerce's plan to provide flight-critical SSA services, taking over the services currently provided by the US Department of Defense. Avanti appreciates the DOC approach to request for information to owner/operators that are potential users of its SSA services. In the following paragraphs, Avanti respectfully provides recommendations on a number of aspects of the SSA service design and provision, for the DOC consideration.

International Cooperation

Avanti is currently a user of the DOD services and of the Space Surveillance and Tracking Service of the European Union (EUSST). Hence, Avanti strongly recommends that:

- **In the design of all SSA services from the Department of Commerce, interoperability and compatibility with the EUSST is prioritized, encouraged, and actively pursued.**

  In particular, in the European Commission's Communication "*An EU Approach for Space Traffic Management*"[1], the EC explicitly favors a multi-lateral approach to STM and a "privileged discussion with the US". The EC proposes building regional contributions to a global effort. We see that as the preferred long-term objective and the design of the new DOC services in SSA should consider and favour that same long-term view.

Governance

Avanti recommends that, in the design, development, testing, and provision of public SSA services, the Department of Commerce follows the below governance principles:

- **Transparency**: We recommend that the DOC provides users of the SSA service with as much information as possible about its own policies, operational processes and procedures, and operational and technological constraints. This is to build trust and allow operators to suggest improvements.

- **User engagement**: We recommend that the DOC organizes webinars and user conferences to provide updates and train operators to the use of the SSA service. We also recommend that the DOC includes in the SSA service a feedback loop to be used by operators to suggest improvements to the service.

- **Continuous improvement**: We recommend that the DOC selects a number of Key Performance Indicator and monitors them. Again, for the sake of transparency and to build trust, we recommend that the DOC provides monthly KPI reports to the SSA service users, together with a list of open actions being undertaken with the objective of improving performances.

[1] https://commission.europa.eu/system/files/2022-02/join_2022_4_1_en_act_part1_v6.pdf

Mission

In designing and developing the system, and in deciding which SSA services to provide, and which services should be free of charge, the mission of the Department of Commerce must be clear.

From the RFI, we infer that the DOC mission is to "*maintain the safety, stability, and sustainability of the increasingly congested and contested space environment*". With that in mind, Avanti recommends that:

- TraCSS holistically provides, to the greatest practical extent, accurate and timely positional knowledge suitable for generating actionable flight safety products for all space objects.

This will require the gathering of best-available knowledge from spacecraft operators, government, and commercial SSA, agnostic of a space object's size footprint, orbital regime, maneuverability, or whether or not the object's owner or legal authority is a participant in DOC's services or cooperates with DOC by sharing their data.

Architecture

Avanti welcomes the idea to involve the private sector in the architecture of the system for provision of SSA services. On this point, Avanti recommends that:

- The Department of Commerce procures observations (RF, optical, laser) from both commercial and institutional providers, but retains in-house the capability to fuse all data together, generate a catalogue of space objects, and provide conjunction warnings to operators.

- The provision of flight-critical services, like the conjunction assessment and warning provision, remains free-of-charge for the end users, to avoid commercial barriers to safety.

- The system architecture allows operators to upload not only ephemerides and maneuver details, but also raw measurements as ranging data. This is to allow fusing all data sources in a single orbit determination process.

- The system allows for ephemeris-vs-ephemeris conjunction assessment, using the operational ephemerides uploaded to the system by spacecraft operators.

- All the interfaces are based on CCSDS standards.

Furthermore, Avanti recommends that:

- The system provides sensible ways of mitigating the risk of close approach between civilian and military satellites, in the respect of National Security concerns.

Service Provision

Avanti has reviewed the 23 potential SSA services considered by the DOC and proposes the following comments and recommendations.

Potential Services	Avanti Comments and Recommendations
1. **Satellite Attributes, Capabilities, Status, and Point of Contact (Included).** To maintain a database of primary (protected) assets, which contains basic satellite attributes (approximate dimensions, mass), indicates satellite trajectory change capabilities and current status, and includes 24/7/365 contact information to coordinate mitigation actions for conjunctions between active satellites.	Agree. In addition, we recommend that the DOC considers ways of enforcing that the O/O provided 24/7/365 contact details are up to date and working (e.g. routine calls, scheduled update of contact details, …)
2. **Receipt and Sharing of Predictions O/Os Ephemerides (Included).** To receive predicted ephemerides from O/Os, store them in a manner that makes them available for download by other interested O/Os, and use them as the representation of the primary object for collision assessments (CA) screenings, risk assessment, and (when appropriate) mitigation planning.	Agree. In particular, we recommend that the DOC enables ephemeris-vs-ephemeris conjunction assessment for the case of close approach between two active satellites (ephemerides to be provided by O/Os).
3. **Routine Collision Assessment (CA) Screening and Conjunction Data Message (CDM) Production (Included).** To screen primary objects against a robust satellite catalog, both routinely and on demand; and to generate CDMs for objects that violate the particular physical volumes used for the screening activity.	We recommend rephrasing as follows: “To screen primary objects against a robust satellite catalog, both routinely and on demand; and to generate CDMs for objects that violate the predefined physical volumes *and/or collision probability thresholds* used for the screening activity.” Furthermore, we recommend that the CA screening can be summarized in a dashboard where events can be filtered and ordered by primary satellite, TCA, PoC.
4. **Special CA Screening and CDM Production (Included).** To perform an on-demand screening against a robust satellite catalog for a particular submitted ephemeris or set of ephemerides (usually for a confirmatory for speculative screening as part of maneuver planning).	Agree. Furthermore, we recommend that the DOC monitors response time between screening request and result delivery, and considers it a key performance indicator.

Potential Services	Avanti Comments and Recommendations
5. **Data Quality Evaluation (Included).** To perform a first-order evaluation of the orbit determination and propagation of the (usually secondary but in principle both) objects' state estimates and co-variances in order to determine whether these inputs are of sufficient quality to serve as a basis for a durable risk assessment calculation	Agree.
6. **Launch Collision Avoidance (COLA) Screenings (Included).** To perform timely screenings of a set of launch nominals against a robust satellite catalog in order to identify specific launch times during a launch window that would create unacceptably high collision risk and therefore should not be used.	Agree.
7. **O/O Ephemeris Generation and Curation with Covariance (Included).** To use O/O telemetry and on-board global positioning system state information, as well as potentially other commercial tracking information, to generate a reliable predicted O/O ephemeris that includes covariance at each ephemeris point and incorporates planned maneuvers (and maneuver execution error).	Agree. In particular, we recommend that the DOC performs data fusion, performing an orbit determination process that gathers data from O/O (e.g. GPS and ranging data) and commercial and institutional sensor networks (e.g. RF and optical data).
8. **Re-entry Management and Assessment (Included).** To perform reentry forecasting and event pacing assistance for primary objects undergoing either natural decays or managed deorbits in order to assist the DoD in orchestrating the overall decay and decataloguing process.	Agree.
9. **Precision Probability of Collision Calculation (Included).** To include in each generated CDM a Probability of Collision (PC) calculation that uses more advanced approaches for determining the appropriate hard-body radius (HBR) and employs a calculation technique appropriate to the particular dynamics of the encounter.	Agree. In particular, it could be beneficial to include in the CDM the probability of collision as estimated through different algorithms (including Max PoC through the Alfano method).

Potential Services	Avanti Comments and Recommendations
10. **Collision Consequence and Debris Production Potentials (Included).** To calculate, using an appropriate model, an estimate of the number of trackable debris fragments that would be generated if a particular conjunction were to result in a collision.	We don't see the need for this to be a basic service as the focus should always be on avoiding collision. We are also concern that this might absorb a lot of the available computational power (TBC).
11. **Conjunction Object Solution Improvements with Additional Tracking (Included).** To obtain additional tracking on the satellites involved in conjunctions of interest (typically the secondary objects), improve these objects' predicted states at the conjunction time of closest approach (TCA), and calculate higher-fidelity risk assessment metrics with this improved information.	Agree. Furthermore, we recommend that the DOC monitors response time between the request of additional tracking and an improved solution being delivered, and considers it a key performance indicator. (To do this, the DOC would have to define what requirements the improved solution needs to satisfy.)
12. **Expected Tracking Determination (Included).** To generate a pass schedule and probabilities of detection for obtaining additional commercial tracking for conjunction-related objects, so that O/Os can infer the potential benefit of additional tracking and be able to schedule mitigation action decision points appropriately.	Agree.
13. **Risk Assessment Time History Plots (Included).** To produce timehistory plots of conjunction risk assessment parameters of interest to allow assessment of conjunction event phasing and stability.	Agree.
14. **Space Weather Sensitivity (Included).** To provide warnings about space weather perturbative events and to assess the effects the perturbation induced atmospheric density uncertainty will have on conjunction risk assessment parameters.	Agree.
15. **Fusion of CA Products (Not Included).** To combine CA products, such as CDMs or predicted ephemerides, from multiple providers into a single, higher-fidelity product that can then be used to enable CA risk assessment.	Agree.

Potential Services	Avanti Comments and Recommendations
16. **PC Variability (Not Included).** By considering bounding scale factors for the "true" size of the primary and secondary objects' covariances, to generate a matrix of possible PC values to allow risk assessors to assign a more conservative "high-water-mark" PC value.	We recommend including this as a Basic Service.
17. **Additional Concierge Services (Not Included).** To provide on-call, personalized telephone support at all times by CA subject matter experts to assist O/Os with the interpretation of conjunction screening and risk assessment products.	Agree, although we recommend that, once all other basic services have been successfully rolled out, the DOC reviews/reassess its current decision to not include this as basic service.
18. **Anomaly Resolution (Not Included).** To arrange for the obtaining and interpretation of anomaly resolution SSA products, such as point signatures (radar cross-section and/or photometry), time-series satellite signatures, and radar and optical imaging.	Agree.
19. **Design-time Assistance for Improved CA (Not Included).** During the satellite construction and mission design phase, to assist O/Os in the prudent selection of mission orbits, satellite construction decisions to produce favorable light pollution properties, and the proper build-out of effective O/O ephemeris construction and CA software and procedures.	Agree.
20. **Maneuver Trade Space (Not Included).** To assemble a visual aid that identifies particular maneuver times and intensities (and, for some maneuver types, durations) to achieve the desired level of conjunction risk reduction (for both the main conjunction and any other conjunctions that the particular maneuver might introduce).	Agree.

Potential Services	Avanti Comments and Recommendations
21. **Optimized Maneuver Recommendations (Not Included).** In addition to the parameters in service (20) above, to include satellite contact restrictions, spacecraft maneuverability limitations, and O/O optimality preferences to construct a recommended maneuver plan to mitigate the main conjunction and ensure against the creation of any serious derivative conjunctions.	Agree.
22. **Breakup Detection, Tracking, and Cataloguing (Not Included).** To commission routine surveillance tracking to detect satellite break-ups; and upon the detection of a break-up, to increase supplementary surveillance tracking to collect break-up uncorrelated tracks (UCT), perform UCT processing, obtain dedicated tracking on new candidate objects, and suggest/perform cataloging actions for stable candidates for which the country of origin can be established.	We recommend including this as a Basic Service.
23. **Maneuver Detection and Processing (Not Included).** To commission heightened surveillance tracking on maneuverable objects; execute maneuver detection algorithms against the tracking obtained from such heightened surveillance; and for objects for which maneuvers are detected, perform appropriate maneuver processing to create a durable postmaneuver state estimate.	We recommend including this as a Basic Service. More specifically, we recommend that the DOC includes the ability to refine planned maneuvers and non-cooperatively detect, characterize, and recover from unknown maneuvers, as this is critical to achieving accurate conjunction assessment. The DOD's current CA screening products have had limited usefulness for maneuvering spacecraft because they do not: incorporate operator maneuver plans and data, recover quickly from non-cooperative maneuvers, incorporate maneuver uncertainties to achieve covariance realism, solve orbits in the presence of maneuvers, and predict through future (planned) maneuvers.