

EU SST–TraCSS Joint Study on Operational Information Exchange

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ABSTRACT

In past collaborative studies, the European Union Space Surveillance and Tracking (EU SST) system and the U.S. Traffic Coordination System for Space (TraCSS) identified the importance of information exchange among national and regional space situational awareness (SSA) centers. Information exchange can improve the quality of spaceflight safety services for users of both systems. Information sharing also reduces the extent to which spacecraft operators receive conflicting information regarding potential collision events from different SSA providers, which is critical to global spaceflight safety. In this follow-on study, we demonstrate the ability to exchange information on an operational basis between two major national or regional SSA centers—EU SST and TraCSS—and we compare the products generated by these two systems. In doing so, we identify important lessons learned for operational information exchange that can help more broadly inform international coordination.

1. INTRODUCTION

With rapid growth in the number of satellites in orbit, access to space situational awareness (SSA) information and services has become increasingly important for maintaining spaceflight safety. In the United States, the Office of Space Commerce (OSC)'s Traffic Coordination System for Space (TraCSS) is developing a new civil SSA system to support this growth. In Europe, the European Union Space Surveillance and Tracking (EU SST) partnership provides SSA services to institutional and commercial users around the world. Both systems share the common objective of improving the safety and sustainability of space operations.

The EU SST and TraCSS have been collaborating to strengthen information exchange among national and regional SSA providers. [1], [2], [3], [4] Building on this collaboration, this study demonstrates the ability to share information on an operational basis between two independent SSA systems and compares the conjunction assessment products generated by the two systems. Specifically, it examines the differences and similarities between the Conjunction Data Messages (CDMs) produced by EU SST and TraCSS and evaluates potential explanations for differences in system outputs.

Some differences in conjunction predictions are expected because the two systems rely, to at least some extent, on different data sources, processing methods, and operational approaches. The goal of this study is to assess the magnitude of these differences, identify their primary causes, and evaluate their operational significance. The results provide insight into the benefits of international information sharing. In addition to forming bilateral coordination between EU SST and TraCSS, we believe that this study can provide useful lessons learned for broader international SSA coordination and information sharing globally.

This study addresses the following research questions:

- Can EU SST and TraCSS successfully engage in operational SSA information sharing on timelines that would support real-world conjunction assessment and response?
 - What challenges and lessons emerged during implementation?
- How do the conjunction assessment products generated by EU SST and TraCSS compare?
 - How do the systems differ in the number of identified conjunctions and the actionability of those events?
 - How significant are the observed differences?
 - What are the primary causes for the differences?

This paper presents the initial results of the investigation. Further analysis involving additional satellites and longer time scales is underway and will be released in future publications. This paper is organized as follows:

- Sections 2 and 3 present EU SST and TraCSS, respectively, and Section 4 provides a preliminary discussion of differences in operational approaches.
- Section 5 describes the signup process for each system as a third party.
- Section 6 describes the data used for the study and how the conjunctions were matched between the systems.
- Section 7 presents statistics on the differences and similarities in conjunctions between EU SST and TraCSS, and Section 8 delves into more details and possible causes for select conjunction events.
- Finally, Section 9 summarizes the main lessons learned and lists steps for further analysis.

2. PRESENTATION OF EU SST

2.1 High-level Presentation of EU SST

The EU SST is a partnership of 19 EU Member States in charge of monitoring and tracking resident space objects (RSOs) to prevent collisions, guarantee the safety of space assets, and support global spaceflight sustainability. [5], [6]

To provide space surveillance and tracking (SST) services free of charge to users all around the world (i.e., EU Member States, EU institutions, spacecraft owner/operators (O/Os), and other public and private entities), EU SST is building an SST system composed of three core functions [5], [6]:

- **Sensor network**—Worldwide network of both ground-based and space-based sensors surveying RSOs in all orbital regimes: low Earth orbit (LEO), medium Earth orbit (MEO), and geosynchronous Earth orbit (GEO).
- **Data processing**—EU SST database and catalog ingesting and processing measurements from the sensor network and making information related to RSOs available to the service provision operation centers (OCs).
- **Service provision**—Three services are proposed: collision avoidance (CA)¹, atmospheric reentry analysis (RE), and fragmentation analysis (FG), all available for users on the SST Portal managed by the European Union Agency for the Space Programme (EUSPA) as the Front Desk.

The high level architecture of the system is presented in Fig. 1. As of 2026, more than 400 organizations already receive these services, and more than 700 satellites are safeguarded from the risk of collision.

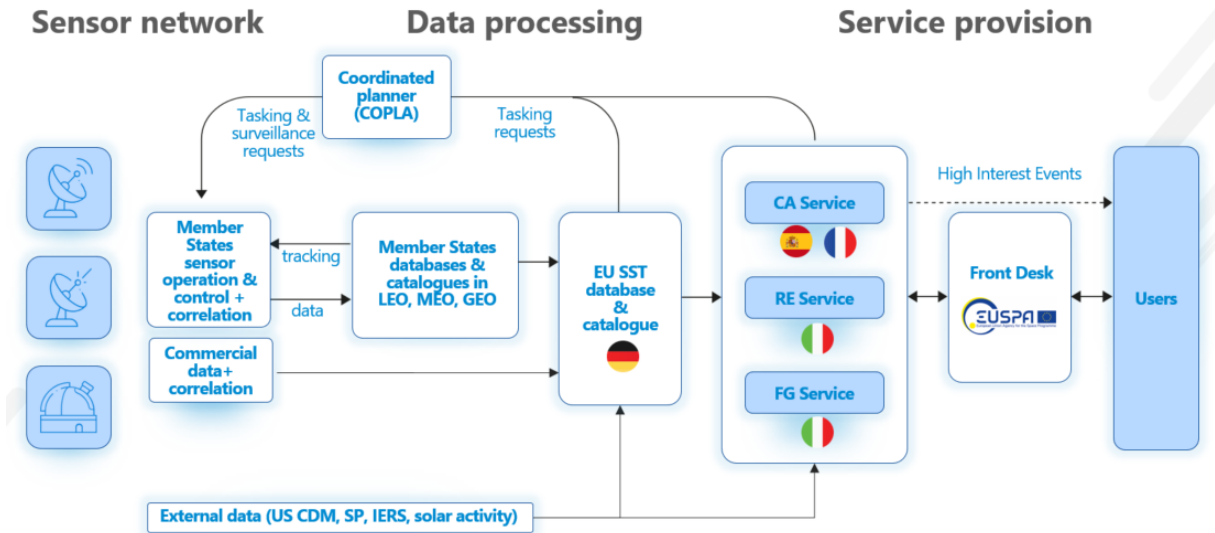


Fig. 1: EU SST high-level architecture. [6]

¹The abbreviation “CA” refers to “collision avoidance” within EU SST and “conjunction assessment” within TraCSS. For simplicity, this paper abbreviates both terms as “CA” since both systems describe similar processes including ephemeris screening and CDM distribution.

2.2 EU SST CA Service

The CA service aims to identify and detect close approaches (i.e., conjunctions), provides collision risk assessment between the operational assets of EU SST's users and other RSOs (either payload, rocket body, or debris), generates collision alerts through CDMs, and recommends mitigation action when necessary/requested. The fleet of satellites under the protection of EU SST is divided among two OCs: the Conjunction Analysis and Evaluation Service: Alerts and Recommendations (CAESAR) team in France and the Spanish Space Surveillance and Tracking Operations Centre (S3TOC) in Spain. Together they operate in hot redundancy; both OCs create CDMs for an identified conjunction, though only one publishes data. Thus, each OC is ready to provide CA services to the entire fleet at a moment's notice, allowing for robust and seamless operations. [5], [6], [7]

On-orbit conjunction risk assessment consists of three complementary analyses [7]:

- **Nominal screening analysis**—routine screenings performed for the nominal trajectory provided by O/Os, which includes information of the nominal maneuver plan of the spacecraft.
- **Special screening analysis**—on-demand screenings of O/O ephemerides to verify whether a mitigation action strategy (e.g., collision avoidance maneuver (CAM)) effectively mitigates an active High Interest Event and does not generate additional conjunctions.
- **Third-party enhanced CDMs**—EU SST reprocesses 19th Space Defense Squadron (19 SDS) CDMs using the latest EU SST primary object operational ephemeris uploaded by the O/O and the available information on the hard body radius (HBR). EU SST also computes O/O orbit covariance, applies its own probability of collision (P_c) methods, and performs P_c sensitivity analysis.

Registered spacecraft ephemerides are screened against other EU SST registered spacecraft ephemerides, objects in the EU SST catalog, objects in the U.S. High Accuracy Catalog (HAC) containing special perturbations (SP) ephemerides (henceforth referred to as the SP Catalog (SPCAT)) without covariance, and non-EU SST spacecraft ephemerides available publicly. Screening frequency and execution times are tailored to each operator considering the orbital regime, ephemeris upload schedule, previously detected events, and any re-evaluation needs identified by the corresponding OC. Under nominal conditions, screenings are performed at least once per day. If a conjunction is classified as a High Interest Event (HIE), it will be reassessed whenever new information is available (e.g., reception of an updated satellite ephemeris or a CDM from the 19 SDS). [7]

To detect potentially dangerous conjunction events, EU SST uses screening volumes (SVs) defined according to the orbital regime of the assets safeguarded by the partnership. Historically, SVs used in the EU SST CA service have been tailored to the needs of different users. Nevertheless, EU SST is transitioning towards a harmonized framework of common SV definitions for all users with similar mission-specific characteristics (e.g., orbital regime).

Conjunction events are classified into three categories depending on the severity of the risk:

- **ALERT**—High Interest Event (HIE)—Conjunction with a high level of risk potentially requiring a CAM performed by the O/O.
- **WARNING**—Interest Event (IE)—Conjunction requiring further investigation due to a heightened risk level.
- **INFO**—Informational Event—Conjunction with a low level of risk.

Within the EU SST system, the severity of a conjunction is determined based on a combination of the following parameters:

- **Time to time of closest approach (TCA)**—User-defined threshold, expressed in hours, to set the risk level of a conjunction according to the time until TCA, the point in time where the miss distance between the two objects involved in the conjunction is at its minimum.
- **Scaled probability of collision (SP_c)**—Maximum P_c computed by performing parametrical analysis using two scale factors (one for the primary object (K_p) and another one for the secondary object (K_s)) that inflate or shrink the assumed covariances of both objects involved in a conjunction.
- **Miss distance (MD)**—Closest distance, in meters, at TCA between the primary and secondary objects during a conjunction.
- **Radial distance (RD)**—Distance, in meters, between the primary and secondary objects involved in a conjunction along the radial direction from the Earth's center.

The P_c computation is based on different algorithms depending on the dynamics of the close approach. For short-term, high-relative velocity encounters, EU SST employs the Akella–Alfriend [8] and Alfano [9] methods, both of

which rely on an assumption of rectilinear motion and the projection of the event geometry onto the encounter plane. For long-term or low-relative velocity encounters where nonlinear effects become significant, EU SST employs the Coppola method [10] together with Monte Carlo techniques to provide a more accurate probability estimation.

It is to be noted that probabilistic criteria (e.g., SP_c) are mainly used for LEO and MEO orbital regimes, whereas GEO uses geometric criteria (both MD and RD), mainly due to the effects of P_c dilution. [5], [6], [7] Historically, the threshold for each parameter has been tailored to the needs of individual EU SST registered O/Os. As with the SVs, EU SST is now progressing toward harmonized thresholds for operators within each orbital regime. Recently registered EU SST O/Os are presented with the applicable thresholds listed in Table 1.

Table 1: EU SST general risk level thresholds.

Risk Level	Regime category	Time to TCA	SP_c	MD	RD
HIE (ALERT)	LEO	3 days	5×10^{-4}	-	-
	LEO (non-maneuverable)	3 days	5×10^{-4}	-	-
	MEO/GEO	7 days	1×10^{-5}	4 km	1 km
IE (WARNING)	LEO	3 days	5×10^{-5}	-	-
	LEO (non-maneuverable)	3 days	1×10^{-4}	-	-
	MEO/GEO	10 days	1×10^{-6}	10 km	2 km

EU SST products are delivered as CDMs together with supporting reports that provide additional metadata and conjunction analysis plots, which are also available in an interactive format through the EU SST Portal. CDMs include information such as the conjunction geometry, P_c , TCA, and other relevant parameters, following the format defined by the Consultative Committee for Space Data Systems (CCSDS).

Since the orbital information used during the conjunction screening process may originate from different data sources, the EU SST generates several categories of CDMs. These can be grouped as follows (see also Fig. 2):

- **Reprocessed U.S. Space Force (USSF) Combined Space Operations Center (CSPOC) CDMs**—These are CDMs initially issued by the 19 SDS that are reprocessed by the EU SST through the replacement of HBR values, allowing the recomputation of P_c and SP_c . They are classified as CDM_CDM, CDM_CDMOO, or other combinations of the two types. Here, the “OO” suffix indicates that the CDM contains O/O-provided operational ephemerides for the object.
- **Enhanced EU SST CDMs**—These correspond to CDMs published by the 19 SDS that are reprocessed by the EU SST using O/O ephemeris for the primary object, while retaining the orbital information contained in the original CDM for the secondary object. They are classified as OPS_CDM or OPS_CDMOO.
 - A further type of enhanced EU SST CDM is generated when an ephemeris from an O/O external to EU SST is used to reprocess a 19 SDS CDM for the secondary object. These products are classified as CDM_EXT or CDMOO_EXT.
- **Autonomous EU SST CDMs**—These are generated directly by the EU SST using O/O orbital information for the primary object together with EU SST catalog data for the secondary object. They are classified as OPS_CAT, SPCAT_CAT, or CAT_CAT.
- **Operator-provided information CDMs**—These are produced using ephemerides supplied by operators, either from within the EU SST framework or from external operators. They are classified as OPS_OPS or OPS_EXT.
- **Operators’ orbits screened against SPCAT**—In this case, operator ephemerides are screened against the SP Catalog, enabling conjunctions to be identified before a 19 SDS CDM is generated. These products are classified as OPS_SPCAT.

Conjunction predictions are continuously refined as EU SST sensors receive updated observations and additional sources of orbital information (e.g., 19 SDS CDMs, external ephemerides) become available, which may modify the predicted conjunction parameters or produce alternative solutions. Consequently, a single conjunction event may comprise multiple CDMs issued by the EU SST CA OCs throughout its lifetime. The event risk level is always established using the most recent and reliable CDM available. For each conjunction at any given time, the EU SST CA OCs identify the preferred CDM source and assess the associated risk level on the basis of the parameters contained in this designated best CDM. [11]

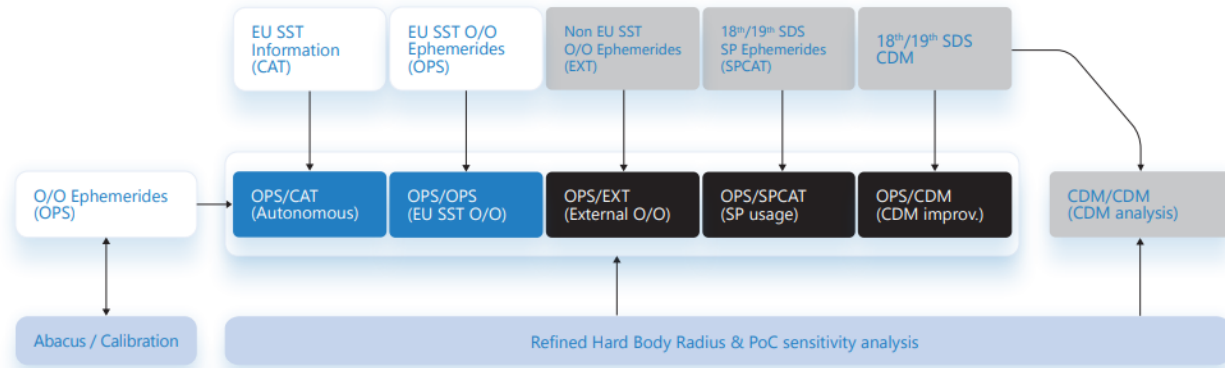


Fig. 2: EU SST CDM types. [6]

3. PRESENTATION OF TraCSS

3.1 High-level Presentation of TraCSS

The United States Department of Commerce (DOC) is currently developing TraCSS to provide spaceflight safety services to spacecraft O/Os around the world in support of global spaceflight safety. TraCSS began providing initial services to a set of beta users in September 2024. In March 2026, TraCSS transitioned to its production release and opened registration to all spacecraft operators around the world to join as pilot users. During this pilot phase, users can access and use TraCSS information and services to gain familiarity with the system. TraCSS also offers National Government accounts, which allow national government officials to access information for all spacecraft affiliated with their nation, providing insight into the spaceflight safety situation of their country. TraCSS continues to follow an agile development process, adding capabilities over time. As of early August 2026, TraCSS has onboarded 68 spacecraft O/Os comprising over 11,000 satellites, as well as nine national government accounts. [12], [13]

An outline of TraCSS' basic conjunction assessment (CA) service provision is illustrated in Fig. 3. TraCSS services include regular screening of both the Department of War (DoW) catalog of space objects (SPCAT) as well as O/O ephemerides six times per day, producing CDMs to alert users of any upcoming close approaches. TraCSS provides access to a directory of O/O contact information to facilitate space traffic coordination. In addition to routine CA, TraCSS offers a range of capabilities and features focused primarily on in-orbit flight safety, including:

- **Ephemeris ingestion and screening**—Users may submit ephemerides in the CCSDS Orbit Comprehensive Message (OCM) format for on-demand CA. These OCMs may be “operational,” indicating a current, intended trajectory, or “candidate,” indicating a potential trajectory. This feature supports O/Os in planning risk reduction or other maneuvers.
- **Public data**—In the future, TraCSS will make several data products available publicly to further support spaceflight safety and international coordination, including notifications of emergency-reportable conjunctions (called TraCSS Conjunction Notifications (TCNs)), the TraCSS Satellite Catalog (TraCSSCat), all operational OCMs, the SPCAT without covariance, CCSDS Orbit Mean-Elements Messages (OMMs) including two-line element sets, and Break-Up Notifications (BUNs).

3.2 TraCSS CA Service

The primary CA product delivered by TraCSS comes in the form of CDMs. By sourcing ephemerides from the SPCAT and O/Os, TraCSS routinely identifies close approaches and generates CDMs for all tracked space objects (payloads, rocket bodies, and debris). Registered users may then access these messages via web or API. TraCSS does

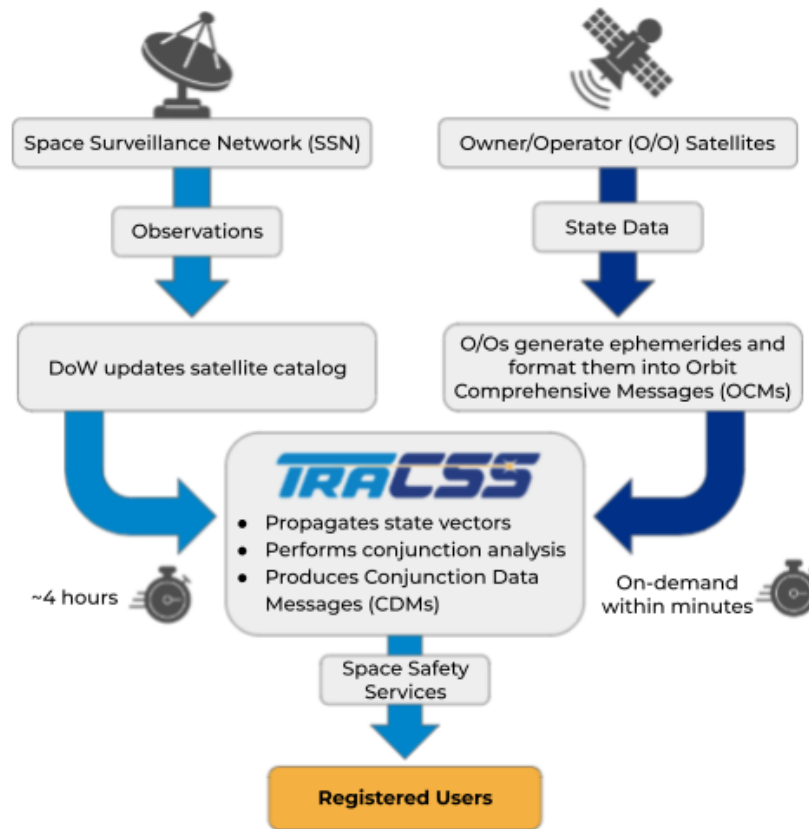


Fig. 3: TraCSS CDM production overview. [12]

not recommend risk mitigation maneuvers, but products like the O/O contact directory enable coordination between operators involved in an upcoming conjunction. [13]

As illustrated in Fig. 3, TraCSS uses data ingested from both the SSN and O/Os who submit ephemerides directly for CA. TraCSS conducts routine CA screenings six times per day. Every four hours, ephemerides for all payload objects are screened as primaries against the entire SPCAT with covariance and the set of current operational OCMs. Two of these CA runs additionally include SP ephemerides for non-payload objects to be screened as primaries, allowing for the identification of conjunctions between debris or rocket bodies with potential to impact the space environment. [12] Depending on the inputs available, TraCSS may produce up to four CDMs per conjunction per screening (i.e., SPCAT vs. SPCAT, SPCAT vs. OCM, OCM vs. SPCAT, and OCM vs. OCM). Within TraCSS, CDMs with these different combinations of orbit data are not noted as distinct types. However, multiple CDM fields are used to facilitate traceability to the original ephemerides used during screening.

TraCSS uses SVs to identify potential conjunctions. During a CA screening, a box-shaped SV is flown along the predicted ephemeris of each primary object according to the orbital regime assigned by TraCSS. If another object is predicted to enter the SV at any point during the propagation period, a close approach is identified, and CDM generation is triggered for the event at TCA. The orbital regimes used by TraCSS and the dimensions of their associated SVs are defined in Table 2.

For every close approach identified during screening, TraCSS calculates P_c using the Foster-1992 method, detailed in [14]. In this calculation, TraCSS applies default values for HBR depending on object type: 5 meters for payloads, 3 meters for rocket bodies, and 1 meter for debris. These default sizes may be larger or smaller than the true size of the space object; future iterations of TraCSS will utilize HBR values submitted directly by O/Os and stored in the TraCSSCat for more realistic calculations of P_c . [12]

Table 2: TraCSS orbital regimes and SVs. [12]

Orbital regime	Definition	Propagation time	Radial SV	In-track SV	Cross-track SV
SPCAT	LEO1 Perigee ≤ 500 km Eccentricity < 0.25	5 days	0.4 km	44 km	51 km
	LEO2 500 km $<$ Perigee ≤ 750 km Eccentricity < 0.25	5 days	0.4 km	25 km	25 km
	LEO3 750 km $<$ Perigee ≤ 1200 km Eccentricity < 0.25	5 days	0.4 km	12 km	12 km
	LEO4 1200 km $<$ Perigee ≤ 2000 km Eccentricity < 0.25	5 days	0.4 km	2 km	2 km
	MEO 2000 km $<$ Perigee ≤ 27000 km Eccentricity < 0.25	10 days	24.5 km	24.5 km	24.5 km
	HEO Perigee ≤ 37500 km Eccentricity ≥ 0.25	10 days	24.5 km	24.5 km	24.5 km
	GEO 27000 km $<$ Perigee ≤ 37500 km Eccentricity < 0.25	10 days	24.5 km	24.5 km	24.5 km
	Deep Space Perigee > 37500 km	10 days	24.5 km	24.5 km	24.5 km
	Other Default when other regimes cannot be assigned	10 days	24.5 km	24.5 km	24.5 km
OCM	Near Earth Period < 225 min	7 days	2 km	25 km	25 km
	Deep Space Period > 225 min	10 days	49 km	49 km	49 km
	Other Default when other regimes cannot be assigned	10 days	49 km	49 km	49 km

Within TraCSS, conjunction events are deemed emergency reportable based on thresholds for time to TCA, MD, and/or P_c outlined in Table 3. It should be noted, however, that generation and distribution of TraCSS CDMs is not dependent on assigned risk level.

Table 3: TraCSS emergency reportable criteria.

Regime category	Time to TCA	P_c	MD
Near Earth (LEO1–4)	3 days	1×10^{-4}	1 km
Deep Space (MEO/HEO/GEO)	3 days	-	5 km

4. COMPARISON OF SYSTEM OPERATIONS

The two previous sections, 2 and 3, presented a high-level overview of EU SST and TraCSS and a description of the CA services provided by each system. This section discusses operational differences between the two systems that lead to expected differences in the outputs produced.

4.1 Screening Input Data

The EU SST and TraCSS both rely primarily on operational ephemerides provided directly by users and external operators that make their ephemerides openly available. Both organizations also use the SPCAT generated by the U.S. DoW. TraCSS receives the SPCAT with covariance from the 18th Space Defense Squadron (18 SDS) six times per day. EU SST receives the SPCAT without covariance once per day, as well as SP ephemerides with covariance for specific conjunction events, provided within CDMs generated by the U.S. DoW.

4.2 Screening Cadence

TraCSS regularly conducts comprehensive screenings of the full SPCAT with covariance as well as stored operational OCMs on a fixed schedule of six screenings per day. O/Os may additionally request on-demand screening of operational or candidate ephemerides at any time. EU SST screens objects operated by registered users as primaries, conducting at least one comprehensive screening per day of stored O/O ephemerides against all other stored orbit data sources, including the SPCAT without covariance. EU SST also conducts CA screening whenever new orbit data are received for objects involved in an upcoming conjunction or on demand when an O/O provides candidate ephemeris.

4.3 P_c Calculation

The two systems employ different methods to calculate collision probability. In order to provide an accurate assessment of P_c for conjunctions with different physical characteristics (namely, relative velocity), EU SST utilizes one of several computation methods. TraCSS, meanwhile, uses Foster-1992, a 2D P_c method relying on an assumption of high relative velocity and rectilinear motion [15].

One critical input to any P_c computation method is the size of the objects involved in the conjunction. TraCSS and EU SST do not necessarily use the same values for HBR. EU SST stores HBR data for registered primaries reported by O/Os, and utilizes external sources like the Database and Information System Characterising Objects in Space (DISCOS) for sizing of secondaries. TraCSS uses default HBR values of 1, 3, or 5 meters for debris, rocket body, or payload objects, respectively in order to retain consistency in relative risk for users familiar with the Space-Track.org platform. A future release will incorporate object sizes reported by O/Os for P_c calculation. Furthermore, P_c results may differ depending on the particular numerical integration methods and parameters employed during computation.

4.4 Event Risk Reporting

Both systems evaluate the risk level of upcoming conjunctions depending on reported P_c and/or event geometry. EU SST identifies three tiers of event risk: ALERT, WARNING, and INFO. Each of these categories is associated with a certain level of expected action; EU SST may recommend CAMs to mitigate the risk of a potential collision. TraCSS has adopted the “emergency reportable” criteria laid out in the Spaceflight Safety Handbook developed by the U.S. DoW. A CDM receiving this categorization does not necessarily prompt further action from TraCSS, but a future release will make information for such events publicly available in the form of TCNs to notify the O/O community of potential to impact the space environment.

For objects in LEO, TraCSS’ emergency reportable criteria are similar to the criteria for ALERT events in EU SST: 3 days to TCA, $P_c \geq 1 \times 10^{-4}$ in TraCSS, and $SP_c \geq 5 \times 10^{-4}$ in EU SST; TraCSS includes a threshold for MD (≤ 1 km). In GEO, EU SST uses a time to TCA threshold of 7 days while TraCSS uses 3 days; the MD thresholds are comparable (5 km in TraCSS, 4 km in EU SST); and EU SST additionally considers SP_c and RD.

4.5 Publication Criteria

EU SST has an established preference order for orbital data and, for a given event, only publishes the CDM(s) with available inputs considered the most reliable. The objective is to present only the most relevant information to O/Os and prevent an overload of information, especially during times close to TCA. Without an O/O agreement specifying otherwise, EU SST does not publish CDMs for conjunction events involving objects in the same constellation (as the constellation operator is likely to be equipped to handle internal CA), for events exclusively assigned INFO-level risk, or for events outside of the time to TCA threshold defined in Table 1 (3 days for LEO, 7 or 10 days for GEO).

On the other hand, TraCSS does not restrict CDM publication based on orbital data source or other criteria; if a close approach within the primary object’s SV is identified during the propagation period (5 or 7 days for Near Earth, 10 days for Deep Space), a CDM is generated and published. This allows O/Os to view all information generated by TraCSS regarding the event rather than just a subset. Thus, TraCSS may distribute up to four CDMs for each event during each routine screening (if both the primary and secondary have both SPCAT and O/O orbital data available).

4.6 CA Service Customizability

CA services provided by TraCSS are consistent for registered users; within each orbital regime, all objects are screened with the same SVs for the same duration, the only difference being a result of the ephemeris source of the primary object. Currently, EU SST offers individual operators a greater degree of flexibility relating to the SVs used for screening and the particular thresholds for event risk criteria, though efforts are underway to make such parameters consistent for more operators. In particular cases, additional agreements with EU SST allow operators to receive more data than the default, such as CDMs for INFO-level events.

5. EU SST AND TRACSS ONBOARDING PROCESSES FOR THIRD-PARTY PARTNERS

One of the goals of this joint study was to demonstrate the ability to share operational information between TraCSS and EU SST. Both systems have built-in capability to enable the sharing of such information by adding a third-party partner in TraCSS and/or a delegated entity in EU SST. This capability is used to enable spacecraft O/Os or other registered users to provide access to organizations with which they have a contractual relationship, generally for spacecraft operations or SSA services. This study tested the ability to use this functionality to enable international operational information sharing. This section aims to briefly present the required steps to register TraCSS as a delegated entity in EU SST and EU SST as a third-party partner in TraCSS.

The instructions for O/Os to delegate their spacecraft to third-party SSA provider are available under “delegated entities” on the EU SST portal. The admin user must create a dedicated group of spacecraft to be delegated in the SAG (Satellite Allocation Group) section and then create a delegation for that group of spacecraft, allowing the O/O to have the entire control over the delegation. Once done, the EU SST Front Desk will receive and process the request. It must be noted that this process allows by default the sharing of CDMs and thresholds selected for each spacecraft. However, allowing the sharing of ephemerides follows a separate process, requiring additional approval from the EU SST Front Desk.

The process to add a third-party partner in TraCSS is similar. An O/O (or National Government Account holder) can add a third-party partner to their account through the online user interface. If the third-party organization is not already registered in TraCSS, they are invited to register. To do so, the third party must agree to the TraCSS User Agreement and provide basic information about their organization. The TraCSS user must then add contact details for the third-party partner’s contact details and manually assign satellites to be shared with the partner organization. Then, the third-party partner will be granted access to download CDMs and upload OCMs for all assigned objects.

6. DATA AND METHODOLOGY

The goal of this study was to compare the outputs of TraCSS and the EU SST to understand the extent to which spacecraft operators are likely to get similar or differing results from the two systems. For our initial study, we identified a collection of public and private spacecraft operators for potential inclusion in the study. Since EU SST only generates CDMs for its registered users, it was necessary to ensure that all the selected organizations were users of the EU SST system. Many of these operators were already registered in TraCSS. Those that were not yet registered were invited to join TraCSS and provide operational ephemerides to allow for an apples-to-apples comparison. The EU SST and TraCSS gained access to each other’s CDMs generated for these users through the third-party provider process described above.

CDMs published by EU SST and TraCSS for spacecraft affiliated with these users were collected over a two-month period (May 15 to July 15, 2026). Additional satellites were added partway into the study to increase the number of LEO objects involved. CDMs for these objects were collected from June 8 to July 15, 2026.

The number of GEO and LEO satellites and the data period for each the objects are shown in Table 4.

Table 4: O/O satellite data included in the study.

	GEO Satellites	LEO Satellites	Data Period
	39	12	Full
		46	From June 8
Total	39	58	

First, CDMs from each system were retrieved from their respective APIs. Then, the CDMs were sorted into conjunctions for each system according to its internal event identifier. At this point, CDMs were discarded if missing critical information, namely²

- Message ID (unique identifier for the CDM),

²As the actual field names differ in EU SST and TraCSS, the list identifies the information, not the CDM key.

- Conjunction ID (internal matching of CDMs to conjunction events),
- CDM creation date,
- CDM originator,
- Primary and secondary NORAD IDs,
- TCA,
- MD, and
- P_c

Missing information was extremely rare, affecting less than 0.01% of all retrieved CDMs. Once CDMs were grouped by conjunction within each system’s dataset, conjunction events were matched across systems based on primary and secondary object NORAD ID and TCA. For LEO events, the perigee and apogee (as recorded in the TraCSSCat) were used to calculate the orbital periods of the primary and secondary objects. The TCA threshold was then set to $\pm 6\%$ of the shorter of these two orbital periods. This method allows for a dynamic threshold that adjusts to be larger for objects at higher altitudes. If the required data to calculate orbital period were unavailable, a default margin of ± 20 min was used. For GEO events, a fixed margin of ± 120 min was used.

7. CDM DATABASE ANALYSIS

This section presents statistics on the quantity of events published by each system and the quantity of CDMs generated for those events. It also includes a high-level analysis of the most representative cases in which differences between systems are observed. The main objective is to present the outputs that users would expect to receive from each system, attending to the specific characteristics and differences described previously in Sections 2, 3, and 4. In this section, the names of participating organizations have been anonymized.

7.1 Published CA Event Counts

Table 5 summarizes the number of conjunction events for which each system published at least one CDM.

Table 5: Event counts in the analysis period.

Regime category	Operator	EU SST	TraCSS	Common	Only EU SST	Only TraCSS	Total
LEO	Operator A	21	375	19	2	356	377
	Operator B	398	32895	396	2	32499	32897
	Operator C	207	7478	174	33	7304	7511
	Operator D	224	12838	189	35	12649	12873
	Operator E	16	2424	13	3	2411	2427
	Operator F	10	6792	10	0	6782	6792
GEO	Operator G	1	133	0	1	133	134
	Operator H	547	716	118	429	598	1145
	Operator I	8	241	6	2	235	243
Total	-	1432	63892	925	507	62967	64399

This table shows that TraCSS publishes substantially more conjunction events than EU SST overall. This is expected to some extent given the operational procedures of each organization as described in Section 4. TraCSS publishes a CDM for all objects that enter the SV of the primary while EU SST generally does not publish a CDM unless the event reaches WARNING or ALERT criteria. Also, TraCSS screens for conjunctions involving four combinations of orbit data source; if any conjunction is identified, that information is made available to users. By contrast, EU SST does not disseminate conjunction information if the CDM with the highest priority data sources (e.g., OPS or EXT data compared to SPCAT data without maneuver information) does not meet risk level thresholds for publication.

Some more detailed explanations of these results have been identified:

- **Events against Starlink objects**—Approximately 90% of the LEO events published by TraCSS in the analysis period involve Starlink objects as secondaries. About 40% of those TraCSS events with Starlink secondaries use SPCAT data for the primary object whereas EU SST exclusively uses higher-priority OPS data. A majority (~70%) of TraCSS CDMs for events involving maneuverable Starlink objects were generated from SPCAT ephemerides for the secondaries. This leads to the identification of conjunctions that are not published by EU SST due to the preference of publishing CDMs with external operator orbit data (EXT) when available.
- **Risk level publication criteria**—TraCSS publishes a CDM whenever a close approach is identified, whereas EU SST generally only publishes CDMs for events classified as WARNING or ALERT. Consequently, events that remain below EU SST publication thresholds are not disseminated while they are published by TraCSS. Excluding events with Starlink secondaries, this accounts for 15% of events in LEO and 95% of TraCSS-only events in GEO.
- **Filters for intra-constellation pairs**—Typically, EU SST does not disseminate CDMs for conjunctions between objects of the same constellation. This type of situation occurs often in GEO. For Operator H in particular, 75% of the TraCSS-only events occur between just three intra-constellation object pairs.

In comparison to TraCSS, there are very few EU SST-only events. The more comprehensive screening approach used by TraCSS means that it rarely fails to report conjunction events published by EU SST. These cases do occasionally occur due to slight differences in screening timing. One notable outlier from this pattern is Operator H. It has been found that TraCSS did not receive any OCMs from Operator H to be screened during the analysis period. As such, all EU SST CDMs for this operator used OPS data whereas all TraCSS CDMs used SPCAT data. It is apparent that, if one system screens O/O ephemerides and the other does not, the former is more likely to identify conjunctions that the latter misses.

7.2 Published CDM Counts

Table 6 presents the number of CDMs published by each system for the events described previously.

Table 6: CDM counts in the analysis period.

Regime category	Operator	EU SST	TraCSS	Common EU SST	Common TraCSS	Only EU SST	Only TraCSS	Total
LEO	Operator A	227	11273	196	739	31	10534	11500
	Operator B	3474	788892	3464	24234	10	764658	792366
	Operator C	2177	78308	1989	4123	188	74185	80485
	Operator D	1260	115430	1134	2941	126	112489	116690
	Operator E	69	22767	63	315	6	22452	22836
	Operator F	19	67299	19	199	0	67100	67318
GEO	Operator G	8	2138	0	0	8	2138	2146
	Operator H	4211	20173	1704	3078	2507	17095	24834
	Operator I	104	13105	87	800	17	12305	13209
Total	-	11549	1119385	8656	36429	2893	1082956	1130934

On average, TraCSS reports more CDMs per event than EU SST. This likely occurs for the same reason as described previously with respect to conjunction events; the effect is heightened due to TraCSS potentially publishing up to four CDMs per event at each screening and routine TraCSS screenings occurring at a high cadence (six per day).

Figs. 4 and 5 below show statistics on the average CDM issuance frequency as well as the average publication times for the first and last CDMs relative to TCA.

As shown in Fig. 4, TraCSS publishes CDMs with a higher frequency than EU SST. The main causes for this are screening cadence (six daily screenings plus on-demand performed by TraCSS compared to EU SST screening once daily or as new inputs are received) as well as TraCSS publishing multiple types of CDMs whereas EU SST generally only disseminates the highest-priority product.

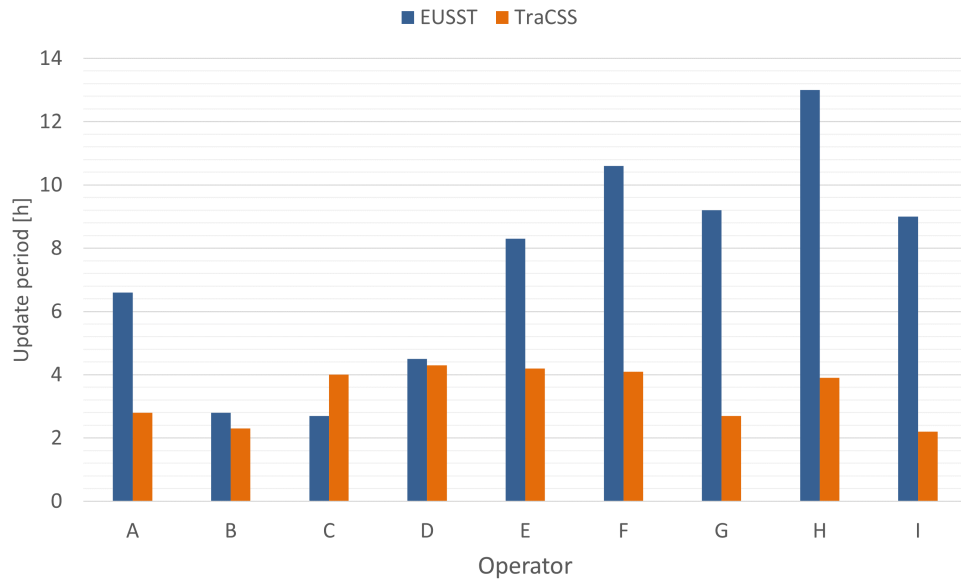


Fig. 4: Average period between CDM publication.

As shown in Fig. 5, TraCSS usually publishes CDMs with a larger lead time before TCA than EU SST. This is primarily explained by the different publication thresholds for time to TCA applied by EU SST and the propagation duration for ephemerides within TraCSS described in Section 4.

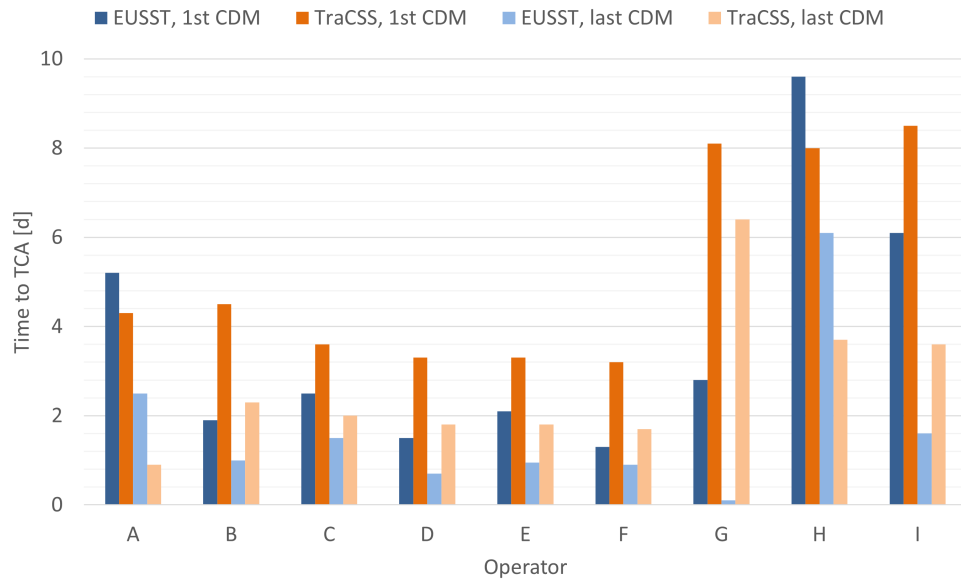


Fig. 5: Average time to TCA for first and last CDM publication.

8. CASE ANALYSIS FOR SELECT EVENTS

The goal of this section is to provide an in-depth analysis of two example conjunctions (in both LEO and GEO) to understand the underlying factors that could explain similarities or discrepancies between CDMs generated by the EU SST and TraCSS systems. This section presents figures including time histories for select risk metrics. Risk levels for EU SST data are presented as they appear in the original CDMs, which are assigned using SP_c and/or MD/RD

as outlined in Table 1. TraCSS CDMs are assigned risk level using the TraCSS Consolidated Pathfinder criteria on a CDM by CDM basis [16]:

- **ALERT**—Events with $P_c \geq 10^{-4}$, which usually require a risk mitigation action;
- **WARNING**—Events with $10^{-7} \leq P_c \leq 10^{-4}$, which require more engaged monitoring but do not usually result in a risk mitigation action; and
- **INFO**—Events with a $P_c \leq 10^{-7}$, which are usually not given any further operational regard.

8.1 LEO Case

This subsection presents an investigation of an example conjunction in the LEO regime.

The main characteristics of the primary and secondary objects are highlighted in Table 7. It can be acknowledged that the HBR used by EU SST and TraCSS are quite different. Whereas EU SST uses the HBR value given by the O/O in the EU SST CA Service Configuration Document (SCD) for the primary object and the European Space Agency (ESA) DISCOS for secondary objects classified as rocket body or debris, TraCSS applies default HBR values based on object type as explained in Section 3.

Table 7: Main characteristics of primary and secondary objects

	Primary object	Secondary object
Object type and maneuverability	Active and maneuverable RSO	Space debris
EU SST HBR	7.9 meters	1.0 meter
TraCSS HBR	5.0 meters	5.0 meters

In Fig. 6, it can be first noted that both systems have similar values and matching trends regarding P_c , distance in the Radial-Transverse-Normal (RTN) frame, MD, and risk level metrics.

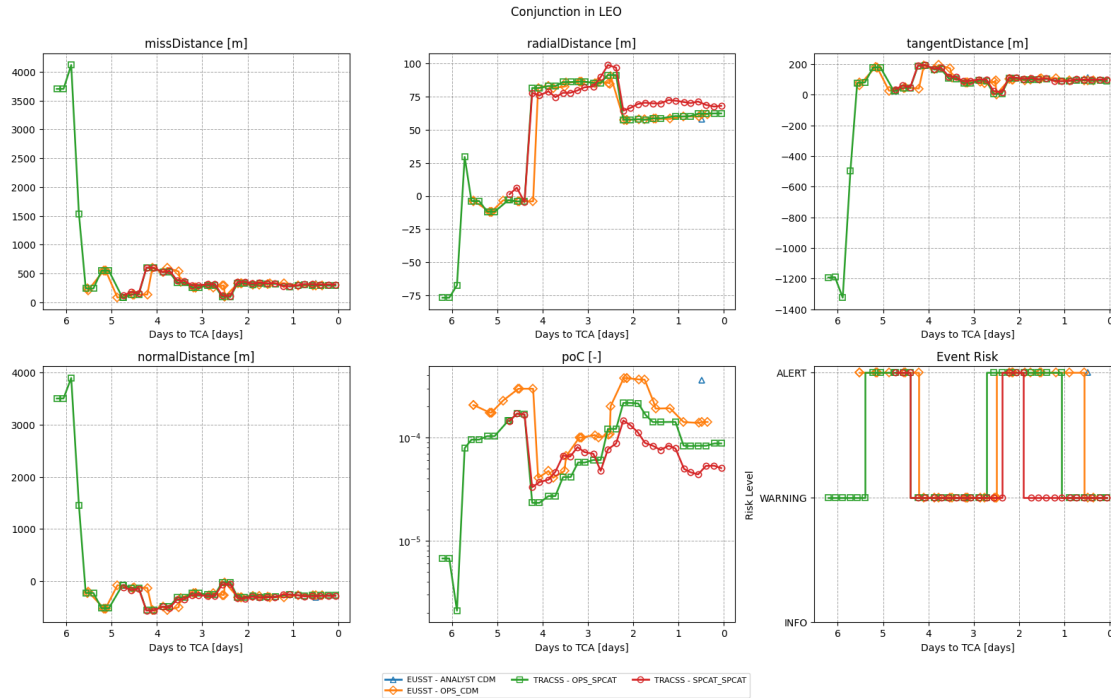


Fig. 6: Evolution of metrics for a LEO conjunction.

One apparent difference is how early each system begins to publish CDMs for the conjunction. TraCSS published its first CDM 6.21 days before TCA, which is consistent with the 7-day propagation time presented in Table 2 as the CDM was generated by screening an OCM for the primary, whose orbital period is approximately 102 minutes. EU SST,

however, published its first CDM 5.53 days before TCA, which is above the time to TCA threshold for LEO described in Table 1. This is explained by the primary having a user-defined 7-day threshold for time to TCA.

Another difference noted in Fig. 6 is the number of CDMs generated by each system: 35 CDMs from EU SST against 66 CDMs from TraCSS. The reason is that, from around 4.75 days to TCA onward, TraCSS consistently generated and published two CDMs (one OPS_SPCAT and one SPCAT_SPCAT) for each CDM (OPS_CDM) that EU SST uploaded to its portal.

Now that key differences have been highlighted, the similarities can be further investigated. Fig. 7 shows the same conjunction event up to 6 days to TCA to make details more visible.

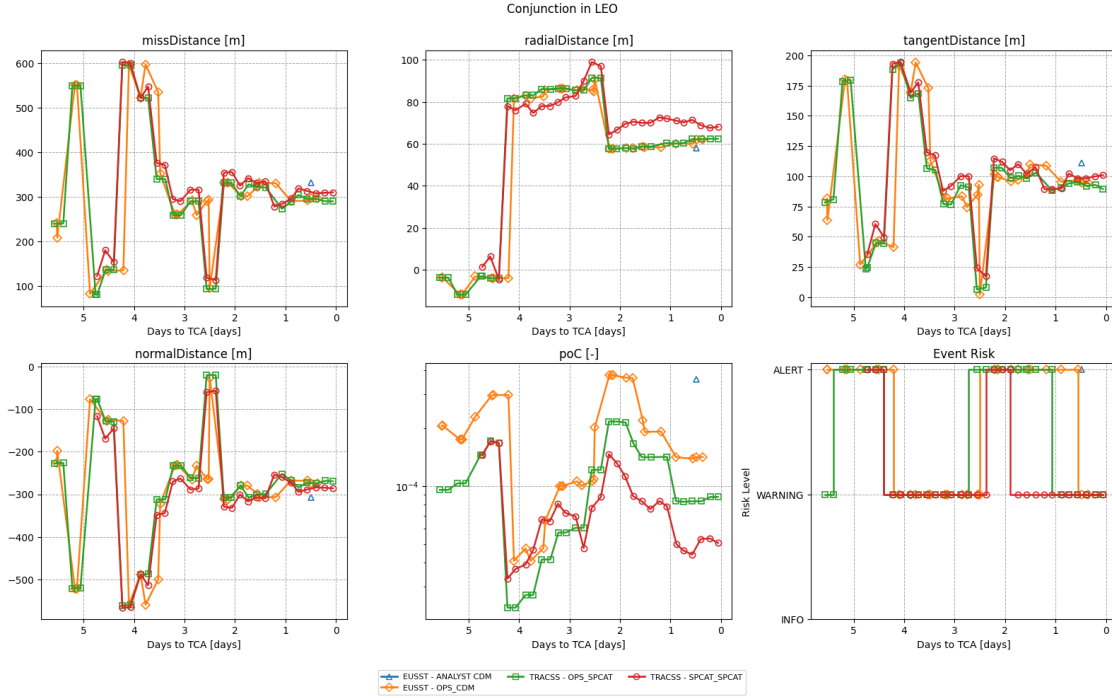


Fig. 7: Evolution of metrics for a LEO conjunction, 0 to 6 days to TCA.

CDMs generated by EU SST with the type OPS_CDM globally show the highest level of risk. CDMs generated by TraCSS with the type OPS_SPCAT have similar P_c and MD metrics compared to EU SST OPS_CDM but with an overall lower P_c . CDMs generated by TraCSS with the type SPCAT_SPCAT also have similar MD but with an even lower P_c , leading to different risk level assignment compared to OPS_CDM and OPS_SPCAT data starting around 1.75 days before TCA.

For this conjunction, EU SST uses operational ephemerides for the primary object and CDMs posted to Space-Track for the secondary object. TraCSS, on the other hand, uses ephemerides from the SPCAT with covariance (only for the secondary object in OPS_SPCAT and for both objects in SPCAT_SPCAT).

Despite significant differences in primary and secondary HBR used by each system, the metrics characterizing the conjunction (i.e., P_c , MD, risk level) were similar. This may be explained with the 2D and 3D P_c calculation method detailed in [15] (slide 14). The HBRs of the primary and secondary objects are combined into a “supersphere” which is then used to compute P_c . For this conjunction, the supersphere HBRs are 8.9 meters and 10 meters for EU SST and TraCSS, respectively. This explanation is consistent with the plots in Fig. 7 where EU SST computes slightly higher P_c and lower MD than TraCSS.

8.2 GEO Case

This subsection presents an investigation of an example conjunction in the GEO regime.

The main characteristics of the primary and secondary objects are highlighted in Table 8. As with the LEO case, the HBR values used by each system are quite different due to the use of default values within TraCSS.

Table 8: Main characteristics of primary and secondary objects

	Primary object	Secondary object
Object type and maneuverability	Active and maneuverable RSO	Inactive and nonmaneuverable RSO
EU SST HBR	15.0 meters	7.5 meter
TraCSS HBR	5.0 meters	5.0 meters

When assessing the plots in Fig. 8, there are clear differences in how early each system tracked the conjunction and how many CDMs each system published. TraCSS begins generating CDMs at 9.85 days to TCA, which is consistent with the 10-day propagation time presented in Table 2 for a Deep Space object screened with OCMs or a GEO object screened with SP ephemerides. EU SST begins generating CDMs at 6.78 days to TCA, which is also consistent with the 7-day time to TCA threshold for GEO described in Table 1. TraCSS published 104 CDMs while EU SST published only 22 CDMs for this event. This can be explained by the fact that TraCSS produced CDMs for 3.07 days before EU SST, and by the increased frequency of screening that TraCSS executes in comparison to EU SST (see Section 3.2).

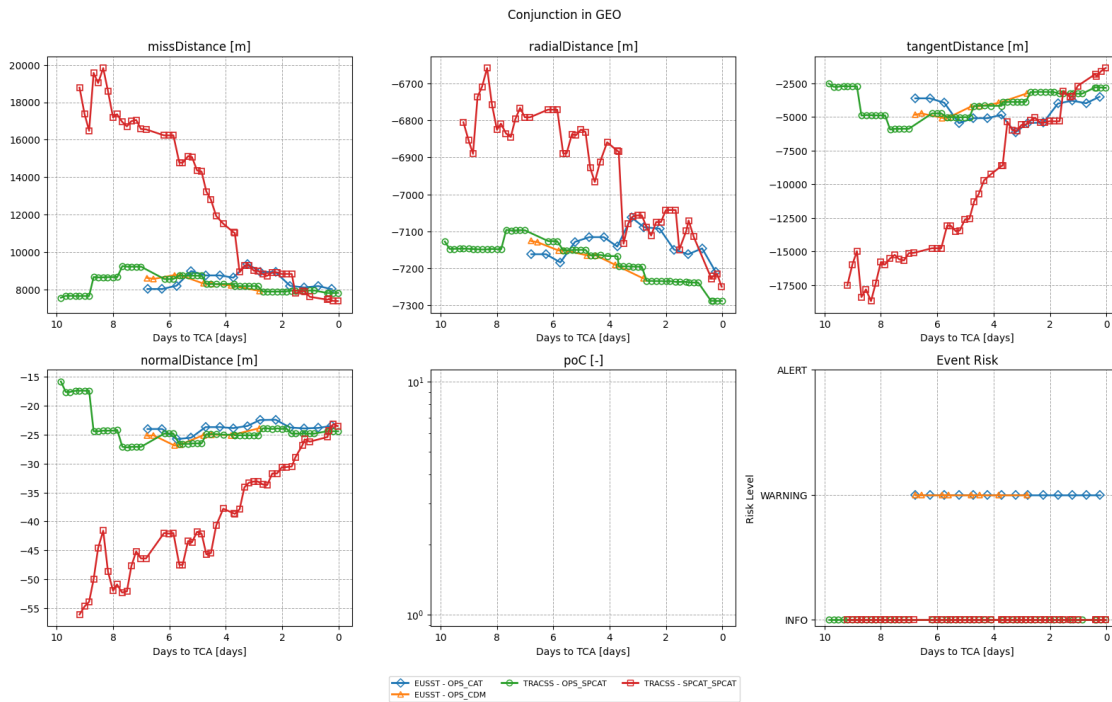


Fig. 8: Evolution of metrics for a GEO conjunction.

One notable aspect of the event history in Fig. 8 is that each system generates multiple types of CDMs, and they do not all produce similar results. Each system produces two different kinds of CDMs to track this conjunction: EU SST generates OPS_CAT and OPS_CDM CDMs whereas TraCSS generates OPS_SPCAT and SPCAT_SPCAT CDMs.

At approximately 10 days to TCA, the two different CDM types TraCSS used produced two vastly different assessments of MD and RD. The SPCAT_SPCAT CDMs assessed the MD at 18,781 m and the RD at $-6,805$ m, while the OPS_SPCAT CDMs show a MD of 7,562 m and the RD at $-7,128$ m. This discrepancy is due to the different data and ephemerides used to track the primary object, which is consistent with the other plots in this study for both LEO and GEO. The SPCAT data likely overestimates the miss distance and RD in comparison to the data provided from the O/O ephemeris.

At approximately 7 days to TCA, both EU SST plots of MD and RD align more closely with the TraCSS OPS_SPCAT assessment than the TraCSS SPCAT_SPCAT assessment, and remain generally consistent with the TraCSS OPS_SPCAT up to TCA. Both EU SST CDM types utilize O/O ephemeris data to track the primary object,

thus it is expected that it would remain consistent with TraCSS when it also uses O/O data. Beginning around 4 days to TCA, the EU SST OPS_CDM assessment appears especially close to the TraCSS SPCAT_SPCAT assessment, likely as a result of the 19 SDS CDM being generated from SPCAT data with covariance, the same ephemeris source that TraCSS uses to evaluate the secondary. It is a positive indication for the accuracy and consistency of the two systems in GEO that they produce similar results when using the same data despite use of different HBRs and P_c calculation methods.

However, the results of this plot also reveal the inconsistencies that arise from assessing GEO conjunctions exclusively using catalog data. The SPCAT_SPCAT CDMs showcase a more erratic assessment of MD and RD when compared to those that use OPS data for the primary. At about 9 days to TCA, the MD increases from 16,475 m to 19,567 m and the RD increases from -6,891 m to -6,737 m between just two CDMs. The RD continues to fluctuate, and the MD decreases until approximately 3.5 days to TCA, where the SPCAT_SPCAT solution finally seems to align more with the MD and RD assessment of the other CDM types. This indicates that the catalog ephemeris data used for both objects results in a less accurate assessment of conjunction risk than if O/O ephemeris data is used for at least one object.

Even as the MD and RD remain consistent between the two systems when using the same ephemeris data, EU SST still evaluates the risk as a WARNING-level event while TraCSS evaluates it as an INFO-level event. Instead of the default thresholds shown in Table 1, the primary object uses a larger RD threshold of 10 km in EU SST, which accounts for the WARNING-level event classification. Meanwhile, TraCSS continues to classify the event as INFO-level due to the event having 0 P_c and the use of criteria from the TraCSS Consolidated Pathfinder to assign risk level to TraCSS CDMs in these time histories.

9. CONCLUSIONS AND SUMMARY

In the analysis period, TraCSS published about 45 times as many conjunction events as EU SST. TraCSS published CDMs for 65% of the 1,432 events published by EU SST. An excess of events published exclusively by TraCSS is expected and explainable by differences in CDM publication rationale—approximately 70% of LEO events from TraCSS involve SPCAT ephemerides for Starlink secondaries, which EU SST will generally not publish when more preferable orbit data sources are available; and 95% of TraCSS-only events in GEO have a risk level below general thresholds for publication by EU SST. The presence of EU SST-only events appears to largely be a result of TraCSS only generating CDMs based on SPCAT data for certain objects. Further investigation is warranted to ensure that all relevant ephemerides are properly received and screened by each system.

These methodological differences do not necessarily suggest superiority of one system over the other. In general, EU SST prioritizes delivery of actionable data generated from high-priority sources. TraCSS takes a more comprehensive approach to screening and distribution of CA products, publishing a much greater quantity of CDMs of various types. Though not analyzed in this paper, both systems also screen and publish data for conjunctions between inactive or non-payload objects. EU SST screens large, non-maneuverable RSOs at least once per day using orbit data from the 18 SDS SPCAT without covariance and EU SST's own sensor network. Resultant CDMs are available to all users registered to the EU SST portal. Two of TraCSS' six daily comprehensive screenings additionally include the most up-to-date orbit data with covariance for all tracked debris and rocket bodies. TCNs for such high-risk events will be made publicly available by TraCSS.

Despite these differences, it became apparent through conducting the study that outputs from the two systems converge when they utilize similar inputs (i.e., operational data provided directly by O/Os). In light of the initial findings presented in this paper, a pragmatic approach based on information exchange for RSOs and orbital events between existing or developing SSA systems in different regions of the world would improve space safety and sustainability as part of a shared global responsibility. In this regard, it is important to improve transparency by ensuring timely access to O/O information. It is therefore essential to encourage O/Os to share their ephemerides (including maneuver plans) and satellite attributes like HBR with SSA systems to improve risk assessment and prevent catastrophic space collisions.

Planned improvements to both TraCSS and EU SST systems indicate a trend toward increased space safety and sustainability; implementation of O/O-reported HBR values for P_c calculation within TraCSS will improve the accuracy of key risk metrics, and standardization of screening parameters within EU SST will lead to more consistent delivery of CA data for operators with similar missions.

While generally it was not difficult to sign up on either system as a third-party provider, it also became clear that sharing information operationally this way is somewhat cumbersome. To send data from TraCSS directly to EU SST, the latter must manually register every individual satellite for which data would be received. Additionally, there are some differences in the data formats used by the two systems, such as the naming of certain optional fields included in CDMs and what information is available from which API endpoints. Increased parity in naming conventions would reduce the workload for O/Os who wish to process and compare outputs between EU SST and TraCSS. Overall operations for O/Os would also be simplified by the two systems establishing a proper pipeline for large quantities of data transfer (e.g., a full ephemeris catalog), though TraCSS planned publicization of operational OCMs and should streamline EU SST's ability to screen data submitted directly to TraCSS.

The team seeks to expand on the findings presented in this paper through further analysis. We aim to present a more in-depth investigation of systematic differences that lead to differences in the quantity of events and CDMs reported, as discussed in Section 6, as well as an exploration of differences in event risk classification between EU SST and TraCSS. Potential routes include:

- More detailed investigation into differences by orbital regime, for which we plan to expand the set of spacecraft analyzed to include objects at higher near-Earth altitudes;
- Application of orbital data source priority filtering on TraCSS CDMs to assess the degree to which such filtering is responsible for excess TraCSS-only CDMs;
- More thorough tracking of orbit data used for screenings, especially in TraCSS;
- Systematic analysis of differences in HBR values used for P_c calculation by each system; and
- Assessment of the different screening volumes used and whether reporting agreement improves when considering the volume screened by both systems.

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- **Daniel García Yarnoz:** Project Administration

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