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Description

Resolution of comments from the New Work Item Proposal to reinstate the project is attached at the end of the draft.

CD 9490

COMMITTEE DRAFT

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Space systems — Space Traffic Coordination

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Introduction

This Space Traffic Coordination document specifies requirements for the coordination of space traffic, which support the aim to promote the safe and efficient use of space. All spacefaring nations share a vested interest and responsibility to create conditions for a safe, stable, and operationally sustainable space environment.

A broad overview of the sections contained in this document is provided in **Figure 1**.

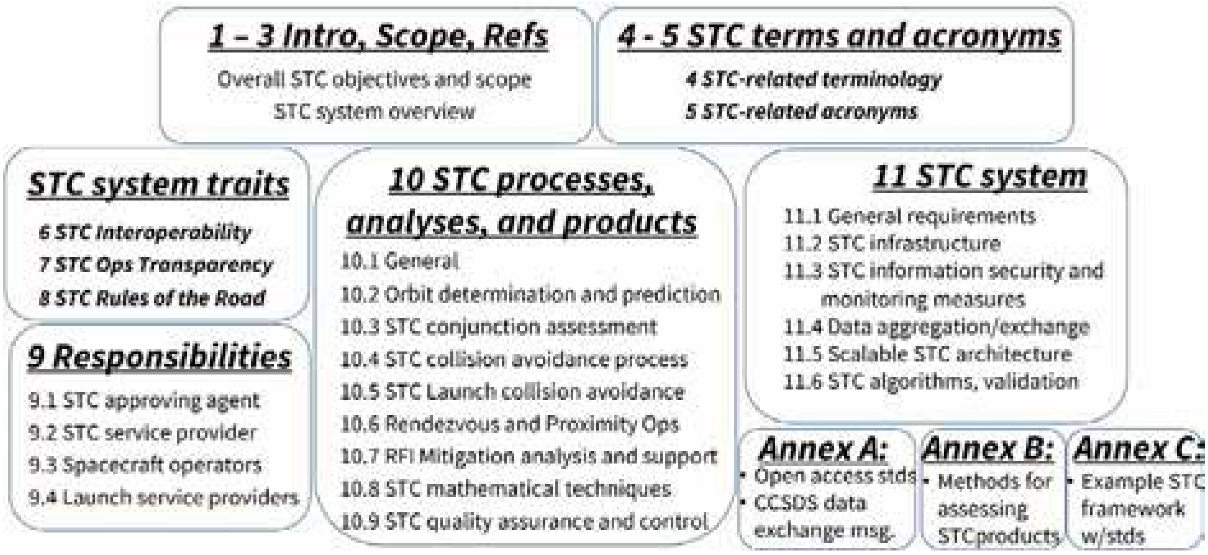

Figure 1 — Contents and topic areas contained in this STC standard, mapped to section numbers

Relationships between STC-relevant terms

To further clarify the interrelationships between many of terms defined above, see **Figure 2**.

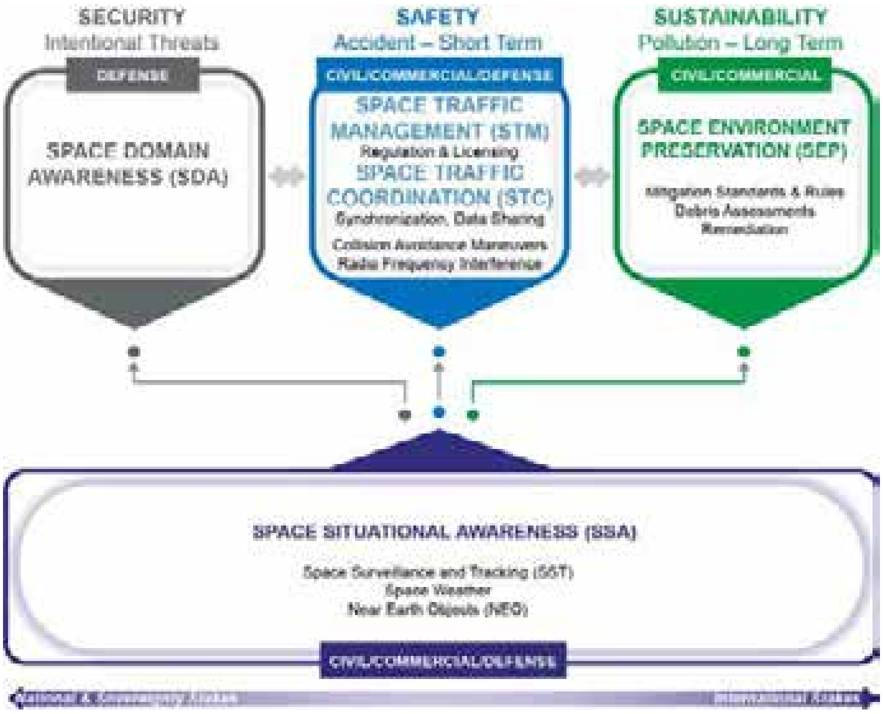

Figure 2 — Relationships between SDA, STM, STC, SEP and SSA [1]

An **STC system** also supports a spacecraft operators' compliance with relevant international standards.

Another view of the relationship between SDA, SSA, SST, STC, and STM is shown using a Venn diagram as shown in **Figure 3**.

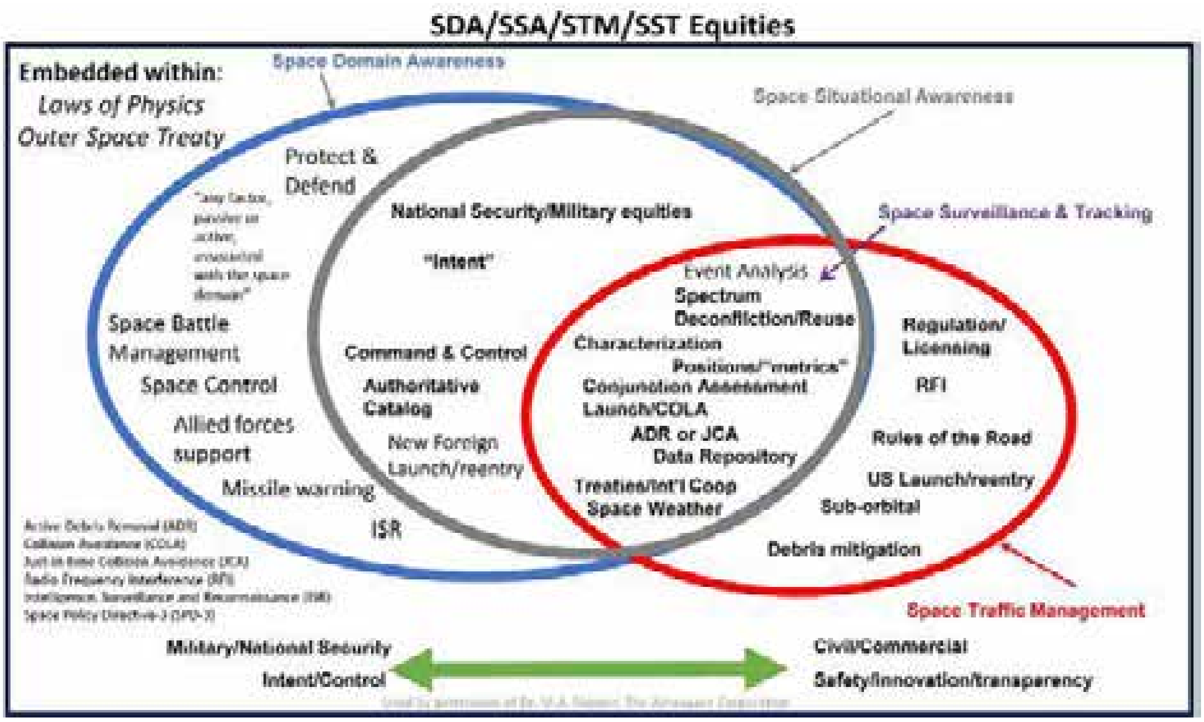

Figure 3 — Venn diagram of relationships between SDA, SSA, STM, and STC.

The range of STC systems is shown in **Figure 4**. For example, in its simplest form, an STC system may be nothing more than a communications path (via text message, telephone call, email or fax) to convey, e.g., small amounts of operator or SSA data between operators, which we refer to as a "**Level 0 STC system**." In its most complex form, a "**Level 2 STC system**" is a data sharing and exchange portal as well as a processing and analysis centre that provides a place where STC service providers, spacecraft and launch service providers, and environment monitoring entities can pool their data for both information exchange and STC system analyses. A **Level 1 STC system** is focused on data exchange and may be collocated with an SSA system.

Accordingly, an STC system may consist of some or all of the elements shown in **Figure 5**. A critical enabler in this figure is the "Standards and protocol-based interoperability layer, which allows different organizations to exchange, interpret and process data seamlessly.

Such coordination and synchronization are accomplished by spacecraft and launch service providers working and interacting collaboratively with both STC and **Space Situational Awareness (SSA)** service providers. This collaboration relies upon the central tenets of data exchange, communications, interoperability, and flight safety analysis capabilities provided by one or more **STC system**(s).

Accordingly, an effective STC system must levy requirements on both the spacecraft and launch service providers, as well as any STC system(s). The effectiveness of the STC system relies upon coordination of space activities conducted by spacecraft and launch service providers and the exchange of STC and SSA information upon which their flight safety coordination is based.

The choice of one or more suitable STC system type(s) may largely be a policy decision. This standard provides requirements related to the many subsystems that an STC system may consist of, to include STC Servers and Network, STC Space Data Interfaces, STC Data Aggregation and Curation, STC Operations, STC Quality Control, and STC Algorithms and Metrics. These are designed to maximize STC analysis and service timeliness, accuracy, completeness, transparency, and are standards-based, progressive, and highly available to support the operators' risk mitigation decision-making processes.

This standard does not address issues of national sovereignty or inherently governmental functions implied by the term **Space Traffic Management (STM)**. The exact nature of and requirement for the bidirectional STC-to-STM feed indicated by **Figure 5** depends upon applicable STM policies and regulations. For example, an STC system can exchange information with STM system(s) to assist in STM monitoring and/or regulatory functions where required by an STM decision authority.

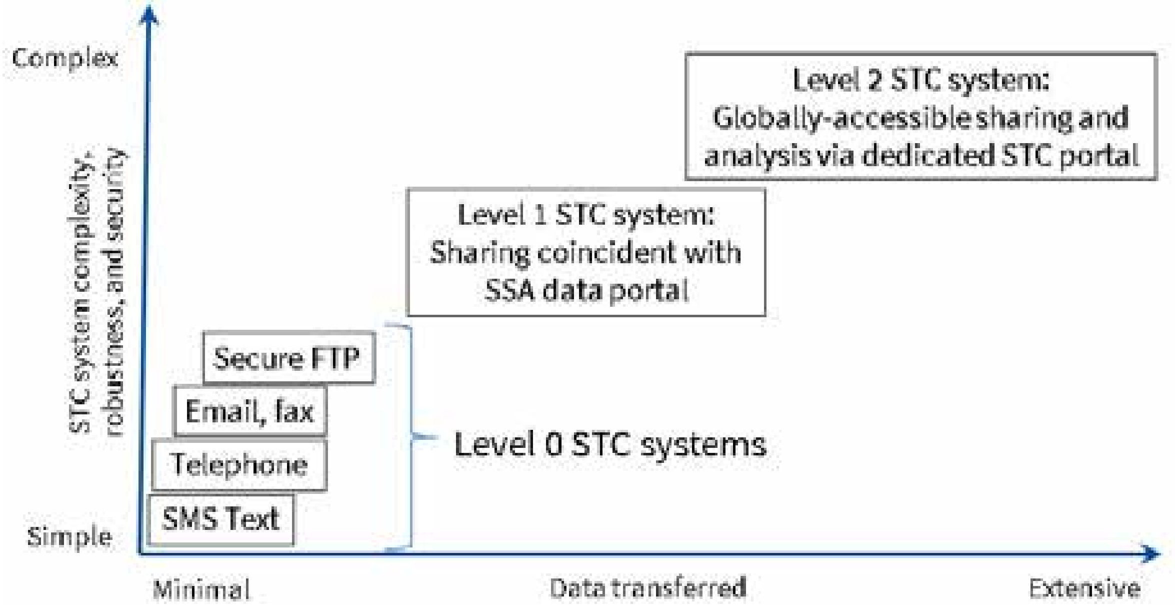

Figure 4 — Possible types of STC communication channels characterized by complexity, robustness, and security

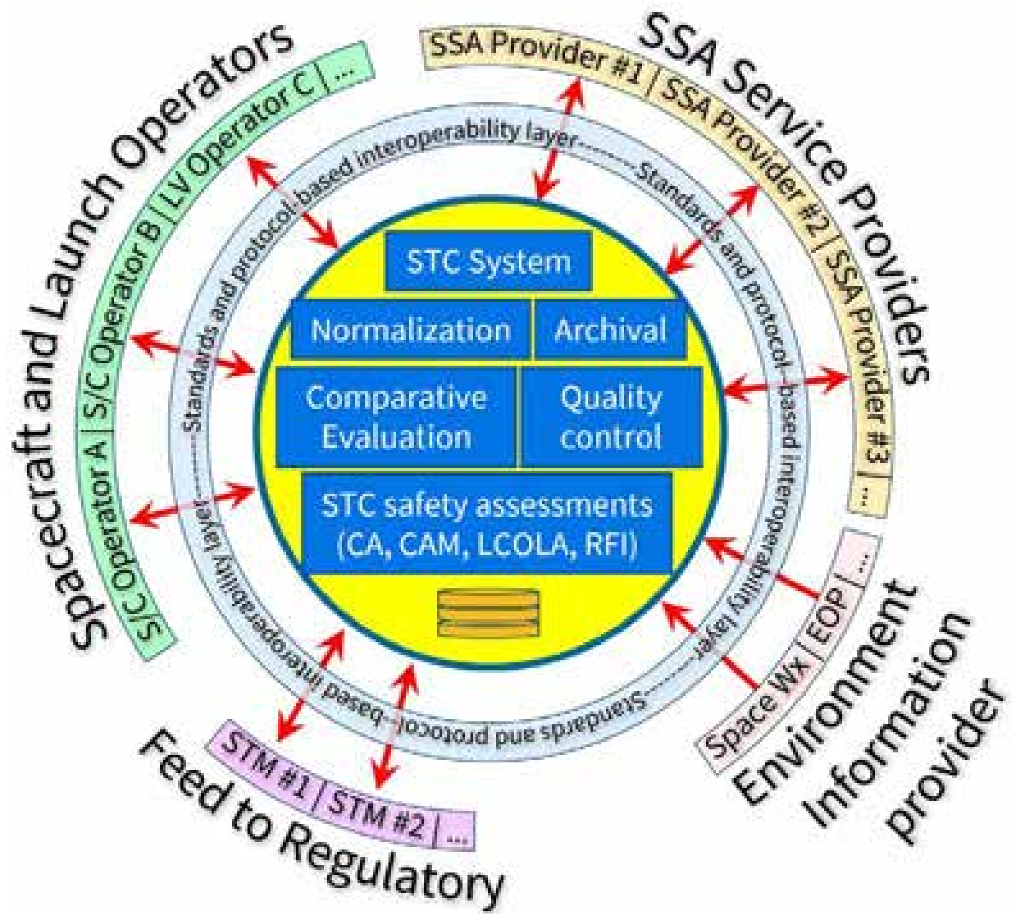

Figure 5 — Interactions by organizations for a dedicated Level 2 STC SYSTEM

Space systems — Space Traffic Coordination

1 Scope

This document addresses the essential elements and protocols needed for **Space Traffic Coordination** (henceforth referred to as "**STC**"). STC is critical to enhance the safety, stability, and sustainability of operations in the space environment." STC enables flight safety, mitigates collision risk (for manoeuvrable spacecraft), and mitigates Radio Frequency Interference (RFI) for all phases of flight, spanning pre-launch safety assessment through manoeuvre plans, on-orbit collision avoidance, RFI mitigation support services, and mission disposal.

This document is designed to enable the effective coordination of space traffic from pre-launch safety assessment to disposal at the end of operation through norms, the effective monitoring, and mitigation of collision risk and RFI. The document is designed for state actors, spacecraft designers, spacecraft operators, and STC system developers and operators.

While this document applies to the range of orbital regions in which current STC and SSA systems can effectively track, monitor, and provide actionable data for space objects, it is envisioned that this document is generally applicable to all orbit regimes and for orbits around all central bodies and barycentres.

1.1 Breakdown of space safety constituents across ISO standards

The space flight safety-relevant topics of Space Traffic Coordination, on-orbit collision avoidance, and launch collision avoidance are closely related. To minimize duplication and maximize document consistency, the various content that serve as the basis for these three disciplines has been divided up as shown in *Fig. 6*.

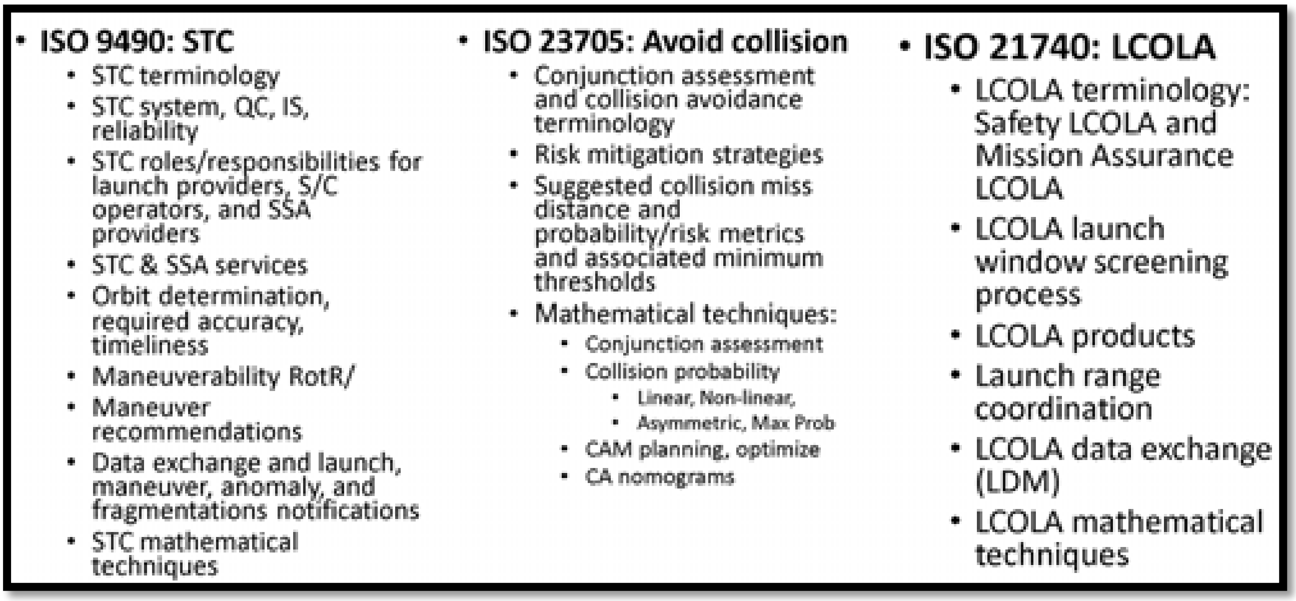

Figure 6 — Division of space safety operations content spanning several ISO standards

2 Normative references

The following documents are referred to in the text in such a way that some or all their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6434, *Space systems — Design, testing and operation of a large constellation of spacecraft*, accessed at https://www.iso.org/committee/46614/x/catalogue/.

ISO 14950, *Space systems — Unmanned spacecraft operability*, accessed at https://www.iso.org/committee/46614/x/catalogue/.

ISO 21740, *Space systems — Launch window estimation and collision avoidance*, accessed at https://www.iso.org/committee/46614/x/catalogue/.

ISO 22639, *Space systems — Design guidelines for multi-geo spacecraft collocation*, accessed at https://www.iso.org/committee/46614/x/catalogue/.

ISO 23705, *Space systems — Identifying, evaluating, and avoiding collisions between orbiting objects*, accessed at https://www.iso.org/committee/46614/x/catalogue/.

ISO 24113, *Space systems — Space debris mitigation requirements*, accessed at https://www.iso.org/committee/46614/x/catalogue/.

ISO 24330, *Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices*, accessed at https://www.iso.org/committee/46614/x/catalogue/.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1

collision probability

quantification of the likelihood of two space objects impacting each other during a *conjunction* event

3.2

collision risk

product of *collision probability* and *collision consequence* for a space object experiencing a single *conjunction* event, or the aggregation of this combination for a space object experiencing multiple *conjunction* events

3.3

collision consequence

outcome of a collision between two space objects

NOTE The outcome of a collision can be characterized in a number of ways, including the likelihood of catastrophic breakup, the number of debris fragments larger than a specified size or mass that might be generated, the lifetime of the resulting fragments [19], or some combination thereof.

3.4

conjunction

event where the positional separation between two objects is at a local minimum and that minimum is either (a) closer than a specified minimum distance threshold, or (b) the estimated probability of collision at this local minimum exceeds a specified collision probability threshold

3.5

Earth Orientation Parameters (EOP)

parameters that specify the orientation of the Earth with respect to one or more reference frames at one or more epochs of interest

3.6

ephemeris

time history of positional and velocity (and optionally acceleration and covariance) state information

3.7

flight safety

condition of travel through its medium where mission-terminating risks have been mitigated

3.8

higher airspace

volume of airspace above altitudes where the majority of air services are provided today (i.e. above Flight Level FL 550)

3.9

higher airspace operations service provider

service provider responsible for separation services for higher airspace operations that are unable to self-separate

3.10

large constellation

collection of one hundred or more spacecraft working together as a system

NOTE In addition to quantity, the spacecraft size, mass, complexity and function of the spacecraft also have a bearing on whether a constellation is regarded as “large,” as detailed in ISO 6434.

3.11

Launch Collision Avoidance

process to identify, coordinate, and avoid conjunctions that can result in a collision between launching objects and other objects in space

NOTE LCOLA processes are fundamentally different from on-orbit collision avoidance due to the on-ground ability to delay launch time by even a few seconds to make a large difference in close approach distance and collision probability, thereby mitigating collision risk. As well, LCOLA launch trajectories typically have much less trajectory accuracy than on-orbit spacecraft, e.g., as much as an order of magnitude worse due to unforeseen and unknowable variations in performance, winds aloft, and guidance errors prior to lift-off.

3.12

Level 0 Space Traffic Coordination system

rudimentary communications path via text message, telephone call, email or fax to convey small amounts of operator or SSA data between operators

3.13

Level 1 Space Traffic Coordination system

mid-level portal primarily focused on data exchange

3.14

Level 2 Space Traffic Coordination system

globally accessible STC information sharing portal, storage, processing, and flight safety analysis endeavour supporting spacecraft and launch service providers, SSA data and information providers

3.15

Long-Term Sustainability (LTS) of Space Activities

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

NOTE This definition is identical to that given in paragraph 5 of the UN COPUOS LTS guidelines, 2019.

3.16

low thrust

spacecraft propulsion system that generates a small, continuous force over extended periods

3.17

normalization

process of converting or mapping data into a common reference frame, units, timing system, element or Cartesian set, and definitions so that analyses and comparisons may be accomplished meaningfully

3.18

Space Assigned Numbers Authority (SANA) Registry

numbers authority for the Consultative Committee for Space Data Systems (CCSDS), providing CCSDS with, “a standardized list of reference frames, element sets, timing systems, attitude specifications, spacecraft and orbit types, atmosphere and gravity models and spacecraft activity status

3.19

space data

information regarding the space environment or activities in the orbital space environment

3.20

space data repository

device, computer, database, or other storage system that allows the population, storage, retrieval, and manipulation of space data

3.21

space object catalog

one-to-one mapping between unique object identifiers and a unique description of what the object is

3.22

Space Domain Awareness

effective identification, characterization, and understanding of any factor, associated with the space domain that could affect space operations and thereby impact the security, safety, economy, or environment of a nation [2]

3.23

Space Environment Preservation

act of protecting, conserving, and sustaining the space operations environment, accomplished by space debris mitigation and remediation

3.24

Space Situational Awareness

Knowledge and characterization of the space environment to facilitate decisions that support safe, stable, and sustainable space activities

NOTE Includes all artificial space objects (spacecraft, rocket bodies, mission-related objects and fragments), natural objects, asteroids (including Near-Earth Objects or NEOs), comets and meteoroids, effects from space weather, including solar activity and its radiation [3]. Assessed risks include potential risks to humans and property in space, on the ground and in the air space due to accidental or intentional re-entries, on-orbit explosions and release events, on-orbit collisions, radio frequency interference, and occurrences that could disrupt missions and services.

3.25

Space Surveillance and Tracking

detection, observation, monitoring, cataloguing and prediction of the movement of space objects and the identification and alerting of derived risks

NOTE Space Surveillance and Tracking is generally accomplished through the operation and calibration of ground-based or space-based tracking sensors using radar, optical, or passive RF technology.

3.26

Space Traffic Coordination

cooperative planning, harmonization, data and information sharing, and synchronization of space activities to avoid collision and radio frequency interference during spacecraft and launch vehicle operations in space

3.27

Space Traffic Coordination Service Provider

entity that operates the STC system pursuant to its obligations set by the relevant STC system approving agent

NOTE STC services can be provided by a combination of one or more commercial, governmental, non-governmental, or international entities, as well as by a mandated or delegated entity assigned by applicable national regulation.

3.28

Space Traffic Coordination system

set of protocols, communications paths, information gathering and exchange, and may additionally include data fusion and SSA analytical services to facilitate flight safety, sustainability, and decision making

NOTE An STC system can be described as being either “Level 0” (simple method to share limited amounts of data) [4.12], “Level 1” (focused solely on information gathering and exchange) [4.13], or at its most complete scope and reach as a “Level 2” STC system [4.14].

3.29

Space Traffic Coordination system approving agent

entity who sets requirements for, monitors, and approves the procurement, management, oversight, implementation, operations, performance evaluation, quality assurance, and monitoring functions of the Space Traffic Coordination system under their authority

NOTE The STC system approving agent’s responsibilities can be handled by a commercial, non-governmental, governmental, or international individual or entity, as well as a mandated or delegated entity assigned by applicable national regulations.

3.30

Space Traffic Coordination system participants

set of entities that manage, operate, or use a Space Traffic Coordination System, including the STC system approving agent, STC service provider, spacecraft and launch service providers, SSA and other STC entities, governments, and academia

3.31

Space Traffic Coordination system user

entity that utilizes STC system products and services to inform and make operational decisions

NOTE Spacecraft operators, launch service providers, Higher Airspace operators, SSA systems, other STC systems, and governments may all be considered to be STC system users.

3.32

Space Traffic Management

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 radio frequency interference

NOTE STM contributes to a safer and more sustainable space operations environment, composed of (1) Space Traffic Coordination (STC), and (2) Regulation and Licensing, and dependent upon a foundation of continuous Space Situational Awareness (SSA).

3.33

State Actor

entity participating in international space activities on behalf of a government

NOTE While the roles of a State Actor could include that of regulator, spacecraft operator, launch service provider, and/or STC service provider, note that this standard does not address regulatory matters.

4 Symbols and abbreviated terms

4.1 Symbols

(TBD)

4.2 Abbreviated terms

ADR	Active Debris Removal
CA	Conjunction Assessment
CAM	Collision avoidance manoeuvre
CCSDS	Consultative Committee for Space Data Systems
COLA	COLision Avoidance
FGUA	Fine-grained user access
GEO	Geostationary earth orbit
HAO	High altitude operations
HEO	High earth orbit
ISR	Intelligence, Surveillance and Reconnaissance
ITU	International Telecommunication Union
JCA	Just-in-time Collision Avoidance
LCOLA	"Launch Collision Avoidance" or "Launch COLA"
LEO	Low earth orbit
LTS	Long-Term Sustainability
LV	Launch vehicle
MEO	Medium earth orbit
O/O	Owner/Operator (i.e., of a spacecraft)
PoC	Point of Contact
RFI	Radio frequency interference
SANA	Space Assigned Numbers Authority
SAST	Static Application Security Testing
S/C	Spacecraft

SDA	Space Domain Awareness
SDR	Space Data Repository
SEP	Space environment preservation
SRP	Solar Radiation Pressure
SSA	Space situational awareness
STC	Space traffic coordination
STM	Space traffic management
TCA	Time of Closest Approach

5 STC system interoperability

5.1 General

There are several ways to promote interoperability of STC systems that State actors, spacecraft and launch service providers, STC service providers, and SSA data and service providers operate and/or depend upon. These include the development and widespread use of (1) common STC terminology, (2) consensus international data exchange formats, and (3) internationally accepted open-access data exchange mechanisms and/or repositories.

5.2 STC terminology

In order to promote interoperability and compatibility, STC system participants should adopt and use the terminology, definitions, orbital element sets, attitude/orientation, orbit centres, organizations, time systems, reference frames, gravity models, and atmosphere models as defined in Section 2 above as well as the SANA registry (https://www.sanaregistry.org/r/navigation_standard_registries) and [3] and [21].

5.3 International space operations and data exchange message standards

Consistent with UN COPUOS LTS [4] Guideline A.2.f [1] and the operational practices of spacecraft and launch system providers and SSA data and analytics entities, STC system participants shall use, where possible, international technical standards.

NOTE 1: The primary developer of STC-relevant consensus-based international standards related to data exchange that are open-access (freely available to everyone) is the Consultative Committee for Space Data Systems (CCSDS). CCSDS, which is space agency-led, and agency funded, publishes their standards via the CCSDS web portal (www.ccsds.org).

NOTE 2: ISO's Technical Committee 20, Subcommittee 13 (ISO TC20/SC13) works in partnership with CCSDS to co-publish relevant CCSDS standards on the ISO site (https://www.iso.org/ics/49.140/x/).

Note 3: See Appendix A for a listing and discussion of the Open-access international CCSDS data exchange standards. Especially noteworthy ones include ISO 19933 (Space systems — Format for spacecraft launch environment test report), ISO 26900 (Space data and information transfer systems — Orbit Data Messages), ISO 19389 (Space data and information transfer systems — Conjunction Data Messages), ISO 13541 (Space data and information transfer systems — Attitude Data Messages), ISO 13526 (Space data and information transfer systems — Tracking Data Message), and ISO 17107 (Space data and information transfer systems — XML specification for navigation data messages), [described in *29, 30, 32, 33, 35, 39, respectively*].

[1] [States should] Consider ... using existing international technical standards, including those published by the International Organization for Standardization (ISO), the Consultative Committee for Space Data Systems and national standardization bodies."

5.4 International space data exchange mechanisms

Spacecraft operators and STC service providers should use bilateral and multilateral mechanisms, to include State Actor, commercial, and international entities, to exchange quality-controlled data that are readily accessible, easy to use, robust, secure, and have a high level of availability to share information where needed to support flight safety, relating to a spacecraft's orbit, attitude, tracking, launch, dimensions, mass, manoeuvre, orbit determination, points-of-contact, covariance, and ephemeris inclusive of planned manoeuvres and covariance information.

6 Operational transparency

6.1 General

As called for in the Outer Space Treaty[2] [5] and other relevant UN documents [42], information sharing and exchange on space objects and events is important for the purposes of ensuring space safety and sustainability.

6.2 Exchange of information on orbital parameters of outer space objects and potential orbital conjunctions

Spacecraft operators and launch service providers shall exchange planned manoeuvres, ephemerides inclusive of those manoeuvres, attitude, potential orbital conjunctions, spacecraft characteristics, and points-of-contact information with affected state actors and private sector STC systems and spacecraft operators.

6.3 Notification of planned spacecraft launches

Launch service providers shall, for the purpose of space safety and collision avoidance, provide pre-launch notifications of space vehicle launches and the mission of launch vehicles to known potentially-affected state actors, spacecraft operators, and HAO Service Providers, using internationally-standardized message formats, including Notice to Airmen [6], Notice to Mariners [7], and CCSDS space data exchange messages [32].

NOTE: Such notifications should be provided at least 10 days prior to the event if possible.

6.4 Notifications on scheduled manoeuvres or fragmentation events that may result in risk to the flight safety of other space objects

Spacecraft operators and launch service providers shall notify, in a timely manner, potentially affected spacecraft operators of scheduled manoeuvres, fragmentation events, or other spacecraft or launch vehicle anomalies that may result in risk to the flight safety of their spacecraft.

[2] "In order to promote international co-operation in the peaceful exploration and use of outer space, States Parties to the Treaty conducting activities in outer space, including the Moon and other celestial bodies, agree to inform the Secretary General of the United Nations as well as the public and the international scientific community, to the greatest extent feasible and practicable, of the nature, conduct, locations and results of such activities."

6.5 Notifications in the case of emergency situations:

Spacecraft operators and launch service providers shall, in a timely manner, notify other known potentially affected States of events linked to natural and man-made threats to the flight safety of space objects. These may include risks caused by the malfunctioning of space objects or loss of control and/or loss of collision avoidance capabilities that could result in a significantly increased probability of a high-risk re-entry event or a collision between space objects.

7 Manoeuvre recommendations and prioritization for when two manoeuvrable spacecraft are at risk of collision

7.1 Collision avoidance manoeuvre coordination

Collision avoidance manoeuvres should be coordinated with the other spacecraft operator(s).

NOTE: This can be accomplished via bilaterally or multilaterally negotiated coordination protocols or agreements and implemented as applicable.

7.2 Spacecraft manoeuvrability categories

Spacecraft shall be categorized into the following six manoeuvrability categories:

i. Non-manoeuvrable; total inability to make flight safety-relevant orbital changes.

ii. Minimally Manoeuvrable Robotic: Only able to perturb one's orbit to a very small degree such that mitigation measures specified in ISO 23705 can be achieved but not within one orbital revolution.

iii. Manoeuvrable Robotic: Able to easily alter the spacecraft course within one orbital revolution using available propellant to mitigate the threat of collision as specified in section ISO 23705.

iv. Automated on-ground collision avoidance (COLA) manoeuvrable capability (robotic spacecraft performing manoeuvres based on on-ground automation (i.e. computation of the manoeuvre on-ground).

v. Automated on-board collision avoidance (COLA) manoeuvrable capability (robotic spacecraft).

vi. Inhabitable (presumed manoeuvrable): An inhabitable space station that can alter its path to avoid collision.

NOTE: These categories may change over time for a spacecraft, e.g., should its manoeuvring system or attitude control system degrade or fail.

7.3 Spacecraft automated manoeuvrability transparency

Operators of spacecraft having automated on-ground and on-board COLA capabilities shall provide operational status updates on the autonomous system.

NOTE: Such operators should also publish information with affected operators and STC system approving agents regarding how the automation system works, its status, and maximize sharing with affected operators and/or STC system platforms of avoidance manoeuvre plans to be taken at least 12 hours before the avoidance manoeuvre takes place and verify that conducted avoidance manoeuvres effectively reduce collision risk as intended.

7.4 Spacecraft manoeuvre recommendations and prioritization

Unless affected spacecraft operators can reach an alternative agreement on an acceptable collision risk mitigation plan, the general baseline manoeuvre recommendations and prioritization are listed in Table 1 shall be applied with the following additional guidance:

a) Spacecraft operators of robotic missions should allow operators of inhabitable space stations to select who manoeuvres.
b) Operators of manoeuvrable spacecraft or space stations should pre-coordinate via bilateral discussions with other operators within their same manoeuvrability category to determine who will manoeuvre in the event of a conjunction and to share their avoidance manoeuvre Go/No-Go metrics and thresholds (**suggested metrics and associated thresholds are provided in ISO 23705**).
c) Should a serious conjunction be detected between two operators who have not pre-coordinated, those operators should engage in bilateral discussions to coordinate their understanding of who will manoeuvre, when, and how.
d) Objects which are not on their operational mission orbit should conduct the avoidance manoeuvre.
e) Operators of large constellations (defined in ISO 6434) should conduct the collision avoidance manoeuvre (referred to as “giving way).
f) Manoeuvrability of involved spacecraft should be considered as a decision criterion according to Table 1.
g) When privately-owned and publicly owned spacecraft conjunct and those spacecraft are in the same manoeuvrability category, the privately-owned spacecraft should conduct the collision avoidance manoeuvre.

Table 1 — Avoidance manoeuvre recommendations and prioritization

	Non-manoeuvrable	**Minimally Manoeuvrable**	**Manoeuvrable**	**On-ground automated collision avoidance**	**On-board automated collision avoidance**	**Inhabitable**
Non-manoeuvrable	N/A	Minimally manoeuvrable S/C moves	Manoeuvrable S/C moves	On-ground automated COLA S/C moves	On-orbit automated COLA S/C moves	Inhabitable space station moves
Minimally Manoeuvrable		Satellites moving into or out of their designated mission orbit should conduct avoidance maneuver to avoid satellites already in their mission orbit. Otherwise, decided in bilaterally negotiated coordination protocol or agreement.	Manoeuvrable S/C moves.	On-ground automated COLA S/C moves	On-orbit automated COLA S/C moves	Inhabitable space station moves
Manoeuvrable			Satellites moving into or out of their designated mission orbit should conduct avoidance	On-ground automated COLA S/C moves	On-orbit automated COLA S/C moves	Transiting robotic spacecraft shall be responsible for avoiding inhabitable space stations by at least 10 km.

			maneuver to avoid satellites already in their mission orbit. satellites in their mission orbit. Otherwise, (or in cases where both satellites are moving into or out of their mission orbits), decided in bilaterally negotiated coordination protocol or agreement.			If both are in mission orbit, then by real-time coordination, operators of robotic missions shall allow operators of inhabitable space stations to select who manoeuvres.
Automated on-ground collision avoidance				Established via pre-coordinated bilaterally negotiated coordination protocol or agreement and/or real-time coordination.	On-orbit automated COLA S/C moves	Transiting robotic spacecraft shall be responsible for avoiding inhabitable space stations by at least 10 km. If both in mission orbit, then by real-time coordination, operators of robotic missions shall allow operators of inhabitable space stations to select who manoeuvres.

On-board automated collision avoidance					Established via pre-coordinated bilaterally negotiated coordination protocol or agreement and/or real-time coordination.	Transiting robotic spacecraft shall be responsible for avoiding inhabitable space stations by at least 10 km. If both in mission orbit, then by real-time coordination, operators of robotic missions shall allow operators of inhabitable space stations to select who manoeuvres.
Inhabitable						Bilateral real-time discussion to determine who manoeuvres.

7.5 Exceptions to maneuver recommendations and prioritization

Exceptions to these default maneuver recommendations and prioritization assignments shall be:

i. Cases where the above is pre-empted by an established spacecraft operator-to-operator bilateral (or multilateral) coordination protocol, agreement, or discussion between both parties.

ii. where both spacecraft belong to the same operator and that operator selects an alternate course of action.

iii. Rendezvous and docking operations.

7.6 Further clarification of avoiding inhabitable spacecraft

With the exception of resupply or transport vehicles sent to dock with inhabitable space stations, manoeuvrable (i.e., excluding non-manoeuvrable and minimally manoeuvrable) robotic spacecraft shall be responsible for avoiding inhabitable space stations by at least 10 km. Failing that, spacecraft operators of robotic missions shall allow through real-time coordination with operators of inhabitable space stations to select who shall “give way” (meaning to take evasive manoeuvring action), because human safety is of paramount importance. Operators of inhabitable space stations shall be able to determine their own levels of acceptable risk, have full control, and have the highest levels of support.

7.7 Communication of operator interpretation of manoeuvre rules, planned avoidance manoeuvres, and spacecraft status

Spacecraft operators should communicate their interpretation of manoeuvre rules and their avoidance manoeuvre plans with spacecraft operators involved in the conjunction for all predicted close approaches, even if the other spacecraft is/are un-manoeuvrable or minimally manoeuvrable.

8 Responsibilities of STC system participants

8.1 STC responsibilities of the STC system approving agent

8.1.1 STC screening metrics and thresholds

The STC system approving agent shall, in close collaboration with spacecraft operators and consistent with any relevant national regulations, set conjunction safety assessment (including both on-orbit and LCOLA) criteria and thresholds, and specify the assessment algorithm(s) used to evaluate those criteria.

8.1.2 STC system requirements

The STC system approving agent shall set STC system accuracy, availability, operations, monitoring, training, timeliness, completeness, performance, security, and quality control requirements and monitor compliance thereof.

8.1.3 STC service provider requirements

The STC system approving agent shall set requirements for their selected STC service provider(s).

NOTE: Suggested topics may include staffing, system backups, network operations, load balancing, system monitoring and quality control, availability, performance reporting, user account maintenance, and training.

8.1.4 STC system security and quality control requirements

The STC system approving agent shall set any additional requirements the STC system, especially regarding flight safety, security, and quality control requirements.

8.1.5 STC system authorized data sources

The STC system approving agent shall authorise sources of information to be used in the STC system, including data from authorized STC users, SSA data providers, and other STC systems.

NOTE: This is especially critical when there is no data available from STC system users or normal SSA data providers.

8.2 STC responsibilities of spacecraft owners and operators

8.2.1 Spacecraft manufacture and operations

In addition to adhering to normative references [Section 3], spacecraft operators should give consideration to additional guidance offered in [8].

8.2.2 Spacecraft collision avoidance reliability

Spacecraft owners shall maximize availability and reliability of collision avoidance maneuver systems. Relevant ISO standards include [9, 10].

Qualification-level testing shall be conducted for protoflight [11, 12] spacecraft, until all critical systems (including those required for maintain spacecraft control and perform active collision avoidance) have been demonstrated on orbit.

8.2.3 Acquisition of STC system services

Spacecraft operators shall obtain support from at least one STC system and its underlying SSA system to obtain the necessary STC and SSA information as mandated by a STC system approving agent.

NOTE: STC services may include data communications, data exchange, interfaces, comparative analyses, data fusion and ensemble modelling, protections of intellectual property and confidentiality, and levels of accuracy, availability, timeliness, and completeness.

8.2.4 Selection of risk assessment procedure and avoidance manoeuvre threshold

Spacecraft operators, working in concert with STC service providers and the STC system approving agent, shall use consensus collision risk assessment algorithms, object dimensions, metrics and thresholds for avoidance manoeuvres.

NOTE: Suggested algorithms, metrics, and thresholds are provided in ISO 23705.

8.2.5 Spacecraft operator contact information

Operators of spacecraft shall register their organization's contact information in a globally accessible repository for designated point of contact(s) (PoCs).

The operator of the selected repository shall be responsible for the security of the spacecraft operator's PoC information.

Identified spacecraft operator teams or PoCs shall respond on a 24/7 basis to flight safety and RFI inquiries and STC data exchange requests from STC service providers, STC system operators, and other space operators within one hour of an emergency request, either by human operators or by an automated system. Such a response can consist of an acknowledgement of message receipt and confirmation that a response is being formulated.

8.2.6 Spacecraft operator provision of space data

Spacecraft operators should provide with known relevant entities, including spacecraft operators and SSA and STC systems they are obtaining support from the following information:

8.2.6.1 Notification of planned spacecraft manoeuvres

All planned manoeuvres that are materially relevant to flight safety and RFI mitigation should be shared with other relevant operators. At a minimum, the shared data elements should include manoeuvre epoch, duration, impulsive velocity change (or thrust, specific impulse, and mass), and manoeuvre direction.

NOTE 1: For low thrust or other long-duration manoeuvres, an acceleration or thrust profile time history (including directionality) may be provided.

NOTE 2: Upon deciding to execute the collision avoidance operation and select the avoidance manoeuvre, the spacecraft operator shall provide its final manoeuvre plan and/or ephemeris inclusive of that manoeuvre plan to relevant spacecraft operators, SSA, and STC systems.

8.2.6.2 Predicted positional information and covariance

Predicted orbit ephemerides that include position and covariance time histories that accurately reflect both planned manoeuvres and post-manoeuvre orbital conditions shall be provided by spacecraft operators and STC systems spanning at least the next 4 days in LEO and 7 days in MEO/GEO within the time allotted in Table 2 after manoeuvre was conducted or the orbit updated.

Such ephemerides shall be provided with positional information at least to the millimetre level, velocities to the nanometre per second level, angular measurements to 1.e-9 degrees, and covariances matrix element significant digits corresponding to the combination of the above position, velocity, and angle measurements, accordingly.

Spacecraft operators should provide the avoidance and returning manoeuvre plan to STC system to confirm the collision risk during the avoidance and retuning manoeuvres.

8.2.6.3 Spacecraft physical characteristics

Spacecraft characteristics required by other operators to manage collision risk with their space objects and mitigate RFI risks, to include spacecraft attitude and pointing uncertainties, maneuver capability (a simple yes/no, at a minimum), spacecraft dimensions and mass, and RF characteristics.

8.2.6.4 Notification of spacecraft incidents and anomalies

Information pertaining to spacecraft incidents and anomalies that affect flight safety and collision avoidance capabilities.

8.2.6.5 Failures in control functions

Upon indication of a critical failure that could lead to a loss of control, in parallel with taking corrective actions, notify known SSA and STC systems and potentially affected spacecraft operators of the situation within two hours.

8.2.6.6 Indications of a spacecraft break-up

Upon indications that an operator's spacecraft has experienced a break-up event, in parallel with taking corrective actions, notify within two hours of occurrence known relevant SSA and STC systems and known potentially affected spacecraft operators of the situation.

8.2.7 Spacecraft operator data exchange

8.2.7.1 Timeliness

When engaging in interactions to enable efficient procedures and safe operations, spacecraft operators shall share data as soon as manoeuvre plans are finalized and, at a minimum, on operationally relevant timescales that are orbit dependent as shown in Table 2.

NOTE: Relevant timescales depend upon a variety of factors including the manoeuvrability of the S/C, its mission, housekeeping strategies, etc.

Table 2 — Spacecraft operator data exchange notification timeliness requirements

	LEO	GEO	Other
Planned manoeuvres	No later than 1 hr prior	No later than 6 hrs prior	No later than 3 hrs prior
Modification of manoeuvres	No later than 1 hr prior	No later than 6 hrs prior	No later than 3 hrs prior

Notification of aborted or failed manoeuvres	No later than 1 hr after spacecraft operator becomes aware of the manoeuvre abort/failure	No later than 1 hr after spacecraft operator becomes aware of the manoeuvre abort/failure	No later than 1 hr after spacecraft operator becomes aware of the manoeuvre abort/failure
Post-manoeuvre ephemeris	No later than 3 hrs after manoeuvre	No later than 12 hrs after manoeuvre	No later than 6 hrs after manoeuvre
Attitude, bus, or manoeuvre control failure notification	No later than 2 hrs after spacecraft operator becomes aware of the control failure	No later than 2 hrs after spacecraft operator becomes aware of the control failure	No later than 2 hrs after spacecraft operator becomes aware of the control failure
Indication of breakup	No later than 2 hrs after spacecraft operator becomes aware of the breakup	No later than 2 hrs after spacecraft operator becomes aware of the breakup	No later than 2 hrs after spacecraft operator becomes aware of the breakup

NOTE: Modifications to manoeuvre plans should be screened to avoid potential collisions.

8.2.7.2 **Spacecraft data exchange message format and standards**

Manoeuvre and orbit information shall be formatted using a mutually agreed upon message format selected from the CCSDS Orbit Data Message family of messages [13] (see section 6 for STC system interoperability requirements).

8.2.8 Conjunction Assessment during routine operation phase

Spacecraft operators shall monitor collision risk estimates obtained from either an STC system or their own, as soon as updated information is available.

8.2.9 Collision risk assessment according to standardized procedure

When notified of collision risks by the SSA or STC system or when estimated collision risk exceeds a spacecraft operator’s threshold, the operators shall provide a short term (e.g., 7 days) ephemeris predict updated by the latest orbit determination to STC systems and confirm that collision risk is below their STC approving agent’s specified threshold using the latest data of the approaching spacecraft.

8.2.10 Coordination of avoidance manoeuvres

When two operational spacecraft conjunct, the spacecraft operators shall coordinate with each other to plan avoidance manoeuvre(s) and manoeuvre(s) which return their spacecraft to their original mission operational orbit(s) as needed, incorporating spacecraft operator data on the two conjuncting spacecraft as well as relevant data from SSA and STC systems.

Note: Spacecraft operators should contact the other spacecraft operator by using a globally accessible points-of-contact database (as defined by each STC system's approving agent) where available.

8.2.11 Support from STC system

When a conjunction with other satellites is found, an STC system shall notify spacecraft operators of the conjunction to let them coordinate for the conjunction risk mitigation.

Note: An STC system may help spacecraft operators to select and plan a collision avoidance manoeuvre by providing manoeuvre-trade-space plots, optimization tools, and/or through direct exchanges (by phone, mail or other mean of communication).

8.2.12 Radio Frequency Interference mitigation procedures

Each spacecraft operator shall follow established processes to coordinate its use of the RF frequency band to avoid harmful interference with other space-based and ground-based users of the RF spectrum, utilizing STC system functions as described in section 10.7.

8.3 STC responsibilities of launch, mission extension, and ADR service providers

8.3.1 Launch notifications

Launch, mission extension, and ADR service providers shall, with the cooperation of spacecraft operators and for the purpose of space safety and collision avoidance, provide pre-launch notifications of space vehicle launches and the mission of launch vehicles to known potentially affected state actors, spacecraft operators, and HAO Service Providers, using internationally standardized message formats, including Notice to Airmen [14], Notice to Mariners [15], and CCSDS space data exchange messages

8.3.2 Acquisition of STC system services

Launch, mission extension, and ADR service providers shall obtain support from at least one STC system and underlying SSA system(s) to obtain the necessary data communications, data exchange, interfaces, comparative analyses, data fusion and ensemble modelling, protections of intellectual property and confidentiality, and levels of accuracy, availability, timeliness, and completeness mandated by the approving agent.

NOTE: Where not available or sufficient through the STC system, such service providers should obtain additional support from one or more SSA service providers to obtain the necessary SSA information at the required levels of accuracy, availability, timeliness, and completeness established by the approving agent.

8.3.3 Launch Collision Avoidance (LCOLA) Conjunction Assessment

Prior to launch, launch service providers planning the orbital injection of space objects shall, either (a) provide the latest orbital ephemerides to STC service providers and STC systems to facilitate the identification of launch times that are at risk of collision with on-orbit objects [16], and/or (b) conduct LCOLA analyses drawing upon comprehensive SSA information and LCOLA algorithms and thresholds validated and certified by the approving agent to identify launch times that reduce post-launch collision risk below the approving agent's acceptable risk thresholds.

Note1: LCOLA analyses allow simple launch time shifts of a few seconds to mitigate collision risk.

Note2: The responsibilities of the launch service provider are not limited to those detailed in this paragraph. For instance, they can include liability and minimisation of risks for third parties on the surface and in the atmosphere during the launch, ascent, and re-entry phases. Procedures agreed with relevant Air Traffic Management service providers can minimise risks for airspace users.

Note3: Coordination between STM and Higher Airspace Traffic Management and Air Traffic Management systems should be established as appropriate.

8.3.4 Selection of LCOLA risk assessment algorithms and screening thresholds

Launch service providers, working in concert with STC system and the STC system approving agent, shall select suitable consensus LCOLA risk assessment algorithms, object dimensions, metrics and thresholds. If multiple threshold limits exist between two or more entities, the more stringent of the thresholds shall be adopted.

8.3.5 Launch vehicle contact information and global points-of-contact database

Launch service providers operating launch vehicles attaining altitudes shall register their organization's contact information in a globally accessible, centralized repository for designated point of contact(s) (PoCs) according to national mandates and contractual requirements with the STC service provider. The STC service provider shall be responsible for the security of the launch service provider's PoC information.

The identified PoCs shall respond on a 24/7 basis to flight safety and RFI inquiries and STC data exchange requests from STC service providers, STC system operators, and other space operators within one hour of an emergency request, either by human operators or by an automated system. Such a response can consist of an acknowledgement of message receipt and confirmation that a response is being formulated.

8.3.6 Launch vehicle orbit information message format and standards

Manoeuvre and orbit information shall be formatted using a mutually agreed upon message format selected from the CCSDS Orbit Data Message family of messages [17] (see section 6 for STC system interoperability requirements).

8.3.7 Launch service provider data exchange content

Launch service providers should share with any relevant entities, sufficient information to allow other operators to manage collision risk with catalogued space objects and mitigate RFI risks.

8.3.8 Launch service provider data exchange timeliness

When engaging in interactions to enable efficient procedures and safe operations, the launch service provider shall share data on operationally relevant timescales as shown in Table 3.

Table 3 — Launch service provider data exchange timeliness requirements

	Timeliness requirement
Launch window	12 hrs prior
Deployment sequence	2 days prior to launch
Pre-launch ephemeris inclusive of staging manoeuvres and deployment imparted velocities for all deployed objects	2 days prior to launch
Control failure notification	No later than 2 hrs after launch service provider becomes aware of the control failure
Indication of breakup	No later than 2 hrs after launch service provider becomes aware of the breakup

8.3.9 Notification of launch vehicle incidents and anomalies

8.3.9.1 Failures in control functions

Upon indication of a critical failure that could lead to a loss of control, the launch service provider, in parallel with taking corrective actions, shall notify relevant SSA and STC systems and spacecraft operators of the situation.

8.3.9.2 Indications of a launch vehicle or upper stage break-up

Upon indications that a launch vehicle or upper stage has experienced a break-up event, the launch service provider shall notify relevant SSA and STC systems and spacecraft operators of the situation.

8.3.10 Radio Frequency Interference mitigation procedures

Each launch service provider shall follow established processes to coordinate its use of the RF frequency band to avoid harmful interference with other space-based and ground-based users of the RF spectrum.

9 STC system functional processes, analyses, and products

9.1 General

9.1.1 Disclosure of STC system/spacecraft operator agreements

Upon finalization of an STC service agreement, the spacecraft owner shall disclose the types of data available from their STC service provider as well as the data security processes implemented to protect the viability and provenance of that data..

NOTE: Data may include PoC information, launch data, ephemerides inclusive of planned maneuvers, spacecraft status (active, backup, or inactive), spacecraft physical characteristics, RF information, planned manoeuvres, spacecraft disposal plans and execution, anomaly status, etc.

9.1.2 Relationship with other spacecraft operators

Upon finalization of an STC service agreement and authorization by the spacecraft operator, the STC Service Provider should disclose the names of spacecraft operators and their respective spacecraft to facilitate the coordination of conjunction assessments and collision avoidance strategies, either conducted directly by the STC system or through coordination with cooperating STC Service Providers.

9.2 Orbit Determination and Orbit Prediction

9.2.1 Orbit Determination solution of time-dependent model parameters

Where present, an STC system's orbit determination (OD) processing function shall have the capability to solve for orbit solutions and time-dependent model parameters (e.g., ballistic coefficient, solar radiation pressure coefficient, manoeuvres) when provided with observational data for any space object.

9.2.2 Noncooperative solving of and recovery from unknown forces

Such an orbit determination function shall have the capability to identify, model, incorporate, recover from and/or solve for the effects of unknown/unanticipated forces, to include low-thrust manoeuvres performed by spacecraft using electric propulsion, on timescales compatible with achieving a STC system approving agent's accuracy and timeliness requirements.

9.2.3 Temporally deterministic propagation of covariance uncertainty

The STC system's Orbit Determination algorithm shall incorporate temporally realistic deterministic propagation of covariance uncertainty, following the best-known dynamical model and accounting for unknown time-dependent force variations and process noise.

9.3 Conjunction assessment

9.3.1 STC system conjunction assessment on operational timescales

An STC system's conjunction assessment should provide conjunction assessment results to spacecraft operators updated at least once per day but ideally whenever either conjuncting object's orbit is updated.

9.3.2 User-selectable conjunction and collision avoidance metrics

An STC system's conjunction assessment capability shall provide the STC system approving agent, spacecraft operators and analysts with a diverse, user-selectable set of conjunction & collision avoidance "Go/No-Go" manoeuvre metrics to assess collision risk as dictated by Table 4.

Note1: The actual Go/No-Go thresholds will be selected by the spacecraft operator in consultation with any other involved spacecraft operator and the STC approving agent.

Note1: Suggested thresholds provided in ISO 23705.

Note2: There are many diverse Go/No-Go decision criteria that operators may use. Typically, screening thresholds for miss distance at TCA, collision probability, or collision risk.

Note3: The type of conjunction assessment and screening thresholds used in the STC system shall be determined by the spacecraft operator (in compliance with any relevant national directives for assessment methods and associated screening thresholds).

Note4: Inputs to the conjunction assessment process depend upon the assessment method used as shown in Table 4. These may include orbital ephemerides (or alternatively, orbit states and planned manoeuvres from which ephemerides can be generated), conjunction screening, collision probability, or collision risk thresholds, and object sizes, covariance time histories, and scale factors (where needed to improve covariance realism).

Table 4 — Screening criteria, thresholds, and required input data for various CA screenings

	Criteria and thresholds			Input data required					
CA criteria:	Miss dist.	Pc	Collision risk	Ephemeris, orbit states, planned manoeuvres, or observational data	Covariance time histories	Object sizes, mass, cross-sections	Space weather	Ballistic and SRP coefficients	Covariance scale factors
Geometric miss distance screening	●			●		●	●	●	
Collision probability Pc		●		●	●	●	●	●	●

Collision risk			●	●	●	●	●	●	●	●

9.3.3 Function to distinguish manoeuvrable spacecraft from other objects

STC systems shall be able to distinguish between manoeuvring spacecraft and other space objects and update this categorization periodically.

9.3.4 Screening of nominal and candidate predictive ephemerides

STC system capabilities shall support the screening of both operational predicted positional time histories that incorporate all planned manoeuvres, as well as non-operational, “candidate manoeuvre” positional time histories.

NOTE: This allows operators to compare the benefits to space flight safety from using a variety of mitigation and avoidance manoeuvre strategies.

9.3.5 Avoidance manoeuvre calibration and manoeuvre verification products

An STC system shall provide the capability to calibrate avoidance manoeuvres and generate manoeuvre verification products.

Note1: The decision to conduct the avoidance maneuver calibration is made by the spacecraft operator.

Note2: Manoeuvre calibration products include estimates of maneuver efficiency, maneuver thrust direction, and manoeuvre timing parameters.

9.3.6 Flight safety notifications

An STC system shall distribute or post alerts of potential flight safety threats to its customer set and any known affected spacecraft operators immediately upon completion of the assessment.

9.4 Collision avoidance process

9.4.1 Standardized conjunction assessment procedure

An appropriate collision avoidance assessment procedure should be used to identify if any future close approaches with other satellites or debris exceed the STC system approving agent’s and/or spacecraft operator’s established conjunction criteria thresholds and warrant an avoidance manoeuvre. The workflow is as follows:

a) Spacecraft operators provide orbital ephemerides and associated covariance information to SSA and STC systems whenever the orbit is changed or a new orbit is determined/updated, inclusive of future planned manoeuvres.

b) Spacecraft operators provide a list of the details of future planned manoeuvres.

c) An STC system uses data from STC service providers, spacecraft operators, and STC system-conducted orbit determinations to identify conjunctions exceeding the established minimum distance and/or collision probability threshold values. whenever orbits are changed or, at a minimum, periodically **assessed at least once per day,** but ideally updated every time the orbit of either conjuncting object is updated,.

9.4.2 Avoidance manoeuvre analysis of alternatives and optimization

An STC system should optionally be able to support avoidance manoeuvre planning function for upcoming collision threat deemed to pose a serious risk based upon collision probability and/or risk, while adhering to a satellite operator's manoeuvring capabilities, mission constraints, and established post-CAM collision avoidance target thresholds.

9.4.3 Collision probability variability and distribution

When the necessary input data support such computations, the STC system should optionally be able to characterize sensitivities to miss distance, ballistic coefficient, covariance realism, aspect ratio of the combined covariance ellipsoid mapped into an ellipse on the relative velocity encounter plane), object dimensions, and attitude [18, 19] when assessing collision probability (one of the more commonly used collision risk assessment metrics, particularly in Low Earth Orbit).

9.5 LCOLA launch window screening process

9.5.1 Geometry-based and probability-based LCOLA screening

An STC LCOLA screening function should optionally be able to perform and support both geometry-based and collision probability-based Launch Collision Avoidance (LCOLA) screening and launch window analysis, as detailed in ISO 21740.

9.5.2 LCOLA supporting multiple deployed objects

To support deployment strategies for multiple deployed objects, STC system LCOLA capabilities should operationally support launch deployment strategies that prevent intra- and inter-spacecraft collision and to maximize SSA tracking efficiency, timeliness, and accuracy.

9.6 Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing (OOS)

An STC system may support coordination with spacecraft operators conducting on-orbit servicing (OOS) and rendezvous and proximity operations (RPO), complying with requirements for RPO and OOS systems as defined in ISO 24330: Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic Principles and Practices.

9.7 RFI

9.7.1 RFI and RF analysis functions

An STC system may be able to generate Radio Frequency Interference (RFI) analyses and products. Such products should be delivered in a timely and accurate manner, including a predictive "Fly-by" RFI analyses, support for geolocation systems, pre-geolocation solution set optimization.

NOTE: RFI is typically assessed as [carrier]/[noise + interference], such that when this ratio falls below the communications system's performance specification, such communications are either degraded or prevented.

9.7.2 RFI coordination function

In the event that RFI is anticipated, the STC system should notify known spacecraft and ground system operators of the expected interference event, provide supporting analytical results, and help coordinate mitigation of RFI, either bilaterally or via the ITU [20].

9.8 STC system mathematical techniques, numerical methods

9.8.1 Mathematical techniques and numerical methods

STC system capabilities shall use proper mathematical techniques and numerical methods for space weather, earth orientation parameters (EOP), definitive and predictive positional time histories and covariance matrices.

9.8.2 Disclosure and documentation of STC system algorithms and procedures

The STC service provider shall document and disclose to its customer an overview of the mathematical techniques, processes, assumptions, and approximations made to generate its STC system products. Where such information is proprietary in nature, such information may be bound by a non-disclosure agreement.

9.8.3 Collision probability assessment using suitable models

STC systems shall use peer-reviewed collision probability estimation techniques which are suitable for the specific conjunction geometry, conditions, and object shapes being analysed, to include high-velocity (linearized) conjunctions, co-orbital/non-linear conjunctions, and aspherical space objects where dimensions and orientation are known quantities.

Note: See ISO 23705 for a description of the various methods and a bibliography of collision probability assessment techniques and algorithms.

9.8.4 Earth Orientation Parameters

An STC system shall regularly update its Earth Orientation Parameters as specified by a STC system approving agent to maximize solution accuracy and compatibility with other operators and STC service providers.

9.8.5 Space weather

An STC system shall regularly update its space weather history and predictions as specified by a STC system approving agent to maximize performance of atmosphere modelling.

9.8.6 Reference frames

Reference frames utilized for space data shall be selected, whenever possible, from consensus international descriptions as contained in [21].

9.8.7 Force model sharing and ingest

The STC service shall transparently and clearly ingest and share force model settings with STC data recipients where possible to maximize compatibility of orbit prediction.

9.8.8 Error covariance realism

An STC system shall yield realistic covariance (error) portrayals, both historical and predictive, including all covariance elements needed to propagate the covariance forward.

NOTE: A discussion of covariance realism is included in Appendix B.

9.8.9 Ephemeris and error covariance step size

An STC system shall promote the use of ephemerides that have at least 90 uniform time steps per orbit revolution for circular orbits or 300 uniform time steps for elliptical/GTO orbits. Alternately, the STC system shall use at least 120 non-uniform time steps if the Sundman time transformation is used for elliptical/GTO orbits.

9.8.10 Ephemeris and error covariance significant digits

An STC system shall provide positional information at least to the millimetre level, velocities to the nanometre per second level, angular measurements to 1.e-9 degrees, and covariances matrix element significant digits corresponding to the combination of the above position, velocity, and angle measurements, accordingly.

NOTE: The required significant digits and interpolation step size are closely related, as detailed in [22]. More stringent limits on the minimum significant digits, formats, and contents may be imposed by the STC system approving agent.

9.8.11 Interpolation of orbit state 3-D vector, error covariance, and reference frame time histories

Orbital state 3-D vectors, covariance matrix, reference frame and vector time histories shall be interpolated using a three-dimensional vector interpolation method authorized by the STC approving agent.

NOTE: Examples of such methods include (1) using orbit-dynamics-aware numerical methods such as those provided in [23]or (2) eigenvalue/vector decomposition and morphing as presented in Appendix B.3 [24, 25, and 26].

NOTE: It is **inappropriate** to interpolate covariance time histories on an element-by-element basis.

9.8.12 Definitive and predictive positional accuracy

The STC service provider shall continuously monitor the suitability of SSA and spacecraft operator data and estimated positional accuracy (as defined by a STC system approving agent) [27, 28] when producing the flight safety products, metrics, and analytics required by flight safety criteria and thresholds selected by each STC system's approving agent.

9.9 Quality assurance and control

9.9.1 Regular positional precision monitoring

An STC system operator shall conduct regular precision assessment overlap tests and comparative SSA analyses for positional input data that the STC system uses to generate safety products.

Note1: Examples of such positional input data may include spacecraft operator ephemerides, STC service provider ephemerides and STC system fused orbit solutions, etc.

Note2: An STC system is encouraged to conduct comparative SSA, comparing its positional information with that provided by the spacecraft owner/operator, other STC systems (as available), and reference orbits solutions to characterize agreements, identify discrepancies, and evaluate and identify potential cross-tags and track mis-associations.

9.9.2 Aspects to monitor in quality control

Pursuant to requirements set by STC approving agent, the STC system operator shall monitor the relevant aspects that the STC system contains, including those document in sections **Error! Reference source not found.**, 10.8.8, 10.8.9, 10.8.10, and 10.8.12.

9.9.3 Notification of out-of-family orbit solutions

For STC systems that conduct orbit determination, out-of-family orbit solutions shall be highlighted immediately to identify potential anomalies and/or other situations requiring operator attention and intervention.

10 Level 2 STC system requirements

10.1 General requirements

An STC system shall adhere to requirements issued by the STC approving agent as well as requirements in the normative standards from Section 3.

Note: A set of **example** topics and requirements is provided in Annex D.

Annex A
(informative)

Open-access international CCSDS data exchange standards

This section of the informative technical annex presents the use of so-called “overlap” tests to empirically estimate the precision, and therefore the best-achieved accuracy, of SSA products.

A.1 Adherence to open-access international standards

Within the ISO/CCSDS context, many space data exchange standards have been published by the space agency-led Consultative Committee for Space Data Systems (CCSDS). Most of the STC-relevant standards are developed and maintained with the CCSDS Navigation Working Group (NAV WG). A mapping of STC disciplines to key published space data exchange messages is provided in Table A.1.

CCSDS standards are under a periodic review cycle of no more than 5 years and cover a wide range of messages and formats. The current scope of international data exchange standards relevant to STC are shown in Table A.1. The left column shows STC needs, and columns indicate existing standards meeting those needs.

Table A.1 — STC-relevant data conveyance needs and standards

	Existing CCSDS messages and related standards										
	Attitude Data Message	Conjunction Data Message	Digital Motion Imagery	Events Message[3]	Orbit Data Message	Pointing Request Message	Radio Freq & Mod. Systems	Re-entry Data Message	Space Data Link Security Stds	Time Code Formats	Tracking Data Message
Attitude	•				•	•				•	
Conjunctions	•	•			•					•	
Manoeuvres					•					•	
Orbit & errors					•					•	
PoC database					•						
Re-entry					•			•			
RF, RFI, Geoloc							•				
RPO/OOS			•		•		•		•		•
Space catalog					•	•				•	•
Space events	•	•		•	•			•		•	•
S/C chars, SoH					•					•	
Sensor trk, obs						•				•	•
STC system									•		

A.2 Data exchange using CCSDS standardized messages

An overview of the freely available CCSDS standards judged to have either direct or derivative STC application by space launch service providers, spacecraft operators, STC service providers, analysts, and message exchange partners is now provided.

A.2.1 Attitude Data Message

The Attitude Data Message (ADM) [29], published in 2023, specifies three standard message formats for use in transferring spacecraft attitude information between space agencies and

[3] Events message currently in development by CCSDS.

commercial or governmental spacecraft operators: the Attitude Parameter Message (APM), the Attitude Ephemeris Message (AEM), and the Attitude Comprehensive Message (ACM). Such exchanges are used for:

– pre-flight planning for attitude estimation support;
– scheduling attitude and data processing support;
– carrying out attitude operations;
– performing attitude comparisons;
– carrying out attitude propagations and/or tracking sensor predictions;
– testing to initialize sub-system simulators (communications, power, etc.).

A.2.2 Conjunction Data Message

The Conjunction Data Message (CDM) [30], published in 2023, is widely used and depended upon for flight safety. The CDM specifies a standard message format for use in exchanging spacecraft conjunction information between originators of conjunction assessments, satellite owner/operators, and other authorized parties. Such exchanges are used to inform affected satellite operator(s) of conjunctions between space objects to facilitate development of an effective response should one be necessary.

A.2.3 Digital Motion Imagery

The Digital Motion Imagery standard [31] The purpose of this document is to provide a common reference and framework of standards for digital motion video and imagery, and to provide recommendations for utilization of international standards for sharing or distributing motion video and imagery between spacecraft elements and ground systems.

A.2.4 Orbit Data Message

The Orbit Data Message (ODM) [32] Recommended Standard is an international standard published in 2023 under the auspices of CCSDS and International Standards Organization (ISO) Technical Committee 20, Subcommittee 13, developed jointly and in concert with the ISO TC20/SC14. As such, this CCSDS standard is also properly labelled as ISO 26900. The ODM specifies a family of four standard message formats for use in transferring spacecraft orbit information between space agencies and commercial or governmental spacecraft operators: The Orbit Parameter Message (OPM), the Orbit Mean-Elements Message (OMM), the Orbit Ephemeris Message (OEM), and the Orbit Comprehensive Message (OCM). Such exchanges are used for:

a) pre-flight planning for tracking or navigation support;
b) scheduling tracking support;
c) carrying out tracking operations (sometimes called metric predicts);
d) performing orbit comparisons;
e) carrying out navigation operations such as orbit propagation and orbit reconstruction;
f) assessing mutual physical and electromagnetic interference among satellites orbiting the same celestial body (primarily Earth, Moon, and Mars at present);
g) performing orbit conjunction (collision avoidance) studies; and
h) developing and executing collaborative manoeuvres to mitigate interference or enhance mutual operations.

A.2.5 Pointing Request Message

The Pointing Request Message (PRM) [33] allows interagency operators, space agencies and operators to exchange information in a standardized format about a requested pointing of a spacecraft. This standard addresses the numerous occurrences in spacecraft operations, when pointing requests must be transmitted from a user, e.g., of an instrument or of a relay service, to the operator of a spacecraft. The standard allows the message originator to request (sequences of) changes to the attitude of the spacecraft or to an articulated spacecraft component.

A.2.6 Radio Freq & Mod. Systems

The Radio Frequency and Modulation Systems—Part 1: Earth Stations and Spacecraft standard [34] is intended for use by participating space Agencies in their development of Radio Frequency and Modulation systems for Earth stations and spacecraft. These Recommendations allow implementing organizations within each Agency to proceed coherently with the development of compatible Standards for the flight and ground systems that are within their cognizance. These Recommendations were developed for conventional near-Earth and deep-space missions having moderate communications requirements. A later document, Part 2, will be concerned with data relay satellites and will address the needs of users requiring services not provided by the Earth stations covered in this document.

A.2.7 Re-entry Data Message

The Re-entry Data Message (RDM) Standard [35] (henceforth 'the RDM' or 'this standard') specifies a standard message format to be used in the exchange of spacecraft re-entry information between Space Situational Awareness (SSA) or Space Surveillance and Tracking (SST)1 data providers, satellite owners/operators, and other parties. This message can be used to inform spacecraft owners/operators of predicted re-entries or warn civil protection agencies about potential ground impacts. The RDM will:

a) facilitate interoperability and enable consistent warning between data providers who supply re-entry prediction data and the entities that use it;
b) facilitate the automation of re-entry prediction processes; and
c) provide critical information to enable timely re-entry decisions (e.g., a change in the controlled re-entry strategy).

A.2.8 Space Data Link Security Standards

The purpose of the Space Data Link Security Standards [36, 37] is to specify the Space Data Link Security Protocol (hereafter referred as the Security Protocol) for CCSDS data links. This protocol provides a security header and trailer along with associated procedures that may be used with the CCSDS Telemetry, Telecommand, and Advanced Orbiting Systems Space Data Link Protocols to provide a structured method for applying data authentication and/or data confidentiality at the Data Link Layer. This Recommended Standard defines the Security Protocol in terms of the protocol data units employed by the service provider; and the procedures performed by the service provider.

A.2.9 Time Code Formats

The Time Code Format [38] establishes a small number of standardized recommended time code formats for use in data interchange applications between Agencies of the CCSDS. This Recommended Standard does not address timing performance issues such as stability, precision, accuracy, etc.

A.2.10 Tracking Data Message

The Tracking Data Message (TDM) [39] specifies a standard message format for use in exchanging spacecraft tracking data between space agencies. Such exchanges are used for distributing tracking data output from routine interagency cross supports in which spacecraft missions managed by one agency are tracked from a tracking station managed by a second agency. The standardization of tracking data formats facilitates space agency allocation of tracking sessions to alternate tracking resources.

Annex B
(informative)

Methods for assessing STC parameters

B.1 Positional precision as a proxy for positional accuracy

This section of the informative technical annex presents the use of so-called "overlap" tests to empirically estimate the precision, and therefore the best-achieved accuracy, of SSA products.

Ideally, one should try to characterize absolute positional accuracy (a primary SSA metric) as a function of time. Unfortunately, there are few publicly available, positionally well-known "truth" objects in space, so it is difficult to draw statistically relevant conclusions about STC system performance from that small set of objects. Since accuracy is a combination of system biases and the inherent repeatability (or precision) of an STC system's predictions, system accuracy can instead be bounded by estimating that system's precision over a large data set. Any observed imprecisions are typically caused by insufficient SSA force models, unknown or unmodelled events (e.g., unknown space weather or unknown manoeuvres), undersampled observations and/or algorithmic or process based SSA deficiencies.

One can characterize the repeatability of predicted positions over a statistically significant set of objects and sufficiently long timespans. For collision avoidance, such precision statistics associated with orbit prediction timespans of between one and two days are typically of greatest interest because that prediction time is most relevant to an operator's typical Observe/Orient/Decide/Act (OODA) loop for conducting collision avoidance manoeuvres.

The median and 95th percentile statistical discrepancies in the precision (repeatability) of one- to two-day positional predictions spanning the entire range of true anomaly (0° - 360°) can be characterized for LEO (0 – 2000 km altitude) as shown in ***Fig. B-1*** and for GEO in ***Fig. B-2***. These statistics must be compared with the accuracy required to operationally support the collision probability threshold of 0.0001 commonly used by spacecraft operators as a collision avoidance manoeuvre Go/No-Go criterion.

Note that while typical, or 50th percentile, SP ephemeris precision often meets (i.e., is on the left-hand side of) this limiting accuracy threshold, there are altitude ranges, orbit types, and manoeuvrability categories for which orbital data performance may fail to meet the threshold. When one further considers higher levels of occurrence, or 95th percentile, this limiting accuracy threshold may often be exceeded for certain orbital regions (e.g., space weather below 700 km and high-eccentricity orbits) and object types (e.g., active, manoeuvring satellites).

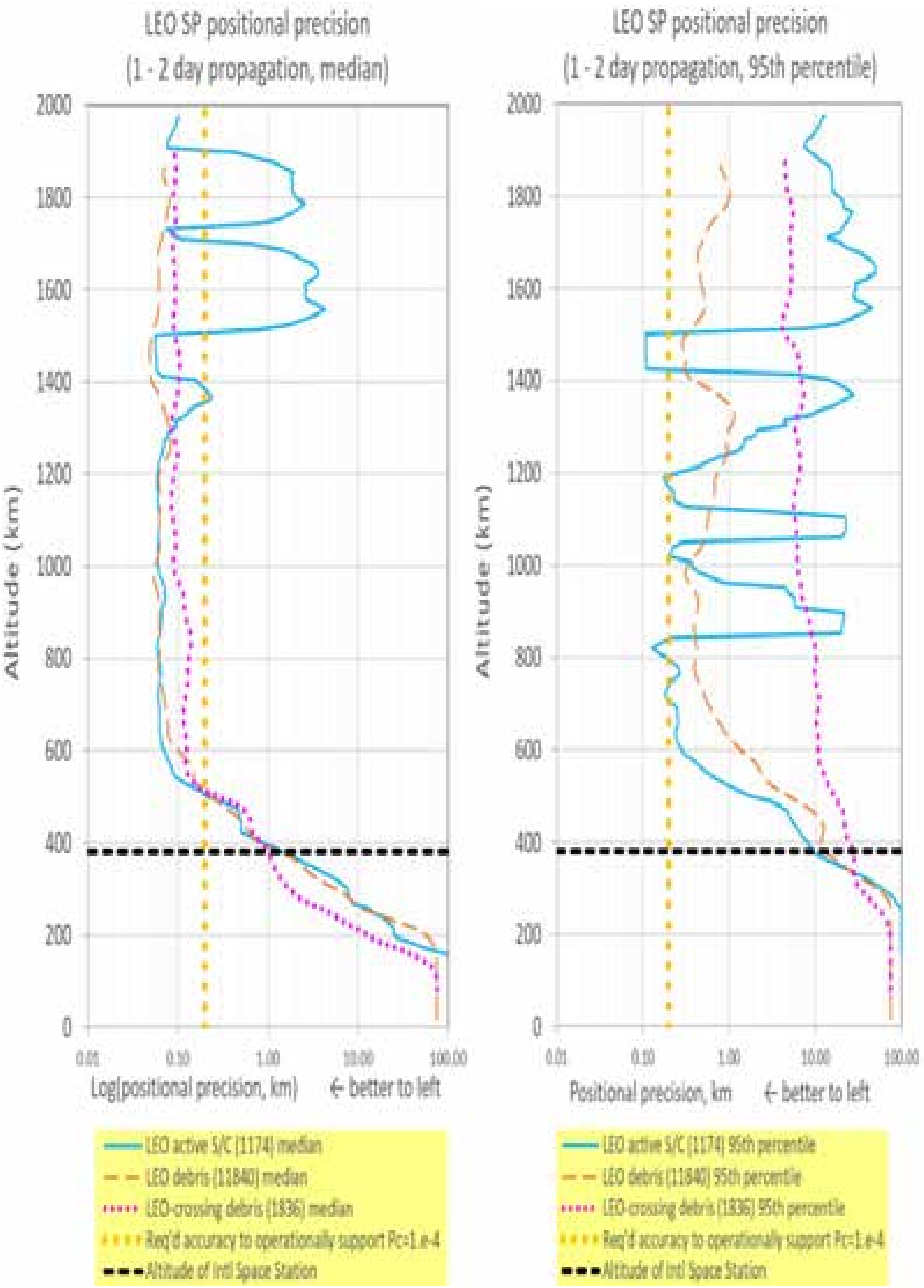

Figure B.1 — Example aggregation of LEO positional precision compared to a minimal conjunction assessment criteria threshold-derived accuracy level.

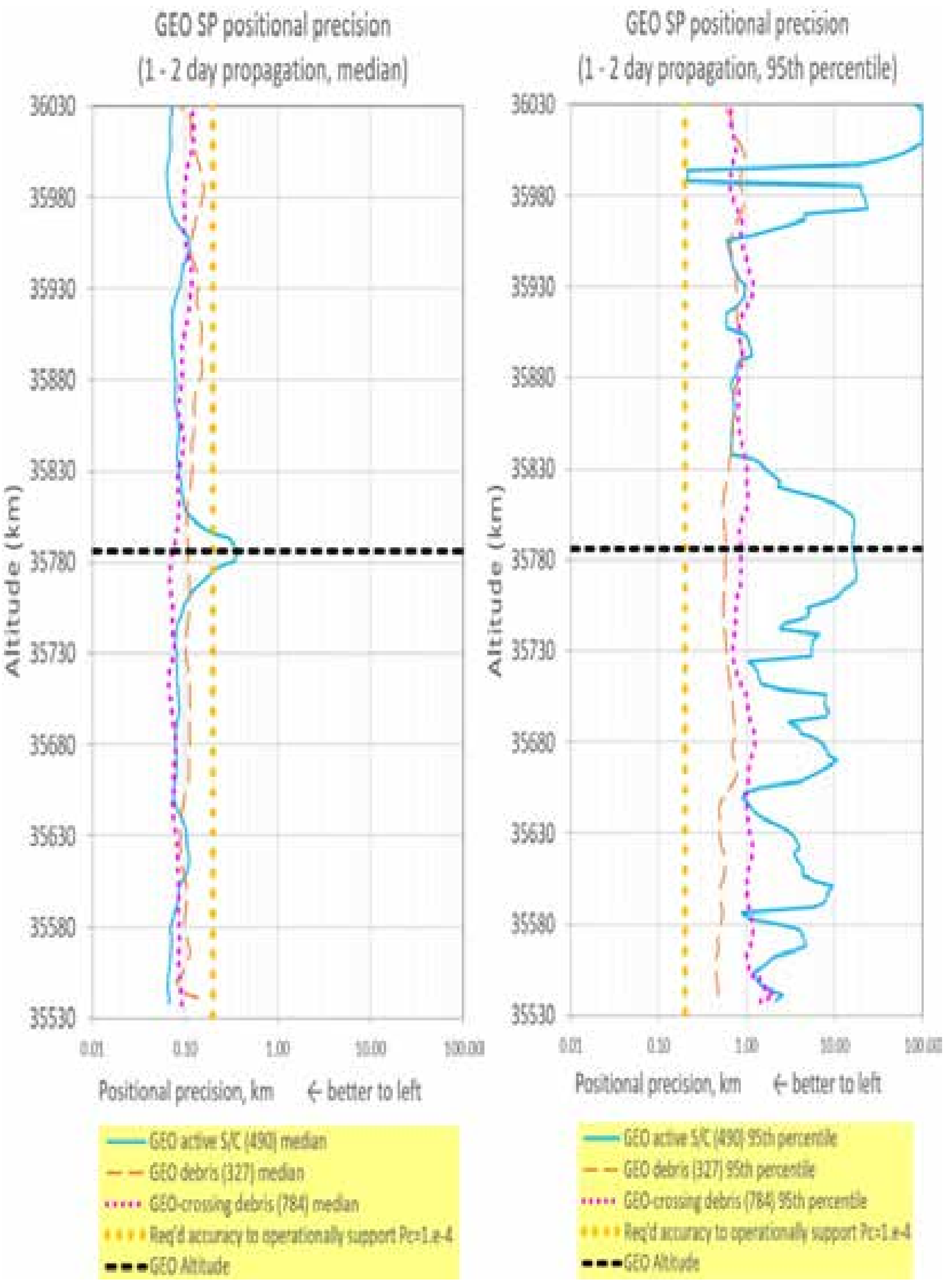

Figure B.2 — Example aggregation of GEO positional precision compared to a minimal conjunction assessment criteria threshold-derived accuracy level.

B.2 Estimation of historical and predictive positional accuracy

This section of the informative technical annex presents an appropriate comparison of predicted positional time histories with definitive reference orbit solutions for the purpose of assessing the accuracy of the predictions.

Though representing a small fraction of the publicly tracked space catalogue, there are today more than a hundred so-called reference or truth orbits. For these reference orbits, laser tracking and global navigation solutions combine with precision orbit determination to accurately solve for the position of the objects on a positional scale that is smaller than that of the collision metric being determined. As such, these reference orbits are ideal for determining "actual accuracy", at least to the positional scale required for flight safety.

In this case, the reference ephemeris may be differenced from all other positional predictions to determine both relative and absolute capabilities as shown in ***Fig. B-3***.

Figure B.3 — Assessment of positional accuracy using precision reference orbits.

B.3 Covariance, attitude, and vector interpolation via the Euler Axis/Angle method

This section of the informative technical annex presents appropriate Euler Axis/Angle methods for interpolation of a time history of covariance matrices, attitude portrayals and three-dimensional vectors.

The Euler Axis and Angle representation of Euler's Theorem (see [40], pp. 10-14) is an effective way to interpolate a series of manoeuvre thrust or acceleration vector directions. The accompanying vector magnitudes (e.g., eigenvalues or thrust or acceleration magnitudes) may be interpolated using standard Lagrange polynomials, linear expressions, or other established methods.

As presented in [24, 25, and 26] and consistent with the nomenclature of [3], where e_1, e_2, and e_3 represent the three vector components of the axis of rotation $\hat{e}$ and φ represents the angle of rotation, a time-based interpolation of two adjacent unit vectors $\hat{v}_A$ and $\hat{v}_B$ can be undertaken as follows:

(1) The axis of rotation $\hat{e}$ can be obtained as: $\hat{e} = \frac{\hat{v}_B \times \hat{v}_A}{|\hat{v}_B \times \hat{v}_A|}$

(2) Assuming a constant rotational rate during this interval, $\varphi(t) = \frac{(t-t_1)\cos^{-1}(\hat{v}_A \cdot \hat{v}_B)}{(t_2-t_1)}$

(3) The orthonormal rotation matrix $[M(t)]$ is then

$$= \begin{pmatrix} (1-\cos\varphi)\hat{e}_{\boldsymbol{x}}^{\,2} + \cos\varphi & (1-\cos\varphi)\hat{e}_{\boldsymbol{x}}\hat{e}_{\boldsymbol{y}} + \hat{e}_{\boldsymbol{z}}\sin\varphi & (1-\cos\varphi)\hat{e}_{\boldsymbol{x}}\hat{e}_{\boldsymbol{z}} - \hat{e}_{\boldsymbol{y}}\sin\varphi \\ (1-\cos\varphi)\hat{e}_{\boldsymbol{y}}\hat{e}_{\boldsymbol{x}} - \hat{e}_{\boldsymbol{z}}\sin\varphi & (1-\cos\varphi)\hat{e}_{\boldsymbol{y}}^{\,2} + \cos\varphi & (1-\cos\varphi)\hat{e}_{\boldsymbol{y}}\hat{e}_{\boldsymbol{z}} + \hat{e}_{\boldsymbol{x}}\sin\varphi \\ (1-\cos\varphi)\hat{e}_{\boldsymbol{z}}\hat{e}_{\boldsymbol{x}} + \hat{e}_{\boldsymbol{y}}\sin\varphi & (1-\cos\varphi)\hat{e}_{\boldsymbol{z}}\hat{e}_{\boldsymbol{y}} - \hat{e}_{\boldsymbol{x}}\sin\varphi & (1-\cos\varphi)\hat{e}_{\boldsymbol{z}}^{\,2} + \cos\varphi \end{pmatrix}$$

(4) From which the interpolated vector at time t is then $\hat{v}(t) = [M(t)]\hat{v}_A$

The eigenvector matrix $[E(t)]$ contains the row-wise storage of the major, intermediate, and minor eigenvectors at time ***t***, taking care to guarantee that this ordered "triad" of vectors adheres to the righthand rule. When interpolating between two eigenvector matrices $[E_1]\ and\ [E_2]$ derived from two adjacent covariance matrices respectively, $[E(t)]$ can be evaluated as follows:

(5) The rotation occurring between $[E_1]\ and\ [E_2]$ is: $[M_{BA}]=[E_2][E_1]^T$

(6) Compute $\sigma = \left(M_{BA_{11}} + M_{BA_{22}} + M_{BA_{33}}\right)$

(7) The angle of rotation from A to B is: $\varphi_{BA} = \cos^{-1}\left[\frac{1}{2}(\sigma - 1)\right]$

(8) Exercising caution to accommodate nonunique cases (when $\sin\varphi = 0$) as described in [40], the axis of rotation $\hat{e} = \left[\frac{(M_{BA_{23}} - M_{BA_{32}})}{2\sin\varphi} \quad \frac{(M_{BA_{31}} - M_{BA_{13}})}{2\sin\varphi} \quad \frac{(M_{BA_{12}} - M_{BA_{21}})}{2\sin\varphi}\right]$

(9) The angle of rotation at time t is $\varphi(t) = \frac{(t-t_1)\varphi_{BA}}{(t_2-t_1)}$

(10) $[M(t)]$ can be computed using the above expression in step (3)

And finally, the eigenvector matrix $[E(t)] = [M(t)][E_1]$

B.4 Apparent-to-Absolute Visual Magnitude relationship

This section of the informative technical annex presents the relationships that may be used to map apparent to absolute visual magnitude for inclusion in an OCM. These equations, based on Reference [41], examine signal magnitude for reflected illumination by a Resident Space Object (RSO) that is exoatmospheric, meaning that its illumination by the Sun is not reduced or impeded by atmospheric transmission losses as shown in ***Fig. B-4*** The equations do not account for spatial distribution across multiple detectors, which involves characterizing the Point Spread Function of the system.

Definitions:

A_{Target}	Effective area of the target $[m^2]$
$E_{EntranceAperture}$	The point source irradiance reaching the tracking sensor aperture [W/m^2]
$d_{SunToTarget}$	Distance from the sun to the target [m] (e.g. 1 AU = $1.4959787066 \times 10^{11}\ m$)

$d_{TargetToSensor}$	Distance from target to tracking sensor $[m]$
dia_{Target}	Effective diameter of the target, $[m]$
E_{Sun}	Exoatmospheric solar irradiance, nominally 1380 $[{}^{W}/_{m^2}]$ at 1 AU
E_{Target}	Target Irradiance at tracking sensor without atmospheric loss [W/m²]
E_0	Ref. Visual Magnitude (Vega) Irradiance $[2.77894\times 10^{-8}\ {}^{W}/_{m^2}]$
F	General shadowing term accounting for the penumbra region's influence [unitless, 0 < F ≤1, 0 = umbra, and 1 = full Sun illumination]
I_{Sun}	Solar Intensity ≈ $3.088374161 \times 10^{25}$ $[W/sr]$
I_{Target}	Intensity of reflected energy from target treated as a point source [W/sr]
$Phase(\varphi)$	Geometric reflectance phase function [unitless, 0 < $Phase(\varphi)$ ≤1]
φ	Critical Angle to the Sun (CATS) from sun to the tracking sensor, as shown in Fig. C-5 and referenced to the observed target [rad]
π	Pi constant
ρ	Reflectance of the target [between 0 (none) and 1 (perfect reflectance)]
$\tau_{Atmosphere}$	Effective transmission of the atmosphere [unitless, 0 < τ ≤ 1]

Given an optical tracking sensor's measured target entrance aperture radiance:

$$E_{target} = \frac{E_{EntranceAperture}}{\tau_{Atmosphere}} \text{ [W/m}^2\text{]}$$

$VM_{apparent} = -2.5 \ \log_{10}\frac{E_{target}}{E_0}$, measured on the visual magnitude scale

or if $VM_{apparent}$ known: $E_{target} = E_0\ 10^{\left[-\frac{VM_{apparent}}{2.5}\right]}$

$$I_{target} = E_{target}\, d^2_{TargetToSensor} \text{ [W]}$$

$$E_{Sun} = \frac{I_{Sun}}{d^2_{SunToTarget}} \text{ [W/m}^2\text{]}$$

$$Phase(\varphi) = \frac{\sin\varphi + (\pi-\varphi)\cos\varphi}{\pi}$$

$A_{Target} = \frac{\pi\, I_{Target}}{\rho\, F\ E_{Sun}\, Phase(\varphi)}$ [m²] {NOTE1: undefined in umbra (F=0=darkness), or no reflection (ρ = 0). NOTE2: If reflectance is unknown, one can assume a standard reference reflectance of fifteen percent]}

From which an effective diameter of the physical object can be roughly approximated as:

$$dia_{Target} \approx \sqrt{\frac{4\ A_{Target}}{\pi}}$$

From the above equations, $VM_{absolute}$ "normalized" to a 1 AU Sun-to-target distance, a phase angle of 0° and an example reference 40,000 km target-to-sensor distance (equivalent to a GEO satellite tracked at 15.6° elevation above the optical site's local horizon), is obtained as:

$VM_{absolute} = -2.5\ \log_{10}\left\{\frac{E_{target}}{E_0}\right\}$, from which:

$$VM_{absolute} = -2.5\ \log_{10}\left\{\frac{\left[E_{Sun_{1\,AU}}=1380\ {}^{W}\!/_{m^2}\right][Phase(0\ rad)=1.0\ ][\ \rho\ A_{Target}\ from\ above,\ \ in\ m^2]}{\pi\ \left[E_0= 2.77894\times10^{-8}\ {}^{W}\!/_{m^2}\right][(40{,}000{,}000^2)\ m^2]}\right\}$$

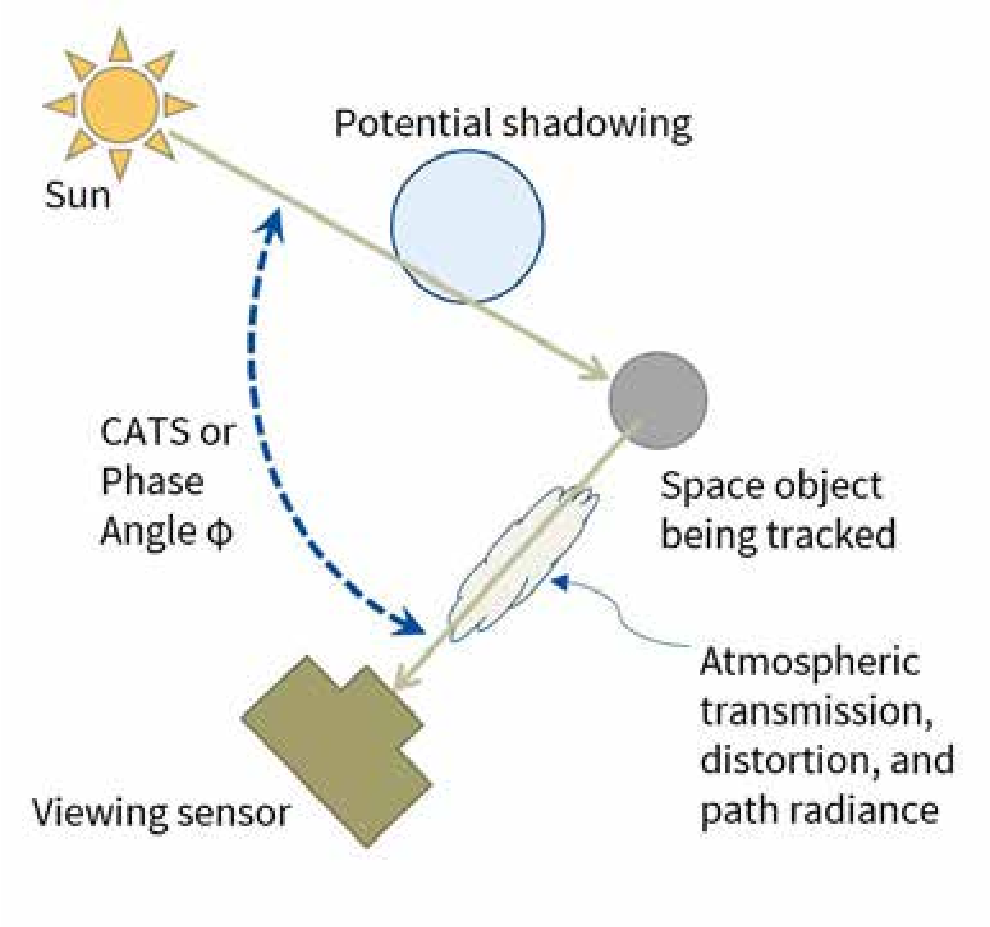

Figure B.4 — Depiction of optical viewing Critical Angle to the Sun (CATS) phase angle geometry

B.5 Benefit of tracking sensor data fusion in STC system

This section of the informative technical annex discusses the wide variety of space object tracking sensors. One may draw a distinction between those that are capable of tracking both space debris and spacecraft (***Fig. B-5***), versus those that require some sort of active spacecraft transmission (***Fig. B-6***).

Sensor type	GEO coverage	LEO coverage	Not lighting dependent	All weather	Range	Range rate	Angles
Monostatic Radar	◒	●	●	●	●	◒	◒
Bistatic Radar	◒	●	●	●	●†	◒	◒
Optical Telescopes	●	◒	○	○	○	○	●
Passive RF (TDOA/FDOA)	●	●	●	●	●†	●	○
LIDAR	●	●	◒	○	●	○	◒

† Derived quantity ● full ◒ partial ○ little or no capability

Figure B.5 — General performance comparison of tracking sensors capable of tracking both space debris and spacecraft

Sensor type	Doesn't require operator cooperation	GEO coverage	LEO coverage	Not lighting dependent	All weather	Range	Range rate	Angles
Spacecraft transponder ranging and range rate	○	●	○	●	●	●	●	◒
1-way Doppler	●	●	●	●	●	○	●	○
Radio Telescopes	●	●	●	●	●	○	○	●
Passive RF (TDOA/FDOA)	●	●	●	●	●	●†	●	○
Onboard GNSS	○	●	●	●	●	●†	●†	●†

† derived quantity ● full ◒ partial ○ little or no capability

Figure B.6 — General performance comparison of tracking sensors only capable of tracking actively transmitting spacecraft

A frequently unexploited way to dramatically improve positional accuracy is by applying advanced orbit determination algorithms that incorporate as wide a mix of tracking sensors, tracking sensor types and viewing geometries as possible. Generally, the more types of tracking sensors and geometries employed, the better. As an example, consider the fusion of radar and optical observations as shown in ***Fig. B-7*** Where it says, "radar or passive RF, that means that only radar or passive RF sensors were used to track the space object, and where it says "optical," only telescopes observed the object. The error "bubble" or ellipsoid around the tracked object depicts the two-sigma error bounds about the estimated position. The "combined" ellipsoid illustrates the substantially reduced error ellipsoid that can be obtained when both radar and optical observations are fused together.

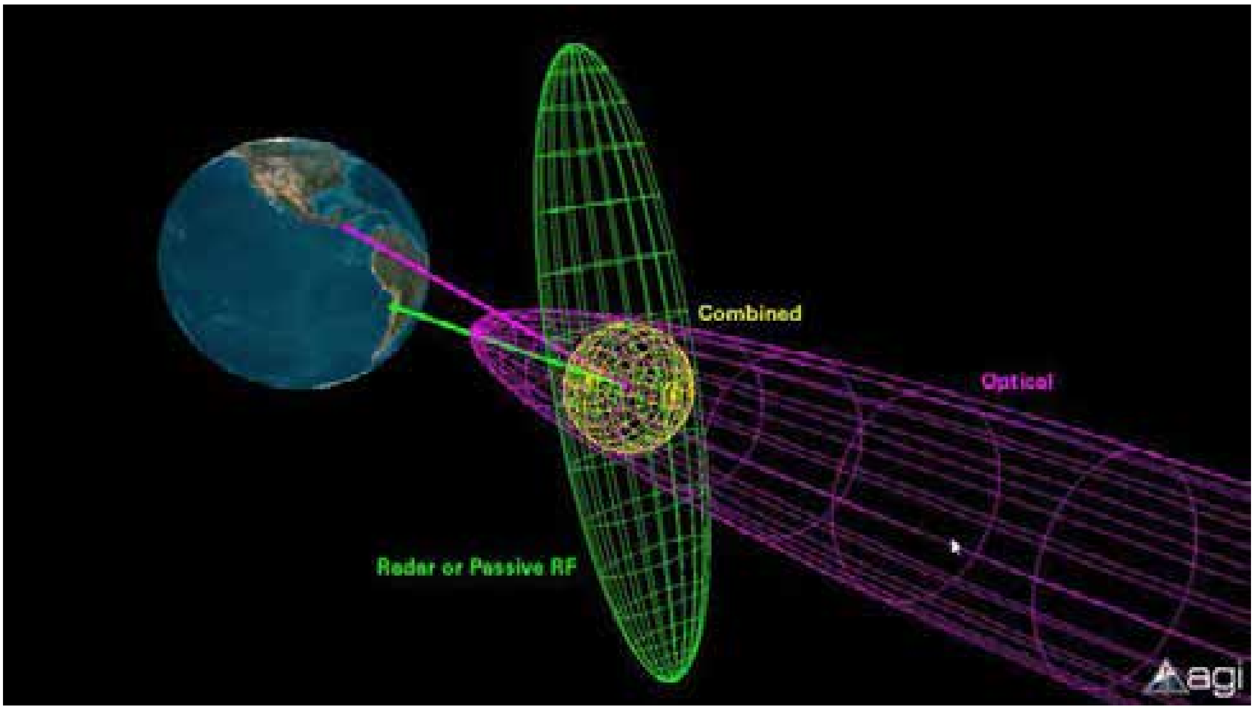

Figure B.7 — Benefit of fusing radar and optical observations together (yellow), as opposed to a radar-only orbit solution (green) or an optical-only solution (magenta)

B.6 STC System Quality Control Processes: Ephemeris upload monitoring

This section of the informative technical annex presents methods for the depiction and monitoring of positional ephemeris time histories to comply with the conjunction screening timespan mandated by a STC system approving agent (diagonal boundaries shown in ***Fig. B-8***) is properly adhered to by the uploaded ephemerides shown by the horizontal lines with triangular endpoint symbols. Such monitoring is especially important when uploads are sparse, as shown in ***Fig. B-9***.

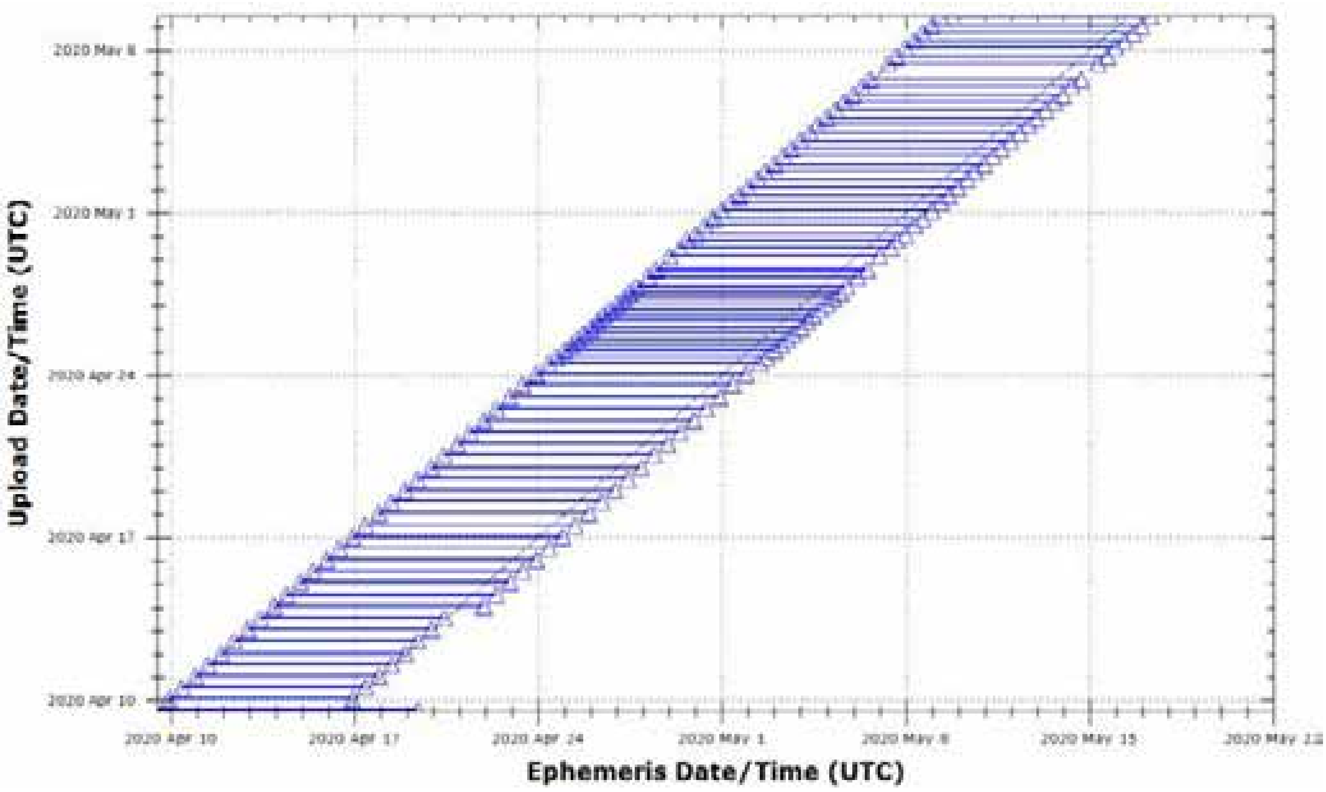

Figure B.8 — Conjunction assessment analysis process within the STC system

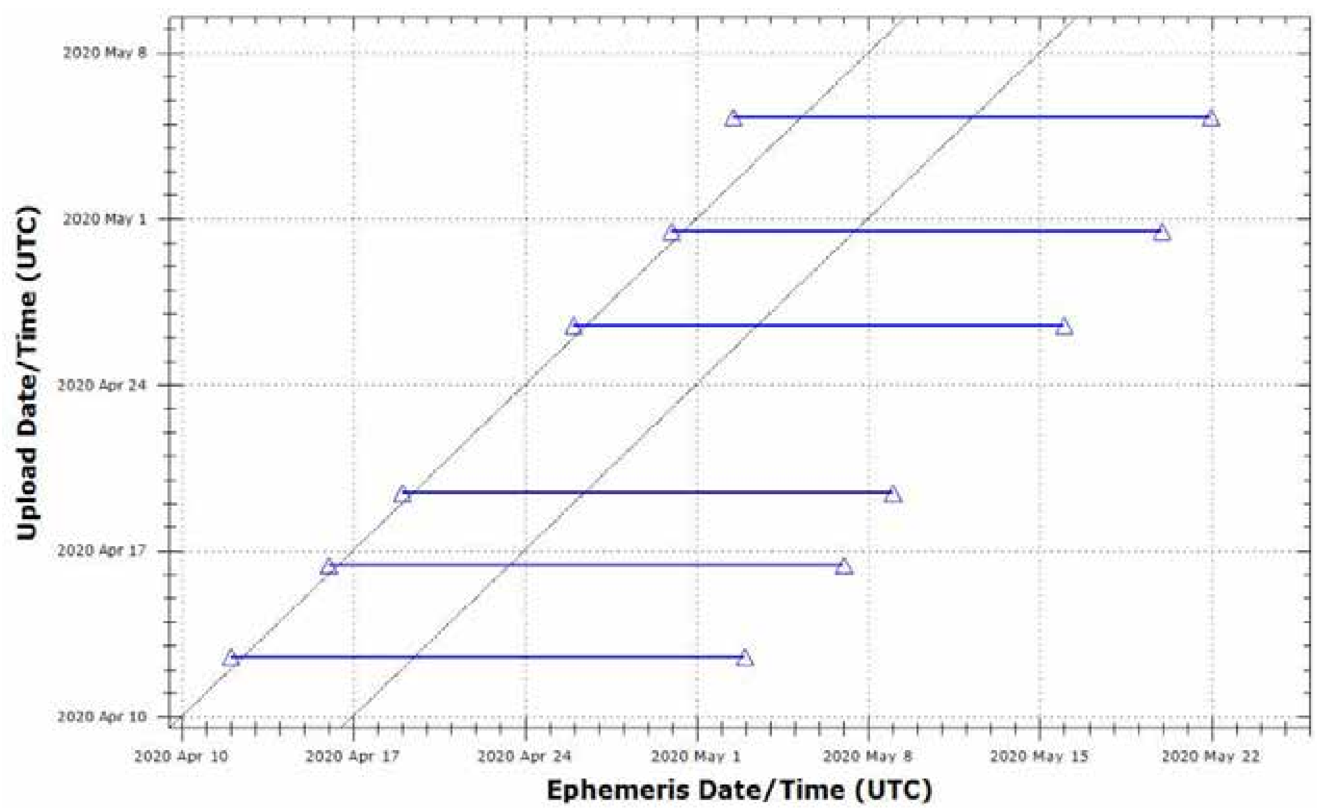

Figure B.9 — Conjunction assessment analysis process within the STC system

B.7 STC system quality control processes: Synthetic covariance by spacecraft and by operator

The STC service provider should monitor the veracity of frequently-uploaded ephemerides provided by spacecraft operators and other SSA and STC systems using synthetic covariances derived from sequential overlap tests as a proxy for covariance. This section of the informative technical annex presents the on-the-fly monitoring of operator ephemeris precision. Synthetic covariances can be computed by statistical comparisons between a determined orbit and the sequence of Predicted Orbits which precedes it as a function of time.

At epoch T, the determined orbit can be compared to the predicted orbit of the previous days at the same epoch T. Special care must be taken to avoid correlations between the determined and predicted orbits. shows a sketch of the concept behind this computation.

Figure B.10 — Attitude dependency of HBR for higher-fidelity Pc estimation

OEM SHOULD BE GENERALIZED TO ODM OR (OEM OR OCM).

THE "OD INTERVAL" IS UNIQUE TO BATCH LEAST SQUARES AND SHOULD BE GENERALIZED

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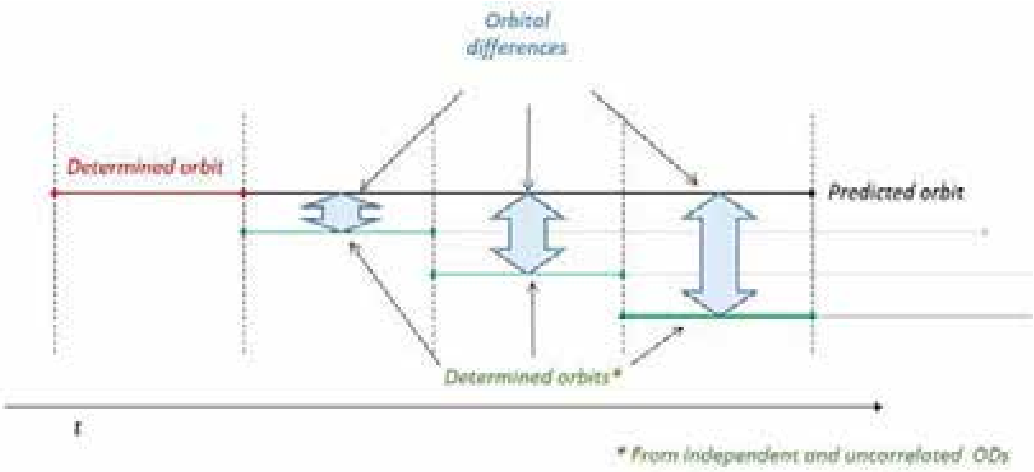

Figure B.11 — Variation in precision of Time of Closest Approach.

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When performed over enough time (e.g., 3 solar cycles of 27 days in LEO), the STC system can compute a synthetic covariance (referred to in the EU as a covariance abacus) in a local orbital frame for the given S/C.

The simplest abacus is an abacus as a function of time, with values provided as 1 standard deviation on each axis of a local orbital frame. An example is provided below during one week at a 1-day time step as shown in Table B-1 and Fig. *B-12*. Velocity uncertainties can be characterized as well to yield 6x6 covariance information.

Table B.1 — STC-relevant data conveyance needs and standards

Time since OD (days)	RADIAL (m)	IN_TRACK (m)	NORMAL (m)
0.0	1.8	26.0	3.9
1.0	1.8	121.1	7.2
2.0	2.8	288.3	10.3
3.0	3.7	515.4	13.1
4.0	4.3	778.9	15.2
5.0	5.1	1096.5	17.1
6.0	5.7	1420.3	18.6
7.0	6.6	1814.1	19.5

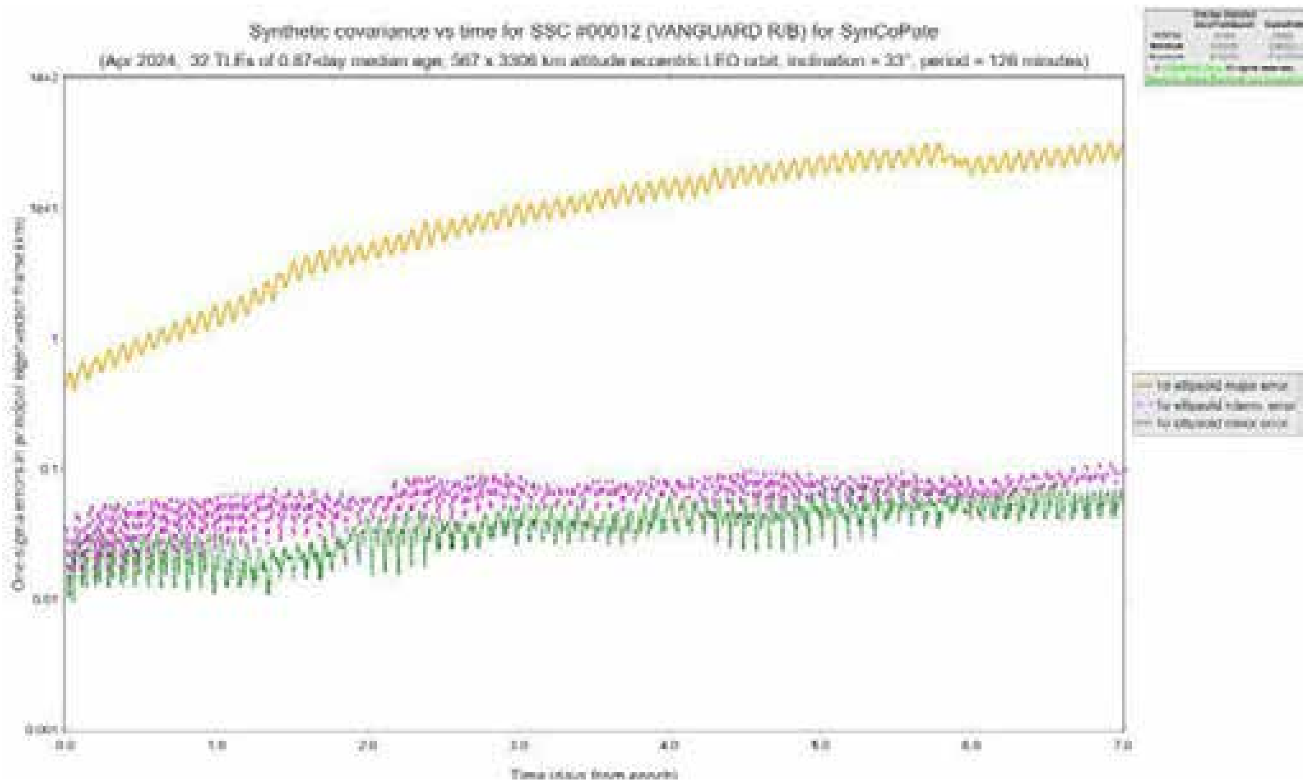

Figure B.12 — Synthetic covariance principal axis dimensions vs time.

Spot check overlap statistics are also quite useful as shown in ***Fig. B-13*** . When data is sparse, overlap tests can still be informative as shown in ***Fig. B-14***.

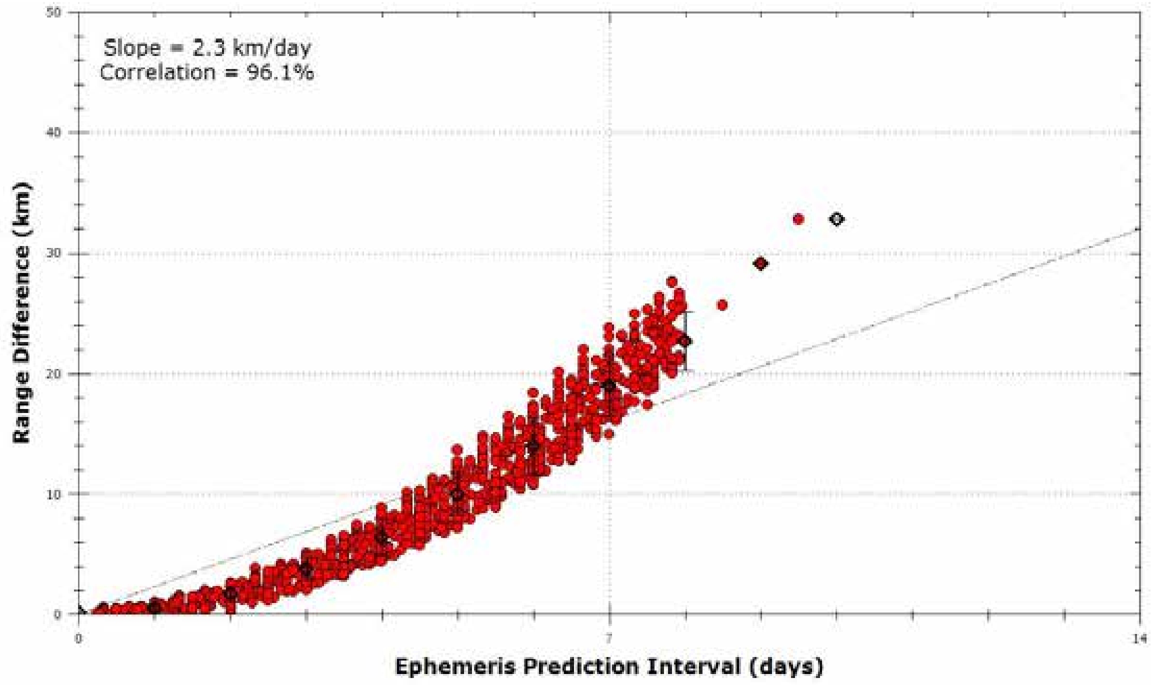

Figure B.13 — Estimation of precision for frequent ephemeris uploads

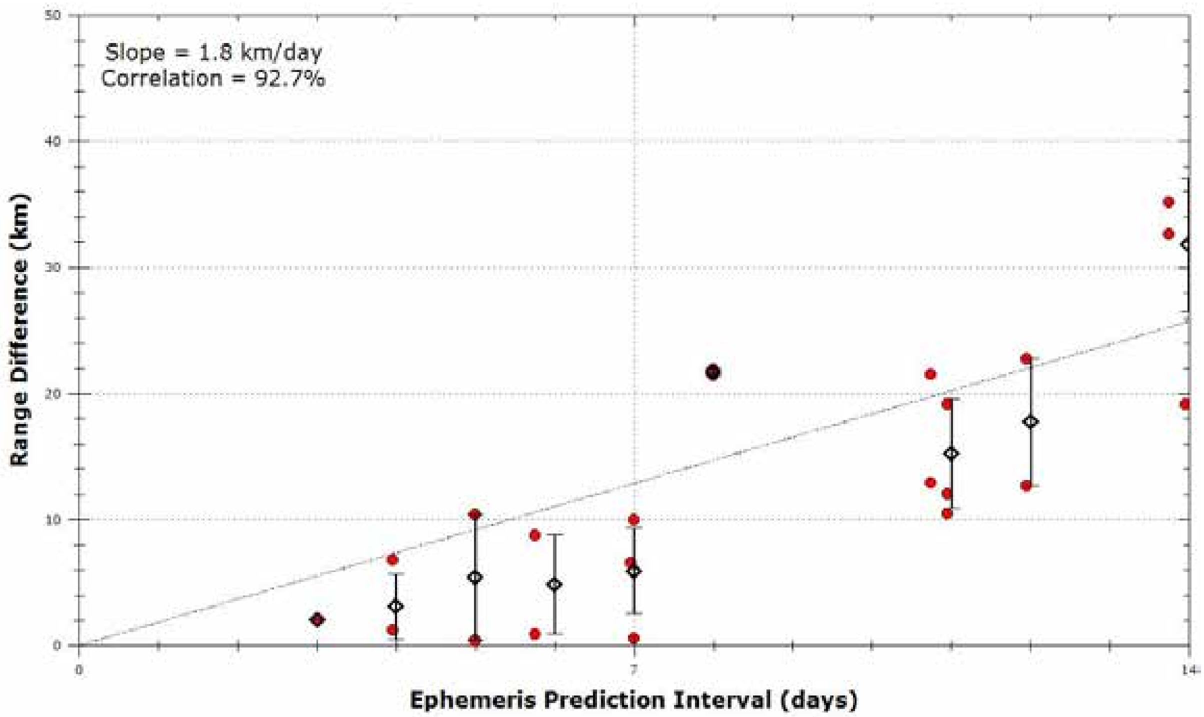

Figure B.14 — Estimation of precision for infrequent ephemeris uploads

B.8 Diverse avoidance manoeuvre Go/No-Go metrics and threshold

This section of the informative technical annex discusses the many different types of warning thresholds, ranging from straightforward (predicted miss distance) to somewhat complex collision probability incorporating the uncertainty in the predicted orbits, and information about the shape and orientation of the objects involved. An operator's choice of threshold type may be driven by crew resources, available data, and the orbit regime their spacecraft occupies.

Compounding this complexity, SSA and STC systems are not one-size-fits-all because the threat profile and the timeliness, completeness, accuracy, and transparency of available SSA data is highly dependent upon the orbit regime. Spacecraft operators in less-dense orbital regimes may have the luxury of being overly careful and manoeuvring whenever another object comes remotely close because they have sufficient fuel margin to enhance safety. Conversely, operators in high-density orbital regimes will not have the luxury to avoid everything that comes remotely close because the millions of potential close approaches would rapidly deplete their staffing resources and fuel budgets.

The safety thresholds that an operator employs tend to be driven by spacecraft cost, mission priority, perceived value to their customer, potential value of derived data, and how long it takes to replace the mission capability by another means. In stark contrast, a spacefaring country (a "State Actor") likely decides to regulate the safety thresholds, algorithms, and metrics employed to be consistent with internationally adopted treaties, principles, and guidelines designed to promote the long-term sustainability of the space environment.

B.9 Conjunction assessment process

This section of the informative technical annex presents the typical conjunction assessment process of an STC system as shown in ***Fig. B-15***.

(Add descriptive text).

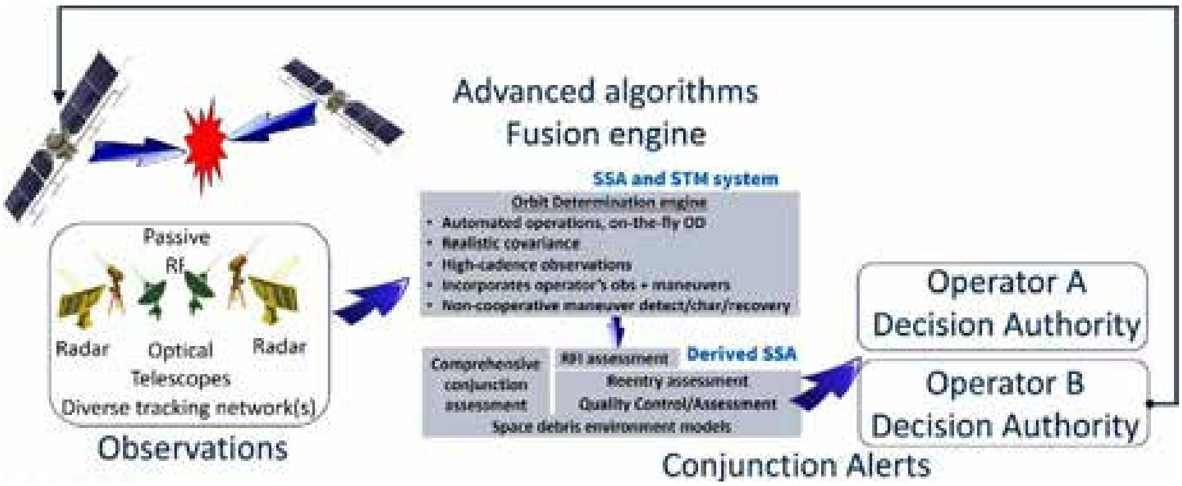

Figure B.15 — Conjunction assessment analysis process within the STC system

B.10 Collision avoidance maneuver optimization process

This section of the informative technical annex presents collision avoidance maneuver optimization techniques.

The resources required to conduct collision avoidance maneuvers include maneuver fuel, maneuver planning by flight dynamics staff, and management decision processes. To minimize the use of these resources, it is important that maneuvers are optimally conducted.

Avoidance maneuver optimizations typically fall into two categories: (1) optimization of the active spacecraft's maneuver in avoiding the specific object which poses a collision threat; and (2) optimization of the active spacecraft's path as measured against all potential collision threats within the upcoming planning cycle.

In the first category, sample analysis products for avoiding a specific object are shown in ***Fig. B-16*** and ***Fig. B-17***. Tools such as these allow the mapping of avoidance maneuver components to resulting collision probability contours.

(Add descriptive text for catalog-wide collision avoidance).

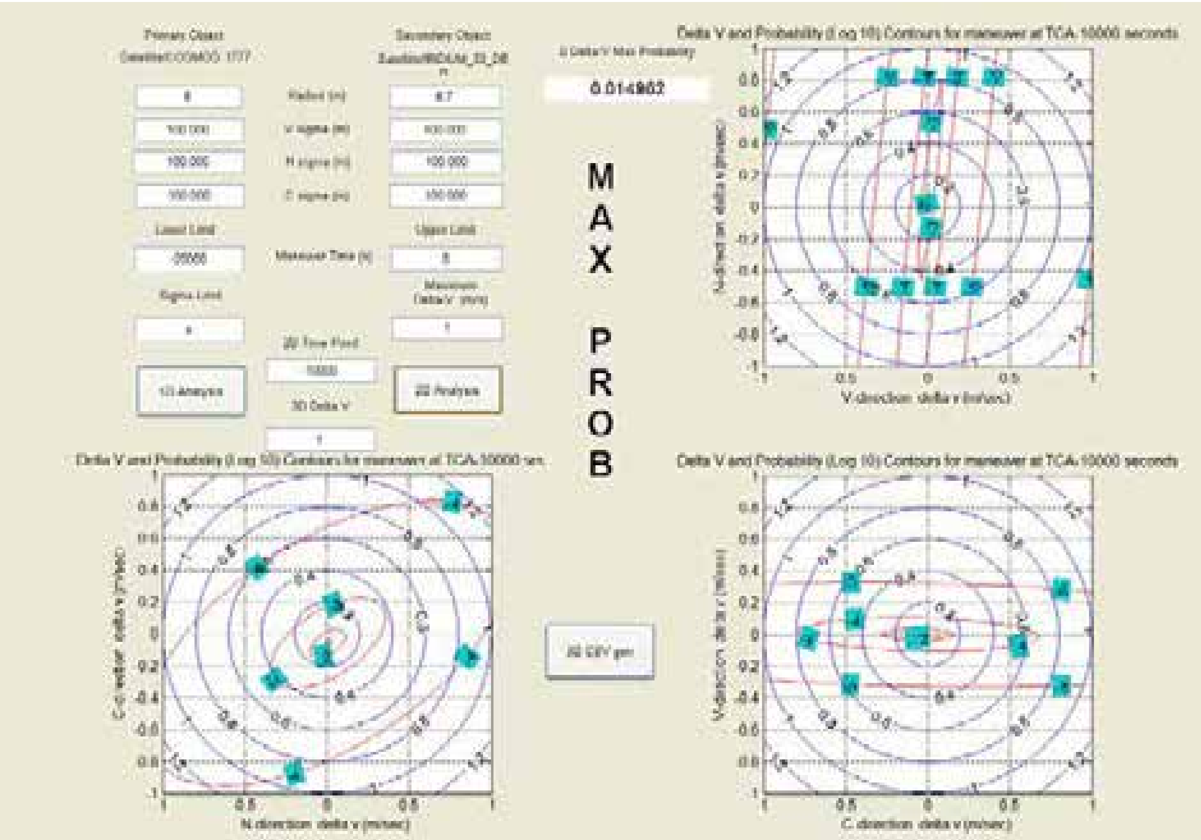

Figure B.16 — Contours of resultant $\log_{10}$(collision probability P) as a function of manoeuvre velocity change mappings normal to velocity (lower left), co-normal (upper right), and cross-track (lower right)

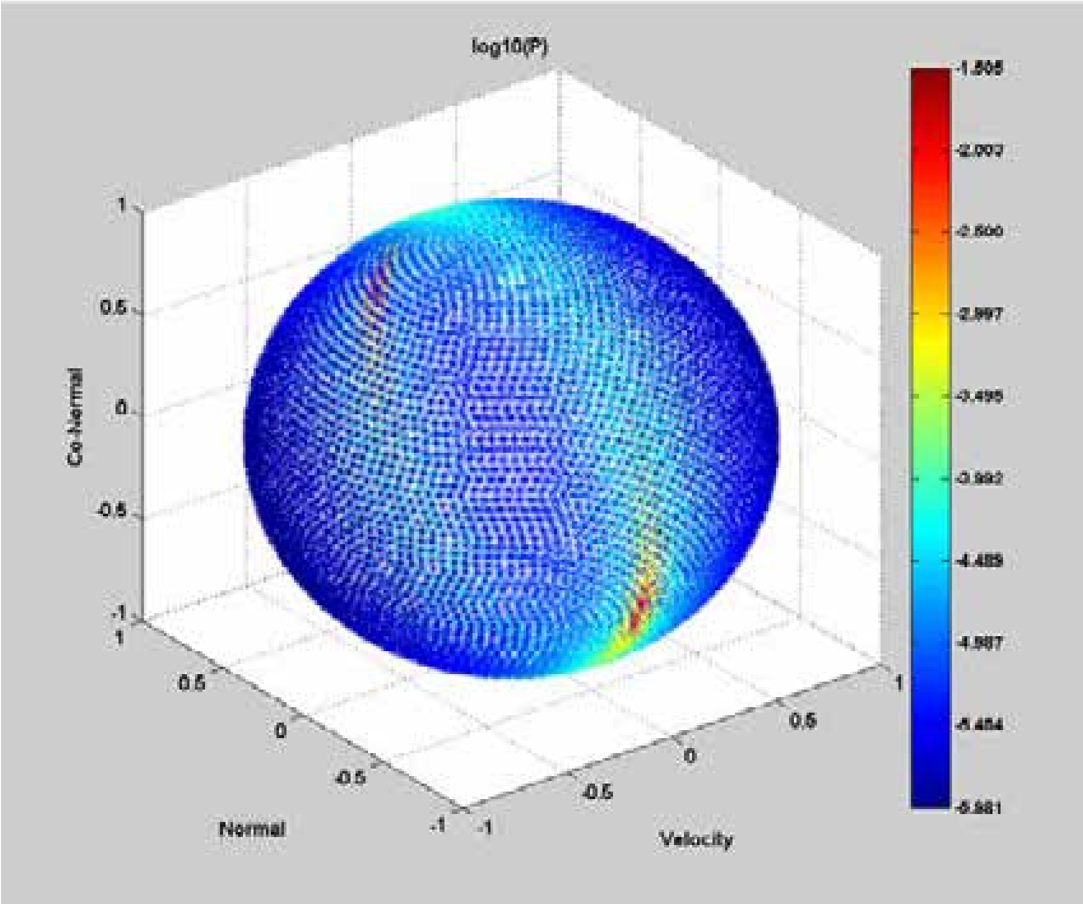

Figure B.17 — Relationship between manoeuvre direction and $\log_{10}$(collision probability P).

Annex C (informative)

Example constructs for both simple and complex STC systems.

C.1 Example of Level 0 STC system.

Again at its most simplistic instantiation, an STC system can be merely a communications path or data portal for the sharing of information as shown in ***Fig. C-1***.

(insert new figure here).

Figure C.1 — Example of a simple Space Traffic Coordination system

C.2 Example of Level 1 and Level 2 STC systems.

A comprehensive, timely and accurate SSA and STC system capabilities enhances the safe and sustainable conduct of space activities. An effective set of STC system capabilities should embrace and incorporate international standards, guidelines, multilateral data exchange, notification and coordination of launch, on-orbit, re-entry, safety, and environmental events. While there are likely multiple approaches to achieving STC, one example STC system is provided in ***Fig. C-2***. Inclusion of the "regulators and monitoring agencies" box on the upper right would depend upon whether a STC system approving agent places requirements on an STC system to provide such functions.

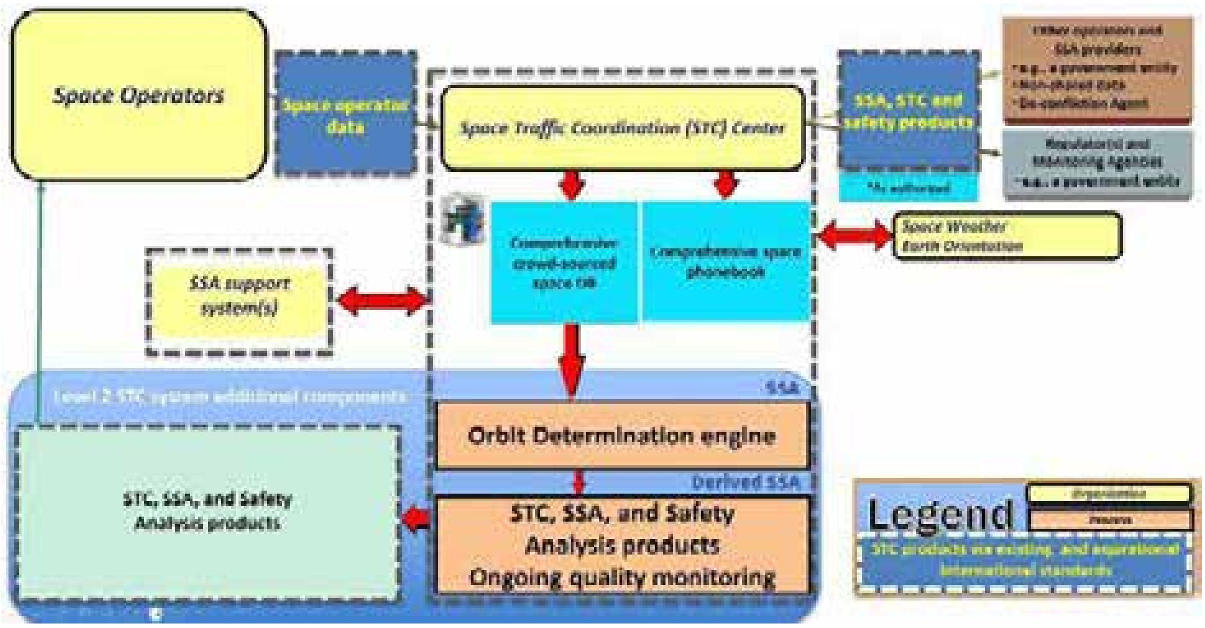

Figure C.2 — Examples of Level 1 and Level 2 (inclusive of lower left blue box) Space Traffic Coordination systems

Standards fit into this example of a complex STC system as shown in ***Fig. C-3***.

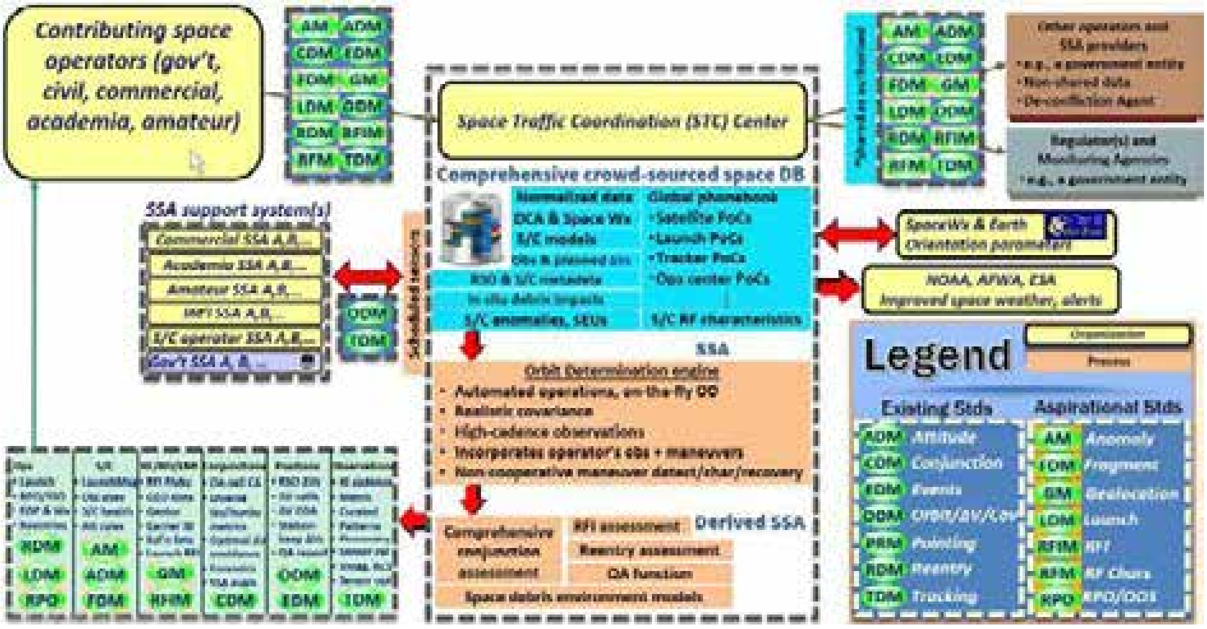

Figure C.3 — Role of international space data message standards (green ellipses) in a complex STC system

Annex D(informative)

<u>Examples</u> of Level 2 STC system requirements.

To facilitate the development of requirements for a Level 2 STC system, the following suggested topics and requirements are provided.

D.1 General requirements.

D.1.1 STC system compliance document.

The STC service provider shall develop an "STC system compliance document" that contains the STC system's base-level compliance with the requirements contained in this document augmented by any additional requirements levied by the STC system approving agent.

D.1.2 STC system service level availability.

An STC system and each of its safety-relevant components (computational infrastructure, network access, data fusion capability, STC system data product generation, and notification services) shall meet the STC system's approving agent's availability requirement.

D.1.3 STC system access controls.

Where possible, STC system capabilities should provide access controls to allow STC account administrators to set appropriate user account permissions for their organization, set personnel roles and responsibilities, and authorize data access for third-party entity access to the various STC system components.

D.1.4 STC system capabilities for rapid inter-operator communications.

An STC system should provide and maintain a spacecraft operator and SSA provider contact information repository for the period of time mandated by the STC approving agent, to facilitate inter-operator communications and rapid resolution of spaceflight safety hazards.

It is recommended that such a repository support definition of personnel roles and responsibilities, including roles for management, information security, flight dynamics, operations floor, and RFI mitigation support.

NOTE 1: Such communications facilitate the overall goals of UN LTS Guideline B.1 and guidelines in [42, 43, 44, 45, 46].

D.1.5 STC system notification of critical events.

An STC system should be capable of notifying users of launch, on-orbit, disposal/End-of-Life, re-entry, and environmental events.

D.1.6 STC system capabilities to assure the safety and sustainable space activities.

An STC system should adopt standards, guidelines, and requirements as mandated by a STC system approving agent to maximize the safety and sustainability of space activities, to include ISO 24113 Space systems – Orbit debris mitigation.

D.1.7 STC system coordination with other commercial, regional, and state actor STC systems.

An STC system should facilitate coordination of SSA, flight safety, and space sustainability information with other STC systems, to include commercial, regional, and state actor STC systems.

D.2 STC system infrastructure.

D.2.1 Assurance of uninterrupted operation.

An STC system and each of its safety-relevant components (computational infrastructure, network access, data fusion capability, STC data product generation, and notification services) should be designed and operated to provide robust, high-availability processing to the user's solicitation when generating products or communicating exchanges as specified by the STC system's approving agent's availability requirement.

D.2.2 Assurance of data archival and retrieval.

The STC system infrastructure should have the capability to archive and restore data as mandated by the STC system's approving agent.

NOTE: Data archival and retrieval are needed to conduct forensic investigations or reproduce situations.

D.2.3 Assurance of rapid reconstitution in case of failure incident.

The STC system infrastructure should be designed and operated to facilitate rapid reconstitution from total failure in the event of a force majeure (e.g., war, strike, riot, crime, epidemic, or sudden legal change) in compliance with a STC system approving agent 's reconstitution requirement.

D.3 STC system information Security and monitoring measures.

D.3.1 Cyber security.

An STC system should by design and operations provide a trusted and secure framework (e.g., adhering to formal cybersecurity standards.

Note: ISO 27001 or NIST SP 800-171 have been used globally as requirements that a computer system must follow in order to store, process, or transmit sensitive or proprietary information or provide security protection for such systems) to protect the confidentiality, integrity, and availability in the presence of cyber threats such as man-in-middle and Denial of Service attacks.

D.3.2 Security logs.

An STC system should maintain and monitor security logs as directed by the STC system approving agent. Security logs should be maintained for a period of at least three years.

D.3.3 Protection of intellectual property.

An STC system should appropriately secure, protect, and control dissemination of data marked by international, governmental, military, civil, and commercial space data and systems.

D.3.4 Release of derivative flight safety information.

Distribution of derivative flight safety information to relevant entities (without release of raw proprietary data) should be allowed.

D.3.5 Data integrity.

All involved parties sending and receiving data should maximize its integrity by applying appropriate hash methods and/or encryption methods, as directed by the STC approving agent.

The STC system approving agent should define which methods are applicable, while the exchanging parties should have the ability to negotiate which methods to apply.

D.3.6 Network encryption support.

An STC system should support bi-directional (inbound and outbound) encrypted network communication interactions where designated by a STC system approving agent for communications and data transfer with STC service providers, spacecraft operators, State actors, and the international space community.

D.3.7 Unidirectional data transfer of spacecraft information to STC systems.

Transfers of spacecraft operator predictive ephemerides, spacecraft characteristics, status, tracking observations, planned manoeuvres and RF information to the STC system should only require outbound (one-way) data transfer from the spacecraft operator systems.

D.3.8 Encryption of STC service provider information.

An STC system should promote the use of encryption for all space data that it interacts with and as designated by a STC system approving agent, both while in transit and at rest.

D.3.9 System notifications, trending, monitoring, and summary reporting.

An STC system should provide flexible options for data export, data interchange, summary reporting and trending.

NOTE1: Summary reporting and trending by internal and/or third-party applications can be used to monitor overall system loading, identify subsystem performance, summarize customer usage, and identify potential data use violations.

NOTE2: Consistent with meeting a minimum safety standard, it is recommended that an STC system allows users to tailor the notifications they receive, when they receive notifications, and how they wish to receive them.

D.3.10 Malware vulnerability scans.

Regular malware vulnerability scans should be conducted on an STC system with a malware scan intervals as approved by the STC approving agent. STC system application source code, binaries and byte codes should be regularly analysed by Static Application Security Testing (SAST) suites to reveal potential security vulnerabilities.

D.3.11 Firewalling of STC system critical systems.

The critical infrastructure of STC systems should not be visible or accessible from the open internet.

D.3.12 Security credentials, Multi-Factor Authentication, and network identity characteristics.

As directed by the STC system approving agent, users of an STC system (launch, spacecraft and STC service provider entities) must use security credentials and support multi-factor authentication or provide unique network Internet Protocol addresses/characteristics that enhance the validity of organizational accesses.

D.3.13 Fine-grained user access and control.

Technical and security controls should make it impossible for STC system customers to access data other than their own, except where expressly authorized by the owner of that space data.

D.4 Data aggregation, exchange, normalization, and curation.

In addition to government and commercial SSA data sources, space operators have a wealth of authoritative information that they may be willing to share with others in the interest of space safety. Consistent with UN LTS Guideline B.1 [42], Satellite Orbital Safety Best Practices [47], NASA best practices [48], Space Safety Coalition Best Practices [49], and others, flight safety requires the exchange of space data. Contributing data providers may include operators of spacecraft, launch booster and upper-stage vehicles, sub-orbital/exoatmospheric vehicles (e.g., space tourism), and high-altitude balloons and airships.

The following requirements are designed to maximize the aggregation, fusion, and integrity of this data.

D.4.1 STC system capabilities to maintain positional and identification information.

STC system capabilities should be designed and operated in a manner that maintains current information on the position and identify of space objects relevant to the orbital regimes that the STC system user's spacecraft inhabit.

D.4.2 STC system space data repository.

The STC system capabilities should support the development, curation and maintenance of its own space object repository created by the aggregation of available data obtained from multi-lateral data exchanges as directed by a STC system approving agent. Such data exchanges could include active satellite observations, orbits, RF conditions, spacecraft metadata provided by spacecraft owners and operators, debris orbits, and metadata provided by STC service providers using non-cooperative tracking methods.

NOTE 1: Each STC system may maintain its own set of ephemeris predicts or adopt those published by other STC or SDA systems.

NOTE 2: Each STC system may maintain its own mapping of a unique space object identifier (e.g., the "international designator contained in a SATCAT) to what that object is or they may adopt such a mapping published by other STC or SDA systems.

D.4.3 Data exchange monitoring and anomaly notification.

STC system capabilities should monitor the data contributed by spacecraft operators and STC service providers, automatically notifying them of any expired or out-of-family data exceeding the data provider's specified accuracy bounds, required time spans, latencies in operator data deliveries to an STC system, and the provision of any orbital or orbit-relative features (e.g., station-keeping boundary constraints, longitudinal slots in GEO, and drift rate).

D.4.4 STC system database integrity and quality control.

STC system capabilities should maximize the integrity of its databases through consistency and quality checks, and data comparisons with STC service provider-specified constraints.

D.4.5 Sharing of ancillary spacecraft data for space safety.

STC system capabilities should have the ability to ingest and fuse, where voluntarily provided by the operator, spacecraft dimensions, attitude time history files, spacecraft current mass and planned manoeuvres, drag and reflectivity coefficients and force model settings using the Orbit Data Message (ODM) family of CCSDS navigation messages.

NOTE: Space object dimensions, attitude and mass are critical to the accurate assessment of collision probability and collision consequence.

D.4.6 Non-cooperatively gathered SSA and spacecraft size/orientation/mass data.

For debris or spacecraft that are not participating in the STC system or for which space object size, orientation and mass data have not been provided, these quantities and their corresponding error margins should be obtained from one or more sources authorized by a STC system approving agent. Use of these data source(s) should be documented and shared with STC system users.

In the decision-making process of authorizing the non-cooperative products, the STC system approving agent should consider the authenticity and accuracy of the product.

D.4.7 Incorporation of planned manoeuvres into SSA and STC systems.

The STC system should provide the ability to ingest and fuse operator-provided planned manoeuvres into SSA and STC system historical and predictive products.

D.4.8 Noncooperative orbit maintenance of manoeuvring spacecraft.

The STC system should be able to react to unknown or unannounced manoeuvres and reflect these promptly in its data sets of manoeuvring spacecraft.

D.4.9 Ingest information on spacecraft anomalies and performance trends.

The STC system should provide the ability to ingest operator-provided information on spacecraft anomalies that may degrade flight safety, to include Single Event Upsets (SEUs), manoeuvre performance degradation, ability to control the spacecraft, and ability to maintain accurate positional knowledge.

NOTE: In this construct, contributing operators are encouraged to report any satellite and launch vehicle anomalies [50] they experience in the interests of a shared understanding of space risk.

D.4.10 Flexible and tailorable STC system user interface or equivalent functionality.

An STC system's conjunction assessment capability should provide flexible and tailorable user interfaces and web services (or equivalent functionalities) to provide safety analysis reports, to include elimination of in-fleet conjunctions, selection and ordering of reported conjunction assessments and RFI parameters.

D.4.11 STC system web services or equivalent functionality.

An STC system's web services or equivalent functionalities should allow users to set up machine-to-machine interfaces easily and robustly to support an operational tempo that may at times be too fast for “human in the loop” operation.

D.4.12 Monitoring compliance of ephemeris files with STC system requirements.

The STC system capabilities should monitor the upload frequency, time span of coverage (start, stop) and step size of ingested ephemeris files to enhance compliance with requirements set by a STC system approving agent.

D.4.13 STC system test environment.

In parallel with the STC system's operational tools and algorithms, the STC system should provide a testing environment to allow the incorporation of new (lower TRL) algorithms and models currently in development using operational data.

D.4.14 Scalable STC system architectures.

An STC system should be scalable and sized to accommodate large constellations, high fragmentation object count breakup events, conjunction storms, and tracking sensor technology improvements that lead to substantially larger space object catalogues.

D.4.15 Algorithms, validation, and development.

STC system algorithms and associated documentation should be rigorously validated against real-world data. Algorithms used in the STC system should be made available for approval by the STC system approving agent and for review by STC system users and their technical advisors.

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Template for comments and secretariat observations

Date:2024-10-05	Document:	Project:

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-001 -001				ge	It can still be observed that sometimes terms are used in different manner; please also carefully review the terms used Figures 3 and 5.	Review document for consistent use of terminology introduced; try to avoid terminology that has not been defined ("flight safety", "return manoeuvre", ...)	Accept.
DE-002 -002			Fig B-1	te	Neither the text, nor the figure caption, nor the title of the axes give any indication to which quantities are displayed here and which units we can see.	Adapt figure or caption text	Accept.
DE-003 -003			Fig.3	ed	The figure contains references to National Policies which do not apply to actors in other states.	Remove reference to SPD-2, SPD-3, etc. Also please cleanup the figure removing clearly visible PPT icons in the lower left. Check consistency of terms used with text.	Accept.
DE-004 -004			Fig.4	ed	The y axis contains the quantifications “simple” and “complex”, but the x axis doesn’t contain any quantified terms.	Either remove simple and complex from the y axis or add “less” / “more” (or something similar) to the x axis for uniformity	Accept.
US - 01- 005			Figure 3		This figure looks a little US centric (mention of SPD2/3 and ODMSP and US Launch/Re-entry)		Accept.
DE-005 -006			Table 1	ge	Table 1 recommends that in case of a conjunction between a manoeuvrable and a minimally manoeuvrable SC the minimally manoeuvrable SC should perform the CA manoeuvre. This recommendation is surprising. The scope of the proposed standard is to ensure flight safety and mitigate collision risk considering a more and more congested space. However, this recommendation makes the impression as it was meant to “penalize” the SC operator of the minimally manoeuvrable SC. The additional condition “unless the time to the close approach is insufficient to move” makes it unnecessary more complex. I can imagine that from a safety standpoint it would be better that the “more capable” spacecraft gives	Please consider swapping the manoeuvre priority to the more capable SC (manoeuvrable SC). Alternatively, if my impression of the recommendation is not correct, provide a justification for the recommendation that ideally fits to the scope and objective of the standard.	Accept.

1 **MB** = Member body / **NC** = National Committee (enter the ISO 3166 two-letter country code, e.g. CN for China; comments from the ISO/CS editing unit are identified by **)
2 **Type of comment:** **ge** = general **te** = technical **ed** = editorial

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					way. On the other hand, regulators should avoid that SC with limited manoeuvrability are placed into congested orbital regimes.		
US - 07- 007			Table 1		Minimally Maneuverable S/C: Don't understand why the minimally maneuverable S/C has the requirement to move when conjuncting with a maneuverable satellite but not with the others. Logic not clear. In every other case the more maneuverable objects are moving…..		Accept.
US - 15- 008			Table 4	tc	Is there a universal definition of what "low thrust" means?	Add definition of low thrust to ensure that everyone is explicitly on the same page.	Accept.
US - 14- 009			Table 4	ed	Missing a "c" in the first row, last column	Should be "collision" not "ollision"	Accept.
DE- 006 -010			Table 7	ed	readability of table is difficult	swap axes, so instead of 10 cols and 5 rows, make 5 cols and 10 rows	Not accept. While we understand the concept of transposing the table, the current table's emphasis on the screening criteria (rows) as being the independent variable is seen as being beneficial.
-011	CN-2	1	1st para	te	The scope includes too much explanatory text, which would be moved to introduction for users to better understand the background of this standard. The scope should be ascribed more simply and clearly for readers and users to know what are specified, and what can be applied to.	The scope can be simplified as: "This standard addresses the essential elements and protocols needed for Space Traffic Coordination (henceforth referred to as "STC"), which will be critical in the future to enable flight safety, mitigate some of the collision risk (for manoeuvrable spacecraft) and mitigation of Radio Frequency Interference (RFI) for all phases of flight, spanning pre-launch safety assessment through manoeuvre plans, on-orbit collision avoidance and	Partially accept; while we relocated two paragraphs to the introduction as you suggest, we merged your last paragraph with CRM-016. Apart from that, we did not alter the technical content of the scope as directed by SC14 resolution 613 from 2023 "to reestablish the cancelled project ISO 9490,

1 **MB** = Member body / **NC** = National Committee (enter the ISO 3166 two-letter country code, e.g. CN for China; comments from the ISO/CS editing unit are identified by **)
2 **Type of comment:** **ge** = general **te** = technical **ed** = editorial

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
						RFI mitigation support services, and eventually to mission disposal. The standard is designed for state actors, spacecraft designers, spacecraft operators, and STC system developers and operators. This standard is not exclusively for Earth-orbiting spacecraft but also applies to spacecraft in other important regimes, to include cislunar space, orbit about Mars, and libration point orbits. ” And, the other remaining words should be moved to Introduction.	Space systems – Space traffic coordination (STC), as an active project and to register the draft document at enquiry stage (DIS stage 40.00) going directly to stage 30.99 (preparing the DIS) following the NP ballot approval, with 24 months development timeframe (NP by 31 January 2024, DIS by 30 November 2024 and publication by 30 November 2025), with same PL (Mr. Daniel OLTROGGE (US), Mr. Dr. Akira KATO (JP), Mr. John DAVEY (UK)) and **maintaining the same scope** and project number. …”
DE-007 **-012**		1.1		ge	Regarding the definition of Enterprise STC system on the first paragraph after Fig. 3: STC service providers are, by definition, operating the STC system. They do not pool data to support STC analyses, but SSA service providers do as highlighted by Fig. 5	Modify the text in line with Enterprise STC system definition and Fig. 5 “An “Enterprise STC system” is a data sharing and exchange portal that provides a place where STC SSA service providers, spacecraft and launch service providers, and environment monitoring entities can pool their data”	Not accept – as was defined in the introduction and terminology section, an enterprise STC system includes processing and analysis.
-013		1.1		ge	Regarding the definition of Enterprise STC system on the first paragraph after Fig. 3: STC service providers are, by definition, operating the STC system. They do not pool data to support STC analyses, but SSA service providers do as highlighted by Fig. 5	Modify the text in line with Enterprise STC system definition and Fig. 5 “An “Enterprise STC system” is a data sharing and exchange portal that provides a place where STC SSA service providers, spacecraft and launch service providers, and environment monitoring entities can pool their data”	(Duplicate of other EU submittal)
DE-008		1.1	Fig 3	ge	Figure title mentions “relationships between SDA, SSA, STM, and STC”, but only SDA, SSA, SST	Change title/figure to remove/add STC	Not accept.

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2 **Type of comment:** **ge** = general **te** = technical **ed** = editorial

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
-014					and STM appear on the figure. The domain covered by STC is not clearly shown.		The figure includes STC in the middle box.
-015		1.1	Fig 3	ge	Figure title mentions “relationships between SDA, SSA, STM, and STC”, but only SDA, SSA, SST and STM appear on the figure. The domain covered by STC is not clearly shown. Also, contents are not fully aligned with other figures which can make the reader confused	It is suggested to remove Figure 3 (or move it to an Annex) as it can be confusing and considering that all the necessary information are available in other parts of the document	Not accept. Other P-members have found this figure highly useful and relevant.
DE-010 -016		2		ed	Technically we do not track or provide actionable data for an orbital region, but rather for a space object Additionally, it seems that last sentence is not needed: at any point in time, the standard will be applicable to orbital region where STC and SSA systems can operate, even if these regions are extended due to capabilities improvement. It will never be applicable to region which STC and SSA systems cannot access.	“While This standard applies to the range of orbital regions that in which current STC and SSA systems can effectively track, monitor, and provide actionable data for space objects, it is envisioned that this standard is generally applicable to all orbit regimes and orbit centres”	Accept.
DE-009 -017		2		ge	We believe the text has (again) significantly improved since the last revision. The number of comments is still a bit larger than one might expect as the standard is very long and complex. Many thanks to the lead author(s) for their comprehensive support and work on the draft.		Thank you for working with us on this project!
-018		2		ed	Technically we do not track or provide actionable data for an orbital region, but rather for a space object Additionally, it seems that last sentence is not needed: at any point in time, the standard will be applicable to orbital region where STC and SSA systems can operate, even if these regions are extended due to capabilities improvement. It will never be applicable to region which STC and SSA systems cannot access.	“While This standard applies to the range of orbital regions that in which current STC and SSA systems can effectively track, monitor, and provide actionable data for space objects, it is envisioned that this standard is generally applicable to all orbit regimes and orbit centres”	(Duplicate of other EU submittal)

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-012 -019	4	2	1st para	ed	By definition of Figure 2 the term “Space Safety” encompasses collision avoidance manoeuvres and mitigation of radio frequency interference. If by “enable flight safety” space safety is meant then it seems superfluous to list the two aspects again. If something else is meant by “flight safety” it should be better defined.	Change flight safety to the defined term “space safety”, if it is meant and potentially remove the superfluous listing of the aspects (or put them in brackets to indicate that they are subordinated to the term space safety).	Partial accept. Defined flight safety (being the more general term). Note that Figure 2 does not explicitly list “space safety”.
DE-011 -020	4	2	1st para	te	“mitigate some of the collision risk” - the word “some” is superfluous. The meaning of mitigate already transports the meaning. If all collision risk was meant, you could write prevent.	“mitigate collision risk”	Accept.
DE-013 -021	3	2	5th para	te	It is ambiguous what is meant by the term “orbit centre” as it is not really a properly defined technical term. It could be the focus of an orbit, the central body or the barycentre of a system.	“…generally applicable to all orbit regimes and for orbits around all central bodies / barycentres.” depending on what is meant	Accept.
DE-019 -022		3		ed	ISO 14950 is actually “Space systems — Unmanned spacecraft operability” ISO 18146 is actually “Space systems — Space debris mitigation design and operation manual for spacecraft” ISO 16164, 23339 and 26872 cannot be found in the catalogue provided as a link…	Replace title of the document with the correct one ISO 16164, 23339 and 26872 have been cancelled and are indicated in IOS website as replaced by ISO 23312 (“Space systems — Detailed space debris mitigation requirements for spacecraft”). As these documents are not further refered to in this standard, it is suggested to remove them, or replace them with ISO 23312	Accept.
DE-018 -023		3		ge	Considering the developments timeframe of ISO 21740 (Launch Collision Avoidance – DIS stage, target publication May 2025) and ISO 23705 (Avoiding collisions – post CD stage, publication limit May 2026, i.e. before current plan for ISO 9490), it would make sense to add these relevant references in this section to anticipate for their potential publication before ISO 9490 Other standards such as ISO 6434 or ISO 22639 could also be relevant additions to the list of normative references	Include in the list of normative references, the standards mentioned in comments	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-017 -024		3		ge	ISO 16164: “Space systems — Disposal of satellites operating in or crossing Low Earth Orbit” is referenced but this standard has been withdrawn. Following consolidation of requirement documents within ISO/TC20/SC14/WG7 these requirements can now be found in ISO 24113.	As ISO 24113 is already referenced to consider dropping the reference to the withdrawn standard.	Accept.
DE-016 -025		3		ge	ISO TR 16158: “Space systems — Avoiding collisions with orbiting objects” is referenced. The work on establishing ISO 23705 “Space systems - Identifying, evaluating, and avoiding collisions between orbiting objects” has already started (passed CD stage) and will eventually replace ISO TR 16158.	Depending on the schedule for ISO 9490,consider referencing to ISO 23705 instead to ISO/TR 16158.	Accept.
DE-015 -026		3		ge	ISO 26872: “Space systems — Disposal of satellites operating at geosynchronous altitude” is referenced but this standard has been withdrawn. Following consolidation of requirement documents within ISO/TC20/SC14/WG7 these requirements can now be found in ISO 24113.	As ISO 24113 is already referenced to consider dropping the reference to the withdrawn standard.	Accept.
DE-014 -027		3		ge	Launch collision avoidance is mentioned as an aspect for STC, see e.g. Fig 1, Fig. 3 or clause 4.10. The work on ISO 21740 “Space systems — Launch window estimation and collision safety” has already started (DIS voting stage) which will provide requirements for Lauch collision avoidance at least for inhabitable space objects.	Depending on the schedule for ISO 9490, consider adding ISO 21740 to the list of normative references.	Accept.
GB8-028		3		ge	ISO 26872 was cancelled as part of WG7’s debris standards consolidation activity. The content was transferred into ISO 23312.	Delete the reference to ISO 26872 from the list. If it is desirable to refer to 23312 then consider adding it to the Bibliography rather than clause 3.	Accept.
GB7-029		3		ge	It is not clear why ISO 24330 is in the list of normative references rather than the Bibliography. Currently, the main text (clause 10.6) only points to 24330 informatively.	Make sure there is a normative statement pointing to 24330 somewhere in the main text. Alternatively, if it is not essential to refer to 24330 in order to comply with this STC standard, then transfer 24330 from clause 3 to the Bibliography.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
GB6-030		3		ge	ISO 23339 was cancelled as part of WG7's debris standards consolidation activity. The content was transferred into ISO 23312.	Delete the reference to ISO 23339 from the list. If it is desirable to refer to 23312 then consider adding it to the Bibliography rather than clause 3.	Accept.
GB5-031		3		ge	ISO 16164 was cancelled as part of WG7's debris standards consolidation activity. The content was transferred into ISO 23312.	Delete the reference to ISO 16164 from the list. If it is desirable to refer to 23312 then consider adding it to the Bibliography rather than clause 3.	Accept.
GB4-032		3		ge	It is not clear why ISO TR 16679 is in the list of normative references rather than the Bibliography.	Make sure there is a normative statement pointing to 16679 somewhere in the main text. Currently, this is missing. Alternatively, if it is not essential to refer to 16679 in order to comply with this STC standard, then transfer 18146 from clause 3 to the Bibliography.	Accept.
GB3-033		3		ge	It is not clear why ISO TR 18146 is in the list of normative references rather than the Bibliography.	Make sure there is a normative statement pointing to 18146 somewhere in the main text. Currently, this is missing. Alternatively, if it is not essential to refer to 18146 in order to comply with this STC standard, then transfer 18146 from clause 3 to the Bibliography.	Accept.
GB2-034		3		ge	ISO TR 16158 may be replaced by ISO 23705 within the timescale of this STC standard's development.	Consider deleting the reference to ISO TR 16158 and adding a reference to ISO 23705 instead. Regardless of whether this is done, make sure there is a normative statement pointing to 16158 or 23705 somewhere in the main text. Currently, this is missing. Alternatively, if it is not essential to refer to 16158 / 23705 in order to comply with this STC standard, then transfer 16158 / 23705 from clause 3 to the Bibliography.	Accept.
GB1-035		3		ge	ISO 14950 relates to unmanned spacecraft operability, not breakup prevention. The breakup prevention standard was numbered 16127. It was cancelled as part of WG7's debris standards consolidation activity. The content was transferred into ISO 23312.	Delete the reference to ISO 14950 from the list. If it is desirable to refer to 23312 then consider adding it to the Bibliography rather than clause 3.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
-036		3		ge	Considering the developments timeframe of ISO 21740 (Launch Collision Avoidance – DIS stage, target publication May 2025) and ISO 23705 (Avoiding collisions – post CD stage, publication limit May 2026, i.e. before current plan for ISO 9490), it would make sense to add these relevant references in this section to anticipate for their potential publication before ISO 9490 Other standards such as ISO 6434 or ISO 22639 could also be relevant additions to the list of normative references	Include in the list of normative references, the standards mentioned in comments	(Duplicate of other EU submittal)
-037		3		ed	ISO 14950 is actually “Space systems — Unmanned spacecraft operability” ISO 18146 is actually “Space systems — Space debris mitigation design and operation manual for spacecraft” ISO 16164, 23339 and 26872 cannot be found in the catalogue provided as a link…	Replace title of the document with the correct one ISO 16164, 23339 and 26872 have been cancelled and are indicated in IOS website as replaced by ISO 23312 (“Space systems — Detailed space debris mitigation requirements for spacecraft”). As these documents are not further refered to in this standard, it is suggested to remove them, or replace them with ISO 23312	(Duplicate of other EU submittal)
DE-020 -038		4		te	No definition of conjunction provided	add conjunction, perhaps include classification levels (?)	Accept.
GB 10-039		4.1		ge	Improve clarity of definition.	Change the definition to: quantification of the likelihood of two space objects impacting each other during a conjunction event	Accept.
GB 11-040		4.2		ge	Improve clarity of definition.	Change the definition to: combination of collision probability and collision consequence for a space object experiencing a single conjunction event, or the aggregation of this combination for a space object experiencing multiple conjunction events	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
US - 02- 041		4.2.2		ge	In 4.24, the STC Approving Agent is explicitly stated to be a government or commercial entity, among other possibilities. However, 4.22 does not explicitly state the type of entities that may serve as a Service Provider.	In 4.22, add an additional statement at the end: "Its responsibilities can be handled by a commercial, governmental, non-governmental, or international entity, as well as a mandated or delegated entity assigned by applicable national regulation."	Accept.
GB 12- 042		4.3		ge	Improve clarity of definition. What does [60F] mean?	Change the definition to: outcome of a collision between two space objects Add the following note: Note 1 to entry: The outcome of a collision can be characterised in a number of ways, including the likelihood of catastrophic breakup, the number of debris fragments larger than a specified size or mass that might be generated [60F], the lifetime of the resulting fragments, or some combination thereof.	Accept.
-043	CN-3	4.4	all	te	The term should not be called as "enterprise space traffic coordination system", but be "space traffic coordination system", without regard to a enterprise system	Only define "space traffic coordination system"	Partially accept. Changed to "Levels" of system as shown in Fig. 4 and C-2.
-044	CN-4	4.7 4.8		te	"higher airspace" is not a precisely described term, which should be deleted in this document	Change to another term	Not accept. "Flight Level" (FL 550) is specifically incorporated into the definition, and Flight Level is an internationally accepted term.
DE- 021 **-045**		4.9		ed	In the definition of large constellation, the last part should be stated as a note, as it is the case in ISO 6434 We could also take exactly the definition from ISO 6434 which has the same meaning and would enable to align definitions over multiple standards	"A hundred or more spacecraft working together as a system Note: although in addition to quantity, the spacecraft size, mass, complexity and function of the spacecraft also have a bearing."	Accept.
GB 13- 046		4.9		ge	Improve clarity of definition.	Change the definition to: one hundred or more spacecraft working together as a system	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
						Add the following note: Note 1 to entry: In addition to quantity, the size, mass, complexity and function of the spacecraft can also have a bearing on whether a constellation is regarded as large.	
-047		4.9		ed	In the definition of large constellation, the last part should be stated as a note, as it is the case in ISO 6434 We could also take exactly the definition from ISO 6434 which has the same meaning and would enable to align definitions over multiple standards	“A hundred or more spacecraft working together as a system Note: although in addition to quantity, the spacecraft size, mass, complexity and function of the spacecraft also have a bearing.”	(Duplicate of other EU submittal)
GB 14-048		4.10		ge	Improve clarity of definition.	Change the definition to: process to identify, coordinate and avoid conjunctions that can result in a collision between a launching object and other objects in space	Accept.
GB 15-049		4.11		ge	Improve clarity of definition.	Change the definition to: 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 Add the following note: Note 1 to entry: This definition is identical to that given in paragraph 5 of the UNCOPUOS LTS Guidelines, 2019 [31?].	Accept.
GB 16-050		4.12		ge	Improve clarity of definition.	Change the definition to: process of converting or mapping data into a common reference frame, units, timing system, element or Cartesian set, and definitions so that analyses and comparisons can be accomplished meaningfully	Accept.

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Template for comments and secretariat observations

Date:2024-10-05	Document:	Project:

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
GB 17- **051**		4.18		ge	Improve clarity of definition.	Change the definition to: act of protecting, conserving, and sustaining the space operations environment, accomplished by space debris mitigation and remediation Add the following note: Note 1 to entry: References [?, ?, etc.] provide specific recommendations and requirements relating to space debris mitigation and remediation.	Accept.
GB 18- **052**		4.19		ge	Improve clarity of definition.	Change the definition to: knowledge and characterization of the space environment to facilitate decisions that support safe and sustainable space activities Add the following note: Note 1 to entry: Awareness of the space environment can encompass: artificial space objects, including spacecraft, rocket bodies, mission-related objects and fragments, natural objects, asteroids (including Near-Earth Objects or NEOs), comets and meteoroids, effects from space weather, including solar activity and its radiation [3], and potential risks to humans and property in space, on the ground and in the air space due to accidental or intentional re-entries, on-orbit explosions and release events, on-orbit collisions, radio frequency interference, and occurrences that could disrupt missions and services.	Accept.
GB 19- **053**		4.20		ge	Improve clarity of definition.	Change the definition to: detection, observation, monitoring, cataloguing and prediction of the movement of space objects, and the identification and alerting of derived risks Add the following note:	Accept, augmented by "launch operations in space."

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
						Note 1 to entry: Space surveillance and tracking is generally accomplished through the operation and calibration of ground-based or space-based tracking sensors using radar, optical or passive RF technology.	
GB 20- **054**		4.21		ge	Improve clarity of definition.	Change the definition to: cooperative planning, harmonization, data and information sharing, and synchronization of space activities to avoid collision and radio frequency interference during the orbital operations of spacecraft and launch vehicle orbital stages	Accept, with minor revision.
GB 21- **055**		4.23		ge	Improve clarity of definition.	Change the definition to: set of protocols, communications paths, and information gathering and exchange systems to enable space traffic coordination Add the following note: Note 1 to entry: An STC system at its most complete scope and reach can be described as an “Enterprise STC system” [4.4]	Accept.
GB 22- **056**		4.24		ge	Improve clarity of definition.	Change the definition to: entity who sets the requirements for and approves the procurement, management, oversight, implementation, operations, performance criteria, quality assurance, and monitoring functions of the Space Traffic Coordination system under their authority Add the following note: Note 1 to entry: The STC system approving agent’s responsibilities can be handled by a commercial, non-governmental, governmental, or international individual or entity, as well as a mandated or delegated entity assigned by applicable national regulations.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
GB 23- **057**		4.26		ge	Improve clarity of definition.	Change the definition to: entity that utilizes STC system products and services to inform and make operational decisions Add the following note: Note 1 to entry: Spacecraft operators, launch service providers, Higher Airspace operators, SSA systems, other STC systems, and governments can be considered to be STC system users.	Accept.
GB 24- **058**		4.27		ge	Improve clarity of definition.	Change the definition to: 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 radio frequency interference Add the following note: Note 1 to entry: STM contributes to a safer and more sustainable space operations environment by encompassing (1) STC and (2) Regulation and Licensing, and is dependent upon a foundation of continuous SSA.	Accept.
GB 25- **059**		4.28		ge	Improve clarity of definition.	Change the definition to: entity participating in international space activities on behalf of a government Add the following note: Note 1 to entry: While the roles of a State Actor can include that of regulator, spacecraft operator, launch service provider, and/or STC service provider, this standard does not address regulatory matters.	Accept.
GB9- **060**		4.x		te	The term ‘conjunction’ is used many times throughout the document but is not defined.	Define the term ‘conjunction’.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-022 -061		6.2		ed	Rather than using the notion of "STC system operators and service providers" which actually are the same (as per definition 4.22), why not using the term "STC system participants" including all those entities (and even more) as per definition provided in 4.25	"In order to promote interoperability and compatibility, STC system developers and participants, operators, and service providers should adopt and use […]"	Accept.
-062		6.2		ed	Rather than using the notion of "STC system operators and service providers" which actually are the same (as per definition 4.22), why not using the term "STC system participants" including all those entities (and even more) as per definition provided in 4.25	"In order to promote interoperability and compatibility, STC system developers and participants, operators, and service providers should adopt and use […]"	(Duplicate of other EU submittal)
DE-023 -063		6.3		ed	Here again to simplify the sentence we could use the newly defined term "STC participants"	"Consistent with UN COPUOS LTS Guideline A.2.f 1, STC participants spacecraft and launch service providers, SSA data and information providers, each STC enterprise shall use, where possible […]"	Accept.
GB 26- 064		6.3		ge	Improve clarity of requirement and add another note. Add ISO 19933, ISO 26900, ISO 19389, ISO 13541, ISO 13526, and ISO 17107 to the Bibliography. Then insert the reference numbers into NOTE 2.	Change to: Consistent with UN COPUOS LTS Guideline A.2.f 1 [Ref ?], and the operational practices of spacecraft and launch service providers and SSA data and information providers, each STC entity shall use, where possible, international technical standards on space operations and data exchange messages. NOTE 1: [OK as is] NOTE 2: References [36, 37, 39, 40, 42, 46] are examples of STC-relevant CCSDS standards. The equivalent ISO standards are References [?, ?, ?, ?, ?, ?].	Accept.
-065		6.3		ed	Here again to simplify the sentence we could use the newly defined term "STC participants"	"Consistent with UN COPUOS LTS Guideline A.2.f 1, STC participants spacecraft and launch service providers, SSA data and information providers, each STC enterprise shall use, where possible […]"	(Duplicate of other EU submittal)

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Template for comments and secretariat observations

Date:2024-10-05	Document:	Project:

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
GB 27- **066**		7.1		ge	The second sentence is not necessary and does not belong here.	Delete: Accordingly, the following is required of spacecraft and launch service providers:	Accept.
DE-024 **-067**		7.2 7.3		ed	Section 7.2 is addressing “affected government” while following section is mentioning “state actors” Also, in section 7.3, acronym HAO (Higher Airspace Operations) is not defined beforehand	Align both wording by changing “affected government” by “affected state actors” Add HAO to the list of accronyms	Accept.
-068		7.2 7.3		ed	Section 7.2 is addressing “affected government” while following section is mentioning “state actors” Also, in section 7.3, acronym HAO (Higher Airspace Operations) is not defined beforehand	Align both wording by changing “affected government” by “affected state actors” Add HAO to the list of accronyms	(Duplicate of other EU submittal)
GB 28- **069**		7.2 to 7.5, 8.3, 9.3.5, 9.4.1		ge	The statement “Where permitted by national laws, regulations, and policies,” is not permissible. A standard cannot make any provision or give any guidance in respect of compliance with the law or discharge of legal obligations. Standards users are expected to obey the law regardless of whether they comply with standards. If the statement were permissible, then it would have to be written at the beginning of every clause in every standard ever published.	Delete: Where permitted by national laws, regulations, and policies,	Accept.
US - 03- **070**		7.3		gc	HAO is not defined.	Suggest adding to the acronym list.	Accept.
-071	CN-6	8		te	Add a new chapter to address the collision risk levels and related alerts, just refer to the ground traffic lights	For green lights, it is safe; For yellow lights, it must issue an alert to be aware dangerous conjunction, and to coordinate manoeuvre ;	Not accept. International community averse to inclusion of “issues of sovereignty” in standard.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
						For red lights, there must be a high level of collision risk, the spacecraft must conduct orbit manoeuvre as soon as possible.	
DE-026 -072		8		ge	In our internal coordinations, repeatedly concerns are being raised with what used to be the "rules of the road" section, that a discussion about who gives way to whom is a matter of international diplomacy and not be defined in an ISO standard but rather needs to be discussed with all nations.	Move 8.2 to 8.11 to an informative annex; that annex could then also contain more technical explanation why manoeuvre recommendations are given with giving one type of operator priority over another operator, which could help inform discussions at other relevant international fora. Or, if this is not acceptable by the group, at least provide technical explanation for the selected rules and make very clear that this is a minimum set of rules, that if adopted allow for reduce number of coordination needed between operators for improved safety.	Not accept. The EU was a key community which demanded that Rules of the Road be included in this standard.
DE-025 -073		8		te	In section 8 slightly different categories for crewed/inhabitable space objects are used which should be harmonized. Ch. 8.2 and Table 1 are referring to “crewed space objects”. In several other places the term “inhabitated or inhabitable” space objects is used, in others "space stations" (8.6).	I would propose to consider only a category “inhabitable space object”, regardless if it is currently inhabitated or not. The status might change over time or might even be unclear because of “communication issues”. Furthermore, an inhabitable space object without crew might even serve as a save haven in case of emergencies with humans in space. IMHO, any inhabitable space object regardless if or if not inhabited should be considered as a privileged and protected object in space. Additionally, every operator of an inhabitable space object should be encouraged to non-ambiguously communicate the crew size along with any plans to change the crew in advance.	Accept.
DE-027 -074		8.2		ed	There are now 6 categories defined, not 5	“Spacecraft shall be categorized into the following five six manoeuvrability categories”	Accept.
-075		8.2		ed	There are now 6 categories defined, not 5	“Spacecraft shall be categorized into the following five six manoeuvrability categories”	(Duplicate of other EU submittal)

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DE-028 **-076**		8.2 iii		te	The category of a spacecraft may change over time due to depletion of propellant or anomalies. For example, a "manoeuvrable robotic SC" (iii) can evolve into a "minimally manoeuvrable robotic SC" or even into a "non-manoeuvrable SC".	Please consider adding a note to the clause indicating that the classification may not be permanent and change over time.	Accept.
US - 04- 077		8.3		gc	Not sure why there is a time commitment in this section. Section seems to address the fact that operators with autonomous maneuver capabilities should be transparent about their algorithm. It seems that whether you are autonomous or manual maneuvering it is important for the other entity to have insight re: timeframe.	Suggest either deleting the "at least 12 hours before the avoidance maneuver takes place" entirely or adding words to clarify that the stipulation applies to any kind of maneuver, not just autonomous ones.	Discuss.
-078	CN-5	8.4		te	It is not so strictly to require that robotic spacecraft to give way for human inhabited or inhabitable space stations, whatever the robotic spacecraft operation status. Because the human space activities have the most important priority.	It must be clearly require that robotic spacecraft shall give way for human inhabited or inhabitable space station, whatever the robotic spacecraft operatio9n status.	Not accept. This was already discussed in Bullet (8.4.a)
DE-031 **-079**		8.4		te	As a general rule, objects moving out of their designated mission orbit should always give way, i.e. the first decision criteria would be whether one is in its mission orbit or not, then only the second criteria the manoeuvrability Reading Table 1, it looks like recommendations are constructed the other way around	Rework the section to specify, as a first priority rule, that objects out of their designated mission orbit should give way An easy and user friendly solution could be to add numbering (instead of the bullets) in section 8.4 before the table to mark the different steps (if step 1 does not solve the problem, then move to step 2, etc…), e.g. 1. Manoeuvrable spacecraft or space station should engage in bilateral discussions (3rd bullet – as coordination is the very first step, as highlighted in 8.1) 2. Robotic missions should allow space stations to select who manoeuvres (1st bullet) 3. Objects not on their operational mission orbit should conduct the avoidance manoeuvre (4th bullet)	Accept.

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
						4. Large constellation operators should conduct the collision avoidance manoeuvre (5th bullet) 5. “Manoeuvrability of the objects should be used as decision criteria according to Table 1 below” (new addition) 5.1 Operators of spacecraft should pre-coordinate within their same manoeuvrability category (2nd bullet – linked to previous point as clarifying one aspect of Table 1) 6. Privately-owned spacecraft should conduct the collision avoidance manoeuvre (last bullet)	
DE-030 -080		8.4		te	Operationally it might be difficult for an operator to know what is the manoeuvrability of another operator and especially it is not clear what ‘roughly the same manoeuvrability’ means and thus which is the difference in the manoeuver capability allowing to distinguish two satellites	To replace ‘roughly the same manoeuvrability’ with ‘spacecraft belonging to the same manoeuvrability category’ in order to better understand why this rule would apply	Accept.
DE-029 -081		8.4		te	In the second bullet it is asked to engage bilateral discussions to coordinate in case of serious conjunction but the word SERIOUS is too vague and might be interpreted in different ways by operators depending on their risk profile.	To add a reference to Table 2 of section 8.8 (collision avoidance manoeuvre Go/No-Go thresholds) to clarify what is considered as a ‘serious conjunction’	Accept.
GB 29- 082		8.4		ge	It is not clear why the six bulleted statements are bulleted.	Remove bulleting.	Accept. (per #79).
US - 06- 083		8.4		tc	6th bullet. Given the different political and economic structures that exist globally, I do not understand this bullet and how one discerns who is “public” and who is “private”. This standard is about safety and coordination. A space operator is a space operator.	Delete this bullet.	Discuss.
US - 05- 084		8.4		tc	5th bullet. Do not think that large constellation operators should be called out separately. (What defines large? What happens when two	Combine bullet 2 with bullet 5. Will clarify. Add a note that the ISO large constellation standard is forthcoming.	Discuss.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					constellations are “giving away” simultaneously in the same orbit)		
-085		8.4		te	In the second bullet it is asked to engage bilateral discussions to coordinate in case of serious conjunction but the word SERIOUS is too vague and might be interpreted in different ways by operators depending on their risk profile.	To add a reference to Table 2 of section 8.8 (collision avoidance manoeuvre Go/No-Go thresholds) to clarify what is considered as a ‘serious conjunction’	(Duplicate of other EU submittal)
-086		8.4		te	Operationally it might be difficult for an operator to know what is the manoeuvrability of another operator and especially it is not clear what ‘roughly the same manoeuvrability’ means and thus which is the difference in the manoeuver capability allowing to distinguish two satellites	To replace ‘roughly the same manoeuvrability’ with ‘spacecraft belonging to the same manoeuvrability category’ in order to better understand why this rule would apply	(Duplicate of other EU submittal)
-087		8.4		te	As a general rule, objects moving out of their designated mission orbit should always give way, i.e. the first decision criteria would be whether one is in its mission orbit or not, then only the second criteria the manoeuvrability Reading Table 1, it looks like recommendations are constructed the other way around	Rework the section to specify, as a first priority rule, that objects out of their designated mission orbit should give way An easy and user friendly solution could be to add numbering (instead of the bullets) in section 8.4 before the table to mark the different steps (if step 1 does not solve the problem, then move to step 2, etc…), e.g. 0. Spacecraft whose collision avoidance capability is temporarily or permanently impaired should have the right of way (stated currently as an exception) 1. Manoeuvrable spacecraft or space station should engage in bilateral discussions (3rd bullet – as coordination is the very first step, as highlighted in 8.1) 2. Robotic missions should allow space stations to select who manoeuvres (1st bullet) 3. Objects not on their operational mission orbit should conduct the avoidance manoeuvre (4th bullet) 4. Large constellation operators should conduct the collision avoidance manoeuvre (5th bullet) 5. “Manoeuvrability of the objects should be used as decision criteria according to Table 1 below” (new addition)	(Duplicate of other EU submittal)

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
						5.1 Operators of spacecraft should pre-coordinate within their same manoeuvrability category (2nd bullet – linked to previous point as clarifying one aspect of Table 1) 6. Privately-owned spacecraft should conduct the collision avoidance manoeuvre (last bullet – could be removed)	
DE-032 -088		8.4	Table 1	te	In case of risk between a manoeuvrable satellite and a crewed one, it is too vague to ask for a 'large miss distance' since an operator could eventually chose any value which is reasonable for him (e.g. 1 km)	To add a reference to section 8.6 where it is required to have a 10 km distance with respect to crewed vehicles	Accept.
-089		8.4	Table 1	te	In case of risk between a manoeuvrable satellite and a crewed one, it is too vague to ask for a 'large miss distance' since an operator could eventually chose any value which is reasonable for him (e.g. 1 km)	To add a reference to section 8.6 where it is required to have a 10 km distance with respect to crewed vehicles	(Duplicate of other EU submittal)
US - 09-090		8.5		ed	Iv: if a spacecraft is temporarily or permanently impaired it is essentially a non-maneuvering vehicle and is covered under Table 1.	Suggest deleting iv: it is redundant.	Accept.
US - 08-091		8.5		ed	Ii: Awkward wording	Suggest: "where both spacecraft belong to the same operator and the operator chooses solution"	Accept.
US - 10-092		8.6		ed	Missing a word	"…… robotic missions shall allow through real-time coordination with operators of human inhabited or…."	Accept.
JP-02-093		8.8		ge	The requirement for "Collision avoidance manoeuvre Go/No-Go thresholds" including Table - 1 "Avoidance manoeuvre minimum thresholds" is almost duplicated with 5.2.8 in CD 23705	The assessment algorithms, approaches and thresholds should be written only in one document.	Accept, assuming you actually meant Table 2. But… this content has been deleted (moved to 23705)

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-035 **-094**		8.8 8.9		te	Having the CAM thresholds introduced in a document not introducing methods for computation does not seem practical (as an operator would need to consult both documents to find the necessary information) Consider moving these sections to ISO 23705 currently under developments Another reason in favour of moving these sections is that LCOLA considerations (including thresholds) are not included in ISO 9490 but rather in supporting standard ISO 21740 Note: In section 8.8, collision avoidance threshold are made requirements with the use of a “shall”, while in ISO 23705 it is provided as a “should” and using “for instance”. As we are in a talking of “manoeuvre recommendation”, use “should” instead of “shall” is prefered	Keep sections 8.8 and 8.9 only in ISO 23705 so that one document contains at the same time methods and thresholds which are linked to each other, and such that LCOLA and COLA handling are consistent	Accept. But… this content has been deleted (moved to 23705)
DE-034 **-095**		8.8		te	Table does not mention threshold for MEO orbital regime	It is proposed to tackle MEO in the same way as GEO	Accept. But… this content has been deleted (moved to 23705)
DE-033 **-096**		8.8		ge	Miss distance of 100m for LEO seems to be very tight (especially in tangential direction)	Increase miss distance criteria or add a criteria on radial separation in the same way it is done for GEO regime	Not accept. The accuracy must be capable of supporting the metrics and thresholds used by the spacecraft operator. Our analysis has shown that for LEO, 100m is required in order to effectively support Pc of one in ten thousand threshold. But… this content has been deleted (moved to 23705)

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
US - 11- 097		8.8		tc	While it is admirable to have a target set of thresholds it seems somewhat problematic to interpret their effectivity given that people are likely going to be using a variety of algorithms, data quality, and parameters to make the calculations.	A threshold does not guarantee safety if the methodology used to generate the metric measured against the threshold is not consistent. Suggest community examine methodology for how the Pc or miss distance is calculated and gaining some consistency in this methodology. Standardizing methodology will be more important for safety then setting thresholds which have no underlying consistent foundation.	Not accept. A discussion of both metrics AND thresholds is needed. But… this content has been deleted (moved to 23705)
-098		8.8		ge	Miss distance of 100m for LEO seems to be very tight (especially in tangential direction)	Increase miss distance criteria or add a criteria on radial separation in the same way it is done for GEO regime	(Duplicate of other EU submittal)
-099		8.8		te	Table does not mention threshold for MEO orbital regime	It is proposed to tackle MEO in the same way as GEO	(Duplicate of other EU submittal)
-100		8.8 8.9		te	Having the CAM thresholds introduced in a document not introducing methods for computation does not seem practical (as an operator would need to consult both documents to find the necessary information) Consider moving these sections to ISO 23705 currently under developments Another reason in favour of moving these sections is that LCOLA considerations (including thresholds) are not included in ISO 9490 but rather in supporting standard ISO 21740 Note: In section 8.8, collision avoidance threshold are made requirements with the use of a "shall", while in ISO 23705 it is provided as a "should" and using "for instance". As we are in a talking of "manoeuvre recommendation", use "should" instead of "shall" is prefered	Keep sections 8.8 and 8.9 only in ISO 23705 so that one document contains at the same time methods and thresholds which are linked to each other, and such that LCOLA and COLA handling are consistent	(Duplicate of other EU submittal)
DE- 036 **-101**		8.8 8.9	Table 2 Table 3	ed	Instead of "Max Pc" the formulation "Scaled Pc" seems to be more appropriate as it was proposed in ISO 23705 latest ballot	As per left	Partial accept. The term "scaled Pc" is less standardized, globally, than "max Pc". Decided to delete "max".

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
							But… this content has been deleted (moved to 23705)
-102		8.8 8.9	Table 2 Table 3	ed	Instead of "Max Pc" the formulation "Scaled Pc" seems to be more appropriate as it was proposed in ISO 23705 latest ballot	As per left	(Duplicate of other EU submittal)
DE-037 -103		8.9		ge	Notes should not contain requirements nor recommendations. Note 1 is introducing the same considerations as Table 3 stated differently. It could therefore be removed Note 2 is contradicting what is stated as a requirement at the beginning of the section, it is proposed to add this note directly at the end of the requirement	"The collision probability target of conducted collision avoidance manoeuvres shall adhere to the targets listed in Table 3, unless a decrease of Pc by one order of magnitude results in manoeuvres leading to significant effects on the S/C operations or even be out of the S/C capability. In that case, the O/O should implement the manoeuvre decreasing the risk as much as possible." And remove note 1	Discuss. But… this content has been deleted (moved to 23705)
-104		8.9		ge	Notes should not contain requirements nor recommendations. Note 1 is introducing the same considerations as Table 3 stated differently. It could therefore be removed Note 2 is contradicting what is stated as a requirement at the beginning of the section, it is proposed to add this note directly at the end of the requirement	"The collision probability target of conducted collision avoidance manoeuvres shall adhere to the targets listed in Table 3, unless a decrease of Pc by one order of magnitude results in manoeuvres leading to significant effects on the S/C operations or even be out of the S/C capability. In that case, the O/O should implement the manoeuvre decreasing the risk as much as possible." And remove note 1	(Duplicate of other EU submittal)
GB 30-105		8.9	Note 2	te	What is the O/O?	Define in clause 5.2.	Accept. But… this content has been deleted (moved to 23705)
DE-038 -106		8.9	Table 3	ed	Table is mentioning "manoeuvre threshold(s)" while it should rather be "collision probability target" Finally, the miss distance specified in LEO robotic and crewed should be minimum miss distances (thus the sing "<" reverted to ">")	Modify Table 3 content as per left	Accept. But… this content has been deleted (moved to 23705)

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
-107		8.9	Table 3	ed	Table is mentioning “manoeuvre threshold(s)” while it should rather be “collision probability target” Finally, the miss distance specified in LEO robotic and crewed should be minimum miss distances (thus the sing “<” reverted to “>”)	Modify Table 3 content as per left	(Duplicate of other EU submittal)
DE-042 -108		8.10 8.11		ge	These sections are directly referring to collision avoidance process and, as a result, seems to be more relevant in ISO 23705 than to be introduced in a “Manoeuvre recommendations and prioritization” section	Keep 8.10 and 8.11 only in ISO 23705	Accept. But… this content has been deleted (moved to 23705)
DE-041 -109		8.10		te	‘At other proximate times’ is too vague.	To specify a duration or at least an order of magnitude (e.g. few days) otherwise a too low duration might be considered by operators. In case it is too complex to define a duration valid for all orbital regimes, at least to add a sentence saying that the values will be specified by the approving agent.	Accept. But… this content has been deleted (moved to 23705)
DE-040 -110		8.10		Table 4	To give ranges for in the column “minimum time between initial TCA notification and manoeuvre” seems to be contradictory. How can a minimum time be a range? How is this to be understood?	Give one value in each row which really is the minimum or make the column heading clearer. For me it is not clear what these times should mean. E.g. as an operator 7 hours after initial TCA notification this table would only help me to decide when to do a manoeuvre if I have LEO low thrust.	Accept. But… this content has been deleted (moved to 23705)
DE-039 -111		8.10		Table 4	The implication of what “minimum time between initial TCA notification and manoeuvre” means is not fully clear. Who needs to act when?	please provide clarification, e.g. as an explanatory NOTE	Accept. But… this content has been deleted (moved to 23705)
-112		8.10		te	‘At other proximate times’ is too vague.	To specify a duration or at least an order of magnitude (e.g. few days) otherwise a too low duration might be considered by operators. In case it is too complex to define a duration valid for all orbital regimes, at least to add a sentence saying that the values will be specified by the approving agent.	(Duplicate of other EU submittal)

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Template for comments and secretariat observations

Date:2024-10-05	Document:	Project:

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
-113		8.10 8.11		ge	These sections are directly referring to collision avoidance process and, as a result, seems to be more relevant in ISO 23705 than to be introduced in a “Manoeuvre recommendations and prioritization” section	Keep 8.10 and 8.11 only in ISO 23705	(Duplicate of other EU submittal)
JP-03-114		8.11		ge	The requirement for “Timeline of collision avoidance manoeuvres” is duplicated between sub-clause 8.11 in 9490 and sub-clause 5.2.12 in CD 23705.	The assessment algorithms, approaches and thresholds should be written only in one document.	Accept. But… this content has been deleted (moved to 23705)
US - 13-115		8.11		tc	Item 7 is not clear. This also seems to be an editorial statement and not related to the process.	Suggest deletion of item 7 or add context on what this statement means for the procedure being described.	Accept. But… this content has been deleted (moved to 23705)
US - 12-116		8.11		tc	(2) is not required. It does not matter where the flight dynamics staff gets its information to study the event. Statement is more of an editorial comment on what an STC center may (or may not do) and not related to the process.	Suggest deletion of item 2.	Accept. But… this content has been deleted (moved to 23705)
-117		8.11	Table 4	ed	MEO regime is not considered in Table 4	Add a line with MEO desired execution times	Accept. But… this content has been deleted (moved to 23705)
-118	CN-8	9		te	Lack of roles of state actors and United nations	Please add the roles and related responsibilities for State actors and United nations.	Not accept. It is clear that state actors will not support standards containing or addressing regulatory matters.
-119	CN-7	9	title	te	It’s not the responsibilities of STC system participant, but the responsibilities of STC participants	The STC system is not the core of STC activities, but only a tool or system to help make decision or command orbit manoeuvre	Accept.
GB 31-120		9.1		ge	The following text at the beginning of clause 9.1 is a hanging paragraph: “The STC system approving agent has a critical role in setting overall system requirements, managing, and enabling the STC system. The following sections provide requirements for the STC system approving agent to achieve these	This text is unnecessary and should be deleted. It is already covered by the definition in clause 4.24.	Not accept. Converted into a requirement instead. This is a valid statement for the role of an STM approving agent.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					goals, which the approving agent may choose to delegate to other entities as allowed by governing laws and policies.”		
DE-043 -121		9.1.1 9.1.3		ed	Both sections seems redundant as they both mention the need for approving agent to set STC systems requirements	Merge both sections, for instance: “The STC system approving agent shall set accuracy, availability, timeliness, completeness, performance, security, and quality control requirements, and monitor STC system for compliance verification.”	Accept.
-122		9.1.1 9.1.3		ed	Both sections seems redundant as they both mention the need for approving agent to set STC systems requirements	Merge both sections, for instance: “The STC system approving agent shall set accuracy, availability, timeliness, completeness, performance, security, and quality control requirements, and monitor STC system for compliance verification.”	(Duplicate of other EU submittal)
US - 16- 123		9.1.3		ed	9.1.3 is redundant to 9.1.1	Delete 9.1.3. Add the word “security” to 9.1.1.	Accept.
GB 32- 124		9.2		ge	The following text at the beginning of clause 9.2 is a hanging paragraph: “The STC system service provider operates the STC system and serves as the system integrator. The following sections provide requirements for the STC service provider.”	The first sentence is a definition and should be moved into clause 4. The second sentence is unnecessary and should be deleted.	Accept.
US - 17- 125		9.2		Tc/gc	This whole section should be deleted. The STC “approving agent” will set the requirements for the STC system. Section 9.2 is establishing derived requirements for the actions of an STC approving agent.	Delete Section 9.2. STC approving agents will set the requirements for their relevant providers.	Accept.
GB 34- 126		9.3		ge	The following text at the beginning of clause 9.3 is a hanging paragraph: “Spacecraft operators have important STC responsibilities. The following sections provide	The first sentence does not say anything important and could be deleted. The second sentence is unnecessary and should be deleted.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					requirements associated with these responsibilities.”		
DE-044 -127		9.3.1		ge	Requirement is specifying a solution to the collision avoidance systems reliability issue. With this requirement a very reliable non-redundant system will not be allowed compared to a redundant but low reliability system It is proposed to rephrase the requirement to get closer to the objective rather than the solution The wording “shall seek” also seems to be more related to a “should” statement	“Spacecraft owners and/or operators shall seek to use manufacturers of their spacecraft maximize the use of redundant maximize availability and reliability of collision avoidance manoeuvre systems capabilities”	Accept.
US - 18- 128		9.3.1		ed	Sentence is unclear.	Suggest: “Spacecraft operators shall maximize the use of redundant collision avoidance maneuver capabilities to the maximum extent practicable.”	Accept.
-129		9.3.1		ge	Requirement is specifying a solution to the collision avoidance systems reliability issue. With this requirement a very reliable non-redundant system will not be allowed compared to a redundant but low reliability system It is proposed to rephrase the requirement to get closer to the objective rather than the solution The wording “shall seek” also seems to be more related to a “should” statement	“Spacecraft owners and/or operators shall seek to use manufacturers of their spacecraft maximize the use of redundant maximize availability and reliability of collision avoidance manoeuvre systems capabilities”	(Duplicate of other EU submittal)
US - 29- 130		9.3.10		tc	This section is redundant to 9.3.5.3 which states that operators should provide predicted ephems, including maneuvers. Purpose of the maneuver is irrelevant.	Delete 9.3.10	Accept.
US - 30- 131		9.3.11		tc	Ditto to previous comment	Delete 9.3.11	Accept.
US - 31- 132		9.3.13		tc	This standard is about space traffic coordination. RFI is out of scope.	Delete 9.3.13	Not accept. RFI is clearly “in scope” per the “Scope” section.

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-045 -133		9.3.2 9.4.2		ed	'at least one STC systemS' Alignment is also necessary for section 9.4.2 where it is still required for launch service providers to obtain the support to one or more STC systems.	Remove the S since it is no longer required to subscribe to one or more systemS, and use the same wording for section 9.4.2	Accept.
US -19- 134		9.3.2		gc	This is a policy statement and does not belong in a standard. In addition, the NOTE is not clear. Also, without a clear identification of what STC DOES include, this statement adds no value to the document.	Delete 9.3.2	Not accept. While state actors should have the flexibility to specify how STC is done, it shall be done by somebody.
-135		9.3.2 9.4.2		ed	'at least one STC systemS' Alignment is also necessary for section 9.4.2 where it is still required for launch service providers to obtain the support to one or more STC systems.	Remove the S since it is no longer required to subscribe to one or more systemS, and use the same wording for section 9.4.2	(Duplicate of other EU submittal)
DE-048 -136		9.3.3 9.4.4		ed	Reference to section 6.7 seems incorrect, it is understood it should be a reference to new section 8.8, or to ISO 23705 A similar reference to ISO 21740 about LCOLA could be introduced in section 9.4.4	Correct reference	Accept.
DE-047 -137		9.3.3		ed	reference to Section 6.7 which doesn't exists	provide correct reference	Accept.
DE-046 -138		9.3.3		te	Last sentence "If multiple threshold limits exist between two or more entities, the more stringentof the thresholds shall be adopted." It is unclear how that can be achieved. How would operator A know the thresholds of operator B? And can an operator	Reformulate that in case of conjunction with other operators, coordination is recommended with the other operator.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					C enforce other operators to maneuvre by setting an artificially low threshold?		
US - 20- 139		9.3.3		tc	This statement is unclear. Is the standard being defined that “consensus collision avoidance algorithms be used”? Clearly this is desirable—but the statement is not useful in a “standard”. What does “consensus” mean in this context? How is this statement relatable directly to a standard? There could be numerous (many!) consensus algorithms identified and, in such circumstances,—there is NO standard!!!!! Suggest the technical community work on specific standards for specific, clearly definable items. (ie.. perhaps hard body radius definition)	Delete 9.3.3	Not accept. Consensus algorithms already exist and have been transferred to ISO 23705. Suggested corresponding thresholds are also in 23705.
-140		9.3.3 9.4.4		ed	Reference to section 6.7 seems incorrect, it is understood it should be a reference to new section 8.8, or to ISO 23705 A similar reference to ISO 21740 about LCOLA could be introduced in section 9.4.4	Correct reference	(Duplicate of other EU submittal)
JP- 04- 141	1	9.3.3	1	ed	While it is written that “Aligned with the requirements of section 6.7”, section 6.7 does not exist in this draft 9490.	Sub-clause 6.7 should be changed to sub-clause 8.8.	Accept.
DE- 050 -142		9.3.4		te	as previously commented; roles are not clear: the first sentence states that operators should provide contact information to a globally accessible "centralized" repository, which seams to imply that there is only ONE repository; but then shall the STC service provide be responsible for the security of information. But he may now be the operator of the repository.	refine responsibilty	Accept.
DE- 049 -143		9.3.4		te	Emergency request is not defined. More importantly this leaves open how long till appropriate response is ready. So, this leaves open that only emergency message is received, but nothing really gets done. Can’t be the intention.	Add target time for readiness of response.	Accept. (already states 1hr response time).

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Template for comments and secretariat observations

Date:2024-10-05	Document:	Project:

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
US - 21- 144		9.3.4		gc	The first sentence states that the contact information should be registered in a globally accessible, centralized repository. The second sentence states that the STC service provider is responsible for the security of the contact information. These two sentences are contradictory. If the information is registered in a centralized repository, the entity that is managing that centralized repository is, at a minimum, also responsible for the security of that information. BTW, who is paying for, managing, and setting the parameters for a central repository? What if one does not exist?	Suggest: "Operators of spacecraft shall register their organization's contact information with an STC service, who shall make that contact information available to other STC services as required to mitigate collisions. All STC service providers shall be responsible for the security of operator's POC information."	Accept.
DE- 052 -145		9.3.5		ed	Sections 9.3.5.1 to 9.3.5.8 are a mix of list of information to share (9.3.5.1, 9.3.5.2, 9.3.5.5, 9.3.5.6), and requirements on operators to provide information (9.3.5.3, 9.3.5.7, 9.3.5.8) There is a "should" in section 9.3.5 for operators to provide information, while section 9.3.5.3 is using a "shall"	Adapt consistently section 9.3.5 and associated subsections	Accept.
DE- 051 -146		9.3.5		ed	Sentence is difficult to understand	provide correct sentence; maybe just a comma is missing after "obtaining support from" ?	Accept.
US - 22- 147		9.3.5		ed	Missing grammar makes the sentence incomprehensible.	"…..policies, spacecraft operators should provide with known relevant entities, including spacecraft operators, SSA and STC systems they are obtaining support from, the following information…."	Accept.
-148		9.3.5		ed	Sections 9.3.5.1 to 9.3.5.8 are a mix of list of information to share (9.3.5.1, 9.3.5.2, 9.3.5.5, 9.3.5.6), and requirements on operators to provide information (9.3.5.3, 9.3.5.7, 9.3.5.8)	Adapt consistently section 9.3.5 and associated subsections	(Duplicate of other EU submittal)

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					There is a “should” in section 9.3.5 for operators to provide information, while section 9.3.5.3 is using a “shall”		
US - 23- 149		9.3.5.1		tc	Is there a universal definition of “low-thrust or long-duration maneuvers” such that entities know when the NOTE applies?	Define low-thrust and long-duration maneuvers explicitly so everyone is on the same page.	Accept.
GB 35- 150		9.3.5.1	Note	ge	The note contains a recommendation. This is not permitted.	Remove the word “NOTE:” at the beginning so that the paragraph becomes a recommendation clause.	Accept.
GB 33- 151		9.3.5.1 to 9.3.5.8		ge	This content should not be provided in the form of numbered sub-clauses.	The content should be provided in the form of a bulleted or numbered list.	Not accept. For the sake of clarity and separation of requirements, the numbered list will be retained.
DE- 053 -152		9.3.5.2		ed	Timeliness of provision of ephemerides and covariance refer to Table 4 while it should rather be Table 5	Correct Table reference	Accept.
-153		9.3.5.2		ed	Timeliness of provision of ephemerides and covariance refer to Table 4 while it should rather be Table 5	Correct Table reference	(Duplicate of other EU submittal)
DE- 054 -154		9.3.5.2; 9.3.5.3	te	It might be unclear to which kind of manoeuvres these clauses refer. They seem to refer to	please clarify		Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
				COLA manoeuvres whereas 9.3.5.1 seems to refer to manoeuvres planed as part of normal operation. This should be clarified. Also making a better distiction between “planned manoeuvres” and “the manoeuvre”. By that, also make clear (in a NOTE ?) what the difference between 9.3.5.2 and 9.3.5.3 is.			
DE-055 **-155**		9.3.5.4		ge	Section does not seem completed, is it meant, as in the previous version of the document, “Whenever manoeuvre plans are modified, spacecraft operators shall provide updated ephemeris data to SSA and STC systems” (which seems to be the only information missing compare to the previous version of the document)? Another possible recommendation for ephemeris updates is daily in LEO and every 3-5 days in GEO, and every time necessary/asked by (e.g.) SSA or STC system provider	Change paragraph to: “Predicted orbit ephemerides incorporating covariance time histories and planned manoeuvres shall be updated on a daily basis in LEO and every 3 to 5 days in GEO, and every time updated data is deemed necessary by known relevant entities (e.g. SSA or STC system provider) Whenever manoeuvre plans are modified, spacecraft operators shall provide updated ephemeris data to SSA and STC systems”	Accept.

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Date:2024-10-05	Document:	Project:

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
-156		9.3.5.4		ge	Section does not seem completed, is it meant, as in the previous version of the document, “Whenever manoeuvre plans are modified, spacecraft operators shall provide updated ephemeris data to SSA and STC systems” (which seems to be the only information missing compare to the previous version of the document)? Another possible recommendation for ephemeris updates is daily in LEO and every 3-5 days in GEO, and every time necessary/asked by (e.g.) SSA or STC system provider	Change paragraph to: “Predicted orbit ephemerides incorporating covariance time histories and planned manoeuvres shall be updated on a daily basis in LEO and every 3 to 5 days in GEO, and every time updated data is deemed necessary by known relevant entities (e.g. SSA or STC system provider) Whenever manoeuvre plans are modified, spacecraft operators shall provide updated ephemeris data to SSA and STC systems”	(Duplicate of other EU submittal)
DE-056 -157		9.3.5.5		te	Manoeuvrability capacity should be provided, at least as YES/NO, in case of a modification of the capability due to an anomaly	Add manoeuvrability capability to the list	Accept.
US - 24- 158		9.3.5.5		tc	The standard is on “Space Traffic Coordination”. Comments on RFI risks seem outside the scope.	Suggest deletion of “mitigate RFI risks” and “spacecraft attitude and pointing uncertainties” and “RF characteristics”	Not accept. RFI is clearly “in scope” per the “Scope” section.
-159		9.3.5.5		te	Manoeuvrability capacity should be provided, at least as YES/NO, in case of a modification of the capability due to an anomaly	Add manoeuvrability capability to the list	(Duplicate of other EU submittal)
DE-057 -160		9.3.5.7; 9.3.5.8	te	These are redundant to 7.4 and 7.5.	Remove redundancies.		Not accept. This “redundancy” is unavailable due to P-member demands that requirements for “organizational roles and responsibilities” AND sections like “transparency” be included.
DE-058 -161		9.3.6		ge	Break up awareness rather comes from SSA observations than satellite telemetries		Not accept. Consider the initial breakup alerts/participation by Sentinel 1A ops crew.

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US - 25- 162		9.3.6		ed	HK is not defined as an acronym.	Add to acronym table.	Accept.
-163		9.3.6		ge	Break up awareness rather comes from SSA observations than satellite telemetries		(Duplicate of other EU submittal)
GB 36- 164		9.3.6	Note 2	ge	The note contains a recommendation. This is not permitted.	Remove the word “NOTE:” at the beginning so that the paragraph becomes a recommendation clause.	Accept.
DE- 059 -165		9.3.6	Table 5	ge	Difference between “Notification of failed manoeuvres” and “Control failure notification” is unclear and seems to be redundant	Clarify difference or remove one of both lines	Accept.
-166		9.3.6	Table 5	ge	Difference between “Notification of failed manoeuvres” and “Control failure notification” is unclear and seems to be redundant	Clarify difference	(Duplicate of other EU submittal)
GB 37- 167		9.3.6.1		ge	It is not permitted to have a single numbered sub-clause in 9.3.6.	Remove the number (9.3.6.1) and title (Spacecraft data exchange message format and standards).	Accept.
US - 26- 168		9.3.7		tc	Some operators have their own collision risk assessment approaches. The statement only allows for risk estimates from an STC system.	Suggest you add words that recognizes spacecraft operators have their own risk assessment techniques.	Accept.
GB 38- 169		9.3.8		te	The statement “acceptably low” is not measurable or verifiable.	Clarify what is meant by “acceptably low”.	Accept.

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US - 27- 170		9.3.8		tc	This section is redundant to 9.3.5.2 and 9.3.5.3 which request predicted ephems (including maneuvers)	Delete 9.3.8	Not accept. The first two sections govern the provision of Ephem + covariance, while 9.3.8 is for obtaining Pc estimates.
DE- 061 -171	NOTE 1	9.3.9		ed	"Orbital return manoeuvre" not clear	Define what orbital return manoeuvre is.	Accept.
DE- 060 -172	NOTE 2	9.3.9		te	Note speaks about "the" global PoC database, whereas 9.3.4 defines that "a globally accessible DB" should be registered at. Also later in 11.1.4 it is clear that each Enterprise STC System should provide such a "globally accessible DB".	propose to use concept of "a globally accessible" everywhere this is mentioned	Accept.
US - 28- 173		9.3.9		tc	This section is redundant to Section 8.11 which states how operators are supposed to coordination to avoid collisions. It does not matter what the activity is that they are maneuvering for.	Delete 9.3.9	Not accept. 8.11 governs the timeline, while 9.3.9 governs roles/responsibilities.
DE- 062 -174		9.4		ge	It seems that 'new' launch service providers, typically orbit tug and dispensers, are not necessarily covered by this section, or at least not explicitly. Thus they might not respect what is required here (e.g. share information on the separation strategy, ensure that there will be no collision with other objects, etc.)	To include dedicated requirements for alternative launch service providers (e.g. orbit tug, S/C dispenser) or at least to clarify what are those of section 9.4 which are applicable also to them.	Accept.
GB 39- 175		9.4		ge	The following text at the beginning of clause 9.3 is a hanging paragraph: "Launch service providers also have important STC responsibilities as directed by established international norms of behaviour. The following sections provide these requirements."	The first sentence does not say anything important and could be deleted. The second sentence is unnecessary and should be deleted.	Accept.
-176		9.4		ge	It seems that 'new' launch service providers, typically orbit tug and dispensers, are not necessarily covered by this section, or at least not	To include dedicated requirements for alternative launch service providers (e.g. orbit tug, S/C	(Duplicate of other EU submittal)

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					explicitly. Thus they might not respect what is required here (e.g. share information on the separation strategy, ensure that there will be no collision with other objects, etc.)	dispenser) or at least to clarify what are those of section 9.4 which are applicable also to them.	
US - 32- 177		9.4.1		tc	Not clear. To whom, specifically, is the standard declaring this information be sent? If there are already international requirements in place (ie.. NOTAMs) then it is not necessary to comment in this standard. Does the standard imply that launch service providers have to globally blast out a notification? If so, what platforms? How does one determine “known potentially affected state actors operators, etc..”?	Either make this statement more specific (so it is actionable) or delete it. As written it is not actionable.	Discuss. Rather than delete this statement because it isn’t clear where to share the data with, we suggest SC14 consider where and how to share it so that this can be (finally) addressed.
US - 37- 178		9.4.10		gc	This standard is about space traffic coordination. RFI is out of scope	Delete 9.4.10	Not accept. RFI is clearly “in scope” per the “Scope” section.
DE-063 -179		9.4.2		ed	Wording would gain to be aligned with section 9.3.2 dealing with spacecraft operators responsibilities	Adapt wording to match section 9.3.2 (which has been reworked in this new version)	Accept.
GB 40- 180		9.4.2		ge	The note contains a recommendation. This is not permitted.	Remove the word “NOTE:” at the beginning so that the paragraph becomes a recommendation clause.	Accept.
US - 33- 181		9.4.2		tc	Statement is so broad as to not be useful. What defines the “necessary data communications etc…”? if a national launch approving authority has specific requirements, then a launching entity knows exactly what data and products are required. If a national launch approving authority does not have specific requirements, this statement is not helpful in determining what data or products (to what specific “accuracy, availability, timeliness” etc..) is suggested.	Either make this statement more specific (so it is actionable) or delete. As written, it adds no value to the standard.	Discuss. These functions must be done somewhere, so the group can seek consensus on the “where”, “how”, and “what”.

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-182		9.4.2		ed	Wording would gain to be aligned with section 9.3.2 dealing with spacecraft operators responsibilities	Adapt wording to match section 9.3.2 (which has been reworked in this new version)	(Duplicate of other EU submittal)
GB 41- 183		9.4.3	Note 3	ge	The note contains a recommendation. This is not permitted.	Remove the word "NOTE 3:" at the beginning so that the paragraph becomes a recommendation clause.	Accept.
DE-064 -184		9.4.4		te	Same comment as to 9.3.3, how to know about other operators thresholds.	remove last sentence	Accept.
US - 34- 185		9.4.4		tc	This statement is unclear. Is the standard being defined that "consensus launch COLA risk assessment algorithms, etc.. be used"? Clearly this is desirable—but the statement is not useful in a "standard". What does "consensus" mean in this context? How is this statement relatable directly to a standard? There could be numerous (many!) consensus algorithms identified and, in such circumstances,—there is NO standard!!!!!	Delete 9.4.4	Not accept. Consensus algorithms already exist and have been transferred to ISO 23705.
US - 35- 186		9.4.5		gc	The first sentence states that the contact information should be registered in a globally accessible, centralized repository. The second sentence states that the STC service provider is responsible for the security of the contact information. These two sentences are contradictory. If the information is registered in a centralized repository, the entity that is managing that centralized repository is, at a minimum, also responsible for the security of that information. BTW, who is paying for, managing, and setting the parameters for a central repository? What if one does not exist?	C	Accept.

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US - 36- 187		9.4.7		tc	This seems redundant to 9.4.1 but at least it is more specific. However the standard is vague—is there a timeframe after launch up to which the launch service provider is providing this info? How is this different than the screening specified in 9.4.3 and the potential adjustment of the launch to avoid collisions? Is this something that is executed after a launch when known potential collisions are identified? Why is RFI mentioned?	Suggest clarification re: questions.. Or delete 9.4.7	Not accept. RFI is clearly “in scope” per the “Scope” section. Further, LCOLA does not mitigate RFI, so 21740 is not the logical “home” for RFI.
DE- 065 -188		9.4.8		te	There are generally no exchanges for LV before launch, thus it is preferred to use a “should” instead of a “shall” for this section	As per left	Accept.
-189		9.4.8		te	There are generally no exchanges for LV before launch, thus it is preferred to use a “should” instead of a “shall” for this section	As per left	(Duplicate of other EU submittal)
-190	CN-9	10		te	Lack of mechanism and procedures for international coordination among different countries. Which is the most important requirements for space traffic coordination	Add the coordination mechanism and procedures between different countries.	Not accept. Multiple “sharing mechanisms” already exist.
GB 42- 191		10.1		ge	Another hanging para.	Text not necessary. Delete.	Accept.
DE- 066 -192		10.1.1 10.1.2		ed	"a STC service contract" seems to imply a commercial contract. I'm not sure that registering to EU SST for example falls into that category.	use more neutral wording	Accept.
US - 38- 193		10.1.1, 10.1.2		ge	In 10.1.1 and 10.1.2, the phrase “Upon finalization of an STC service contract” clearly implies that the STC Service Provider is a commercial entity.	In 10.1.1 and 10.1.2, replace “contract” with “agreement.”	Accept.

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US - 39- 194		10.1.2		tc	The idea behind this statement is logical. However, I would suggest it is easier if we have the spacecraft operators have a public announcement of the STC systems they have a relationship with. The coordination that will need to occur is likely connecting two O/O. Consequently if an STC provider does not have a particular O/O in their system, they can easily find which STC system to coordinate with by looking at the O/O website etc.. Much more efficient. In addition, the statement as written, does not indicate to whom the STC service provider is disclosing.	Delete from this section and place statement under space operator responsibility (ie.. have publicly available where they get their STC services from).	Discuss. The "economy of scale" exists at the STC level (where this is more feasible), and NOT with the individual operators.
US - 40- 195		10.2		ge	The "shall" statements in this section imply that the STC system has an orbit determination capability.	Add a sentence at the beginning of Section 10.2 saying, "If an STC system has an orbit determination capability, it will follow these guidelines."	Accept.
US - 41- 196		10.2.2		tc	The statement comments on "live data metrics" for quality monitoring. What does "live" mean? All registered users of that system? Publicly? What is "user-selected" risk criteria? The whole statement precludes/assumes certain design solutions for a system.	Either clarify or delete. This statement seems too "in the weeds" on this topic.	Accept.
US - 42- 197		10.2.3		tc	This statement seems redundant to 10.2.1. If an OD process can do 10.2.1, then they can do 10.2.3.	Delete 10.2.3. This statement seems too "in the weeds" on this topic.	Accept.
US - 43- 198		10.3		tc	Statement is vague and too broad. What defines "decision-quality"? In addition, it is not a given that temporal updates necessarily reduces accuracy (the quality of the state being updated is also a factor).	Suggest: "Conjunction assessment should be, at a minimum, performed once per day but it is desired to perform CA as frequently as states are being updated."	Accept.
DE- 068 -199	NOTE 1	10.3.2		te	I don't think that it is the intention to mandate the STC system approving agent to select GO/NO-GO thresholds for an operator; as NOTE 2 states, that's something that operators will have to decide. The criteria for warning thresholds may be mutually agreed, but the decision is to be taken by the	reformulate to avoid misunderstanding; operator finally has to decide	Accept.

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					operator (and he may decide not to move). See also NOTE 1 to 10.3.5		
DE-067 -200	NOTE 4	10.3.2		ed	“used by a spacecraft operator shall be determined by the spacecraft operator” reads weird/triggers an immediate response. Even if this is the true intention, revising the sentence to make this less explicit would be better.	revise note	Accept.
GB 43-201		10.3.2		ge	The NOTE numbering is incorrect (1,2,4,5). These notes contain a mixture of requirements and permissions. This is not allowed.	Write the notes as informative statements, or change them into clauses.	Accept.
DE-069 -202		10.3.2	Note 4	ed	Sentence does not seem very clear. It could be replaced by “The type of conjunction assessment and screening thresholds provided by the STC system used by a spacecraft operator shall be determined by the spacecraft operator”	Change sentence as per left	Accept.
-203		10.3.2	Note 4	ed	Sentence does not seem very clear. It could be replaced by “The type of conjunction assessment and screening thresholds provided by the STC system used by a spacecraft operator shall be determined by the spacecraft operator”	Change sentence as per left	(Duplicate of other EU submittal)
DE-070 -204		10.3.2	Note 5 Table 7	te	In Note 5, orbital states can be associated to a manoeuver plan (if relevant) in order to have the best estimation of state vector propagation. Similarly, in Table 7, add manoeuver plan next to orbit states	“(or alternatively, orbit states associated to existing manoeuver plan from which ephemerides can be generated)” Add “manoeuver plan” after orbit states in Table 7	Accept.
-205		10.3.2	Note 5 Table 7	te	In Note 5, orbital states can be associated to a manoeuver plan (if relevant) in order to have the best estimation of state vector propagation. Similarly, in Table 7, add manoeuver plan next to orbit states	“(or alternatively, orbit states associated to existing manoeuver plan from which ephemerides can be generated)” Add “manoeuver plan” after orbit states in Table 7	(Duplicate of other EU submittal)
DE-072 -206		10.3.3		te	It seems more relevant to determine if a spacecraft is “manoeuvrable” rather than “active”.	Add requirement or modify existing one: Title: “Function to distinguish manoeuvrable spacecraft from other objects” Paragraph: “STC systems shall have a function to distinguish manoeuvrable spacecraft from other	Partial accept. For conjunction assessment, for example, the Duck/Dodge requires attitude.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
						space objects and update the categorization periodically."	
DE-071 -207		10.3.3		ed	The wording make it seems that an STC system shall have an autonomous function that determines whether a satellite is active (i.e. in the sense "opposed to dead"). Purpose should not be to introduce an autonomous function of the STC system, but rather that the STC system shall be able to distinguish active S/C from other space objects with internal and external source (e.g. space-track).	Change paragraph to "STC systems shall be able have a function to distinguish active spacecraft from other space objects and update the categorization periodically."	Accept.
-208		10.3.3		ed	The wording make it seems that an STC system shall have an autonomous function that determines whether a satellite is active (i.e. in the sense "opposed to dead"). Purpose should not be to introduce an autonomous function of the STC system, but rather that the STC system shall be able to distinguish active S/C from other space objects with internal and external source (e.g. space-track).	Change paragraph to "STC systems shall be able have a function to distinguish active spacecraft from other space objects and update the categorization periodically."	(Duplicate of other EU submittal)
-209		10.3.3		te	It seems more relevant to determine if a spacecraft is "manoeuvrable" rather than "active".	Add requirement or modify existing one: Title: "Function to distinguish manoeuvrable spacecraft from other objects" Paragraph: "STC systems shall have a function to distinguish manoeuvrable spacecraft from other space objects and update the categorization periodically."	(Duplicate of other EU submittal)
GB 45-210		10.3.6		ge	The statement "and in line with applicable national laws and policies" is not permissible. See previous discussion above on this point.	Delete statement.	Accept.
GB 44-211		10.3.6		te	The statement "necessary level of automation" is not measurable or verifiable.	Clarify what is meant by "necessary level of automation".	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
US - 44- 212		10.3.6		tc	This statement is vague and unclear. What does “necessary level of automation using the latest validated data to fullfil desired safety performance” mean? An STC system will have requirements set forth by the approving agent for performance and timeliness. The implementation of those requirements may or may not include autonomy. This statements is an implementation statement and does not belong in a standard.	Delete 10.3.6	Accept.
US - 45- 213		10.3.7		tc	While the goals of this standard are logical and desirable, it is also written as an implementation standard. The standard should be “immediate distribution of alerts and potential safety threats”. For some small entities (for example) perhaps manual operations can meet this; autonomy might not be possible nor economically efficient.	Suggest changing the title to “Flight Safety Notifications” and rewording “An STC system shall distribute or post alerts of potential flight safety threats to its customer set and any known affected spacecraft operators immediately upon identifying such situations”. Then you can add a NOTE: Automation increases the efficiency and timeliness of safety notifications.	Accept.
DE- 073 -214		10.4.2		ed	The introductory sentence is inconsistend as it first states that "the standardized collision avoidance manoeuvre procedure" should be used and then later "by either the standarsized method or another"	"An appropriate collision avoidance manoeuvre procedure should be invoked to mitigate upcoming close approaches with other satellites or debris identified by either the standardized conjunction assessment procedure defined below or other collision risk notification process."	Accept.
US - 46- 215		10.4.2		tc	This is redundant to section 8.11 which is titled “Timeline of collision avoidance maneuvers”.	Streamline by combining and collapsing 8.1.1 and 10.4.2. No need to have the same info in the standard twice.	Accept.
GB 46- 216		10.4.3, 10.4.4, 10.6, 10.7.1		ge	The phrase “should optionally be capable of” sounds rather odd and could cause confusion.	For clarity, it would be better to remove the word “optionally”. Alternatively, write a permission statement, i.e. use “may” instead of “should optionally be capable of”. For example: 10.6: An STC system may support and coordinate with spacecraft operators….	Accept.
DE- 074 -217		10.5.1		te	make this optional (like e.g. 10.6)	"The STC system should optionally be capable"	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
US - 47- **218**		10.5.1		gc	Statement does not take into account requirements from national authorities, regulations or policy. If the authorization agent does not require geometry based, for example, why do they need it?	Add “As related to national requirements, the STC system shall” (or some other words like that).	Accept; changed to “may”.
US - 48- **219**		10.7		tc	This is a space traffic coordination standard. RFI Is out of scope.	Delete 10.7	Not accept. RFI is clearly “in scope” per the “Scope” section.
DE-075 **-220**		10.8.10		te	Precision on position, velocity etc. are required from the STC system, but should also be required from the STC operator when providing the STC system with ephemerides.	Add requirement on precision on the ephemerides provided by the STC operator in 9.3.5. E.g. in 9.3.5.2, add: “Such ephemerides shall be provided with positional information at least to the millimetre level, velocities to the nanometre per second level, angular measurements to 1.e-9 degrees, and covariances matrix element significant digits corresponding to the combination of the above position, velocity, and angle measurements, accordingly.”	Accept.
-221		10.8.10		te	Precision on position, velocity etc. are required from the STC system, but should also be required from the STC operator when providing the STC system with ephemerides.	Add requirement on precision on the ephemerides provided by the STC operator in 9.3.5. E.g. in 9.3.5.2, add: “Such ephemerides shall be provided with positional information at least to the millimetre level, velocities to the nanometre per second level, angular measurements to 1.e-9 degrees, and covariances matrix element significant digits corresponding to the combination of the above position, velocity, and angle measurements, accordingly.”	(Duplicate of other EU submittal)
US - 52- **222**		10.8.11		tc	Is this statement implying that only the techniques in the appendix are acceptable? What does “generally accepted” mean? What happens as techniques are updated?	Define what “accepted” means or change the text to clarify.	Not accept; clearly says “Example” throughout.

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Template for comments and secretariat observations

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
US - 49- 223		10.8.2		tc	This statement is not practical. If information is proprietary, does that mean that the company has to sign an NDA with everyone? To whom is this information disclosable? It's users? Other STC organizations? Nation-states? The public?	Suggest more discussion on what is really important to disclose and specify that. For example, instead of "math techniques/processes", perhaps "assumptions"? This needs some more work!	Discuss.
DE- 076 -224		10.8.3		ed	Second sentence is not part of the requirement	Make seconde sentence a NOTE	Accept.
GB 47- 225		10.8.3		ge	The following requirement is not measurable or verifiable: "STC systems shall use collision probability estimation techniques whose soundness is generally accepted,…."	At the very least one would expect a technique to be published in a textbook or peer-reviewed journal. Perhaps this is a measure of soundness that is generally accepted?	Accept.
US - 50- 226		10.8.3		tc	Is this statement implying that only the techniques in the appendix are acceptable? What does "generally accepted" mean? What happens as techniques are updated?	The language pointing to the Annex should point out that the content of the Annex are current general practices and will likely evolve; these are examples for consideration.	Accept.
US - 51- 227		10.8.7		tc/gc	Share with whom? What if the force model settings are proprietary? Compatible with what?	Add clarity.	Accept.
US - 53- 228		10.9.2		tc	The STC approving agent will have requirements for the QA/QC that the SSA system is required to maintain. 10.9.2 implies derived requirements for the STC approving agent.	Delete 10.9.2. or replace: "Pursuant to the requirements for QA levied by the STC approving agent there should be quality control to monitor relevant aspects of the STC system. Suggestions are section ….."	Accept.
GB 48- 229		10.9.3		te	The statement "unacceptably poor accuracy" is not measurable or verifiable.	Clarify what is meant by "unacceptably poor accuracy".	Accept.
US - 54- 230		10.9.3		gc	This sentence is incomprehensible- even for a native English speaker. I think the point of the statement is "out of family solutions need to be highlighted immediately to identify potential	Suggest simplifying to quote in previous column if that is the intent of the statement.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					anomalies and/or other situations requiring operator attention and intervention." If that is not what the statement is trying to say, then I have no idea.		
-231	CN-10	11		te	For this standard, It should only focus on the rules of road, space traffic lights, responsibilities of STC participants, international coordination mechanism and procedures. The STC system should not be included in this standard.	The STC system should be addressed in a separated document, as a supporting document to ISO 9490.	Not accept. Per resolution 613 from 2023 "to reestablish the cancelled project ISO 9490, Space systems – Space traffic coordination (STC), as an active project and to register the draft document at enquiry stage (DIS stage 40.00) going directly to stage 30.99 (preparing the DIS) following the NP ballot approval, with 24 months development timeframe (NP by 31 January 2024, DIS by 30 November 2024 and publication by 30 November 2025), with same PL (Mr. Daniel OLTROGGE (US), Mr. Dr. Akira KATO (JP), Mr. John DAVEY (UK)) and **maintaining the same scope** and project number. …"
GB 49-232		11		ge	Another hanging para.	Fix.	Accept.
US - 55-233		11		gc	This section appears to describe how to build an IT system (which happens to be an STC focused IT system). Not applicable because there are other standards for how to build an IT system. For example, an IT system has compliance requirements. An IT system has SLA. An IT system has system access controls.	Simply reference ISO standards for how to build an IT system. Parse out the specific STC stuff from IT.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-077 -234		11.1.1		ed	Reference 2.2.19 does not exist	revise	Accept.
US - 56- 235		11.1.1		gc	This statement is requiring any national STC center (or any center, actually) to comply with this standard and show how they do so. Up until this point, this document has been careful to point out that a STC approving agent may have their own requirements. 11.1.1 is completely in contradiction to that philosophical approach. An STC approving authority MAY choose to decide that they care about compliance with the standard and can request such a document. But you cannot have the standard require compliance with the standard. It is internally illogical.	Delete 11.1.1	Accept.
US - 57- 236		11.1.2		gc	The reliability and availability of a STC system is up to the STC approving authority. Period. Does not even need to be in this standard.	Delete 11.1.2	Accept.
US - 58- 237		11.1.3		gc	This statement is telling people how to design their IT system. Furthermore, this statement has more to do with how to design IT systems that allow access to multiple entities and have to parse data. This is NOT a statement that has anything to do with space traffic coordination and does not belong in this standard.	Delete 11.1.3	Accept.
US - 59- 238		11.1.4		gc	This statement is redundant, and in somewhat contradiction to, statement 9.3.4. The intent is the same (where it is redundant).	Suggest collapsing and combining with statement 9.3.4.	Accept.
GB 50- 239		11.1.4	Note	ge	The note contains a recommendation. This is not permitted.	Remove the word "NOTE:" at the beginning so that the paragraph becomes a recommendation clause.	Accept.

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US - 60- 240		11.1.6		gc	While the sentiment is admirable, this statement does not belong in this standard. How a nation decides to address orbit debris mitigation has nothing to do with how they provide information on space traffic coordination —which is the focus of this standard. In essence this sentence says “Do what your STC approving agent tells you to do”. (With an additional random comment about ISO 24113)	Delete 11.1.6	Accept; moved to informative annex.
US - 61- 241		11.2		gc	This section also appears to describe how to build an IT system (which happens to be an STC focused IT system). Not applicable because there are other standards for how to build an IT system. For example, an IT system has compliance requirements. An IT system has SLA. An IT system has system access controls.	Delete 11.2	Accept.
DE- 078 -242		11.2.1		ed	Repetition of 11.1.2?	Remove 11.1.2 or 11.2.1	Accept.
US - 62- 243		11.2.1		gc	This is redundant to 11.1.2 and in any case, should be deleted per comments re: 11.1.2	Delete 11.2.1	Accept.
-244		11.2.1		ed	Repetition of 11.1.2?	Remove 11.1.2 or 11.2.1	Accept.
DE- 079 -245		11.2.2		ge	The (TBD) could concern: the duration data shall be archived for, the type of data that shall be archived/restored, the max time of restoration of the data…	No idea for the moment	Accept.
US - 63- 246		11.2.2		gc	The STC approving agent has purview over archival strategies—which could vary widely based on resources (for example) and national data laws.	Delete 11.2.2	Accept.

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-247		11.2.2		ge	The (TBD) could concern: the duration data shall be archived for, the type of data that shall be archived/restored, the max time of restoration of the data…	No idea for the moment	(Duplicate of other EU submittal)
DE-080 -248		11.2.2.		ed	TBD	remove TBD	Accept.
US - 64- 249		11.2.3		gc	The STC approving agent/nation has purview of this requirement. Should not be in the standard.	Delete 11.2.3	Accept.
US - 65- 250		11.3.		gc	This is a space traffic coordination standard. There is no need to mention or go into specific cybersecurity standards and re-invent the wheel. If the group would like to reference ISO cyber standards, just make a list. HOWEVER, each nation has its own LEGALLY required cybersecurity standards that the STC approving authority will require. Out of scope for this standard to deal with cyber in any detail.	Delete all of section 11.3 with the exception of a list of relevant ISO cybersecurity standards if desired.	Accept.
DE-082 -251		11.3.1		ed	delete parenthesis before “such”	as per left	Accept.
DE-081 -252		11.3.1		ed	Very long sentence with the parenthesis	make text in parenthesis a NOTE	Accept.
-253		11.3.1		ed	delete parenthesis before “such”	as per left	(Duplicate of other EU submittal)
DE-083 -254		11.3.10		ed	"with a scan intervals"	make either singular "with a scan interval" or plural "with scan intervals"	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-084 **-255**		11.3.4		ge	"Distribution", to who? "shall be allowed", by who? If an entity (national, commercial, military, s/c operator…) decides that some flight information is not to be disclosed, does this requirement override their decision for the sake of flight safety? If this section is correctly understood, I it should probably not belong to this document.	Remove this section	Accept. Moved to informative annex.
US - 66- **256**		11.3.4		gc	The relationship between the STC entity and the users and vendors providing data will ultimately decide what "derived" means and the permissions on sharing.	Delete 11.3. 4	Accept. Moved to informative annex.
-257		11.3.4		ge	"Distribution", to who? "shall be allowed", by who? If an entity (national, commercial, military, s/c operator…) decides that some flight information is not to be disclosed, does this requirement override their decision for the sake of flight safety? If this section is correctly understood, I it should probably not belong to this document.	Remove this section	(Duplicate of other EU submittal)
GB 51- **258**		11.4		ge	Another hanging para.	Fix.	Accept.
US - 70- **259**		11.4.10		gc	Statement discusses specific implementation and should instead stick with the intent.	Suggest: "An STC system should provide a user interface commensurate with the types of data, products and services that users will receive."	Accept.
US - 71- **260**		11.4.11		gc	Ditto. Statement indicates implementation. Covered by suggested re-write of 11.4.10.	Delete 1.4.11	Accept. Moved to informative annex.

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US - 72- 261		11.4.12, 11.4.13, 11.5, 11.6		gc	Statements indicate implementation and are placing derived requirements on an STC approving authority. STC approving authority will determine design and QA processes for their respective systems. These statements are too “in the weeds” for this standard. System design is independent from the execution of the space traffic coordination function that is the subject of this standard.	Delete 11.4.12, 11.4.13, 11.5, 11.6	Accept. Moved to informative annex.
DE-085 -262		11.4.2		te	Second sentence lists a number of data sources, but not all of them will eventually be used	"Such data exchanges could include active satellite observations..."	Accept.
US - 68- 263		11.4.2		gc	The NOTE is confusing. If the point is that different systems are going to have different catalogs and some may choose to use similar catalogs, say that more clearly. If that is not the point, then I don’t know what the NOTE is trying to convey.	Clarify. What is the difference between “space object catalog” and “SATCAT” and why it will be unique. Not sure everyone understands the nomenclature/definition.	Accept.
US - 67- 264		11.4.2		gc	Change the “should” to a “may”. RF is not space traffic coordination specific.	Suggest: “Such data exchanges may include….”	Accept.
GB 52- 265		11.4.6	Note	ge	The note contains a recommendation. This is not permitted.	Remove the word “NOTE:” at the beginning so that the paragraph becomes a recommendation clause.	Accept.
US - 69- 266		11.4.8		gc	This is a policy statement. This statement is creating a derived requirement for SSA approving authorities to have access to sensors or direct tracking data. It is up to nations to determine at what level they are building their systems. Does not belong in this standard. How does this relate to the fact that any STC system may NOT have all RSOs in their repository, regardless of whether they maneuver or not? The statement implies that the ability to follow maneuvers makes sure that the conjunction screening can be up to date. But if	This is a bigger issue than the standard. How does an STC system obtain and update non-cooperative objects? Are we forcing them to either 1) make a deal with the DoD to get the HAC, 2) build their own sensor network or 3) contract with one or more commercial companies to create a comprehensive catalog?	Not accept. This is not a policy statement by any interpretation, but rather, a requirement that the STC system can respond to maneuvers. And since it was brought up, the “HAC” is not a solution either, because it does not effectively accommodate noncooperatively maneuvering spacecraft.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					they don't have the objects in the first place, the ability to track the maneuvers is irrelevant.		
DE-086 -267		4,24		te	First sentence very complex definition. Propose to make it as simple as possible, just stating "there must be someone responsible for setting requirements and monitoring their implementation".	"Person or entity who sets requirements for and monitors and approves their implementation within an Space Traffic Coordination system under their authority."	Accept.
DE-087 -268		4,3		ed	What does [60F] mean? Is it a reference that does not exist in the bibliography?	clarify	Accept.
DE-088 -269		5,2		ed	Missing Abbreviations	add: CA, HAO, O/O	Accept.
DE-089 -270	heading	7,2		ed	Exchanges of information	Exchange of information	Accept.
DE-090 -271		7,3		te	What is the min. lead time of the notification	Add a minimum lead time for notifications	Accept.
DE-091 -272		8,11		ge	The first paragraph contains a recommendation ("should") and the second paragraph contains a requirement ("shall"). However, the two paragraphs seem to be related and therefore the verification is unclear.	Please, restructure chapter 8.11 and clearly separate requirements from recommendations.	Accept.
DE-092 -273		8,3		te	The clause contains several requirements: * provide operational status updates on the autonomous system * publish information for peer review by affected operators and STC system decision authorities regarding how the automation system works * coordinate with other operators (to include	Consider splitting clause into separate sub-clauses.	Accept.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					establishment of bilateral agreements) to maximize sharing of avoidance manoeuvre decision/plans with affected operators and/or STC system platforms at least 12 hours before the avoidance manoeuvre takes place * verify that conducted avoidance manoeuvres effectively reduce collision risk as intended		
DE-095 -274	1st line	8,4		ed	A "that" is missing in the sentence	"The general baseline manoeuvre recommendations and prioritization that are listed in Table 1 should be…"	Accept.
DE-094 -275		8,4		te	The whole section is not very concise, but exactly here it is important to be very concise.the bullet list is not properly introduced. * The text before refers to table 1 and talks about the possibility for operators to reach an alternative agreement, but its unclear if the bullet list are meant as recommendations for reaching an alternative agreement, an addition of table 1 or for other purposes * Since the bullet list says that human inhabited space satations select who manoeuvres, but the table says that robotic missions should manoeuvres in any case (except for non manoeuvrables), I assume that the bullet list is meant as recommendations for reaching alternative agreements * It is unclear how the recommendations relate to each other. Does the first point have precedence over the later points? Then I would recommend to use a numbered list instead to make this clearer. Without a hierarchy there are cases conceivable where the points are contradicting each other, e.g. a publicly owned large constellation VS. a privately-owned satellite that have the same manoeuvrability. Point 5 would say that the public constellation has to give way, but point 6 says that the private satellite should give way	Rework section to be more precise and concise	Accept. Removed clause in 8.4.

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
DE-093 -276		8,4		te	“roughly the same manoeuvrability” this phrasing is very ambiguous. What is roughly the same?	provide clarification	Accept.
DE-096 -277		8,5		te	“that operator chooses the opposite decision” I don’t see a need to limit it to the opposite decision. The operator could also decide e.g. on a manoeuvre split. I was confused to understand what is meant by opposite decision at first.	“where both spacecraft belong to the same operator and that operator chooses another decision”	Accept.
DE-098 -278		8,6		ed	The clause contains several separate requirements addressing different types of space objects.	Split clause into several sub clauses.	Accept.
DE-097 -279		8,6		te	How are robotic re-supply vehicles for inhabitable space objects covered by this clause?	Please clarify and add to clause (e.g. NOTE ?)	Accept.
DE-099 -280		8,7		te	Wrt: “for all predicted close approaches” -> this is not feasible and not needed. Firstly, the level of close approach needs to be defined. We routinely get CE, C2 even HIE warnings for which we do not need to communicate with anybody. In fact, in our case, WrlZ will provide an avoidance manoeuvre plan in case of a C3. I assume they also take care of communicating and/or coordinating with the other operator…	revise	Discuss.
DE-100 -281		8,9		Table 3	targets are "<1 km" for LEO and "<50 km" for GEO	targets should be "> 1km" and ">50km"	Accept.
DE-101 -282		9,1		ge	The new section 9.1 could limit the way STC systems would organize themselves and makes it very hard to trace back and interlink all the other requirements mentioning that something needs to be approved by "the STC approving agent". It	To avoid risk of inconsitencies, remove Section 9.1 completely; (and simplify Terms and definitions "4.24 Space Traffic Coordination system approving agent")	Not accept. – we believe this to be an essential section per insistence by P-members that

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MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					should be sufficient, if in relevant requirement it states that values, thresholds, etc. should be approaved by app.agent instead of trying to re-capture this all here (again). (Repetition and risk of inconsistency).		roles/responsibilities be clearly delineated.
DE-102 -283		9,2		te	"viability" and "quality of service" are note mentioned or defined earlier	propose to remove; just keeping a simple description in 4.24	Accept.Moved to informative annex.
-284	CN-1	all		ge	This document should be the top level standard for STC. So, the priority in this document should only focus on the coordination principles, interfaces, rules, responsibilities, process and coordination mechanism.	The structure for this standard can be reorganized as: Introduction 1 scope 2 terms and aberrations 3 STC principles 3.1 interoperability 3.2 transparency 4. Levels of collision risks 4.1 Yellow alert for space traffic 4.2 Orange alert for space traffic 4.3 Red alert for space traffic 5 STC rules of road 6 STC technical process 7 STC responsibilities 7.1 spacecraft operator 7.2 launch service provider 7.3 state actor / government authority 7.4 UN 8 STC international mechanism	Not accept. As previously stated, we cannot alter the technical content of the scope as directed by SC14 resolution 613 from 2023 “to reestablish the cancelled project ISO 9490, Space systems – Space traffic coordination (STC), as an active project and to register the draft document at enquiry stage (DIS stage 40.00) going directly to stage 30.99 (preparing the DIS) following the NP ballot approval, with 24 months development timeframe (NP by 31 January 2024, DIS by 30 November 2024 and publication by 30 November 2025), with same PL (Mr. Daniel OLTROGGE (US), Mr. Dr. Akira KATO (JP), Mr. John DAVEY (UK)) and **maintaining the same scope** and project number. …”
JP-01-285		All		ge	The relation of structure of requirements between CD 23705 and 9490 is presented in the attached	Best solution : The assessment algorithms, approaches and thresholds should be written in one	Partially accept. While we don’t plan to cancel, we have separated content vs 23705.

MB/ NC[1]	Line number	Clause/ Subclause	Paragraph/ Figure/Table	Type of comment[2]	Comments	Proposed change	Observations of the secretariat
					chart (It will be sent to PL and the other experts directory). While PL declared that “At present, 23705 is focused on the assessment algorithms and approaches, not providing thresholds”, it has not been realized in the current drafts, both 9490 and 23705. Examples : “Collision avoidance manoeuvre Go/No-Go thresholds” is duplicated between sub-clause 8.8 in 9490 and sub-clause 5.2.8 in CD 23705, “Timeline of collision avoidance manoeuvres” is duplicated between sub-clause 8.11 in 9490 and sub-clause 5.2.12 in CD 23705.	document. Namely integrate with 23705 and cancel 23705. Secondary solution: The relationship between 23705 and 9490 should be clarified in the introduction. It should be made clear that the conjunction assessment methodology, and conjunction assessment concept are broadly described in 23705. It should also be made clear whether users should review 23705 essentially before applying 9490. Also, call out the relevant sub-clause in 23705 in the appropriate sub-clauses in 9094. Delete one of the duplicate sub-clauses.	
US - 73- 286		Appendix C		gc	The utility of Appendix C is not evident. It is one opinion of what a system might look like—what is the purpose?	Delete Appendix C	Accept.
-287		General		ge	Some terms may lack proper definition, such as for instance “SSA system”, “SSA service provider”, “STC information”, “SSA information” (all of them can be at least found in the document scope), “HAO service provider” (section 7.3 and 9.4.1)	Define associated terms	Accept.
-288		General		ge	Coordination between regional STC systems does not seems to be mentioned anywhere in the document	Add a specific general requirement highlighting the need for coordination between regional STC systems	Accept.
DE- 103 -289		Introduction	Fig 1	ed	Annex C is missing in Fig. 1	Adapt Fig. 1 accordingly	Accept.
-290		Introduction	Fig 1	ed	Annex C is missing in Fig. 1	Adapt Fig. 1 accordingly	(Duplicate of other EU submittal)
- 291_rm					“Enterprise system” is a confusing term.	Change “enterprise” to “Level 2” and low-level STC system to Level 1”	Accept.

1 **MB** = Member body / **NC** = National Committee (enter the ISO 3166 two-letter country code, e.g. CN for China; comments from the ISO/CS editing unit are identified by **)
2 **Type of comment:** **ge** = general **te** = technical **ed** = editorial