



**International
Standard**

ISO 23705

**Space systems — Identifying,
evaluating and avoiding collisions
between orbiting objects**

*Systèmes spatiaux — Identification, évaluation et évitement des
collisions entre objets en orbite*

**First edition
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The process for perceiving, evaluating and avoiding collisions among orbiting objects begins in stage 1 as shown in the top-level workflow contained in [Figure 1](#). In this stage, the best possible positional information on all potentially conjuncting objects is obtained from a combination of either spacecraft operators or STC^[1] systems or both. A standardized way to share such information is specified in ISO 26900^[2]. Spacecraft positional information can be provided by collaborating spacecraft operators and from observers who are capable of viewing spacecraft. This data can then be compared with each other to discern physically feasible approaches that could result in collisions. The trajectories so revealed can then be examined more closely to estimate the probability of collision. It is also important to know the nature of each object if possible. This information includes the size, mass, geometry, and the operational state (e.g. active or inactive). Collision probability estimates consider the inevitable imprecision associated with orbit determination and other hypotheses and measurements. This information then allows analysts in stage 2 to screen for threatening close approaches. Where the possibility of a collision has been identified which violates the thresholds established by a spacecraft operator, the spectrum of feasible manoeuvres is examined in stage 3 to take an effective course of action.

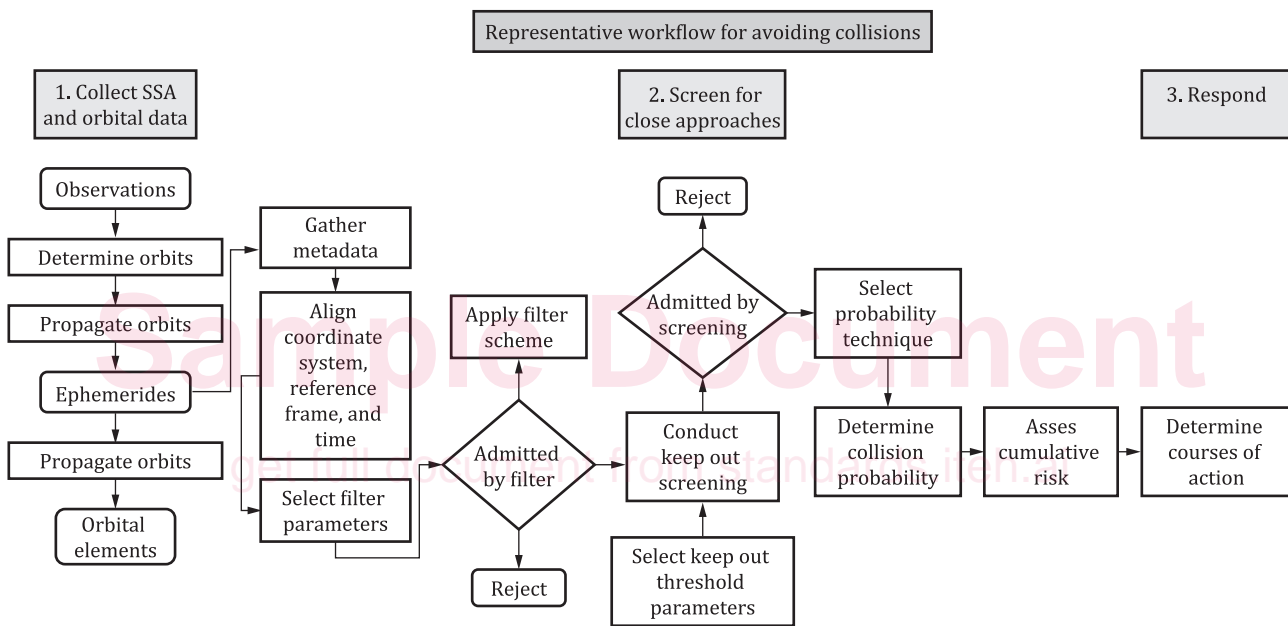


Figure 1 — Top-level collision avoidance workflow

There are several different approaches to conjunction assessment. All have merits and deficiencies. Many focus on how closely spacecraft approach each other. This is often very uncertain since changes in spacecraft orbits under the influence of non-conservative forces, as a rule:

- a) evolve more rapidly than observations of spacecraft in orbit can be acquired; and
- b) cannot be modelled accurately enough to obtain credible results of propagation even when the initial orbit determination is accurate.

Spacecraft operators require the fullness of orbit data to judge the credibility and quality of conjunction perception.

This information includes the moment in time of the last elaboration of orbit (the epoch) and the standard time scale employed, positional ephemerides or orbit state vector values or elements at that moment in time, the coordinate system description that presents the orbital data, the forces model description that is used for orbital predictions, and information about the estimated positional errors associated with those predictions. Essential elements of information for this purpose are specified in ISO 26900^[2].

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There are also diverse approaches to estimating the probability that a close approach can result in a collision. This is a statistical process very similar to weather forecasting. Meteorologists no longer make definitive predictions. They provide the probability of precipitation, not whether it will rain. All conjunction assessment approaches are in some way founded in probabilities. Probability of collision is also a highly desirable element of data. It can be accompanied by metadata that allows operators to interpret the information within their own operational procedures.

How near two spacecraft can be to each other and the probability they can collide if they were that close are only two discriminants of potentially catastrophic events. Since the objective is that the spacecraft survives despite many potential close approaches, cumulative probability of survival is also important information. Responding precipitously to the close approach nearest at hand can only delay the demise of the spacecraft or even contribute to a subsequent more serious event. The evolution of close approaches is thus also important.

Finally, the state of each of the conjunction partners, their ability to manoeuvre or otherwise avoid contact, and the outcomes of past events that are similar guide courses of action.

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 is divided up as shown in [Table 1](#).

Table 1 — Division of space safety operations content between ISO 9490,^[1]ISO 23705 and ISO 21740^[3]

ISO 9490: STC	ISO 23705: Avoid collision	ISO 21740: LCOLA
— STC terminology	— Conjunction assessment and collision avoidance terminology	— LCOLA terminology: safety LCOLA and mission assurance LCOLA
— STC system, QC, IS, reliability	— Risk mitigation strategies	— LCOLA launch window screening process
— STC roles/responsibilities for launch providers, S/C operators, and SSA providers	— Suggested collision miss distance and probability/risk metrics and associated minimum thresholds	— LCOLA products
— STC and SSA services	— Mathematical techniques:	— Launch range coordination
— Orbit determination, required accuracy, timeliness	— Conjunction assessment	— LCOLA data exchange (LDM)
— Manoeuvrability RotR/	— Collision probability	— LCOLA mathematical techniques
— Manoeuvre recommendations	— Linear, non-linear,	
— Data exchange and launch, manoeuvre, anomaly, and fragmentations notifications	— Asymmetric, max prob	
— STC mathematical techniques	— CAM planning, optimize	
	— CA nomograms	

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Space systems — Identifying, evaluating and avoiding collisions between orbiting objects

1 Scope

This document provides the workflow and technical requirements for perceiving, evaluating and avoiding collisions among orbiting objects, data requirements for these tasks, identifies techniques that can be used to estimate either the probability or the consequence of collisions, or both, and provides requirements and guidance for executing collision avoidance manoeuvres.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 collision

instance of one object striking another

3.2 collision probability

quantification of the likelihood of two space objects impacting each other during a *conjunction* (3.3) event

3.3 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;
- b) the estimated probability of *collision* (3.1) at this local minimum exceeds a specified *collision probability* (3.2) threshold; or
- c) a combination of miss distance, probability and/or other metrics (e.g. “risk”)

3.4 covariance

measure of how much variables change together

Note 1 to entry: For multiple dependent variables, covariance is a square, symmetric, positive definite matrix of dimensionality $N \times N$, where N is the number of variables.

3.5 encounter plane

plane normal to the relative velocity at the time of closest approach

3.6

ephemeris

time history of positional and velocity (and optionally acceleration and *covariance* (3.4)) state information

3.7

false alarm

statistical error, when a statistical test fails to reject a false null hypothesis

3.8

interface control document

specification that describes the characteristics that must be controlled at the boundaries between systems, subsystems and other elements

[SOURCE: ISO 15388:2022, 3.1.22, modified — The abbreviated term "ICD" has been removed.]

3.9

orbital elements

parameters that describe the evolution of the trajectory and which can be used to estimate the trajectory in the future

3.10

scaled P_c

scaled collision probability

collision probability (3.2) that is estimated using *covariance* (3.4) matrices that have been numerically adjusted by the square of a scaling factor

3.11

space situational awareness

SSA

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

Note 1 to entry: SSA 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.^[35] 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* (3.1), radio frequency interference, and occurrences that can disrupt missions and services.

Note 2 to entry: This definition is adopted from Reference [4].

3.12

SSA service provider

space situational awareness service provider

entity that operates a *space situational awareness (SSA)* (3.11) system to maintain an operational picture of the space environment and potential risks

Note 1 to entry: SSA 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.

3.13

SSA system

space situational awareness system

set of information gathering and exchange protocols enabling the characterization of the space environment and dissemination of its knowledge

3.14

space surveillance and tracking

SST

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

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.

3.15

space traffic coordination

STC

cooperative planning, harmonization, data and information sharing, and synchronization of space activities to avoid *collision* (3.1) and radio frequency interference during spacecraft and launch vehicle operations in space

Note 1 to entry: This definition is adopted from Reference [4].

4 Symbols and abbreviated terms

4.1 Abbreviated terms

ANSI	American National Standards Institute
AIAA	American Institute of Aeronautics and Astronautics
CA	conjunction assessment
CAM	collision avoidance manoeuvre
CCSDS	Consultative Committee for Space Data Systems
CDM	conjunction data message
COLA	collision avoidance
ESA	European Space Agency
FDS	flight dynamics staff
GEO	geostationary Earth orbit
LCOLA	"launch collision avoidance" or "launch COLA"
LEO	low Earth orbit
MEO	medium Earth orbit
O/O	owner/operator
NASA	National Aeronautics and Space Administration
PDF	probability distribution function
RCS	radar cross section
SANA	Space Assigned Numbers Authority
S/C	spacecraft

SSA	space situational awareness
SST	space surveillance and tracking
STC	space traffic coordination
TCA	time of closest approach
UTC	Coordinated Universal Time

5 CA Requirements for SSA systems and SSA service providers

5.1 General requirements

5.1.1 Documentation describing conjunction assessment methodology

SSA systems and SSA service providers shall create and maintain documentation describing their own catalogue update strategies (including detection of new objects), update of external orbits (ephemerides from spacecraft operators, catalogue maintained by other SSA entities), assessment of the quality of the data used, conjunctions detection, risks assessment and mitigation strategy provision.

NOTE These data requirements enable a well-understood workflow and interactions among the potentially multiple organizations involved in mitigating the potential consequences of conjunctions and collisions.

5.1.2 Conjunction assessment operational concept

SSA systems and SSA service providers shall develop and maintain an operational concept that describes the roles, relationships, tasks, processes, and information flows amongst stakeholders and the way systems and processes will be used to provide conjunction assessment to spacecraft operators.

5.2 SSA systems and SSA service providers responsibilities

5.2.1 Data exchange with SSA systems and SSA service providers

SSA systems and SSA service providers shall have the capability to exchange orbits and measurements with other SSA systems and SSA service providers, and with SST service providers.

Where applicable, machine-to-machine interfaces adhering to CCSDS standards such as ISO 26900 orbit data message, ISO 19389 conjunction data message, and CCSDS attitude data message, along with their accompanying SANA registry normative content, should be used.

5.2.2 Interface with spacecraft operators

SSA service providers shall provide an interface to operators to receive input data (such as ephemerides) and generate CDMs.

5.2.3 Establishment of service conditions between spacecraft operators and SSA service providers

Exact service conditions shall be established between the satellite operator and the SSA service provider(s) before the start of the service. The liability of the SSA systems and SSA service providers shall be clarified.

Unless specified otherwise, the owners and operators shall be responsible for deciding mitigating courses of action.

NOTE Such conditions can already be established for all participants in a common definition of services document, adopted data exchange formats, and definition of liability. In cases where these are not established by default or if not well-suited for a particular spacecraft operator, an interface control document can be established to delineate such terms as agreed between SSA service providers and spacecraft operators (see [6.2.2](#)).

5.2.4 Update of the space object catalogue for debris and non-cooperating operators

SSA service providers shall obtain or maintain the most current, complete, timely, and accurate SSA catalogue data on debris and non-cooperating actively manoeuvring spacecraft, either by building their own catalogue or by acquiring data from an external entity, or both.

5.2.5 Update of the space object catalogue for cooperating operators

The SSA system or SSA service provider shall keep up to date their database of orbits shared by spacecraft operators.

5.2.6 Quality assessment of the data used

SSA service providers shall check the consistency and accuracy of external data before use, by performing comparisons with statistical analysis, with measurements or with other orbits sources.

SSA service providers should notify spacecraft operators if the ephemerides or covariances provided does not pass the quality checks.

5.2.7 Coordination with third parties

In case of a conjunction between two or more active S/C, organizations shall have the capability to describe their risk assessment process, methodology and analysis results to any parties unfamiliar with them.

5.3 Risk assessment methodology

5.3.1 Screening threshold

SSA service providers shall use the risk assessment methodology, screening metrics and associated thresholds as specified by their decision authority.

Minimum metrics and thresholds should be selected in accordance with [Annex C](#) and [Annex D](#).

NOTE See Reference [6] and [Clause D.2](#) for representative metrics and thresholds used by commercial spacecraft operators.

5.3.2 CDM computation

SSA service providers should be able to identify which orbit source is the most adequate for a given conjunction at a given time. SSA service providers shall clearly indicate the data source (O/O ephemerides, own catalogue, external catalogues) used for the primary and secondary objects in the generated CDMs.

5.3.3 Adopted spacecraft or debris equivalent cross-sectional area

SSA service providers shall use sources for estimated “equivalent cross-sectional area” for spacecraft and debris objects deemed most reliable.

NOTE 1 Generally, the following prioritization order can be used: data provided by the spacecraft operator or debris originator, values computed from geometry available on open-source information, default values derived from RCS or optical magnitude information, or a default value when no other information is available.

NOTE 2 Default values can be derived from statistical median “typical” values of other objects of known cross-sections within a mission type, orbit class or category, ballistic coefficient estimates, or year of manufacture.

5.3.4 Adopted spacecraft or debris mass

SSA service providers shall obtain or define the estimated mass of either the spacecraft or the debris object, or both, involved in the conjunction based on the following priority order: data provided by the spacecraft operator or debris originator, open-source information available, default values derived from RCS or optical magnitude information, or a default value when no information is available.

5.3.5 Spacecraft activity status

SSA service providers shall obtain the operational status of any spacecraft involved in a conjunction.

5.3.6 Notification and reporting of upcoming conjunctions

SSA service providers shall alert operators of conjunctions that exceed predefined metric thresholds as specified by their respective decision authority.

NOTE 1 Examples of conjunction metrics and thresholds are provided in [Annex D](#). Such thresholds typically support the identification of three separate phases of the analysis: a) initial screening; b) warning associated with the adopted reporting criteria; and c) exceedance of the go/no-go avoidance manoeuvre threshold.

NOTE 2 The notification can contain recommended mitigation actions for a few standard cases (such as a chemical manoeuvre performed 0,5 orbits before TCA) to help the spacecraft operator select and define their mitigation strategy.

6 CA requirements for spacecraft operators

6.1 General requirements

6.1.1 Documentation describing collision avoidance methodology

Spacecraft operators shall create and maintain documentation describing their collision avoidance detection, evaluation and mitigation strategies.

NOTE These data requirements enable a well-understood workflow and interactions among the potentially multiple organizations involved in mitigating the potential consequences of conjunctions and collisions.

6.1.2 Collision avoidance operational concept.

Spacecraft operators shall develop and maintain an operational concept that describes the roles, relationships, tasks, processes and information flows amongst stakeholders and the way systems and processes will be used to perform collision avoidance actions.

NOTE 1 Since conjunction and collision assessment involves multiple stakeholders, providers and action recipients, a commonly understood, normative operational concept is essential. [Figure 3](#) and [Figure 4](#) provide a representative operational concept depicting each of the elements in the collision avoidance workflow.

NOTE 2 See, for example, ISO 14950,^[7]ISO 17666^[8] and ISO 19971^[9] for guidance on developing and maintaining operational concepts.

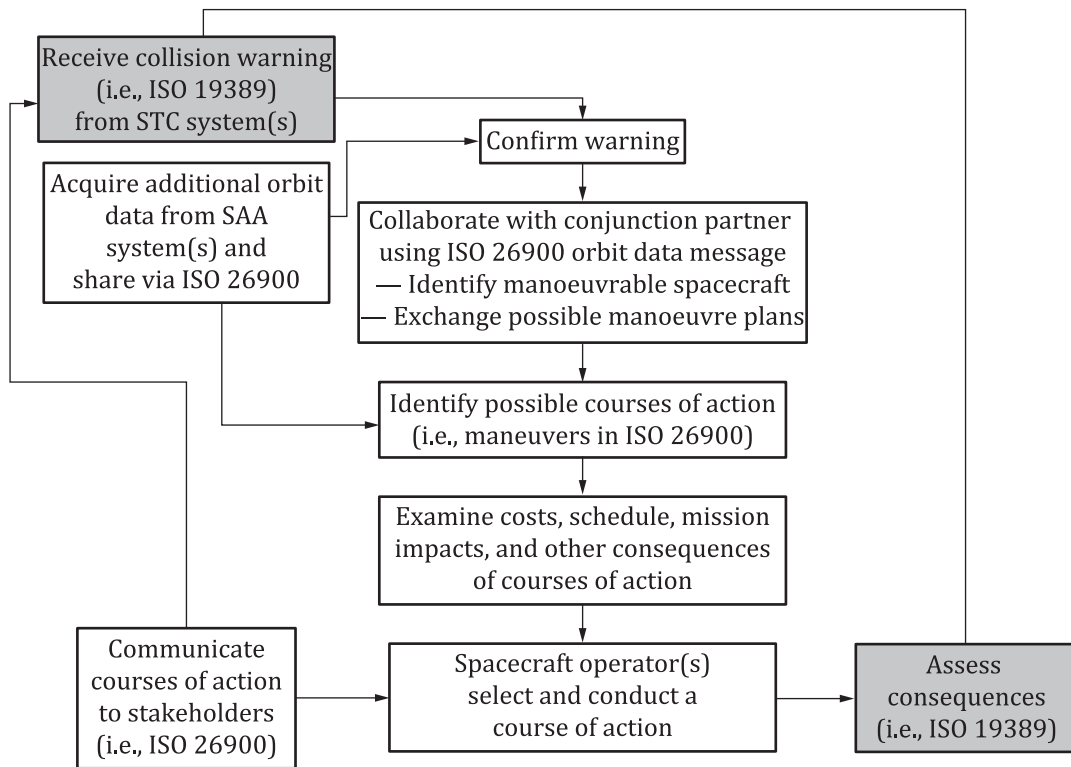


Figure 3 — Representative collision avoidance operational concept

Figure 4 provides details for the “Select and execute course of action” box from Figure 3, including consequence assessment^[10].

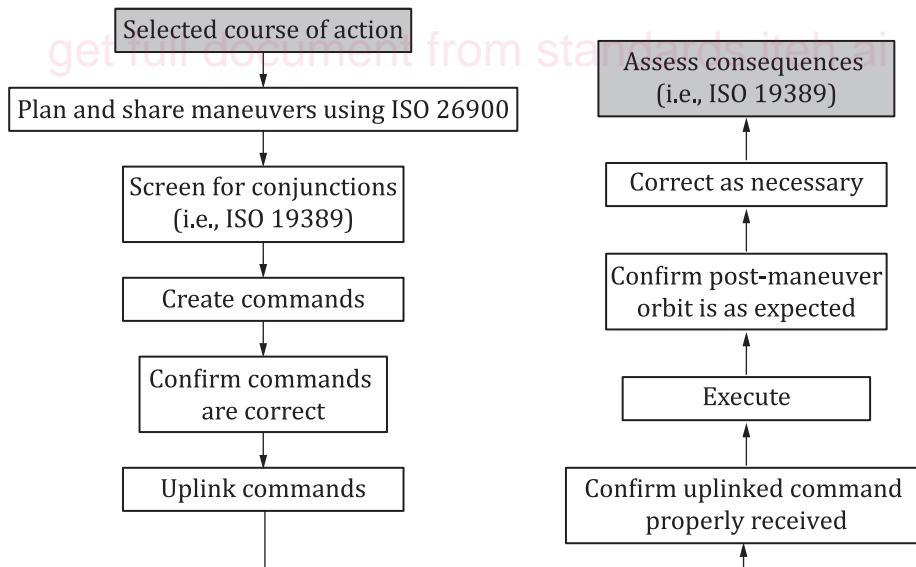


Figure 4 — Diagram detailing components of selecting and executing a course of action

6.2 Spacecraft operator collision risk mitigation and notification responsibilities

6.2.1 Spacecraft collision avoidance metrics and thresholds

Spacecraft operators shall mitigate collision risk which exceeds their respective decision authority's specified collision avoidance metrics and associated thresholds.