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Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices

Systèmes spatiaux — Opérations de proximité et de rendez-vous et services sur orbite — Principes et pratiques programmatiques

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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 documents 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This document outlines the principles and practices that rendezvous and proximity operations and on-orbit servicing (RPO/OOS) service providers are expected to follow in order to ensure safe operations and to encourage a healthy RPO/OOS industry. International law, treaties, and agreements have been researched for compliance and reference. If additional, more specific requirements are needed for Human Spaceflight (HSF) these can be provided in the future.

This document is intended to be the highest-level standard for the discipline of RPO/OOS for spacecraft systems. As such, there are several places in the document where a requirement is stated, but alternative acceptable methods of verification of compliance exist. Examples include but are not limited to: notification of authorities (4.2.2); certifications of design or operational procedures (5.1.1, 5.1.2, 5.1.3). Clauses 4 and 5 specify programmatic principles and operational practices respectively. Annex A contains information related to Clause 4 (A.1) and Clause 5 (A.2). Annex B outlines notional RPO/OOS mission phases.

Initial drafts were produced by the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) team, an international team of 26 initial companies promoting standardization for RPO/OOS missions to improve safety and promote development of the RPO/OOS industry. Work was performed over a period of 18 months at six international workshops in the US and Germany. With this issue, the draft has been handed over to ISO TC 20/SC 14 for vetting and processing with the normal ISO standardization processes. In the further development within ISO, parallel commercial and governmental RPO/OOS efforts have contributed to the consensus requirements herein.

CONFERS is an independent, self-sustaining forum created to advocate and promote the spacecraft servicing industry and encourage responsible commercial RPO/OOS. CONFERS collaborates on research, development, and publication of voluntary consensus principles, best practices, and technical and safety standards. CONFERS also engages with national governments and international bodies on policy and oversight of spacecraft servicing activities.

Space systems — Rendezvous and Proximity Operations (RPO) and On Orbit Servicing (OOS) — Programmatic principles and practices

1 Scope

This document establishes guiding principles and best practices at the programmatic level for all participants in the rendezvous and proximity operations (RPO) and on-orbit servicing (OOS) industry. These principles and practices establish the broadest boundaries for behaviour of participants in the RPO/OOS industry and precede more detailed standards. In principle, the document also covers both robotic and HSF missions, but requirements are derived from robotic missions.

This document is applicable to a broad array of RPO/OOS industry participants from spacecraft equipment manufacturers, spacecraft operators, service providers, developers of RPO/OOS simulation, planning and safety tools, and insurers. It helps to establish responsible norms of behaviour for RPO and OOS that industry participants are supposed to achieve and to promote throughout the global industry.

2 Normative references

The following documents are referred to in the text in such a way that some or all of 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 23312, *Space Systems — Detailed space debris mitigation requirements for spacecraft*

ISO 24113, *Space systems — Space debris mitigation requirements*

ISO 27875, *Space systems — Re-entry risk management for unmanned spacecraft and launch vehicle orbital stages*

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
capture
act of establishing a connection between two space objects

3.2
client
organization contracting for the service

3.3
proximity operations control volume
control volume
operations zone
volume of space established for non-interference and to assure relative navigation control while the *servicer spacecraft* (3.15) and *client* (3.2) space object are within close proximity

3.4
client space object
space object being serviced by the *servicer spacecraft* (3.15)

Note 1 to entry: It is property of the *client* (3.2).

3.5
coordinated
active, interactive participation between both *servicer spacecraft* (3.15) and *client space object* (3.4)

Note 1 to entry: The antonym is uncoordinated.

3.6
docking
process wherein a servicing spacecraft's GNC actuators are used to execute a controlled contacting trajectory to a *client space object* (3.4) in such a manner as to align and mesh the interface mechanisms

3.7
on-orbit servicing
OOS
on-orbit activities by a *servicer spacecraft* (3.15) which requires *rendezvous* (3.12) and/or proximity

Note 1 to entry: This may include *servicing operations* (3.16).

3.8
passively safe trajectory
trajectory which does not interfere with a convex envelope, volume, zone or any area defined to avoid contact with sufficient margin of the *client space object* (3.4) when control is lost

3.9
prepared
status of the *servicer* (3.14), *servicer spacecraft* (3.15), *client* (3.2) and *client space object* (3.4) having taken actions to be ready for RPO or OOS

3.10
proximity operations
series of orbital manoeuvres executed to place and maintain a spacecraft in the vicinity of another space object (artificial or natural bodies) on a relative planned path for a specific time duration to accomplish mission objectives

3.11
relocation
<service> operation to change the orbit of the *client space object* (3.4)

Note 1 to entry: See also *re-orbit* (3.13).

3.12
rendezvous
process wherein two space objects (artificial or natural bodies) are intentionally brought close together through a series of orbital manoeuvres at a planned time and place

3.13
re-orbit
operation to change the orbit of the *client space object* (3.4)

Note 1 to entry: See also *relocation* (3.11).

3.14
servicer
organization that provides *on-orbit servicing* (3.7) operations by contract

3.15
servicer spacecraft
spacecraft performing the *servicing operation* (3.16)

3.16
servicing operation
action provided by *servicer spacecraft* (3.15) to the *client space object* (3.4), including but not limited to inspection, *capture* (3.1), *docking* (3.6), *relocation* (3.11), refuelling, repair, upgrade, assembly and release

4 Programmatic principles for rendezvous and proximity operations (RPO) and on-orbit servicing (OOS) missions

4.1 Responsible design and operations

4.1.1 Promote safety and mission success

In order for the industry to flourish, servicers shall ensure their activities are planned and conducted to promote safety and mission success, to include other space assets, their activities, the orbital environment and ground environment.

4.1.2 Space debris

4.1.2.1 Servicer spacecraft manufacturer and servicer shall ensure conformity to ISO 24113.

4.1.2.2 Further, the Servicer shall ensure that both the Servicer spacecraft and the Client Space Object under the Servicer's responsibilities avoid generating space debris during servicing operations.

4.1.2.3 Provisions shall be made in service planning and operations for mitigating the adverse consequences of a close approach, such as a collision that generates space debris.

4.1.2.4 In the case of a mission extension service (e.g. refuelling, relocation/re-orbit or components replacement), the client shall verify that the client space object meets ISO 24113 requirements throughout its extended mission lifetime.

NOTE This explicitly makes ISO 24113 applicable to the client space object, even if it was manufactured or placed into operation prior to the publication of ISO 24113.

4.1.3 Effective communications

During a servicing operation, the servicer and client organizations shall establish and maintain effective communications in support of safe and successful operations.

4.1.4 Liability for damage and insurance

A servicing operation shall be insured to cover the risk of damage to the activity of third parties.

NOTE The liability for damage can be covered by conventional insurance, financial reserves, alternative operational support or other means.

4.2 Transparent operations

4.2.1 General

The servicer and client conducting servicing operations shall work within the principle of transparency to promote safety and trust.

4.2.2 Notification to states

It is presupposed that the servicer and client involved in servicing operations notify the proper state authorities of the intended operations (general nature, timing, locations) and results of servicing operations according to relevant law. See Article XI of the OST[1].

4.2.3 Communications with entities

The servicer and client conducting servicing operations shall take reasonable measures by sufficient communication and coordination with entities not associated with the RPO/OOS activities that have safety concerns, due to proximity, about the intentions or interference by the servicing operation to support safety and avoid harmful interference. See Article IX of the OST[1].

4.2.4 Notification protocols

The servicer and client conducting the servicing operations shall develop and implement a protocol that provides timely public notification of anomalies or mishaps that can have an adverse impact on other entities or the space environment.

4.2.5 Lessons learned

The servicer and client conducting servicing operations shall look for opportunities to share lessons learned from operational successes and anomalies while protecting intellectual property and competition-sensitive information.

4.2.6 Notification of re-entry hazard

4.2.6.1 Assessment of re-entry hazard

If a mission purpose is to capture a client space object and place it into a re-entry trajectory, the servicer shall assess re-entry risk for all spacecraft and objects which will re-enter as a result of service operation.

4.2.6.2 Notification of re-entry event

In the case of re-entry, relevant state actors (e.g. civil aviation, communications or maritime authorities) require the notification of the servicer of anticipated re-entry risk(s). This notification supports notification to the United Nations Office of Outer Space Affairs registration of objects launched into outer space. Re-entry shall be in accordance with ISO 24113 and ISO 27875. See Convention on Registration of Objects Launched into Outer Space (1976)[2].

4.2.7 Registration of orbit

It is presupposed that the initial orbit and subsequent significant orbital changes are registered in accordance with relevant registration regulations.

5 Programmatic practices for rendezvous and proximity operations and on-orbit servicing missions

5.1 Design for mission success

5.1.1 General

For coordinated RPO and OOS, servicers should develop a state-of-the-art/best practices and holistic approach to the system design and verification, and design and verification of operations of their servicing system to enhance safety and mission success.

The system design shall consider risk mitigation and operational safety practices across the layers of control specified in 5.1.2 to 5.1.6.

5.1.2 Formal review of hardware design

Hardware provides essential guidance, navigation and control (including propulsion, attitude control, etc.) and mechanism capabilities for RPO and OOS. This includes but is not limited to a relative navigation sensor system, on- and off -board navigation systems, interfaces in terms of sensor support patterns or docking/capture mechanisms and attitude determination and control subsystems. Modelling, simulation, component and system-level testing, and documentation of as-built hardware are critical to providing a reliable and sustainable system.

The systems involved in OOS shall verify hardware design for system and operational safety. (See ISO 23135 for verification standard requirements).

5.1.3 Resilient software design and verification

Software provides both the ability for varying levels of RPO and OOS automation and autonomy as well as fault detection and corrective logic. Software designs and functionality should be verified using, for example, extensive simulation runs to model sensor inputs to the relative navigation algorithms. Baselining, performance verification, and the ability to update or patch in-flight are key to resilient software design that shall help ensure confidence in mission execution.

The systems involved in OOS shall have software design verified for system and operational safety.

5.1.4 Concepts of operation

Concepts of operations (CONOPS) define the full set of expected and acceptable RPO and OOS scenarios, implementing the elements/components of the expected system architectures, and techniques to be utilized that focus on spaceflight safety. Specific techniques may include passively safe orbits, safety zones, and keep-out spheres or volumes for RPO and OOS activities. For experimental or first use activities, a “crawl, walk, run” approach to assessing capability, verifying functionality and performance while building confidence and experience is an essential prerequisite to implementing in sensitive environments (e.g. geostationary belt or near crewed spacecraft).

The systems involved in OOS shall verify the concept of operations for system and operational safety and a hazard assessment analysis. See ISO/IEC/IEEE 29148 for general CONOPS standard requirements. See ISO 23135 for verification standard requirements.

5.1.5 Approved and proven procedures

Organizationally controlled procedures (i.e. configuration-controlled procedures) along with defined guidelines, constraints and limitations are the foundation to ensure safety and success in baselining the plan to achieve RPO and subsequent servicing. The approved procedures should align with the CONOPS and establish the foundation for the servicer to execute.

Procedures, including operational procedures and instructions as well as flight rules and test and operational Limits, shall be reviewed and tested for completeness, correctness, and safety.

5.1.6 Trained and qualified operators

Servicer spacecraft and client space object operators are critical to safety and enabling mission success. An operations team that is trained, experienced, disciplined and rehearsed is a substantial confidence builder for sustainable and repeatable servicing missions.

Servicer spacecraft and client space object operators shall be trained, experienced and have rehearsed procedures to detect anomalous navigation and control conditions, system health, and mission performance, as well as to manually intervene, if necessary, to limit material safety risks and hazards.

5.2 Design servicing operations to minimize the risk and consequences of mishaps

5.2.1 Contractual relationship with client

5.2.1.1 General

RPO and OOS operations shall be performed by a servicer for a contracted and cognizant client.

5.2.1.2 Cases with no known owner

For cases where the owner cannot be identified (e.g. space debris objects), perform RPO and OOS operations in a safe and transparent manner. This may include providing public notice and communication of intent to States that are possibly the source of the object.

5.2.1.3 Cases with an owner identified after servicing operations begin

If the source is identified during/following the service, the relevant source shall be notified. See Convention on Registration of Objects Launched into Outer Space (1976)[2].

5.2.2 Communications discipline

Sufficient communications discipline shall be employed between the servicer and client to ensure positive control of both objects during the servicing operation.

5.2.3 Trajectory practice

5.2.3.1 Passively safe trajectories

Except while in or establishing a proximity operations control volume (See B.7), passively safe trajectories shall be used.

5.2.3.2 With other than client space objects

Close approaches with space objects other than the client space object shall be avoided.

5.2.3.3 Propagation uncertainty

The trajectory propagation to be considered shall include all navigation uncertainties, process noise and perturbations.

5.2.4 Third party notifications

Servicers and/or clients shall notify and exchange information with affected third parties in advance of close approaches to support safety of spaceflight (e.g. operator points-of-contact, ephemerides, ability to manoeuvre, and manoeuvre plans) while respecting owner/operator intellectual property and proprietary information. See 5.2.1 for situations where no owners can be identified.

NOTE The client can satisfy this requirement by proxy arrangements through the servicer.

5.2.5 Collision avoidance practices in proximity

5.2.5.1 General

To minimize the likelihood of and adverse consequences from interference, collisions and generating space debris (4.1.2) servicing operations shall define and control the operations environment.

5.2.5.2 Proximity operations control volume

Within the mission phases (B.7), a proximity operations control volume is identified for operations.

Servicers shall reasonably define proximity operations control volumes to ensure the physical safety of rendezvous and servicing objects and that of other non-participatory spacecraft.

NOTE Safety in this case is related to third party spacecraft passing through the proximity operations control volume and being affected by the physical or electro-magnetic interference of the servicer spacecraft and client space object as identified in 5.3.

5.2.5.3 Allowed presence

The servicer shall ensure that only space objects planned as a part of the operation are in an operating zone while proximity operations are underway and minimize close approaches with space objects other than the client space object at all times.

5.2.6 Anomaly resolution

5.2.6.1 Anomaly resolution protocols (often called contingency operations plans) shall be prepared and practiced.

5.2.6.2 If anomalies happen, specifically when there is a potential effect outside the operating zone such as in break-up or loss of control, servicers shall provide a situational notice to the public.

5.2.6.3 When anomalies occur, servicers shall enact contingency actions to minimize the adverse effects on other space users or the orbital environment.

5.2.7 On-orbit checkout

5.2.7.1 General

Initial first-time on-orbit checkout procedures and demonstrations shall be performed at altitudes that minimize the impact on internationally recognized protected orbital zones as defined and in accordance with ISO 24113 for definition and requirements for internationally recognized protected regions. When this requirement is not executable, such as possibly for spacecraft without propulsion, the servicer shall find other means to satisfy the intent of this requirement.

5.2.7.2 LEO checkout altitude

Checkout and demonstration in low Earth orbit (LEO), especially all critical systems required for controlling the spacecraft, performing collision avoidance or post mission disposal shall be as defined and in accordance with ISO 23312, to occur at sufficiently low altitudes to naturally comply with the 25-year rule while also being considerate of human spaceflight activities.

5.2.7.3 GEO checkout altitude

Checkout and demonstration in geosynchronous Earth orbit (GSO) shall be higher or lower than the geostationary to ensure that potentially objects left in orbit remain outside the GEO protected region for at least 100 years.

5.3 Avoidance of interference

5.3.1 General

Servicers and clients shall avoid physical or electro-magnetic interference during all phases of operations.

5.3.2 Avoiding physical interference

Servicers shall exercise positive control of RPO and OOS activities with client space objects and avoid physical interference with other space activities during all phases of operations. See 5.2.2.

5.3.3 Avoiding electromagnetic interference

Servicers shall exercise all reasonable measures to avoid electromagnetic interference with other space activities during all operational phases.

5.4 Information sharing

5.4.1 General

Servicers and clients shall share information on resolution of spacecraft anomalies/failures and related root cause analysis.

5.4.2 Development of anomaly resolution standards

Servicers and clients shall participate in the development of anomaly resolution standards and sharing architectures. See ISO/IEC/IEEE 42010.

5.4.3 Sharing of anomaly information

Servicers and clients shall, to the extent it is practical, share information among spacecraft servicers and regarding servicing operations (the community involved in spacecraft servicing) on specific examples of anomaly resolution and attribution that can impact the community as a whole.

Annex A
(informative)

Information related to programmatic principles and practices

A.1 Information related to programmatic principles

A.1.1 General

This clause is related to Clause 4. The informative language is broader than the normative language in Clause 4.

A.1.2 Consensual operations

RPO/OOS for on-orbit services with artificial space objects should be conducted via agreements between consenting parties using generally accepted business and contractual practices.

A.1.3 Compliance with relevant laws and regulations

Beyond the scope of this document, it is clear that the collaborating parties of both the client space object and servicer spacecraft, as well as any third parties engaged in the activity (e.g. separate contract with an observation spacecraft), comply with all appropriate licensing and regulations, of all cognizant national jurisdictions of the involved parties. Moreover, the collaborating parties conduct their operations in full compliance with the treaties, such as the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (the "Outer Space Treaty" or "OST") and others listed in the Biblography.

A.2 Information related to programmatic practices

A.2.1 General

This clause is related to Clause 5. The informative language is broader than the normative language in Clause 5. Implementing the programmatic principles for RPO and OOS in Clause 5, servicers and clients should begin with developing recommended design and operational practices. It is expected that adopting these practices is an effective way to enhance operational safety and success. The practices in A.2.2 to A.2.7 represent lessons learned from prior servicing operations, which have historically been conducted by governments. These practices are intended to evolve based upon experience gained through servicing operations.

A.2.2 Design for mission success

Spacecraft servicers should develop a holistic approach to the design and operations of their servicing system to enhance safety and mission success.

A.2.3 Design spacecraft to facilitate safe and effective spacecraft servicing

Servicer spacecraft should be designed in such a way as to facilitate the safety and effectiveness of spacecraft servicing activities. Servicer spacecraft and future client space object designs should include methods to improve interface compatibility and the trackability of the spacecraft, among other considerations.

A.2.4 State cooperation

A.2.4.1 General

Working with the proper State authorities is expected to provide notifications of ongoing RPO/OOS operations.

A.2.4.2 Notification of RPO/OOS plan

The plan of the RPO and OOS should be open to the public, including its general concept of operations, rough time schedule, responsible organization, relevant systems, affected orbital zones, anticipated benefits, and potential risks.

A.2.5 Avoidance of interference

Servicers should take reasonable measures to ensure that other entities (i.e. entities not associated with the RPO/OOS activities) that may have reason for concern about intentions or interference due to proximity are provided adequate notice. Servicers should not assume responsibility for the collection and quality of SSA data used to perform RPO and OOS missions but should advocate for its availability and continuous improvement as an important external resource.

A.2.6 Information sharing

A.2.6.1 General

Spacecraft anomaly/failure detection, resolution, recovery and attribution are critical to improving the safety, reliability, and transparency of spacecraft operations. Spacecraft servicers and servicing operations (and other stakeholders in the spacecraft servicing community) benefit from clear anomaly attribution and can also potentially contribute to attribution assessments during their operations. Although competition is essential to a healthy servicing sector, it is also in the best interest of the servicing community to abide by the practices specified in A.2.6.2, taking into account national export control laws and proprietary business confidential/intellectual property restrictions, to help prevent anomalies and failures that can undermine trust in the servicing community.

A.2.6.2 Sharing best practices

Servicers and clients should develop and share best practices for the anomaly attribution processes within the servicing community.

A.2.7 Promote sustainability

A.2.7.1 General

Servicers and clients should promote the long-term sustainability of space activities. Members of the space community believe that a well-maintained space environment is essential to the success of the industry and that the long-term sustainability of the space environment should be considered at every step. Members should strive to follow the practices specified in A.2.7.2 and A.2.7.3.

A.2.7.2 Comply with existing standards

Servicers and clients should comply with existing, relevant internationally recognized standards for the long-term sustainability of space activities, including those developed by the International Organization for Standardization (ISO) and the Consultative Committee for Space Data Systems (CCSDS).

A.2.7.3 Collaborate

Servicers and Clients should collaborate with State authorities and the broader space community to identify emerging space sustainability challenges and participate in the development of future guidelines and standards that enhance space sustainability.

Annex B
(informative)

RPO/OOS mission phases

B.1 General

This annex establishes a baseline of mission phases that is intended to describe the functions of all OOS missions. All phases do not apply to all OOS missions, but all OOS missions should find general descriptions of the functions of all of their phases. Functions or phases that are not unique to OOS missions are not included. For example, collision avoidance (COLA) procedures are continuously performed for all missions, and hence are not included in this document. Similarly, all phases require diligence in prevention of generating space debris, although some (e.g. servicing phases) more than others. Sometimes phase titles for such phases may be included with a note that explains that there is no content that is unique to OOS missions.

The actions and responsibilities identified herein are assigned to the servicer and client organizations. If other organizations are required to fulfil the actions of a phase, it is the responsibility of the servicer and client organizations to secure those resources and ensure the required functions are performed.

B.2 Overview diagram

Figure B.1 is an overview of most of the key mission phases described in the B.3 to B.12.

On orbit servicing (OOS) mission functional diagram – all phases

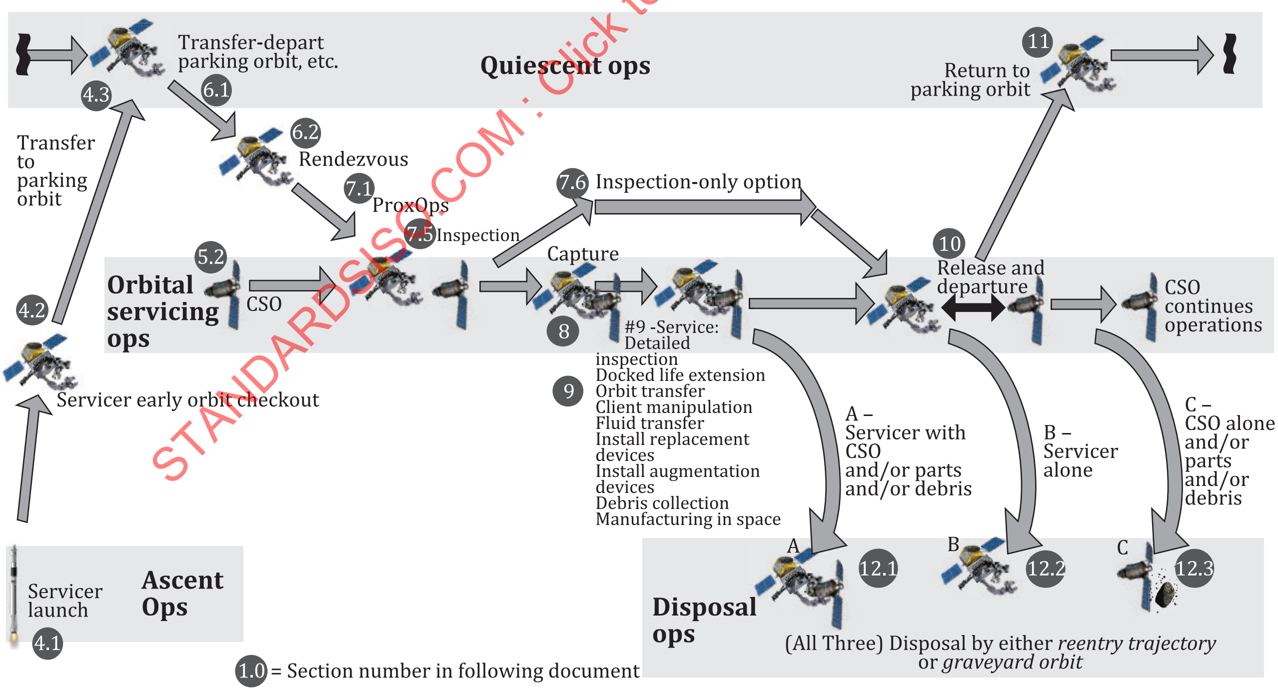

Figure B.1 — On-orbit servicing (OOS) mission functional diagram

B.3 Pre-mission

B.3.1 Mission assessment

The servicer and client assess the mission.

The servicer and client assess the needs of the client space object against the capabilities of the servicer spacecraft and determine if there is adequate mutual interest to proceed with contracting.

B.3.2 Service contracting

The servicer and client establish servicing agreements and contracts which address, e.g. risk assessment, insurance provision.

B.3.3 Perform compatibility assessment

The servicer and client (and their supporting organizations) collect relevant data (including health of the client space object and servicer spacecraft) and perform analysis to ensure compatibility between the servicer spacecraft and the client space object.

B.3.4 Service planning

The servicer and client exchange and coordinate servicing plans. They develop detailed sequence of events, operational procedures and contingency plans.

B.3.5 Inform and coordinate with other stakeholders as appropriate

The servicer and client ensure necessary regulatory bodies and reasonably affected space actors are informed of the plan and intentions to the level of detail required to provide adequate transparency.

This phase may be executed in a different place of the timeline, e.g. by different service providers.

B.3.6 Licensing

The servicer and clients coordinate and establish relevant licensing approvals from State authorities as required.

B.3.7 Insurance

B.3.7.1 General

The servicer and client ensure adequate insurance is in place for their own interests and those of relevant third parties.

B.3.8 Prepare Servicer Spacecraft, Client Space Object and associated operations systems

B.3.8.1 Design, build, test and launch servicer spacecraft and operations systems (as required)

When a new servicer spacecraft is required to be developed, the servicer should design, assemble, and test the servicer spacecraft according to recognized best practices (see 5.1.1).

B.3.8.2 Update servicer spacecraft and associated operating systems (as required)

When a servicer spacecraft is already on-orbit, the servicer updates (as needed) servicer flight software and operational procedure adaptations and tests.

B.3.8.3 Prepare client space object and associated operating systems (as required)

Any required, flight software adaptations on the client space object or associated operations systems should be developed, tested and verified.

B.3.9 Train mission operations team

The servicer and client conduct training and mission simulations (standalone or joint) as required.

B.3.10 Servicer pre-Launch ground operations (at the launch site)

This phase has no content that is unique to OOS missions. Normal spaceflight/spacecraft processes apply.

B.4 Launch and prepare servicer spacecraft

B.4.1 General

If using a servicer spacecraft that is already in amenable orbit, skip this phase.

This phase consists of three subphases that place a servicer spacecraft in a position where it is ready to rendezvous with clients. The subphases are launch, commissioning, and quiescent operations.

B.4.2 Servicer spacecraft launch

The servicer launches a servicer spacecraft into an initial orbit. The servicer monitors systems during ascent.

B.4.3 Servicer spacecraft commissioning

The servicer performs initial activation and checkout of the servicer spacecraft and verifies that the servicer spacecraft is ready for its mission(s).

B.4.4 Servicer quiescent operations

If the servicer spacecraft will rendezvous with the client space object immediately, skip this subphase.

Following servicer spacecraft commissioning or after departing a client space object, if the servicer spacecraft is not immediately beginning rendezvous operations for its next client space object, then it enters quiescent operations before beginning rendezvous operations with the next client.

A quiescent parking orbit may be any suitable orbit where a servicer spacecraft awaits between missions.

When a resupply station is present, the servicer spacecraft may rendezvous and dock with the resupply station, following a procedure like the phases that follow for client space objects.

B.5 Client operations pre-servicing

B.5.1 Reposition client space object

If there is no need to reposition the client space object, skip this phase.

The client space object is transferred from its current orbit to the orbit in which it will be serviced by the servicer spacecraft. This includes pre-positioning or phasing of the client space object's orbit to achieve the defined proximity operations control volume.

