CONFERS Recommended Design and Operational Practices

Implementing the CONFERS Guiding Principles for Commercial rendezvous and proximity operations (RPO) and on-orbit satellite servicing (OOS) will begin with developing recommended design and operational practices. We believe that adopting these practices is an effective way to enhance operational safety and success. The following practices 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 future commercial and government servicing operations.

I. **Design for mission success**. Satellite servicers should develop a holistic approach to the design and operations of their servicing system to enhance flight safety and mission success. The system design should take into account risk mitigation and operational safety practices across the following six layers of control:

a. **Certified hardware design**: Hardware provides essential guidance, navigation and control, propulsion and mechanism capabilities for RPO and OOS. This includes a relative navigation sensor system, on- and off-board navigation systems, and attitude determination and control subsystems. Modeling, simulation, component and system-level testing, and documentation of as-built hardware are critical to providing a reliable and sustainable system.

b. **Resilient software design:** 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 validated 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 will help ensure confidence in mission execution.

c. **Concepts of operation:** Concepts of operations (CONOPS) define expected and acceptable RPO and OOS scenarios, expected system architectures, and techniques to be utilized that focus on spaceflight safety. Specific techniques may include passive 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).

d. **Approved and proven procedures:** Procedures, including operational procedures and instructions as well as Flight Rules and Test and Operational Limits, should be reviewed and tested for completeness, correctness, and safety. Organizationally-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.

e. **Trained and qualified operators:** Servicer spacecraft operators are critical to flight safety and enabling mission success. Servicer and client spacecraft operators should detect anomalous navigation and control conditions, system health, and mission performance, as well as manually intervene, if necessary, to limit material safety risks and hazards. An operations team that is trained, experienced, disciplined and rehearsed is a substantial confidence builder for sustainable and repeatable servicing missions.

f. **External resources:** External resources are capabilities that are not provided by the servicer or client spacecraft but which provide independent and coordinated data and information to plan and inform RPO and OOS activities. These can include external space situational awareness and modeling or simulation capabilities.

II. **<u>Design satellites to facilitate safe and effective satellite servicing.</u>** Satellite servicer spacecraft should be designed in such a way as to facilitate the safety and effectiveness of commercial satellite servicing activities. Servicer spacecraft and future client spacecraft designs should include methods to improve interface compatibility and the trackability of the spacecraft, among other considerations.

III. **<u>Design servicing operations to minimize the risk and consequences of mishaps.</u>** In general, satellite servicing operations should strive to abide by the following practices:

a. Perform RPO and OOS operations for a contracted and cognizant client's space object. For cases where no owner can be identified, e.g., space debris objects, perform RPO and OOS operations in a safe and transparent manner. This may include providing adequate public notice and communication of intent to States that may have reasonably been the source of the object. If the source is identified during/following the service, notify the relevant States.

b. Practice sufficient communications discipline between the servicer and client to ensure positive control of both objects during the servicing operation.

c. Utilize "passively safe" trajectories and avoid close approaches with space objects other than the client space object.

d. Notify affected third parties in advance of any close approaches and exchange information to support safety of spaceflight (e.g. operator points-of-contact, ephemerides, ability to maneuver, and maneuver plans) while respecting owner/operator intellectual property and proprietary information.

e. Design servicing operations to minimize the likelihood of and adverse consequences from collisions and generating space debris.

   i. Ensure only space objects planned as a part of the operation are in the operating zone while RPO operations are underway.

   ii. Work with the proper State authorities to provide notifications of ongoing RPO operations.

f. Prepare and practice anomaly resolution protocols.

g. When possible, perform initial first-time in-orbit checkout procedures and demonstrations at altitudes that minimize the impact on internationally-recognized protected orbital zones.

   i. Checkout and demonstration in Low Earth Orbit (LEO) should occur at sufficiently low altitudes to comply with the 25-year rule while also being considerate of human spaceflight activities.

   ii. Checkout and demonstration in geosynchronous Earth orbit (GSO) should be adequately higher or lower than the geostationary altitude to minimize the consequences from possible debris generation.

IV. **<u>Avoid physical or electro-magnetic interference during all phases of operations.</u>** In addition to positive control of RPO and OOS activities with client space objects, servicers should also exercise all reasonable measures to avoid physical or electromagnetic interference with other sanctioned space activities during all operational phases. Servicers should take reasonable measures to ensure that other entities (ie. 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 will not assume responsibility for the collection and quality of SSA data used to perform RPO and OOS missions but CONFERS will advocate for its availability and continuous improvement as an important external resource in line with 1G above.

V. **<u>Share information on resolution of spacecraft anomalies/failures and related root cause analysis.</u>** Spacecraft anomaly/failure detection, resolution, recovery and attribution are critical to improving the safety, reliability, and transparency of satellite operations. Satellite servicers and servicing operations will benefit from clear anomaly attribution and can also potentially contribute to attribution assessments during their operations. Although competition is essential to a healthy satellite servicing sector, it is also in the best interest of the servicing community to abide by the following practices, all while respecting national export control laws and proprietary business confidential/intellectual property restrictions, to help prevent anomalies and failures that could undermine trust in the servicing community:

a. Develop and share best practices for the anomaly attribution processes within the servicing community.
b. Participate in the development of anomaly resolution standards and sharing frameworks.
c. To the extent it is practical, share information within the satellite servicing community on specific examples of anomaly resolution and attribution that could impact the community as a whole.

VI. **<u>Promote the long-term sustainability of space activities.</u>** Members of the Consortium 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:

a. Comply with relevant internationally-recognized guidelines and standards for the long-term sustainability of space activities, including those developed by the Inter-Agency Space Debris Coordination Committee (IADC), United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS), International Organization for Standardization (ISO), and the Consultative Committee for Space Data Systems (CCSDS).
b. 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.

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