

Standard

In-Space Storable Fluid Transfer for Prepared Spacecraft

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Standard

In-Space Storable Fluid Transfer for Prepared Spacecraft

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Abstract

This document defines best practices and requirements for the design, verification, and operation of prepared in-space storable fluid transfer systems and interfaces. The term “prepared” describes a spacecraft, spacecraft interfaces, and other accommodations intentionally designed to enable safe and efficient servicing. Modification of an existing spacecraft storable fluid transfer interface is outside the scope of this document. However, any spacecraft modified to meet the criteria stated herein may be considered “prepared.” The term “in-space” describes an environment outside a planetary atmosphere. This document includes requirements and recommendations for both servicer and client spacecraft. At present the recommendations’ scope is limited to storable (non-cryogenic) propellants and associated pressurants.

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Foreword

This AIAA S-157 standard was prepared by the On-Orbit Servicing and Assembly Committee on Standards. This standard is focused exclusively on In-Space Fluid Transfer.

At the time of approval, the members of the AIAA **On-Orbit Servicing and Assembly Committee on Standards** were:

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The above consensus body approved this document on 6 August 2024.

The AIAA Standards Steering Committee accepted the document for publication on 10 December 2024.

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Introduction

This document provides the current industry best practices for development of prepared interfaces for in-space fluid transfer (including but not necessarily limited to initial fueling, refueling, and refilling) of storable propellants and other storable fluid commodities. It is intended to provide guidance to developers and operators of both the servicer spacecraft and client spacecraft.

This document builds upon a foundation of on-orbit servicing consortium (www.satelliteconfers.org) documents including the [On-Orbit Guiding Principles](#), the [On-Orbit Recommended Design and Operational Practices](#), and [On-Orbit Servicing \(OOS\) Mission Phases](#) (Figure 1) which are the foundation of the international standard (ISO 24330 Space Systems — Rendezvous and Proximity Operations (RPO) and On-Orbit Servicing Programmatic Principles and Practices). The scope of AIAA S-157 is within the context of services for #9 in Figure 1. It is notable that the consortium allows for servicing of something that is not a spacecraft, and so defines a “client space object.” For this document the interaction is between two spacecraft, so the terms “servicer spacecraft” and “client spacecraft” are used.

[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. This standard and recommendations collected here are based on years of engineering development experience garnered through work with NASA and DARPA on in-space fluid transfer technology development programs augmented by relevant commercial industry experience.

There are no patent licensing issues associated with the content of these recommendations.

On Orbit Servicing (OOS) Mission Functional Diagram – ALL PHASES

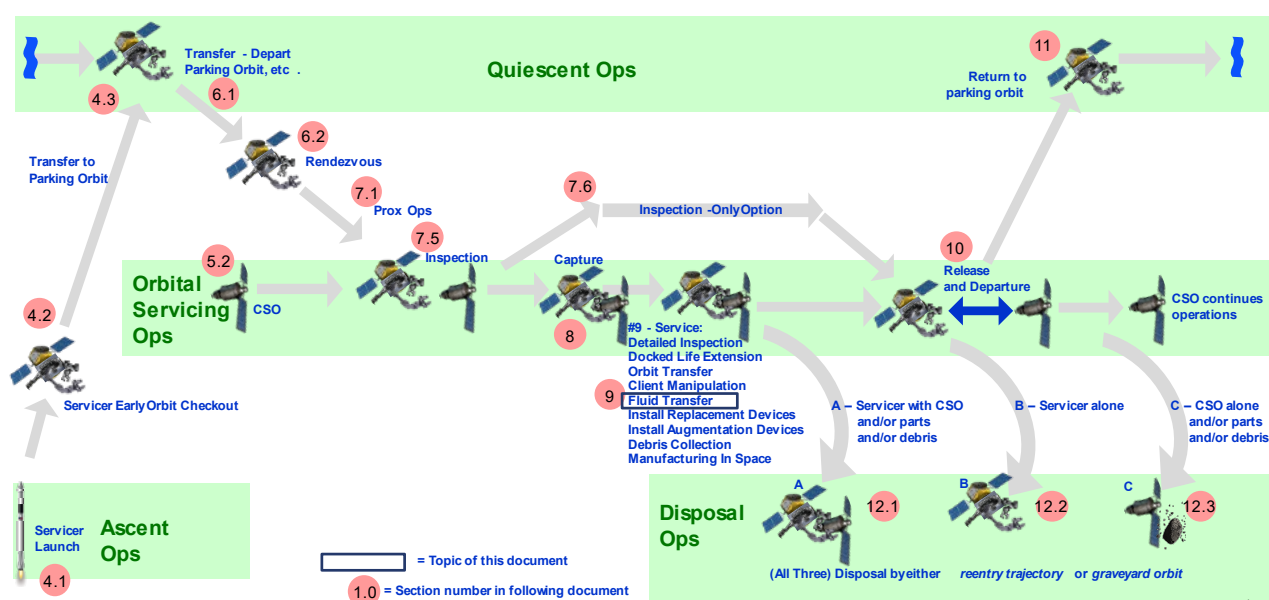


Figure 1: OOS Mission Functional Diagram (reference ISO 24330) showing scope of this document

In-Space Storable Fluid Transfer for Prepared Spacecraft

1 Scope

While ISO 24330 provides more general spacecraft design and operations requirements for RPO and OOS, this document defines best practices and requirements for the design, verification, and operation of prepared in-space storable fluid transfer systems and interfaces. The term “prepared” describes a spacecraft, spacecraft interfaces, and other accommodations intentionally designed to enable safe and efficient servicing. Modification of an existing spacecraft storable fluid transfer interface is outside the scope of this document. However, any spacecraft modified to meet the criteria stated herein may be considered “prepared.” The term “in-space” describes an environment outside a planetary atmosphere. This document includes requirements and recommendations for both servicer and client spacecraft. At present the recommendations’ scope is limited to storable (non-cryogenic) propellants and associated pressurants.

The recommendations in this document are a collection of best practices in the development of any prepared storable fluid transfer systems, interfaces, and operations, to include in-space, on-orbit fueling. Figure 2 illustrates the scope of this document. Elements within the dashed line are in scope. The scope includes general technical requirements and concept of operations (CONOPS) for prepared in-space storable fluid transfer operations with a refueling example. This document focuses on the design, verification, and operations of the fluid coupling interface and associated combined servicer and client considerations for a specific interface and does not address the servicer spacecraft to client space object capture. The scope of docking or berthing is outside the scope of this document; however, the docking/berthing system and the fluid transfer system need to be compatible, with the docking/berthing system providing sufficient stability and alignment, and/or the fluid transfer accommodating the stiffness and alignment provided by the docking/berthing system.

This document does not specify a particular form factor. The intent is to leverage existing standards to the maximum extent practical and promote progress, safety, capability, reliability, and capacity while not hindering innovation or specific mission requirements. Any successful storable fluid transfer interface hardware that:

- 1) completes qualification
 - 2) becomes widely adopted could form the basis of a future fluid coupling standard interface.
- Content of this document intends to inform an “interface standard,” whereas normative statements for form, fit, and function would be addressed in program/project interface specifications.

While the initial scope is limited to transfer of storable propellants and other fluids in-space, future versions may expand/tailor to include cryogenic fluid transfer and fluid transfer operations on planetary surfaces. It should also be made clear that this document focuses on the “in-space” fluid transfer. Although the same interface may be used for pre-launch ground fueling, requirements for such features/capabilities are not considered within the scope of this document. Specific requirements and guidelines applicable to use for ground (re)fueling are contained within SSCMAN91-710V3, Range Safety User Requirements Manual — Ground and Launch Personnel, Equipment, Systems, and Material Operations Safety Requirements or other Range documents.