ANSI/AIAA S-153-2021

Standard

Human Spaceflight: Spacecraft Architecture and Systems Engineering Ontology

Approved American National Standard

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Human Spaceflight: Spacecraft Architecture and Systems Engineering Ontology

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Abstract

This is the first level of a three-level standard defining a human spaceflight (HSF) spacecraft ontology from architectural and system engineering viewpoints. It provides guidance for systems and architecture design emphasizing human-system integration (HSI) requirements and constraints. While adopting a holistic approach, this complex domain is stratified using a three-dimensional roadmap (lifecycle, function, location) that guides the user to a high-level, fundamental, and context-specific design requirement based on the HSF program, mission and spacecraft goals.

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Foreword

This ANSI/AIAA S-153 standard was prepared by the Space Architecture Committee on Standards, the Systems Engineering Technical Committee, and the Space Architecture Technical Committee of the American Institute of Aeronautics and Astronautics. This standard is focused exclusively on Human Spaceflight (HSF) Spacecraft Ontology from Space Architecture and System Engineering perspectives.

At the time of approval, the members of the AIAA **SPACE ARCHITECTURE COMMITTEE on STANDARDS** were:

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The above consensus body approved this document in July 2020.

The AIAA Standards Steering Committee (Michelle Bailey, Chair) accepted the document for publication in April 2021.

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Introduction

This standard is proposed to define a currently nonexistent standard on ontology of HSF spacecraft and their architectures within the Commercial Space Transportation domain. This includes subsystems and human safety requirements. It organizes the complex interdisciplinary environment of the human space flight systems. This standard interconnects existing system engineering, system design, operation and process standards relevant to Human Spaceflight (HSF).

This standard will support execution of more cost-effective Human Spaceflight vehicle design and mission planning from the perspective of vehicle complexity, national and international scope and vehicle application. It does so by introducing a common language and navigation structure within the HSF standardization environment.

1 Scope

This is the first level standard of a three level standard set defining a human spaceflight (HSF) spacecraft ontology from architectural and system engineering viewpoints. It provides guidance for systems and architecture design emphasizing human-system integration (HSI) requirements and constraints. While adopting a holistic approach, this complex domain is stratified using a three-dimensional roadmap (Figure 5) that guides the user to a high-level, fundamental and context-specific design requirement based on the HSF program, mission and spacecraft goals.

Examples:

- The International Space Station is a spacecraft in Low Earth Orbit (LEO).

- NASA's Space Transportation System (STS) is an example of another HSF program yielding a specific type of reusable spacecraft, the Space Shuttle, enabling transport between the ground and LEO.

A human spaceflight mission involves a variety of activities from concept development to manufacturing and operations to full mission realization. The architecture of a mission consists of various elements such as the mission concept; ground segment; command, control and communications; orbit and trajectory design; launch system; payload; and spacecraft systems. While this standard is focused on the spacecraft element, other elements will need to be considered.

This first level standard describes a Human Spaceflight ontology that captures the spacecraft architecture via three high-level areas: development activities or processes related to the spacecraft lifecycle (e.g., concept and engineering design activities, simulations, testing, etc.), a specific application or function of the spacecraft (e.g., space transportation, tourism, exploration, resource mining, construction, etc.) and destination or operating environment of the spacecraft (e.g., suborbital, orbital, cis-lunar, lunar surface, etc.). It provides organizational guidance for effective spacecraft architecture development. The first and second levels focus on the more specific design requirements definition, while the third level identifies specific values for the engineering of subsystems and the HSI process.

The three levels composing this three level standard set are organized in the following manner:

1st level – Ontology of HSF spacecraft domain. This serves to structure the HSF domain by defining categories of spacecraft, fundamental environmental requirements within a specific phase of the spacecraft lifecycle, and their relationship, and provides a guide to a systematic design requirements definition (see Figure 6).

2nd level – Spacecraft types and their properties related to HSI. This includes human-imposed vehicle requirements, and environmental constraints of vehicles vis-à-vis mission and duration, e.g., suborbital point A to point A vehicle (returning to the departure spaceport), long duration habitat.

3rd level – Human requirements and subsystems properties related to HSI (e.g., atmosphere requirements, radiation shielding).

The 2nd level standard develops spacecraft types drawn from the 1st level document (S-153-2021). It describes the specific requirements for each category of spacecraft and its components related to the spacecraft operational environment in form of typical scenarios and typical requirements on the vehicle. The 2nd level standard also references existing standards by third parties. The scope of the 2nd level standard includes:

- Spacecraft function

- Duration of spaceflight

- Details of the operational environment, destination

- Spacecraft occupancy, etc.