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**Human Spaceflight: Spacecraft Architecture** **and Systems Engineering Ontology**

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Foreword

This AIAA nnn-n standard was prepared by Space Architecture Standards Committee, Systems Engineering Technical committee, and Space Architecture Technical committee of American Institute of Aeronautics and Astronautics.

0 Introduction

1st LEVEL STANDARD

This is the first level standard in a set of three-level standard documents for the architecture of crewed spacecraft and related ground system segments. It describes systems architecture, systems engineering and human-system integration requirements and constraints in a holistic manner, within the context of human presence in space. Programs, such as the International Space Station, are examples of human spaceflight programs. Its scope includes process categories or flight purpose categories for public, academic, research, industrial or government use. **This first level standard defines an HSF ontology of a spacecraft life time and relevant PROCESSES (design, simulations, testing etc.) within a specific APPLICATION (suborbital, orbital transportation, space tourism, cis-lunar missions etc.) category,** and provides organizational guidance for an effective spacecraft system architecture development.

Individual APPLICATION CATEGORIES are defined by NORMATIVE CONTEXT requirements in the 1st level and ENVIRONMENTAL CONTEXT requirements in the 2nd level standard that form a design constraints framework of the spacecraft application.

This standard, along with second and third level standards, form a complex three-level international standard entitled «**Human Spaceflight: Spacecraft Architecture and Systems Engineering**». The structure of this three-level spacecraft architecture is following:

1st level – **Ontology** of HSF architectural systems serving as organizational structure *(e.g., defining differences of spacecrafts and environmental requirements)*

2nd level – **Spacecraft** properties to HSI (human imposed vehicle requirements, environmental constraints imposed to vehicles relative to their mission and duration: *e.g., suborbital A-A vehicle, long duration habitat*)

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

The 2nd level standard develops individual categories drawn from the 1st level standard. It addresses specific requirements and constraints of spacecraft models (or CATEGORIES), and presents a quantitative and qualitative framework for practical human-system parts definition:

* Spaceflight function
* Spaceflight duration or destination
* Spacecraft occupancy
* Environmental context
* Etc.

The 3rd level standards are developing 2nd level standard PARTS in the 2nd level standard spacecraft defined CONTEXT and address specific activities, scenarios, task allocation in nominal and off-nominal and emergency scenarios for all occupants and artificial agents and all relevant context of the human spaceflight activity. This standards level defines all necessary subsystems for applications according to the 2nd level standard requirements by definition of the spacecraft subsystems based on human-system integration requirements of physical and cognitive ergonomics from perspective of human functional activity, social interaction and medical condition such as:

* Spacecraft autonomy
* Spacecraft automation
* Radiation protection
* Atmosphere
* Human body consumables and waste (ISO 16157)
* G-load (acceleration) dependent restraint principles and requirements
* Etc.

Level 1

Three major areas define the system of systems structure for HSF missions: Vessel Lifecycle, Application Function, Application Placement [ADD reference?][][][]. Each area is summarized in terms of a category (Type) and description with the tables below. All process categories address each application unless otherwise indicated.

A – Vessel Lifecycle Categories *(relate to existing standards)*

Thelifecyclefordesigning a vessel typically includes the following activities [ADD reference?]. A concept phase involves defining goals and requirements. An engineering and development phase involves defining (sub)systems, drawing on available standards. Virtual and physical simulations are conducted to better understand and design the spacecraft.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | Type | Description |  |  |
| 0 | Concept | Process of definition of primary and secondary goals of the vehicle. HSF systems and context design process (systems and context parts description e.g., ECLSS, PHM, spacesuit etc.) |  |  |
| 1 | Engineering, development and standardization | Process of definition of a space vessel from system to subsystem level to manufacturing phase utilizing relevant and available standards |  |  |
| 2 | Simulations | Processes of HSF virtual or physical simulations |  |  |
| 3 | Training | Processes of knowledge transfer for vessel operations or usage |  |  |
| 4 | Certification | Process of normative approval for operation |  |  |
| 5 | Operations | Relevant procedural guidelines |  |  |

B – Application Function Categories

Various HSF missions or applications are described below. They include transportation, exploration, tourism, governmental, in-situ resource utilization and construction, etc. Each has one or more specific functions to fulfill.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | Type | Description |  |  |
| 1 | Space transportation | Primary function of this system is to transport SFPs from point A to point B |  |  |
| 2 | Space exploration | Primary function of this system is discovery, simulation and research |  |  |
| 3 | Space tourism and commercialization | Primary function of this system is space sightseeing and spaceflight experience or commercial non-research purposes |  |  |
| 4 | Space resources mining, processing and utilization | Primary function of this vessel is to be a platform for search, collection, refining and application of space-based resources |  |  |
| 5 | Systems construction and deployment in space | Any system that serves construction, self-construction or assembly or deployment according the tier 3 classification: Prefabricated, Deployable, Utilizing ISRU |  |  |
| 6 | Medical | Systems for search, containment, stabilization, rescue and treatment of crew or SFPs |  |  |
| 7 | (U.S.) government applications | (U.S.) government applications.  <<Because this is a circular description, Insert example>> |  |  |
| 8 | International government applications | International government applications  <<Because this is a circular description, Insert example>> |  |  |

C - Application Placement Categories

The trajectory, orbit and overall operational environment of spacecraft for HSF missions are described below. This table presents a non-exhaustive list.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| # | Type | Description |  |  |
| 1 | **Suborbital** | **Vessels designed to carry humans to an altitude of suborbital trajectory from any planetary surface** | *TBD* |  |
| 1.1 | Suborbital Earthbound (INT) | Vessels designed to carry human to an altitude of suborbital trajectory from any planetary surface and may transit internationally | *TBD* |  |
| 2. | **Orbital** | **Vessels that reach orbital velocities** | *TBD* |  |
| 2.1 | Orbital Stationary | Vessels that reach and sustain a target orbital velocity | N/A |  |
| 2.2 | Orbital Stationary Earthbound (INT) | Vessels that reach and sustain a target orbital velocity and may de-orbit or are traceable from earth internationally | N/A |  |
| 2.3 | Orbital Earthbound (INT) | Vessels that reach orbital velocities and may transit internationally | N/A |  |
| 2.4 | Orbital Planetary | Vessels that reach and sustain orbit around a target planetary body |  |  |
| 3 | **Surface** | **Vessels that are operated on planetary surface** | N/A |  |
| 3.1 | Surface Mobile | Vessels that are operated on planetary surface and have an integrated transport capability | N/A |  |
| 3.2 | Surface Stationary | Vessels that are operated on planetary surface and have and do not have integrated transport capability | N/A |  |
| 3.3 | Surface Temporary | Vessels that are operated on a planetary surface which are temporary in use or function |  |  |
| 4 | Interplanetary/Interstellar | Vessels that are operated in transit trajectories between planetary bodies or stars |  |  |
|  |  |  |  |  |