AIAA 2019

Working Document Reference Number: **ANSI/AIAA S-153-20XX**

Date: 2019-04-22

Document Reference Number: **WD 19-03-A**

Committee identification: AIAA SACoS

Human Spaceflight: ~~– Space Vessel~~Spacecrafts~~s~~ Architecture and Systems Engineering Ontology

Warning

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Document type: **International Standard**
Document subtype: **1st level standard**
Document stage: (00) Preliminary Draft
Document Language: E

Comment [rr1]: Is it necessary to have 'Human Spaceflight' with ' : ' in the title? Does that suggest there will be another publication with a different phrase after the ':'?

Consider these titles:
a) Human Spaceflight Architecture Ontology
b) Guidance on Human Spaceflight Architecture Ontology Development
c) Preliminaries of Human Spaceflight Architecture Ontology
d) Ontology development for Human Spaceflight Architecture
e) The Human Spaceflight Architecture Ontology
(FYI: d is if the document will present an actual ontology file, rather than concepts for developing one)

Ultimately, the title should reflect whether this standard is putting forth (i) guidance or (ii) a specific ontology model for HSF. In other words, ideally the title will reflect the scope and domain of the ontology. *We should take care to not have too wide a scope*. But HSF Architecture is very wide in itself.

RECOMMENDATION: clearly establish the scope of the ontology. Currently the scope is not clear. The title can come later.

For example, will the scope (what the ontological model will represent) include…
a) Manned spacecraft architectures
   a. What does this mean exactly? – classifying types of manned spacecraft, and representing their physical structure, requirements for their use and mission-execution?
b) Space Systems Engineering
   a. COMMENT: this is
c)

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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 ~~regarding~~ for ~~an~~ the architecture of ~~both human spaceflight vessel~~ crewed spacecrafts ~~architecture for short or long duration human spaceflight~~ and related ground system~~s~~ segments. It describes systems architecture, systems engineering and human-system integration requirements and constraints in a holistic manner, ~~considering the complex~~within the context of human presence in space. ~~and latest experience on space p~~Programs, such as the International Space Station, are examples of human spaceflight programs ~~program~~. 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 ~~space vessel~~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 ~~vessel~~spacecraft system architecture development.

~~Following vessel~~spacecraft ~~lifetime (product lifecycle) PROCESS CATEGORIES are addressed:~~

~~I. DESIGN - HSF systems and context design process (systems and context parts description e.g., ECLSS, PHM, spacesuit etc.)~~

~~II. SIMULATIONS - HSF systems simulations~~

~~III. CERTIFICATION – HSF vessel crewed spacecrafts~~

~~IV. TRAINING - space systems training~~

~~V. OPERATIONS - space systems' operations~~

~~Following vessel~~spacecraft ~~APPLICATION CATEGORIES are addressed (VESSEL~~SPACECRAFT ~~PRIMARY FUNCTION):~~

~~A. Space transportation (unmanned and manned~~

~~B. Space exploration~~

~~C. Space tourism~~

~~D. Space resources mining, processing and utilization~~

~~E. Systems construction and deployment in space~~

~~F. Medical~~

~~G. (U.S.) government applications~~

Comment [rr2]: In all, it's difficult to follow and grasp because of the jargon and undefined terms.

Comment [rr3]: Regarding AN architecture (a particular architecture) or regarding architecture in general?

Comment [rr4]: Recommend rephrasing. It's unclear what is meant so I do not have specific editorial recommendations at this time.

Comment [rr5]: *Consideration for Rephrasing.*
It may be easier to understand by saying: for the architecture of human spaceflight (HSF).

And then proceed to define what HSF architecture or missions includes, e.g., crewed spacecraft, ground segments, etc.

Comment [rr6]: (Referencing #1 and #2 in my email to you and Hilary)

This sounds like the scope/domain-establishing part. But this is a too wide and general a scope.
It might be unwieldy.

Unclear. Does this means that the standard will present a holistic concept model of these generic systems areas? If so, then it should not be about spaceflight systems as that would be a sub-domain of it.

Comment [rr7]: 1) *Unclear*.
What's the difference between process and flight purpose categories?

Comment [rr8]: This acronym was not previously introduced.

Comment [rr9]: *Unclear. (*referencing #1 and #2 in my email)

What is meant by 'defines'?

Comment [rr10]: *Unclear/Ambiguous.*
'design' like 'simulations' and 'testing' can mean…
A design.
A design process

Comment [rr11]: There is room for clarification among these examples. For example….

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

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

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

2nd level – **~~Vessel~~Spacecraft~~s~~** 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~~s~~ ~~are~~ develop~~sing~~ individual categories ~~of~~ drawn from the 1st level standard, ~~and~~ It address~~es~~ specific requirements and constraints of ~~space vessel~~spacecraft models (or CATEGORIES), and present~~s~~ a quantitative and qualitative framework for practical human-system parts definition:

- Spaceflight function
- Spaceflight duration or destination
- ~~Vessel~~Spacecraft occupancy
- Environmental context
- Etc.

The 3rd level standards are developing 2nd level standard PARTS in the 2nd level standard ~~vessel~~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 ~~space vessel~~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:

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

Comment [rr12]: What is HIS? Human-systems integration?
Recommend spelling-out the first instance of the word, followed by acronym in parentheses.

Comment [rr13]: Isn't there more to Spacecraft arch?
What about a 4th level for ground segment components?
And other aspects?

Comment [rr14]: Does this mean there will be three separate documents? If so, then state it.

For example,
Part 1 document = a conceptual big-picture overview of the HSF domain (the intended scope and domain). The *ontology of* (= the philosophical explication of) the target HSF domain.

Then subsequent parts can delineate parts of HSF and describe them in detail, presenting essential concepts. E.g.,

Part 2 doc = Spacecraft constrains and requirements, perhaps spacecraft components, functions; types of spacecraft ...

Comment [rr15]: This sounds like what I was suggesting... ...

Comment [rr16]: It addresses?
Or it describes?

Comment [rr17]: *Unclear.*
A model is not a category. ...

Comment [rr18]: *Unclear.*
What is a human-system? What is meant by its part?

Comment [rr19]: *Recommend rephrase.*
What does this mean?
(Not easy to understand.)

Comment [rr20]: *Unclear.* ...

Comment [rr21]: *Recommend rephrase.*
Too long. Difficult to understand. ...

Comment [rr22]: *Recommend rephrase.* See previous comment.

Comment [rr23]: How are these different?

Comment [rr24]: Clarify.
Internal/cabin atmosphere, the atmospheres the craft is designed to operate in, etc.

Level 1

Three major areas ~~are~~ define~~ing~~ 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 ~~are~~ address~~ing~~ each application ~~category~~ unless ~~determined and justified~~ otherwise indicated.

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

The lifecycle for designing 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		

Comment [rr25]: Unclear. What does 'addressing' mean?

Comment [rr26]: Rephrase. Unclear.

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Comment [rr27]: What is the reference source for these 3 areas?
Are they established areas in the HSF sector?
Is there a textbook that describes these?
Are they in the Spacecraft Mission Design book?

If the goal is to describe HSF architecture at a high-level then we need to make sure we are representative and accurate of the HSF sector.

Comment [rr28]: *Recommend* adding a description of Vessel Lifecycle (and Application Function/Process) after the section title…

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Comment [rr29]: What is the difference between Type and Category?

Comment [rr30]: What goes in this column header?

Comment [rr31]: What is a context design process?
Is this an established phrase in the community?

Comment [rr32]: Are you saying that a concept is a process of definition?

If so, then ontologyicall/philosophically this is not correct. A concept is akin to an idea, or …

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Comment [rr33]: If the goal is to define …

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Comment [rr34]: 'operations' can mean t…

Comment [rr35]: This seems to be about …

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Comment [rr36]: Unclear. Too many …

2	Space exploration	Primary function of this system is discovery, simulation and research		
3	Space tourism and commercialization	~~S~~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 ~~that have capability~~designed to carry humans, to an altitude of suborbital trajectory from any planetary surface**	*TBD*	
1.1	Suborbital Earthbound (INT)	Vessels ~~that have capability~~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*	

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Comment [rr37]: If the standard being developed can be applied to any HSF program across the globe, then it should not have labels that single out the US.

However, if the standard is focusing only on US concepts for HSF design, then ok.

Comment [rr38]: This seems to be about the intended operating environment and

Comment [rr39]: *Unclear.*
The title—Application Placement—suggests a positional aspect.
But the description of each category/type is of a vessel, not a position, altitude, or orbital regime.

Is this a category list for types of vessel, or mission type, or …?

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Comment [rr40]: *Recommend* researching definitions of 'Suborbital flight' and 'suborbital mission' to identify altitudes, etc.

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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		

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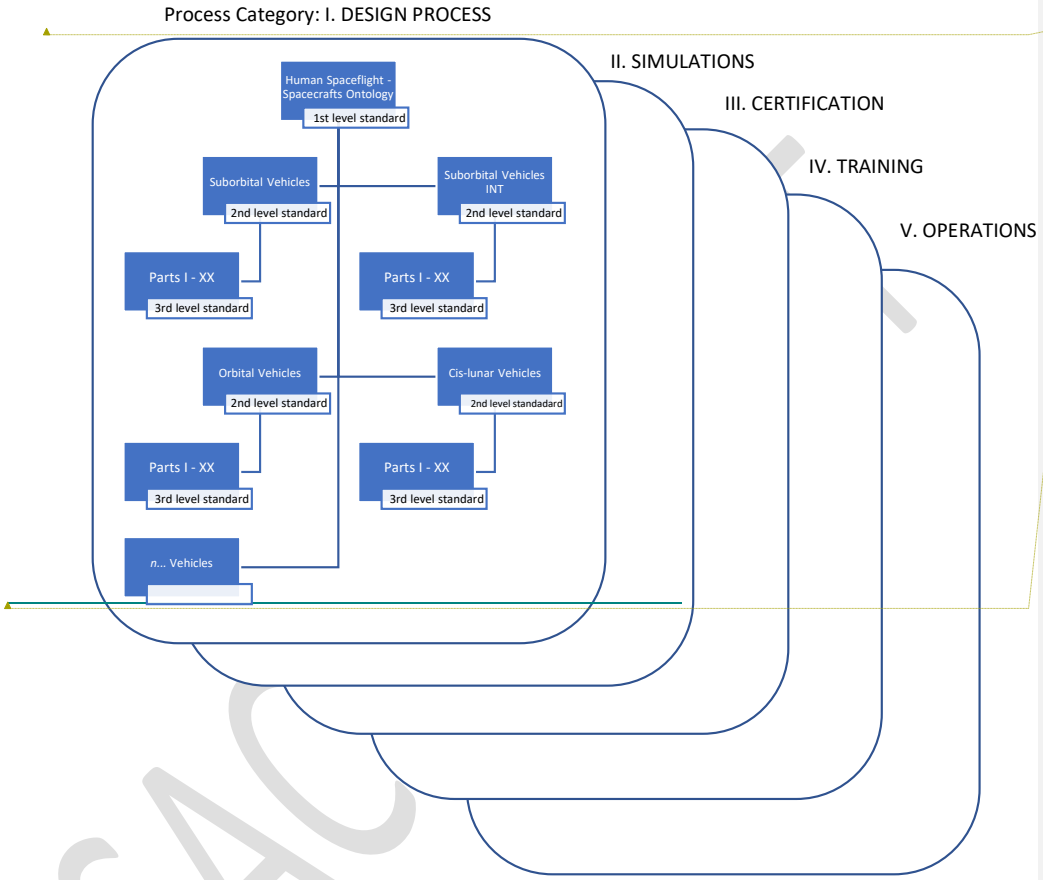
~~Figure below indicates possible structure of different categories and functions and possible multidimensional character of the ontology.~~



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