

**Acronyms:**

AIAA: American Institute of Aeronautics and Astronautics

CoS: Committee on Standards

DISA JTA: Defense Information Systems Agency Joint Technical Architecture

EIA: Electronics Industries Alliance

HSF: Human Spaceflight

IEC: International Electrotechnical Commission

IEEE: Institute of Electrical and Electronics Engineers

ISO: International Standardization Organization

PHM: Prognostics and Health Management

SACoS: Space Architecture Committee on Standards

SDO: Standard Development Organizations

SATC: Space Architecture Technical Committee

SETC: Systems Engineering Technical Committee**Definitions:****ARCHITECTURE (identical with SYSTEM ARCHITECTURE) – ANSI/IEEE 1471-2000, ISO/IEC/IEEE 42010 (E)**

(Architecture of systems of artificial or natural nature) - Architecture is an abstract consisting of fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution.

It can be described as: An architecture describes, at an abstract level, the following:

- |   |   |  |
|---|---|--|
| <ol style="list-style-type: none"> <li>1. System</li> <li>2. Fundamental concepts</li> <li>3. Properties of system</li> </ol> | } | in its environment, embodied in its elements, relationships, and in the principles of its design and evolution [ISO/IEC/IEEE 42010:2011 (E)] |
|---|---|--|

The architecture of a system constitutes what is essential about the system considered in relation to its environment. There's no single characterization of what is essential or fundamental to a system and can include:

- System elements
- ~~Elements arrangement~~ Arrangement of the elements, and the –or– relations between the elements
- Principles of the system's organization or design
- Principles governing the evolution of the system over its life cycle
- Etc.

**Rationale:**

The Architecture architecture rationale records-is an explanation, justification or reasoning about architecture decisions that have been made.

**Interpretation:**

In summary, and using a metaphor, ARCHITECTURE can be seen as involving the following:

- Blueprints
- Literature
- Language

**Comment [rr1]:** Recommend eventually numbering or formatting the file so that each term is more easily identified, e.g., bullet-pointed, numbered, etc.

**Comment [rr2]:** Inaccurate by some recommended practices in terminology, taxonomy and ontology development, as well as by conceptual, linguistic, and philosophical (ontological) perspectives... A System Architecture is a type of Architecture. 'System' qualifies 'Architecture'. If there can be other kinds of architecture besides that of systems, then 'Architecture' cannot be synonymous with 'System Architecture'.

This is an opportunity to improve such inaccuracies in terminology use. I realize that using a term from another standard doc., might be desirable to some, but if it is inaccurate it would only perpetuate that and encourage inaccurate or misinformed practices.

**Comment [rr3]:** For comparison, consider this nice definition from Wikipedia:

"A **system architecture** or **systems architecture** is the conceptual model that defines the structure, behavior, and more views of a **system**. An **architecture** description is a formal description and representation of a **system**, organized in a way that supports reasoning about the structures and behaviors of the **system**."

**Comment [rr4]:** Unclear.

Does this mean 'abstract' in the sense of a short written description or summary?

If not, then rephrase. But if this is verbatim from the referenced standard, then I recommend asserting a new definition that is more accurate.

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**Comment [rr5]:** Define. What is a system element? E.g., Only the physical parts of a system?

**Comment [rr6]:** Define. What is meant by principles of org and design? E.g., rules by which a system is designed and organized?

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## - Decision

Architecture is an abstract that is shared with the stakeholders through an **Architecture Description**, which is created by **Architecting** using **Architecting Methods** and is developed for the architected system for the entire life cycle. Architecture and Architecture Description can be used interchangeably due to domain different definitions. See ARCHITECTURE DESCRIPTION

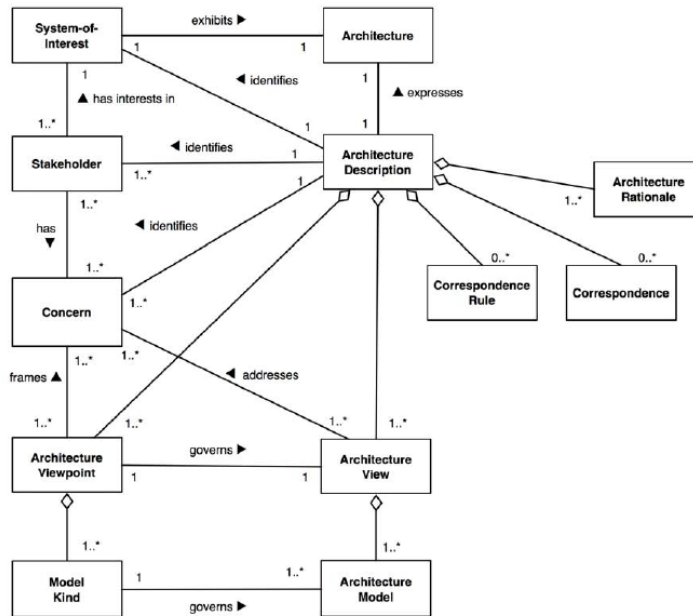


Figure 1: Architecture description [ISO-IEC-42010-2011]

**Comment [rr7]:** Unclear how an architecture can be seen as any of these in isolation.

I am not versed in systems architecture, or architecture in general, but here's my two cents from an ontology and philosophical perspective...

The architecture of a physical system like a spacecraft appears to be either (a) an abstraction or conceptual representation of the structure and interrelational arrangement of the system and its parts; or (b) the actual physical structure, parts and their arrangement.

An architecture may be described as an abstract description of the arrangement and interrelationships of the components of the systems.

An architecture seems to be similar to a blueprint.  
(both seem to be high-level abstractions or conceptualizations of something (e.g., a system) that has been made or will be made)

An architecture—as a manmade construct—involves decisions, but it is not the same as a decision.

An architecture involves and requires a language to be express, whether visually or verbally.

**Comment [rr8]:** Unclear. Same concern as above.

**Comment [rr9]:** Unclear. Same concern as above.

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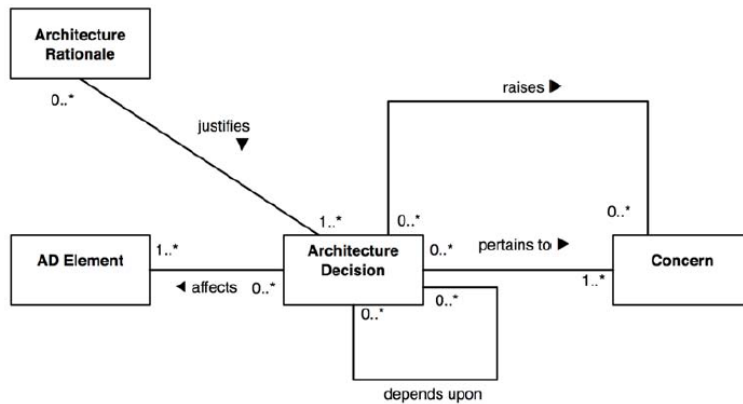


Figure 2: Architecture rationalization [ISO-IEC42010-2011]

**ARCHITECTURE CLASSIFICATION – IEEE 610.12, DISA JTA<sup>1</sup>** – Architecture as a structure of components, their relationships, and the principles and guidelines their design and evolution over time can be defined on various extensional levels. There are three types of architectures by DISA (3-5) and two defined by SACoS (1-2) to encompass all possible phenomena and entities:

- **Fundamental Architecture** – A description of the natural or artificial system purpose and relationships including ideological values regarding its environments (natural, artificial, physical, mental, social) to enable formation of the Enterprise Architecture
  - o Example:
    - Societal rules and cultures
    - State, federal frameworks
    - (Co)existential motivations
- **Enterprise Architecture** – A description of all components of an economically productive human-organizational environment designated to definition of goals, strategy, products, services and required infrastructure in current and future states based on the input from the Fundamental Architectures to enable Operational, System and Technical Architectures.
  - o Example:
    - Corporations
    - Governmental entities
    - International organizations
- **Operational Architecture** – Description of the operational elements, assigned tasks, and information flows required to accomplish or support the **warfighting Enterprise** function. It defines the type of information, the frequency of exchange, and what tasks are supported by these information exchanges
  - o Example:

**Comment [rr10]:** Unclear. To what does 'their' refer to?  
Does it mean the relationships *between* components?  
Does it mean the relationships of an architecture to other things?  
Etc.

*Recommend* rephrasing to either 'their interrelationships' or 'the relationships between components'

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<sup>1</sup> DISA JTA ([HTTP://www-jta.itsa.disa.mil/jta/sect1.html#S1\\_1\\_3](http://www-jta.itsa.disa.mil/jta/sect1.html#S1_1_3))

- Space Mission Architecture (describing specific functions of the mission as a line of business or a vertical silo of an Enterprise Architecture)
- Group of activities or a program
- **System Architecture** – A description of the system and interconnections providing for or supporting functions. This architecture defines the physical connection, location and identification of the key nodes, circuits, siteworks, platforms and specifies its performance parameters. It is constructed to satisfy the operational architecture requirements per standards defined in the technical architecture. It shows how multiple systems within a subject are linked and interoperate.
  - Example:
    - Vehicle
    - Building
    - Product
- **Technical Architecture** – set of rules governing the arrangement, interaction, and interdependence of the parts or elements whose purpose is to ensure that a conformant system satisfies and specified set of requirements. The technical architecture identifies the services, interfaces, standards, and their relationships.”
  - Example:
    - Vehicle, building or products types specified by the configuration and types of their subsystems

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**ARCHITECTING – ISO/IEC 12207, ISO/IEC 15288** – Is a process of an architecture creation. “Architecting takes place in the context of:

1. An organization:
  - person or a group of people and facilities with and arrangement of responsibilities, authorities and relationships
2. A project:
  - Endeavor with defined start and finish criteria undertaken to create a product or service in accordance with specified resources and requirements”

**ARCHITECTURE DESCRIPTION - ISO/IEC/IEEE 42010 (E)** – A work product to be usable for architecting. Description methods are document-centric, model-based, and repository based. Description includes one or more architecture views. They are used for documenting essential aspects of the system and their rationalization. They are used for communicating amongst stakeholders for development, production, deployment, operation, maintenance etc. Description includes rational for each architecture viewpoint and address stakeholders, concerns providing evidence of the consideration of alternatives and the rational for the choices made.

“Architecture” (by TOGAF<sup>2</sup>) may be used as a synonym of “architecture / system description.” “Architecture” designates the structure and principles of the system, independent of its description. Architecture is communicated as a formal **description of a system** (ARCHITECTURE DESCRIPTION), i.e., detailed plan of the system at component level, to guide its implementation. Realized architecture exists without its description.

<sup>2</sup> Desfray, Philippe. Modeling Enterprise Architecture with TOGAF: A Practical Guide Using UML and BPMN (The MK/OMG Press) (Locations 563-568). Elsevier Science.

**Comment [rr11]:** Ambiguous phrasing.

Can be interpreted as...

- a) The process of creating an architecture, i.e., the architecture creation process
- b) A process that a creation (presumably a physical system) engages in
- c) a creation made by an architecture.

Intuitively ‘architecting’ sounds like (a).

Recommend rephrasing to ‘is a process of creating an architecture’ or something similar.

**Comment [rr12]:** Unclear.How is this different from the above? The above types of architecture are mostly defined as *descriptions*. So what’s the difference?

**ARCHITECTURE DESCRIPTION ELEMENT = AD ELEMENT = ARTIFACT** – is any construct in an architecture description.

**ARCHITECTURE FRAMEWORK - ISO/IEC/IEEE 42010 (E)** – Established structure (abstract), principles and practices for the description of architectures within a specific domain of application and/or community of stakeholders:

Examples:

- Enterprise Reference Architecture and Methodologies GERAM [ISO 15704]
- Reference Model of Open Distributed Processing [ISO/IEC 10746]

Architecture framework facilitates communication and interoperation amongst stakeholders and projects and it includes:

- Information defining the framework
- Relationship of concerns and stakeholders to the framework

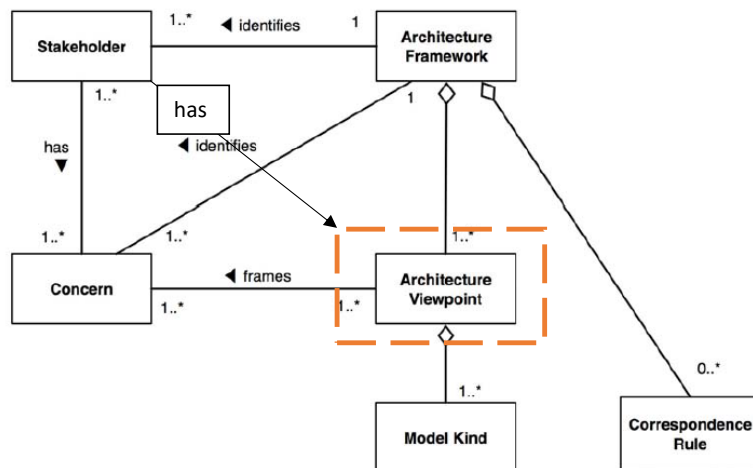


Figure 3: Architecture Framework

**ARCHITECTING METHOD** – A systematic approach to create creation of an architecture description e.g., existing architecture models, via evolution of the models, via sketching, digital or physical modeling process flow modeling, 3D, 2D digital or physical modeling or animating etc.

**ARCHITECTURE VIEW / VIEWPOINT – ISO/IEC/IEEE 42010 (E)** “Architecture description (Work product) expressing the architecture of a system for the perspective of specific system”. An architecture viewpoint frames one or more concerns of the stakeholders. Examples:

- Technical view of an Architecture
- Plumbing view of an Architecture
- Business view of an Architecture

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View types<sup>3</sup>:

- Logical Architecture /Operational Architecture – Implementation-independent design
- Physical Architecture – Mapping logical onto physical components
- Conceptual / Technical Architecture – Standards, principles, rules and rationale

**DOMAIN SPECIFIC SYSTEM ARCHITECTURE [DSSA] – Structure, processes, infrastructure, concept or set of concepts that support the development of:**

- Domain model
- Reference Requirements
- Reference Architecture
- Architecture
- Architecture component
- Support of application within specific domain such as e.g., Product Lines:
  - o [Http://htc.honeywell.com/projects/dssa](http://htc.honeywell.com/projects/dssa)
  - o <http://wiley.com/compbooks/catalog/33280-1.htm>

**ENVIRONMENT – ISO/IEC/IEEE 42010 (E)** “Context determining the setting and circumstance of all influences upon a system (physical, or mental: natural, technological, engineering, operational, organizational, business, economic, legal, political, social)”

**LIFECYCLE – ISO/IEC 15288:2015, ISO/IEC12207** – Lifecycle of man-made products that “concern hardware, software, data, humans, processes (e.g., processes for providing service to users), procedures (e.g., operator instructions), facilities, materials and naturally occurring entities.”

**SPACE ARCHITECTURE** - The theory and practice of designing and building inhabited environments in outer space, responding to the deep human drive to explore and occupy new places.

Architecture organizes and integrates the creation and enrichment of the built environment. Designing for space requires specialized knowledge of orbital mechanics, propulsion, weightlessness, hard vacuum, psychology of hermetic environments, and other topics. Space Architecture has complementary relationships with diverse fields such as aerospace engineering, terrestrial architecture, transportation design, medicine, human factors, space science, law, and art...<sup>4</sup>

Following terms are suggested as new definitions due to the large architectural scope of this standard that includes surface vehicles as well as orbital, and transcends government and industry use. Terminology in industry is ununified / chaotic

**SPACECRAFT**

**Definition:** ~~unmanned/uncrewed/unoccupied~~ or ~~manned/crewed/occupied~~ orbital or planetary surface vessel or system. **Clarification:** A high level term describing an artificial object created by human and designated designed to operate in the outer space operations environment.

**Comment [rr13]: Concern.**

What is context?

‘Context’ should be defined or otherwise stated to be a primitive.

The concept of context is an ambiguous and complicated one. It is, arguably, more complex than that of environment. According to some definition principles, it should therefore not be included in the definition.

A simple edit to this definition may make it clearer...

“The physical, social and non-physical setting and circumstances[.]”

**Comment [rr14]: Unclear. Inaccurate. Possible confounding of distinctions.**

If ARCHITECTURE is a description, then so is SPACE ARCHITECTURE. How can it be a practice (activity) as well? The activity is the architecting, or the design process, not the architecture or the design itself.

**Comment [rr15]:** This sounds like a comment, not part of a definition.

It sounds like content that supplements the definition, such as clarifying or elucidating information.

Recommend separating it into a new paragraph, perhaps with a heading of ‘comment’ or ‘supplemental information’

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**Comment [rr16]:** In my ontologies I’ve defined ‘spacecraft’ as a craft designed to operate in the outer space environment, ...

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**Comment [rr17]:** ‘(un)occupied’ is not synonymous with ‘(un)manned’ or ‘(un)crewed’. ...

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**Comment [rr18]:** No need to indicate orbital

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**Comment [rr19]:** Unnecessary to say ‘created by human’ because it is in the ...

<sup>3</sup> DISA JTA ([HTTP://www-jta.itsa.disa.mil/jta/sect1.html#S1\\_1\\_3](http://www-jta.itsa.disa.mil/jta/sect1.html#S1_1_3))

<sup>4</sup> Osburg, J., Adams, C., Sherwood, B., “A Mission Statement for Space Architecture”, SAE 2003-01-2431, 2003

Examples: e.g., telecommunication satellites, remote sensing satellites, space probes, space stations, planetary rovers.

Alternative Terms: <<insert if any>>

**SPACESHIP** – manned/crewed/occupied orbital or planetary surface space vessel/vehicle  
e.g., Spaceship 2, New Shepard, Dragon, Orion = A transport system for crew

**SPACE STATION** – manned/crewed/occupied orbital or surface space vessel in a stationary position (orbital or surface)  
e.g., ISS

- SPACE BASE...
- SPACE OUTPOST...

**SPACE INFRASTRUCTURE** – A crewed/manned/occupied or uncrewed/unmanned/unoccupied physical space system, architecture or a normative element and process supporting one or more space operation, space mission and space mission type.

- DEEP SPACE NETWORK
- LAUNCHPAD
- SURFACE POWER STATION
- KNOWLEDGE BASES
- Etc.

**SPACE VESSEL** – A crewed/occupied space system  
e.g., Spaceship, Space Station, Rover (pressurized/unpressurized)  
A spacecraft that has a human habitat as a component part.

**SPACE SETTLEMENT** – A coordinated set of space station and space infrastructure components that can accommodate operations of Space Vessels

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Comment [rr20]: Recommend establishing a standard format for presenting term definitions.

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Comment [rr21]: Inaccurate.

A spaceship is not a surface vessel/vehicle.

Comment [rr22]: DISCUSSION REQUIRED.

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Comment [rr23]: NOTE: these are instances

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Comment [rr28]: If using 'space system' if

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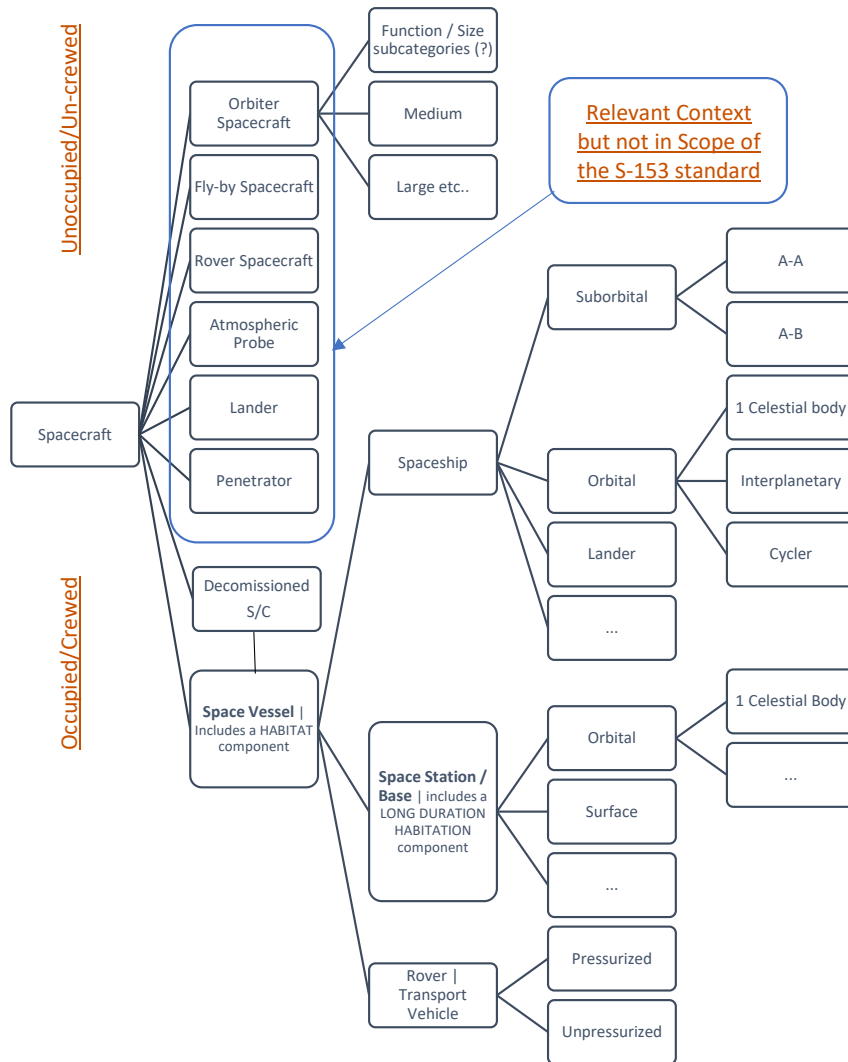
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Comment [rr30]: DIAGRAM COMMENT.

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**STAKEHOLDER** – Individual, team, organization, ~~or classes thereof~~, having an interest in a subject of a architecture (system) that are or will be affected, influenced or regarded by it. Architecture description identifies all architecture stakeholders ~~such as~~:

- Users
- Operators
- Occupants
- Crew
- Acquirers
- Owners
- Suppliers

Comment [rr31]: Unclear. Rephrase.



- Developers
- Engineers
- Scientists
- Architects
- Builders
- Maintainers

**SYSTEM – [ISO/IEC 15288]:** is a “man-made” or natural combination of elements that are physical and/or abstract and are functioning in harmony. “It may be configured with one or more of the following: hardware, software, data, humans, processes, procedures, facilities, materials and naturally occurring entities”. Systems are classified according to their scope and nature as:

**Natural System** – “elements, objects or concepts which exist outside of any practical human control. Examples: the real number system, the solar system, planetary atmosphere circulation systems.”<sup>5</sup>

**Social System** – “elements, either abstract human types or social constructs, or concrete individuals or social groups”.<sup>6</sup>

**Technological System** – “elements, man-made artifacts or constructs; including physical hardware, software and information”.<sup>7</sup>

**SYSTEMS ENGINEERING:** Systems engineering is the practice of engineering from the systems viewpoint.<sup>8</sup>

An interdisciplinary collaborative approach to derive, evolve, and verify a life-cycle-balanced system solution that satisfies stakeholders’ expectations and meets public acceptability.<sup>9</sup> It is a methodical, multi-disciplinary approach for the design, realization, technical management, operations, and retirement of a system.<sup>10,11</sup>

**Comment [rr32]:** Incorrect. There are many natural systems humans can manipulate. A better definition is a system that was not created by human beings.

FYI: the definition of natural-artificial is common one in philosophy, and has some associated challenges and questions with it.

## § 1 - What is the SACoS?

The SACoS is established to write standard type documents (Standards, Guidebooks, etc.) in the AIAA (a recognized SDO). The SACoS subject matter has historically originated in discussions within the SATC. The SACoS and the SATC are peer-level organizations with similar but independent purposes and products.

## § 2 – SACoS Goals & Purpose

<sup>5</sup> SEBOK, INCOSE

<sup>6</sup> SEBOK, INCOSE

<sup>7</sup> SEBOK, INCOSE

<sup>8</sup> Dickerson, Charles; Mavris, Dimitri N.. Architecture and Principles of Systems Engineering (Complex and Enterprise Systems Engineering) (Page 24). CRC Press.

<sup>9</sup> Dickerson, Charles; Mavris, Dimitri N.. Architecture and Principles of Systems Engineering (Complex and Enterprise Systems Engineering) (Page 29). CRC Press.

<sup>10</sup> National Aeronautics; Space Administration. NASA Systems Engineering Handbook (Location 483). National Aeronautics and Space Administration.

<sup>11</sup> SEBOK, INCOSE

### § 2.1 Goals

Identification of a set of top-level guidelines, standards and references governing the design, development, fabrication, testing, deployment and operation of pressurized habitable ~~vessels~~spacecraft of all kinds that support, sustain and protect human life beyond Earth.

While Human Spaceflight (HSF) sub-systems and engineering are being addressed in other SDOs or CoSs, this CoS is focused on the systems and mission's architecture of ~~human-spaceflight-vessels~~ crewed spacecraft. Which essentially are artificial environments supporting human activity. Not constrained to government or commercial worker, the SACoS addresses living spaces for all people, in the timeline of 2020-2025. Future work will expand on this initial work. SACoS addresses any self-contained ~~vessels~~spacecraft and component of human spaceflight of any duration.

The SACoS was formed to establish the first organizational systems architecture ontology and other guiding or standard type documents, to provide a structured approach to ~~Human-Spaceflight (HSF)~~ vessel-crewed spacecraft design and development.

The SACoS undertakes a collaborative effort to define a three-level standard to structure and organize the complex international environment of human spaceflight, from the perspectives of human spaceflight systems design, development, simulations, training and operations.

### § 3 – SACoS Coordination with other CoS

It is the intent of this CoS that, after publication, these products be consistent with Systems Architecture, Systems Engineering, Space Architecture and Human Spaceflight standards in the global space industry. AIAA standards are not enforceable except as cited in contracts, while other standards products, from other SDOs, may be legally enforceable in some countries. It is the desire, not a requirement, of the SACoS to work in liaison with these other SDOs for mutual benefit.

### § 4 – SACoS Communication and standard development process

Meetings are held by telecon or conferences where physical and teleconference meetings are possible. All products and draft products are shared electronically. SACoS standard development activity is based on voluntary contributions of its members. CoS members are expected to communicate (that is, attend), according to their availability, and to vote or update / contribute to development of SACoS work items according to the development plan provided by the SACoS chair. SACoS chair will solicit feedback and contributions either via telecons, emails or personal ad-hoc communication in agile manner.

### § 5 – SACoS Standard development process

Standard or guide development is documented by individual text documents with reference numbers. The development is structured in phases. Each phase prior its completion or freezing is required to be supported by a quorum of 60%. The consensus is solicited by the committee chair. Every guide or standard must be reviewed every 5 years according to AIAA requirements. SATC members can review the frozen/ completed documents of SACoS with higher priority to public reviews. SATC members do not have vote unless they are members of SACoS.

### § 6 – SACoS Membership

Per AIAA rules, membership should only include those who will be directly and materially impacted by the work program. Additionally, membership should be balanced across the various types of stakeholders (product users, developers, etc.).

The primary activity of a SACoS member is to review, comment and constructively critique the team effort to develop the standard. SACoS members respond in a timely manner, referencing their inputs using either professional standards, experience, industrial requirements or government documents to support the definition of the standard components.

There are two types of membership available based on the stakeholder interests:

**A: Committee member** – Full involvement in the development of technical documents and all communications

**B: Committee Technical monitor** – Feedback-type involvement based on regularly shared documents under development provided by committee chair