

# A Mission Statement for Space Architecture

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## ABSTRACT

In an effort to define and advance the new discipline of Space Architecture, the AIAA technical subcommittee on Aerospace Architecture organized a Space Architecture Workshop that took place during the World Space Congress 2002 in Houston, Texas. One of the results of this workshop is a "Mission Statement for Space Architecture" that addresses the following core issues in a concise manner: definition, motivation, utility, required knowledge, and related disciplines. The workshop also addressed the typology and principles of space architecture, as well as basic philosophical guidelines for practitioners of this discipline. The mission statement, which was unanimously adopted by the workshop participants, reads as follows ([1], [2], [3]): *"Space Architecture is 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 built environments. 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."* This paper will document the genesis of this mission statement, expand on its key statements, and give an overview of the typology, the principles and the philosophical guidelines of space architecture.

## INTRODUCTION

For centuries, if not millennia, designing structures for humans to live and work in has been the challenge of the architect or master-builder. Now, with humanity

leaving the boundaries of our home planet and establishing the first permanent outposts on the frontier of outer space [4], the knowledge and experience accumulated during that long history can benefit the design of inhabited off-Earth structures, such as space stations, planetary bases and interplanetary transfer vehicles. However, designing for space traditionally has been the task of the engineer or "rocket scientist".

Recognizing the advantages of integrating space engineering and architecture, but realizing the many difficulties facing those who want to integrate these two domains, several professionals have been active during recent years in developing the field of Space Architecture. They include members of the Aerospace Architecture subcommittee of the AIAA Design Engineering Technical Committee [1], as well as many contributors to the Aerospace Architecture sessions at the International Conference on Environmental Systems and similar events.

First tangible examples of applied space architecture exist as well, such as the ISS modular rack system, the Temporary Early Sleep Station (TESS), and the architecture of the TransHab inflatable module developed for potential use on the International Space Station [5].

The decadal World Space Congress, in Houston, Texas, in October 2002, offered an opportunity for practitioners of both space architecture and space engineering to exchange ideas and coordinate future efforts. For this purpose, the AIAA aerospace architecture subcommittee organized a Space Architecture symposium, one of whose major objectives was to enable future discourse by generating a definitive, common mission statement for this new field. Toward this end, one of the active current practitioners (Adams) organized and led a workshop for symposium participants.

Conceived over a year earlier, this Workshop's coordination began in earnest in the early spring of 2002 when the organizers broadcast to all known active Space Architects a call for responses to the question, "What is Space Architecture?" Although it took some time to elicit a significant body of responses, by late summer the organizers had some two dozen offerings with which to work. These responses were particularly valuable in that they represented the considered reflections of the profession's most active theoreticians and practitioners, on what constituted the fundamental principles of their work. Prior to the Workshop, these answers were reviewed and each individual idea was culled and pasted onto its own sheet of paper. Thus, as the Workshop opened, the 50-odd attendees had over 100 concepts of fundamental principles defining or related to the field to review; these principles both stimulated a very high level of discourse and served as the outline and major talking-points for most of the document which was to emerge at the end of the day.

In conceiving and planning this summit meeting, the organizers looked for examples of prior gatherings of this kind; for this, they found a perfect paradigm very much in keeping with architectural tradition: the "Congrès Internationaux d'Architecture Moderne" or CIAM, which gathered together the architects of the early Modern movement between 1928 and 1959 [6]. The CIAM was created in response to a shared feeling on the part of Architects the world over that new building technologies combined with new political, social and economic requirements constituted a radical change in the profession of Architecture and its goals, methods, and significance [7]. Although disrupted for a decade around the Second World War, the CIAM delegates convened a total of ten times, and the deliberations and manifestoes generated by each of these Congresses were published. The planners for the tenth Congress, known as "Team X", represented such an important meeting of minds that their deliberations between 1954 and the 1956 CIAM X meeting would ultimately challenge the dynamic which had driven the "old guard" CIAM [8].

Arguably, the challenges of designing accommodations for humans in outer space—and the changes in approach to technical, economic, and social issues which this profession requires—places Space Architecture in a similar position to that in which the Modernists found themselves. Thus, rather than simply use the CIAM as a model, the organizers contacted Team X members. In a sense, the soliciting of their participation served to revive the CIAM and to pass the torch to a new generation and a new field of architecture. To pay homage to this continuity, the workshop was titled "Team XI" [8].

The workshop took place at the Glassell School of Art of the Museum of Fine Arts in Houston, Texas, on Saturday, October 12, 2002. The culmination of many months of intense debate and preparatory effort, Team XI successfully produced a concise set of

statements to define the emerging field of Space Architecture [9]. These results are described in the following, starting with the mission statement and subsequently addressing the typology, the principles and the philosophy of Space Architecture.

## THE MISSION STATEMENT

The mission statement provides a description of the definition and purpose of Space Architecture. Its focus is deliberately on *architecture*, not architects, to be as inclusive as possible of the various disciplines required to make human environments, and to emphasize the importance of mindset, process and tools over individual practitioners. The elements of the mission statement are, in this sequence, definition, motivation, utility, required knowledge, and related disciplines. Each element is described below, with annotations to explain its genesis and expand on its meaning.

## DEFINITION

*Space Architecture is the theory and practice of designing and building inhabited environments in outer space, [...]*

The term "Architecture" has already found its way into many areas unrelated to the design and construction of buildings, from computer chip and network design to "Naval Architecture" and "Systems Architecting" [10]. However, traditional terrestrial architecture encompasses a special body of knowledge and methods, derived from a long and successful history, that makes it especially applicable to the complex and crucial area of human integration into inhabited space structures ([11], [12], [13]). Since this is an inevitable part of the development process, it includes the design and construction of terrestrial prototypes of such structures ([14], [15], [16], [17]). Theory provides the space architect with conceptual foundations, overall vision and a source of ideas, while the prominent mention of practice acknowledges the fact that only actual design work resulting in built structures offers the potential for improvement through feedback collected from real-life designers, builders and users.

## MOTIVATION

*[...] responding to the deep human drive to explore and occupy new places.*

The various motivations for sending humans into the hostile environment of outer space can be grouped into two categories: utilitarian and cultural [13]. Both represent pertinent reasons driving Space Architecture. The former involves the technical aspects of Architecture and the greater area of evolution for the profession, in that its requirements radically alter the scale at which Space Architecture interacts with applied scientific knowledge as well as objective data regarding human-machine interface and environmental stressors on social interaction. Unlike most areas of terrestrial

practice, the specialty of Space Architecture demands the highest level of attention to utility in the form of user performance on the one hand, and the greatest possible conformity with mission and program goals on the other. Finally, the *architekton* (or, “master builder”) has always been in one aspect a pioneer of engineering and a repository of the history of building methods and technology; and in Space Architecture this role is of critical importance to the efficiency and success of any program [18].

The cultural aspect of human spaceflight is another major driver for progress in this emerging profession; our species’ seemingly inextinguishable drive to expand its sphere of knowledge and physical presence. Whether rooted in a “genetic imperative” or in the hope of profiting from a physical frontier (and its conquest) [19], transforming humanity into a multi-planet civilization could contribute to the ultimate survival of our species [20] and, in the shorter term, contribute to reinvigorating our global civilization [21]. With these expectations come obligations; this is why the Team XI workshop also produced statements on philosophical guidelines and societal boundary conditions affecting Space Architecture.

## UTILITY

*Architecture organizes and integrates the creation and enrichment of built environments.*

Part of an architect’s role consists of integrating many discipline-specific contributions into an overall system (see remarks above under “Definition”), as well as acting as a catalyst for constructive interdisciplinary exchange. These functions are again reflected in the sections on “Required Knowledge” and “Related Disciplines” below. They are the hallmark of successful architecture, be it in space or on Earth.

## REQUIRED KNOWLEDGE

*Designing for space requires specialized knowledge of orbital mechanics, propulsion, weightlessness, hard vacuum, psychology of hermetic environments, and other topics.*

[AKA, Internal Knowledge; i.e., knowledge required of the Architect personally]

When designing structures for the unforgiving environment of outer space, the very lives of their users are at stake, along with substantial shareholder interests in the form of extraordinary amounts of money –. Space Architecture must therefore be built upon foundations of solid science and engineering. This notion is not new to architecture: over 2000 years ago, the prominent Roman architect Marcus Vitruvius Pollio had this to say on the subject [22]:

“The architect... should be inventive and fond of learning, because neither with inventiveness alone nor with learning alone can one construct a perfect building. He should also be a good writer, expert in drafting, learned in geometry, knowledgeable about history; he should be versed in the works of philosophers, know music, should be not ignorant of medicine, understand the laws, and should be familiar with the interrelationships of the celestial bodies.”

Mastering associated science and technology is the only responsible way to ground visionary designs for the next century in realism and credibility.

## RELATED DISCIPLINES

*Space Architecture has complementary relationships with diverse fields such as aerospace engineering, terrestrial architecture, transportation design, medicine, human factors, space science, law, and art.*

[AKA, External Knowledge; i.e., specialties with which the Architect must be trained and prepared to collaborate at an expert level; professional alliances the Architect should form]

This list mentions disciplines with obvious relationships to the design of inhabited space structures, and is intended to be indicative rather than exclusive. Again, a comparison to the fields of learning mentioned by Vitruvius shows that some of the foundations of applied technology have remained remarkably constant across the ages.

## SPACE ARCHITECTURE TYPOLOGY

In addition to generating a mission statement, Team XI participants also dealt with the issue of defining a taxonomy of archetypes appropriate to Space Architecture. Due to the complexity of the field and its scope<sup>1</sup>, group consensus was that a traditional, hierarchical breakdown should be avoided. The focus was instead put on the various boundary conditions that affect the design space in which Space Architecture is created. Each instance of Space Architecture has a multidimensional coordinate describing the levels of gravity, pressure, speed etc. of the environment for which it was designed (cf. Figure 1). This type of topology can also address mission-related design drivers. The result of this approach is a very flexible, nonhierarchical typology.

## SPACE ARCHITECTURE PRINCIPLES

In addition to mission statement and typology, Team XI members felt the need for providing practitioners of Space Architecture with an initial set of principles derived from their understanding of the field and its interaction with human society. Table 1 summarizes these statements.

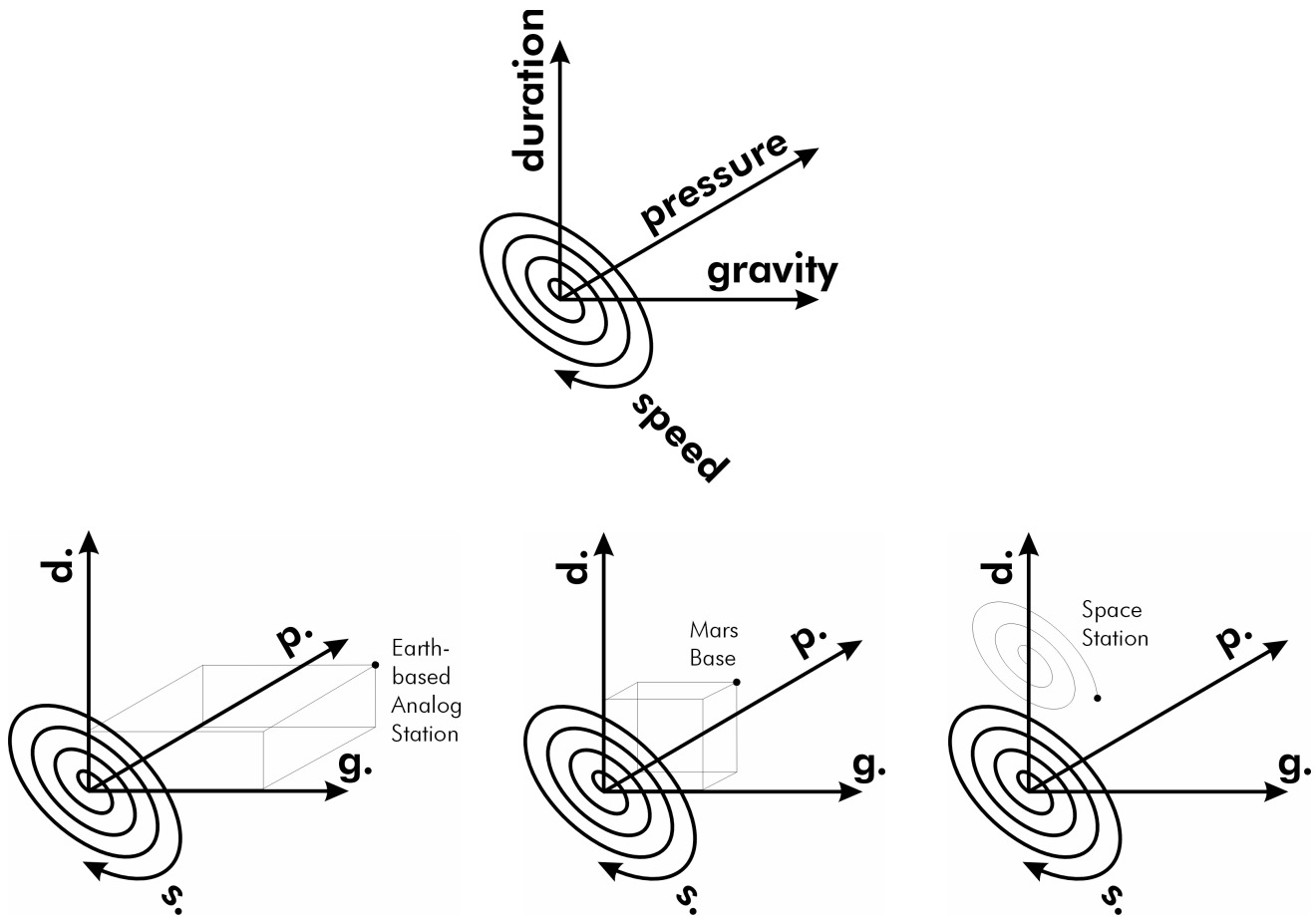


Figure 1: Environmental dimensions of Aerospace Architecture: generic coordinate system (top) and examples

## PHILOSOPHICAL GUIDELINES

As a final step, Team XI proposed a set of philosophical guidelines appropriate to the significance and potential impact of the new discipline of Space Architecture:

- We seek to improve the human life experience by providing environments conducive to intellectual, spiritual and social enhancement.
- Our work is to be accomplished in an environment of cooperation, in which no single idea or concept is considered greater than the whole, and the focus is always on the needs and desires of the user.
- We seek to understand the implications of our presence in space and what kind of footprint we want to leave.

## CONCLUSIONS

Defining Space Architecture and formally establishing a discipline associated with it is a process that has just started. Currently on the agenda of the involved professionals and organizations are, among many other issues:

- Designing professional standards and educational curricula
- Whether and how to institute professional licensure and certification
- Strategies for achieving formal integration into ongoing space projects

It already seems obvious that this highly dynamic field holds the promise of improving the design of inhabited (aero)space systems, as well as the potential to make a positive contribution to the development of Earth-bound structures. The most direct impact on home-world architecture might simply stem from the changed perspective that comes with the possibility of building in space: on inhabitable planets, how will we have to adapt what we know from architecture that we currently use on Earth? This approach leads directly to an emphasis on careful integration of structures and environment, preservation of resources, and meaningful, holistic designs for terrestrial buildings [3].

Some of the first design-to-build applications of Space Architecture were for low-Earth orbit habitation modules such as Skylab, the Salyuts, Mir and ISS [5] and Earth-based planetary analog stations such as NASA-JSC's Lunar-Mars Life Support Test Facility and BIO-

Plex/Integrity, the Mars Society's Flashline Mars facility and others [14]. The near-term future will hold more of the same. This will provide a solid foundation of real-life experience and lessons learned on which to base structures and systems to support human pioneers on Mars and other possible destinations.

The implications of the tasks at hand and the necessary interdependencies that result are quite serious. Space Architecture is not a safe harbor for sloppy fantasy; it is a disciplined profession of enormous complexity and difficulty, and the methods its practitioners are developing for integrating the Architect's skills and training into the culture and processes of cutting-edge Engineering have a great deal to offer designers and specialists in other fields. If the projects on which we are working are to be built, they will require that nations work together, that private wealth and public assets collaborate in extending humanity's fields of knowledge. It will be necessary for the trend of cultural interchange already underway in the International Space Station program to continue, and to expand; and most importantly, it will be necessary for approaches to be developed and applied to sustain the long term future of our planet and our kind.

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<sup>1</sup> Team XI member and architecture professor Ted Hall addressed this issue with the following thought-provoking statement: "All architecture is Space Architecture. Earth architecture is just the subset with whose constraints we are most familiar." [3]

ISSUE	STATEMENT
Sustainability	"As in earth architecture, sustainability is multidimensional and bears on the following areas: Ecology, Technology, Economics and Society. In the context of Space Architecture, sustainability also requires robustness: flexibility to adjust to unknown or unpredicted situations."
Human Interaction	"Space Architecture is particularly influenced by the interaction between human and human, human and machine, and human and environment."
The User	"Because user needs and well-being are key to mission success and thus critical components of mission and vehicle design, user contributions and feedback [4] are indispensable in the practice of Space Architecture."
Human Factors	"Human requirements for inhabited space systems are fundamentally similar to our requirements for daily life on earth."
Human Condition	"Space Architecture is concerned with the continuum and the future of the human condition (cf. the "Motivation" subsection above)."
Social Aspects	"Community life, communication and interaction among space voyagers are important considerations for space architecture. Space Architecture affects – and is affected by – the question of how to organize society in permanent off-Earth environments. This includes ownership issues, control over buildings and building configurations, crew composition, and much more."
Environmental Conditions	"Space architecture must respond to a wide range of different environmental boundary conditions."
Education	"Space Architecture uses a multi-disciplinary approach to manage the complex nature of space projects. From the start of each project, success is derived from collaboration."
Life Cycle	"The life cycle of architectural elements is an essential aspect of mission planning and design."
Humility	"Architecture involves forging harmony around the human system, balancing culture, biology, planetary knowledge and technology in counterpoint to the unknowable."
Benefits	"The involvement of Space Architecture from a project's onset provides great benefit to space development and exploration: measurable savings in cost, time, maintenance as well as extended usability. Knowledge and techniques derived from the practice of space architecture can improve the sustained quality of life on our human mother ship, the Earth."

**Table 1: Some Principles of Space Architecture**