What is Space Architecture?

By Anastasia Prosina

First, let us define what architecture is. Architecture is the art and science of designing buildings and other physical structures. Space architecture is a part of architecture, which shares the niche of small architecture with tiny housing, small living apartments/houses, vehicle design, capsule hotels, and more (Figure 1). The principles of successful design for a small space habitat are similar to the design principles applied to the variety of small living areas on Earth. They all aim to be multifunctional and to mitigate the sensory deprivation of existing in a small space.

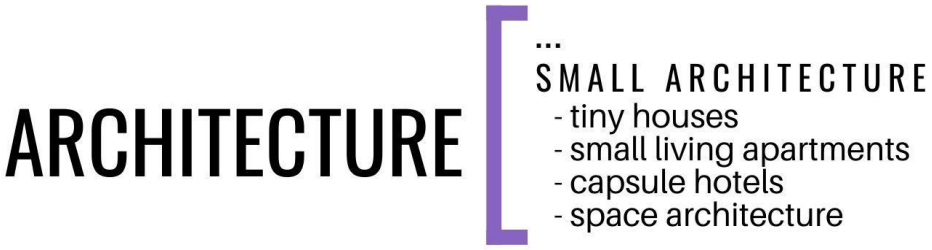

Figure 1: Space Architecture within Architecture

The processes of creating architecture and space architecture are different (Figure 2). In architecture, the vision of an architect comes first, and then an engineer helps to make that vision a reality. In space architecture, the process starts with a group of engineers who design and assemble the spacecraft, outfitting it with the necessary systems. A space architect comes afterwards to help to design for human needs in the confined environment.

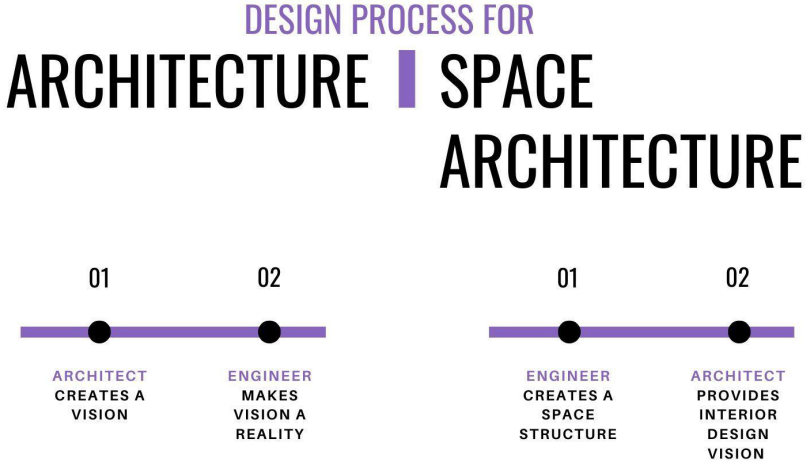

Figure 2: Design Processes in Architecture and Space Architecture

Although architects are creative and visionary, they are rarely so radical that they design structures that cannot be built with modern engineering. Certainly, they always need to sacrifice some of their vision to the necessities of engineering, yet architects have intuitions about what is physically feasible (Figure 3).

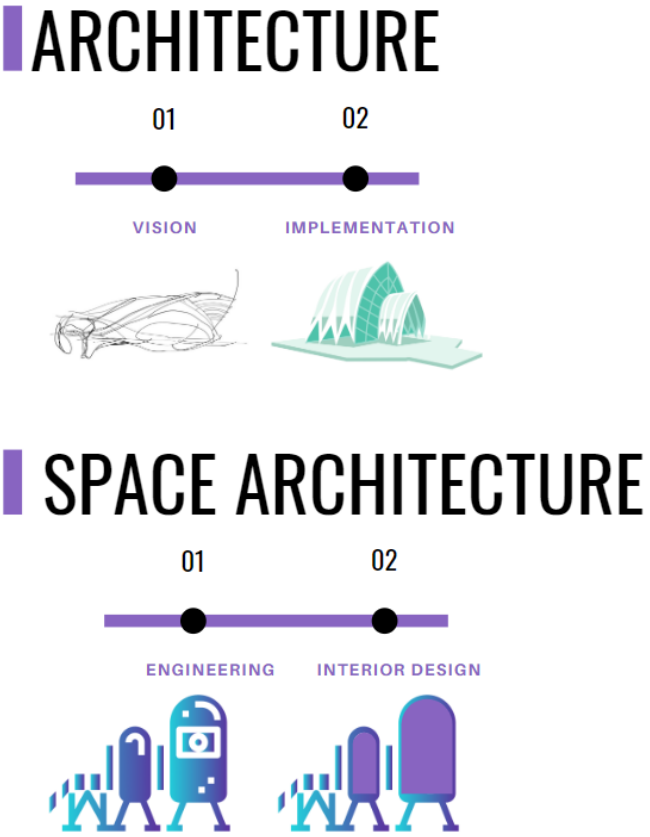

Figure 3: Differences between the Design Processes in Architecture and Space Architecture

In contrast, the spaceflight industry has strict requirements, because a spacecraft is an extensive, interdependent system that cannot be changed. Seeing the engineering constraints first is much more efficient for a space architect. He or she can then work within those constraints rather than implementing the vision and then working with an aerospace engineer to see if this vision is achievable. Creating space architecture that way would be inefficient because each architect's vision would require the design of a new spacecraft. In aircraft design, which is a similar process, architects design the interior of an aircraft, but they do not design the plane itself. For them to implement the vision and then to create the aircraft is not practical. For highly constrained regimes such as aircraft and spacecraft, doing the engineering first and then implementing the architectural vision makes sense.

Who is a Space Architect?

Traditionally, space architects have been systems engineers, because systems engineers were the only members of the design team with enough knowledge about spacecraft to design an interior. Now, people can be trained to be actual space architects, whose duties are to create interiors within constraints. System engineers no longer need to do this job; instead, they can advise space architects on constraints.

In space architecture, it is not practical to design first and then to see what can be implemented through engineering. This is because the diversity of available structures for space travel and the cost ranges are minimal—that is why everything needs to have dome, sphere, torus, cylinder, or pillow shapes.

Space architects used to be and were referred to as systems engineers, but this is no longer necessary. With the increasing demand for designing valuable interiors for spacecraft and space habitats, it makes more sense to have real space architects rather than systems engineers who do space architecture.

Why Should Systems Engineers Decide the Spacecraft Structure?

System engineers should design the structures because the costs involved in introducing additional mass and volume are huge. Thus, deviating from a mathematically ideal structure dramatically reduces the funding available for the interior design. Doing so is rarely, if ever, worthwhile. In other words, the added value of an architect-designed structure is not enough to offset the dramatic increase in cost of introducing additional mass, additional volume, and nonideal sizes and forms into rockets.

Deviating from things that are not efficiently packed into cylinders dramatically decreases the volume available to architects. Rather than having architects try to guess what structures are viable, engineers should continue to provide the constraints, such as the available rockets, their payload masses, fairing sizes, and spacecraft restrictions in terms of the spacecraft's available volumes, forms, inputs, and outputs.

In the far, far future, this could change when the cost of space travel comes down dramatically, possibly as people live in larger numbers on other worlds, rather than only in orbit. For the foreseeable future, however, space architecture should focus on designing within existing engineering constraints and beginning after the engineers' work is done.

CubeSats have a well-defined size, and everyone can put anything they want into CubeSats, provided it fits. Anyone can go out and design the interior of the CubeSat, as people already do, greatly expanding the diversity of things that are implemented in CubeSats. The same scenario could exist for spacecraft interiors. Engineers can design the rockets, rocket cabins, space stations, and habitats, and then space architects can fill those structures.

Why Do Systems Engineers Get to Decide the Shapes of a Space Habitat?

The most significant determinant of the best shape for a habitat from an engineering perspective is whatever best accommodates the internal pressure of the living volume and fits adequately into rockets. The cost is smaller if one proceeds with a minimal mass and volume for the habitat structure, thus reserving more funding to maximize the mass, volume, complexity, and function of the furniture and the interior structures of the habitat.

The cost of deviating from ideal structures for space travel is so high that it dramatically reduces the funding available for interiors. Supporting the perfect exterior arrangement for space travel significantly reduces the baseline structural cost and dramatically increases the funding available for internal design.

During long-duration missions, astronauts and space tourists will struggle with seeing the same people, performing routine tasks, isolation, and the small volume of a space habitat. It will cause rising conflicts, as well as affecting the overall wellbeing of each person. Not everyone can tolerate the isolation and loneliness of a long space flight, but a well-thought-out, human-centered design can significantly relieve these issues, thus helping humanity to explore space without suffering harm.

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About the Author: Anastasia Prosina is an award-winning aspirational futurist and practitioner in Space Architecture, the nascent field of helping people thrive in small spaces in outer space. She is the Founder and CEO at Stellar Amenities, a company with the mission of complementing space habitats with lightweight, deployable and reconfigurable elements to support wellbeing in space.

She holds a Masters in Space Architecture from Sasakawa International Center for Space Architecture in proximity to and collaboration with NASA Johnson Space Center in Houston. Anastasia received a Bachelor's in Urban Design from Novosibirsk State University of Architecture, Design, and Art.

Editors' Notes: Anastasia Prosina scopes this article around architecture for spacecraft in which humans will travel. There is a huge difference between Earth-based and Space-

based architecture. The sometimes trial-and-error option for Earth architecture is too risky for Space. There will also be a huge difference between spacecraft architecture and the architecture for human research and settlements on the Moon and planets. Space Architecture is a well-established discipline linked with university academics, NASA, and the AIAA, and Space Tourism is now included in this discipline. It will be essential for the next Space era advancement. ***Bob Krone and Gordon Arthur.***