

## **Activity: ICES 2010, Barcelona**

Space Architects at the 40<sup>th</sup> International Conference on Environmental Systems presented 18 peer-reviewed papers in five Space Architecture sessions, plus two papers in an Education Outreach session. Taken together, our contributions comprised the largest number of papers in one topical area at the conference, continuing our strong tradition of making ICES a compelling event. SATC Chair Ted Hall organized and chaired the Space Architecture sessions.

The conference venue was the Hotel Fira Palace, near Plaza Espania. By coincidence, Spain won the Soccer World Cup the same evening as our opening reception, so attendees were treated to all-night national (and Catalanian) festivities in the streets.

### ***Space Architecture papers***

#### **Space Architecture A – Inflatable structures and membranes**

G. I. Petrov, K. S. Park, C. M. Adams – **Optimization of Inflatable Spacecraft Interior Volume Using Constraints Driven Design**. AIAA 2010-6070. Georgi Petrov presented numerical optimization of a horizontal, off-axis inflatable module skin, and concepts for how the resulting volume could be subdivided and outfitted for planet-surface use.

V. Stavrev – **A Shape Grammar for Space Architecture I: Pressurized Membranes**. AIAA 2010-6071. Based on the physics of inflated membranes, Val Stavrev presented a language comprising basic feasible shapes, and feasible options for fusing them to yield large-volume habitat structures.

A. W. Daga, I. Schneider, Z. Uzman, P. de Leon, I. Schneider Puente, G. Harris – **Habitat Architecture Concept Definition for “Integrated Strategies for the Human Exploration of the Moon and Mars” (A NASA-Funded Study)**. AIAA 2010-6072. Irene Schneider presented a concept with an inflatable fabric membrane constrained by an internal rigid frame, constructed from a kit of parts, that supports concentrated loads from outfitting and rigid connections to other elements.

S. Gormly, M. Flynn, A. Polonsky – **Membrane-Based Habitat Wall Architectures for Life Support and Evolving Structures**. AIAA 2010-6073. Mike Flynn presented a concept for integrating liquid and gas osmosis bags into the walls of an inflatable structure, allowing a lower-tech and highly redundant approach for water and air purification, radiation shielding, and solid waste processing.

#### **Space Architecture B – Spatial layout, packing, and logistics**

D. Nixon, S. Antonetti, P. Clancy – **An Underground Isolation Laboratory for Human Space Mission Simulations**. AIAA 2010-6047. David Nixon presented a preliminary design project for adapting an existing Belgian deep tunnel into an isolation simulator for ESA, showing how he addressed challenges of narrow gauge, single egress route, functional program accommodation, and isolation psychology.

B. Sherwood – **Module Architecture for *In Situ* Space Laboratories.** AIAA 2010-6048. Brent Sherwood presented guiding metrics for equipment layout and packing density for planet-surface laboratory modules, by analyzing ISS capabilities and usage, laboratory functional needs, and terrestrial analogues for wet and dry lab outfitting.

T. Sakashita, T. Kamiya – **How the HTV Cargo Vehicle is Fully Stuffed: Cargo Loading Capability Enhancement and Related Issues.** AIAA 2010-2046. Tetsuya Sakashita presented JAXA's post facto solution to take fuller advantage of HTV volume for transporting soft-packed cargo to ISS. The solution is implemented on the second HTV flight, upcoming.

A. S. Howe, R. Howard – **Dual Use of Packaging on the Moon: Logistics-2-Living.** AIAA 2010-6049. Scott Howe presented approaches developed by NASA to optimize packing density and utilization access in lunar surface logistics modules, and to convert rigid and soft elements of the packaging into furniture and other uses as supplies are unpacked.

### **Space Architecture C – Personal Space in Space**

J. L. Broyan, D. A. Welsh, S. M. Cady – **International Space Station Crew Quarters Ventilation and Acoustic Design Implementation.** AIAA 2010-6018. David Welsh presented how NASA developed and tested the design for the ventilation system integrated into the new, individual CQ to meet acoustic standards for sleep. Duct configuration, baffling, and acoustic materials compensated for the noise exceedance of pre-selected fans.

B. Imhof, W. Hoheneder, K. Vogel – **Deployable Getaway for the International Space Station.** AIAA 2010-6019. Barbara Imhoff presented design development for a collapsible, quickly deployable crew privacy cabin that could be used throughout ISS, while still allowing crew to sequester and quickly retrieve their personal items.

C. Lauer, F. Nuovo, M. Onuki – **Design Aspects of Intimate Spaces – A Case Study in the Cabin Interior Design for the XP Spaceplane.** AIAA 2010-6020. Chuck Lauer presented design development being completed for the XP Spaceplane to accommodate experiential expectations for five suborbital spaceflight customers despite a small cabin.

S. Haeuplik-Meusburger – **My Home is My Spaceship – An Investigation of Extra-Terrestrial Architecture from a Human Perspective.** AIAA 2010-6021. Sandra Haeuplik-Meusburger discussed the interface among people, space, and objects in extra-terrestrial environments, focusing on sleep, hygiene, food, and work in the Apollo Command and Lunar modules, Space Shuttle, Salyut, Skylab, Mir, and ISS.

### **Space Architecture D – Earth Applications and Analogs**

M. Luther, T. Hall – **Exergy Applied to Lunar Base Design.** AIAA 2010-6107. Mark Luther presented “Part 1” of this discussion of the difference between energy quantity and exergy. High-grade electrical energy is needed to power

lights and machines, but heating can be done with lower-grade energy. A lunar base should extract benefit from as much of its input energy as possible.

R. Polit-Casillas – **Applied Space Architecture**. AIAA 2010-6108. Raúl Pólit-Casillas presented a study of the relationship between terrestrial and extra-terrestrial architecture and the ways in which each can contribute to the other, with particular focus on energy challenges and design processes.

R. Peldszus, H. Dalke, C. S. Welch – **Science Fiction Film as Design Scenario Exercise for Psychological Habitability: Production Designs 1955-2009**. AIAA 2010-6109. Regina Peldszus presented a detailed analysis of the aspects of living in space examined by many films. Professionals who are experienced in creating narrative could be valuable team members during habitation design development.

H. Broughton – **Antarctic Research Stations: Parallels for Interplanetary Design**. AIAA 2010-6106. Hugh Broughton updated us on the construction progress of the British Halley VI station, which is nearing assembly completion in the field. He also previewed Spain's Juan Carlos I station and described salient design and materials differences.

### **Space Architecture E – Multivariate Design Analysis**

M. Cohen – **Trade and Analysis Study for the Lunar Lander Habitable Module Configuration**. AIAA 2010-6134. Marc Cohen's Northrop Grumman colleague Ron Pirich presented a configuration permutation study that systematically generated and filtered alternative arrangements of ascent module, airlock, and surface module for the Constellation Altair lander concept.

G. Misra – **The Tesla Orbital Space Settlement**. AIAA 2010-6133. Gaurev Misra presented a student paper for a large asteroid mining settlement based on advanced concepts adapted and integrated from extensive literature research.

### **Education Outreach A**

Two space architecture papers placed in an Education Outreach session led to a rich discussion that effectively introduced space architecture to a more general conference audience.

T. Berns, T. Garvey, M. Jemtrud – **Non-Terrestrial Approaches to Space Inhabitation**. AIAA 2010-6172. Torben Berns described the philosophical basis for a new studio course at McGill University that integrates space architecture topics with social networking work methods. He outlined a forthcoming design competition for teams collaborating through a distributed network, about a solar sail docking station.

O. Doule – **Space Architecture – Theory and Educational Strategy**. AIAA 2010-6174. Ondrej Doule described a survey conducted among space architects about what they do and how they view it, resulting in a Venn framework that relates terrestrial, extreme-environment, and space architecture into a “universal architecture” construct.

### ***Related conference activities***

Brent Sherwood moderated a panel session **Challenges of Environmental Control and Life Support for Long-Duration Missions Out of Low Earth Orbit**. The panel comprised Grant Anderson (chair, from Paragon), Michael Ewert (NASA JSC), Bob Bagdigian (NASA MSFC), Tim Nalette (Hamilton Sundstrand), Christophe Lasseur (ESA), and Masato Sakurai (JAXA). Topics included: requirements imposed by 8-18 month NEO missions; how much in-space testing will be needed and how to conduct it on an operational space station; sparing vs. super-reliability; expanding component performance ranges to make integrated system performance more robust; prospects for relying on plant-based life support on deep-space missions.

Members toured ESA's **MELiSSA ground pilot plant**. MELiSSA is a 40-year development project for hybrid life support technology based on microbial and plant reactors. The project is at the halfway point and its pilot plant is in Barcelona. With six bioreactor compartments (five operating so far) it processes CO<sub>2</sub>, urine, feces, and plant wastes into water and oxygen for one equivalent person (keeping a rat colony alive), with food production for 1/5 equivalent person.