ASTE 527 Graduate Space Architecting Studio

aka ASTE 527-Space Exploration Architectures Concept Synthesis Studio

Tuesdays 6:40-9:20pm, RTH109 DEN Studio, DEN Webcast

Refine Creative Skills, Topic Oriented Team Project, Visiting Expert Lectures, and Reviewers

2016 Fall Studio Topic: Human Spaceflight: Analogs and Simulations[See Section 8 for Outline]

Mandatory Midterm and Final Presentations – Midterms Oct04, Finals Dec13

M.Thangavelu, Conductor

1. Introduction

ASTE527 all about creativity and ideation, the conception, birth or the origination of ideas. The area of investigation is complex space systems. Participants are taught to quickly create concepts and present them before a group of professionals and academics for review and feedback.

The core of the instruction is all about providing inspiration to create new products and processes. It is done primarily through engaging the studio with a variety of presentations by visiting guest lecturers who have created and continue to create innovative products. Debate and discussion are key to development and refinement of ideas. Graduate students from all disciplines of engineering, architecture, medicine and the law are encouraged to apply and participate in the studio. A basic appreciation of the sciences, space systems and the space environment is a useful prerequisite for this course.

2. Course Mechanics

This highly interdisciplinary course is all about the adumbration or early formulation and articulation of creative ideas. It is also about visionary and imaginative speculation; visualizing “big picture” future applications for space technology and space activity. Inductive and analogous processes, synthetic thinking, associative logic, metaphorical models and other system architecting tools are employed to quickly create alternative "concept architectures", which in essence, are rudimentary but global ideas or visions of a project. Besides presenting poignant, project specific, interdisciplinary scientific concepts and engineering theory behind space system architectures, participants will be introduced to architectural concept generation theory, methods, form finding processes, visualization and presentation techniques followed by a unique, hands-on studio approach that allows the participants to realize their own concept architecture project in a rapid manner.

Participants work on both a small individual mini project and a larger team project. These concept architectures are then presented to an expert panel of faculty, agency and industry professionals for feedback and discussion. The studio also feature lectures on relevant topics by visiting professionals who are experts in the field.

For the individual mini-project(due at mid-term) participants are free to explore creative, new ideas of their own choice as well for space transport and human and robotic facilities in space. Options for concept architectures include but are not limited to :

- Space Transportation systems and their evolution
- Orbital debris mitigation systems
- On orbit assembly of large scientific platforms, modular stations/vehicles
- Solar Power Satellites

- Innovative communication satellite architectures
- Solar System Exploration strategies and human expeditions to the Moon, Mars and beyond
- Space Tourism and Adventures
- Recreational vehicles/facilities, advertising in space and other innovative ideas

Fast-paced topic oriented studio. Strongly advise students to pay close attention to all class meetings. Active participation and feedback during visiting lectures and coordination proceedings recommended. Selected projects may be presented at various professional meetings and conferences.

3. Final Design Team Project Focus:

Using current NASA studies and ongoing as well as proposed space mission projects as baseline, studio participants will jointly create alternative system architectures (both robotic and human) for a variety of missions including lunar exploration and interplanetary mission technology development and verification. The Team Project will focus on a range of topics of interest to the space community and our nation including human and robotic exploration, commercial space activities and planetary defense. Merits and limitations of different architectures are discussed and documented.

Past team projects have included :

- Lunar Mission Concepts
- Mars Exploration
- Solar Power Satellites
- Visions for Human Space Activity
- International Space Station
- Planetary Defense Architectures

Past presentation materials may be accessed at: http://denecs.usc.edu/hosted/ASTE/527_20111/

4. Grades

Midterm Individual Concept Architecture Presentation – 30%

Final Team Project Presentation – 70%

All students must present their work in real time, either in the studio or via a reliable broadband link through USC DEN service to a panel of reviewers for evaluation and feedback on which the grades are based entirely.

5. Mid-term and Final Presentation Dates and Venue

Midterm Oct 04, Finals Dec 13. Presentations will happen during regular studio hours, 6:40-9:20pm, Ronald Tutor Hall RTH109. DEN students will present projects in real time via USC DEN Webex service.

6. Textbook

- The Moon : Resources, Future Development and Settlement - Schrunk, Sharpe, Cooper & Thangavelu, 2nd edition, Springer/Praxis 2007, ISBN-13: 978-0387360553
- Space Systems Concepts Creation Class Notes - M. Thangavelu

7. Recommended References

- The Moon : Resources, Future Development and Colonization - Schrunk, Sharpe, Cooper & Thangavelu, John Wiley and Sons 1999, ISBN 0-471-97635-0
- Encyclopedia of Aerospace Engineering, John Wiley and Sons(2012) - ISBN: 9780470686652
- The Lunar Base Handbook – P.Eckart, McGraw Hill 2006, 2nd ed. ISBN-13: 978-0073294445
- Spaceflight Life Support &Biospherics –P.Eckart, Microcosm Press, 1996 ISBN 1-881883-04-3

- NASA Man Systems Integration Standards(MSIS 3000/3001)
- NASA(2010) Human Integration Design Handbook(HIDH), NASA Johnson Space Center
- NASA(2001) International Space Station Users Manual, NASA Johnson Space Center
- Out Of This World:…Space Architecture, AIAA (2009), Howe, A.S etal - ISBN-10: 1563479826
- Space Vehicle Design, 2nd Edition – Griffin, M.D., French, J.R., ISBN-13: 978-1563475399
- Space Stations & Platforms, (1986)Woodcock, G.,
- Space Exploration: Mission Engineering, Woodcock G.(2011)
- The Dream Machines, Miller, R.G.(1993)Kreiger Publishers, ISBN-10: 0894640399
- Space Architecture Education for Engineers and Architects: Designing and Planning Beyond Earth(2016) Häuplik-Meusburger, S., Bannova, O. - ISBN 978-3-319-19279-6
- Current journals, topical magazines and space related periodicals are recommended

Textbooks prescribed for ASTE Astronautical Engineering and SAE System Architecting are useful. Class handouts will include pertinent material on Space Exploration, ranging from history of Space Exploration to programs and current thinking on the subject.

8. Fall 2016 Team Project Topic - Human Spaceflight: Analogs and Simulations

Human spaceflight missions are perhaps some of the most complex operations that we conduct routinely today. The ISS keeps her crew safe and productive with the help of round-the-clock mission control monitoring. Careful, advance planning, including initiating anomaly resolution protocols and crew safety measures to combat potential hazards like approaching debris or excessive radiation, trigger appropriate responses and safeing procedures, initiated both automatically and manually, across a whole range of systems, executed deftly and methodically, all at a moment's notice. EVA operations also require a level of monitoring and contingency plans, to assure astronaut safety that is not seen elsewhere in practice. How do crew and mission control make such complex operations happen with few anomalies?

High fidelity simulations have proven their worth in preparing crew for complex operations. Pilots and operators of complex systems are routinely trained on sophisticated simulators. And human spaceflight employs such carefully choreographed exercises to ferret out design flaws and eliminate potential weakness in operational capability before real mission manifest. High fidelity simulators and analogs are routinely used by astronauts not only to shake out new systems and tools, but also to evolve better and more efficient operational capabilities. Simulators are being used by various space agencies to even test-run long duration, end-to-end mission studies. Such experiments involve large, specially designed chambers in which crew are tasked with mission duties and anomaly resolution, and monitored carefully for human factors issues and productivity. Research to date from simulators as well as flown data indicate that human crew performance is the most variable and susceptible parameter in mission success, and ironically, also the most flexible and valuable for quick and efficient anomaly resolution !

Buoyancy tanks are used to simulate orbital EVA missions, and NASA uses analogs like the Desert Research and Test Studies(D-RATS) program to evaluate performance of both crew and systems. Robots and vehicles are deployed in testbeds around NASA centers to quickly gain confidence in their applicability. Civilian experiments like the ones conducted in NASA's Aquarius underwater laboratory and those in Antarctica bases have gleaned useful information about design of remote outposts as well as operational protocols. Military camps, forward bases and long duration missions aboard submarines provide valuable deployment and operations insight. Private facilities like the Mars Desert Research Station run by the Mars Society are also at the forefront of such activity, and new, collaborative and independently run facilities are sprouting up, both within universities and in the private sector, that can help in high fidelity simulations for ambitious, complex space missions that are being planned. DoD, NASA, NOAA all routinely use virtual simulators, employing supercomputers to study complex, dynamic phenomena. It is possible to inject random anomaly conditions into such programs, that further enhance the study of crew response and behavior. Recent developments in consumer gaming technologies create total immersive environments and could find effective use in space mission simulation as well.

The Fall 2016 studio will look at how and why space mission simulations and analogs are being developed, some state-of-the-art examples, and their prospects for accelerating the speedy development of both robotic and human space activity. The 2016 studio will explore the world of simulations to create a variety of concepts, based on ongoing work in this important field of engineering and architecture, and propose new and innovative ways and means to economically glean data that could be vital to safe, effective and productive human spaceflight missions as we expand our spacefaring activities beyond low Earth orbit.

Instructor Bio

Madhu Thangavelu is the conductor of the ASTE527 graduate Space Exploration Architectures Concept Synthesis Studio in the Department of Astronautical Engineering within the Viterbi School of Engineering and he is also a graduate thesis adviser in the School of Architecture at USC. He holds degrees in both engineering and architecture and has contributed extensively to concepts in space architecture, especially dealing with extraterrestrial development. He is the author or co-author of over 50 technical papers in space architecture, lunar base design and human factors, and co-author of the book The Moon: Resources, Future Development and Settlement (1999) published by John Wiley and Sons and second edition by Springer/Praxis in 2007. He is the invited author of the chapter "Living on the Moon" in the Encyclopedia of Aerospace Engineering, a major reference work published by John Wiley and Sons in 2010 and the on-line second edition updated in 2012. He is a member of the USC team that won the consecutive NASA NIAC Phase I award in 2011 and Phase II award in 2012. He is on the faculty of the International Space University, an international organization that educates promising leaders and space professionals in an interdisciplinary, intercultural and international environment.

Recent news on studio :

2008 - http://viterbi.usc.edu/news/news/2008/from-the-earth.htm
2008 - http://news.usc.edu/29302/Making-Space-for-Some-Big-Plans/
2011 – Aldrin Visit to studio http://viterbi.usc.edu/news/galleries/slideshow_20111220.htm
2011 – NASA: http://www.nasa.gov/pdf/716069main_Khoshnevis_2011_PhI_Contour_Crafting.pdf
2012 – Lunar Super Computer, Wired http://www.wired.com/2012/10/supercomputer-moon/
2012 – NASA NIAC Award USC Engg. and USC Architecture, https://arch.usc.edu/topics/nasa-research
2013 – 3D Printing Space Food, Wired http://www.wired.com/2013/02/3-d-food-printer-space/

Queries? Contact instructor at : mthangav@usc.edu