The International Space Station: Investing In Humanity's Future

2010-Utilization, 2015-Evolution, 2020-Life Extension
Tuesday Dec 15th 2009, 6.30-9:10pm

USC Distance Education Network
Course Description:

This highly interdisciplinary course is all about the formulation and articulation of creative ideas. It is also about speculation; visualizing future applications for space technology. The aim of this synthesis oriented program is to encourage and refine programmatic and conceptual design synthesis skills for the creation of complex high technology projects. Space exploration and space applications are the areas of focus. Inductive and analogous processes, 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. These alternative concept architectures even precede engineering requirement documents and, in fact, they help in critically examining the need for a project and then assist in creating solid requirements through the crucial iterative processes involving inductive reasoning, debate and discussion. This exercise directly contributes to the speedy evolution of resilient "strong boned" complex architectures.

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 will 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 class will also feature lectures on relevant topics by visiting professionals who are experts in the field.

For the fall of 2009 semester, the group term project was to design for the utilization, evolution and life extension of the International Space Station. With the international community and political implications in mind, the students set out to define the needs, benefits and possibilities of the international space station into the next decade.
Agenda:

6:30 - 6.40pm - Studio Introduction - Madhu
6.40 - ISS Team Project Overview - Joe

2010
6.50 - Synergy Through Policy: Giving Freedom to ISS - Ian
7.00 - ISS for Earth Observation: Seeking Out New International Partnerships - John
7.10 - ISS: Earth Preservation and Space Exploration - Joe
7.20 - Ballute Cargo Recovery System (BCRS) for ISS Experiments - David
7.30 - Space Nutrition: Improving Consumption Regimen for the ISS - Andron
7.40 - The "Farm": An Inflatable Centrifuge Biology Research Module on the International Space Station -Laura
7.40-8.00 Refreshment Break

2015
8.00 - Non-Destructive Testing and Evaluation - Andy
8.10 - Debris Mitigation System and New Service Module - Eddie
8.20 - International Commercial Model - Will

2020
8.30 - ISS Life Extension - Jeff
8.40 - ISS Nuclear Systems Testbed - Cody
8.50 - Construction of an International Space Vehicle Using the Space Station - Dan
9.00 - Discussion
9.30 – Fin
Synergy Through Policy: Giving Freedom to ISS

Ian Dawson

Abstract

The International Space Station (ISS) is one of the few man-made artifacts visible to nearly the entire world’s population. Current policies that govern the US’ use of ISS, however, restricts most to only this fleeting glimpse in the sky. This project proposes to re-imagine these policies by promoting greater cooperation by removing ISS responsibilities from NASA in favor of private sector corporations and research institutions.

Currently, interaction with the ISS is restricted by NASA and its Congressionally approved budget, limiting the scientific freedom ISS can offer the world. This restriction can be eliminated through re-distributing operation and management tasks to contractors through competitive bidding. Activities such as logistics, ISS astronaut training, data processing, and day-to-day oversight can be handled by private sector corporations and managed by a board. The management board, where each company would have a chair, would maintain the strategies and synergy between ISS companies without a large and financially significant NASA management overhead structure. In addition, a science and technology council would be charged with reviewing proposals for on-board experiments, providing financial grants, and developing strategies to achieve high-level science and technology objectives laid out by NASA and the multi-national ISS Council. This council would be comprised of members from industry and universities, headed by NASA’s Space Operations Mission Directorate, which would receive and vote on proposals from “feeder contractors” charged with validating these requests.

While full implementation of these solutions would be years away, individual tasks can be distributed piecemeal by NASA, immediately allowing a smooth transition of responsibility. This re-distribution would be carried out much as the Commercial Orbital Transportation Services program is, resulting in an amalgamation of companies that have a refined and efficient method towards accomplishing the specific activities assigned to them. Thus, NASA’s responsibility to the ISS is reduced and replaced by a constellation of organizations who can provide efficient and low-cost solutions to maintaining ISS’ scientific viability through the next decades.
ISS for Earth Observation:
Seeking Out New International Partnerships

J. DeWitt

Dept. of Astronautics and Space Technology, Viterbi School of Engineering, USC

Abstract

The goal of the ISS for EO initiative is to propose concepts that will have an impact on the International space community by stimulating international collaboration in the critical area of Earth Observation. This initiative consists of two primary concepts: 1) Development and implementation of LEO free flyers to be deployed and serviced from the ISS and 2) Ground Penetrating Radar (GPR) platform deployed on the ISS boom to survey critical geological regions.

The ISS Free Flyer concept is a dynamic platform of individual satellites to aide in Earth Observation. This concept is unique in that it is comprised of a series of Free Flyer satellites that can be deployed for various tasks and missions and have the capability to return to the ISS for resupply or refitting of instruments. Free Flyers can be deployed for global disaster response, climate and weather monitoring, or imaging for educational purposes. The low altitude of the ISS allows for more affordable payloads and for frequent revisit rates.

The Ground Penetrating Radar concept is an ideal candidate for the ISS. GPR allows imaging of important geological features such as underground river beds and detection of earthquake fault lines. The ISS is the ideal platform to host a GPR system, primarily because of its high power capability, serviceability, and extended mission duration. Rooting these systems to the ISS greatly increases collaboration within the global EO community, and provides the opportunity to expand the ISS group of partners to include even more nations.

1. Graduate Student, Dept. of Astronautics and Space Technology, USC
Abstract

From the vantage of low Earth orbit, the International Space Station (ISS) surveys the globe whereon mankind struggles for survival even amidst the flourish of technology. Among man’s many contemplations rest the concerns and dreams of space exploration as the ultimate accomplishment. The ISS represents the magnificence wrought by human cooperation and intellect, yet its own destiny hangs balanced against pragmatic concerns which ever multiply in a troubled world. My concept advocates intensifying the importance of the ISS as a political and technological tool. The political focus achievable with the ISS would seek to galvanize a major worldwide attention toward peace and proper stewardship of our most treasured spaceship, Earth. The space technology mission would endeavor to fully develop mankind’s commitment to continued understanding and exploration of space especially regarding long range missions to Mars.

The specific political plan utilizing the ISS must circumnavigate many confounding influences which arise from the diverse priorities of world nations. A singular focus could unite international attentions and energies to attain an ultimate modern goal – resolution of global warming. From an unsurpassable sentry position, the ISS floats poised for monitoring the plight of Earth’s atmospheric disruptions and the progress of mankind’s necessary interventions. The 51 degree inclination ISS orbit allows 85% Earth coverage at a readily accessible 350 km spacecraft altitude. The United States should endeavor to broaden worldwide ISS ownership and occupation in a cooperative effort to overcome the shared problem of global warming which inextricably binds all nations.

The ISS space technology mission component should be dedicated to the construction and testing of space vehicles and components destined for long range space missions beyond Earth orbit. The vast technological effort required for successful manned missions to Mars will demand immense dedication toward the development of resilient and capable hardware with several years of deep space endurance. Man’s destiny throughout evolution has embraced exploration and knowledge. Now, more than ever, the great abyss of space beckons with promise and fulfillment.
Abstract

During the post-space shuttle period of operations for the International Space Station (ISS) return-cargo logistics will prove to be a limiting factor in any attempt to increase research utilization. A novel concept for increasing the rate of ISS utilization is to return cargo to Earth using the Ballute Cargo Recovery System (BCRS). The BCRS uses a ballute to return *EXPediting the Processing of Experiments to Space Station* (EXPRESS) payloads, offering an affordable, timely, low risk solution to the future down mass cargo deficiency. The BCRS also offers the possibility of expanding appeal for ISS use to the broader international community by allowing non-ISS partner nations to recover any experiments they might sponsor directly to their home territory.
Abstract

Nutritional requirements definition requires immediate evaluation with emphasis placed on establishing limitations and boundaries to frequency and quantity of consumption for any particular consumable specific to each crew member. As post-flight results have shown, not having such processes in place resulted in a crew members having a varied consumption pattern of key nutrients. The intent of this proposal is to provide suggestions for redefining the daily nutrient intake by establishing positive constraints to reduce cases were excessive consumption of any particular nutrient could occur, resulting in various health ailments.

Dietary intake during space flights has not been consistent, rather being extremely low or extremely high, which can greatly compromise health. For the purpose of maintaining the same body mass in orbit as on Earth, astronauts are told to EAT, EAT, EAT!

Those with more aggressive consumption patterns recover more easily and rapidly than those with a more conservative diet, however, without limitations, this could lead to other health implications. Increased risk of muscle atrophy and bone loss due to excretion of calcium, to the growing risk of cardiac arrhythmia due to low potassium count or more convincingly the negative ramifications of high protein consumption due to the need to enhance muscle grow, it is safe to say constraining the daily consumption regimen is essential to the crew’s longevity.

This proposal highlights two approaches to helping to better constrain consumption regimen. First, the over arching tenet of establishing positive constraints or boundaries to the quantity based on intake level of any particular nutrient that would be consumed on a daily basis. This is grounded on the principle of allowing the body morphometry or physical characteristics to be the system driver rather than generalizing these key criteria. Secondly, supplementing fat infused products with a fat substitute will allow for a more healthy meal without compromising flavor.

While implementing these suggestions of re-defining consumption patterns through consumption constraints and using fat substitutes, overall health could be maintained in a more effective manner.
Abstract

Rather than disposing of or abandoning the International Space Station (ISS), the United States should invest in extending the station's lifetime by a minimum of 15 years and attach an inflatable centrifuge module. Providing a new "Farm" module provides scientists with the tools needed to study the effects of microgravity and the space environment, areas of research fundamental to facilitating long-duration and far-reaching manned missions beyond Earth’s local environs. In the “Farm,” scientists will explore questions including whether the side effects of living in a zero-gravity environment can be overcome with centrifugal effects, how to sustain both plants and animals in a space-bound greenhouse to provide nutrition for astronauts, and how to integrate these same plants and animals into a closed life support system.
Non-Destructive Testing and Evaluation
Andrew Charles

Abstract
In late 2010 or early 2011, the final segment of the International Space Station (ISS) will be in place, completing the envisioned construction of this U.S.-designated National Laboratory and symbol of international cooperation. This landmark in human space exploration is the result of decades of engineering and experimentation, over $100 billion in investments, 14 years of launches and on-orbit construction, and untold diplomatic effort. Therefore, it would be unthinkable to abandon the progress, investment, and our partners when so much potential exists in the ISS’s future. It would be equally unwise to operate onboard without periodic and accurate evaluations of the protective outer hull that is constantly subjected to the challenging space weather and critical to the safety of those embarked.

Non-destructive testing and evaluation (NDT&E) will provide engineers the necessary data to assess the impact of damage caused by micrometeoroids and orbital debris and the rate at which the exposed surfaces are degrading due to the impact of electron and ion bombardment. Rather than rely on models and estimates, the detailed NDT&E reporting allows accurate decisions to be made on when materials near dangerous states and need replaced. In the near-term, a surface “crawler” provides an optimal platform from which to deploy electromagnetic acoustic transducers, eddy current test equipment, and various optical devices, such as Nanofocus’s µsurf, to identify surface variations, subsurface cracks, and material thickness measurements. As lift-off distances improve in the NDT&E technology, “ISS orbiters” can conduct sweeps of the surface, using milli- or micro-Newton thrusters for precision movements, to allow for macro-level evaluation and for the crawler to focus only on the micro-level evaluation.

Armed with accurate and periodic readings, engineers can make more informed estimates of how to approach preventative maintenance to protect the lives of the embarked explorers. Money can be applied more precisely to build those replacement components that are truly nearing their expiration, rather than wasting time and money replacing components that were “weathering the storm” better than expected. In today’s world, needless loss of life is unacceptable, but so is needless spending of capital. Through NDT&E, the international community can prioritize spending on the ISS to significantly extend its service life while ensuring the safety of those embarked.
Debris Mitigation System and New Service Module

Edward Nicoloso

Abstract

The International Space Station (ISS) has had many problems in its history. These problems range from system failures to an increasing risk of a collision with orbit debris. I am proposing two concepts that can fix some of these problems and add a new and higher level of safety to the crew aboard it. The first is a debris mitigation system consisting of an All Gas-phase Iodine Laser (AGIL). AGIL will be used to deflect orbital debris or micrometeorites away from the station. The other is a service module which includes extra docking locations for the Soyuz spacecraft, an emergency power supply system, and a secondary attitude control system.
Abstract

The United States is at a crossroads between the desire to explore space and the ability to pay for it. With less than ideal economic conditions to fund NASA's aggressive exploration goals, new multinational frameworks for cost-sharing should be examined and NASA's charter adjusted accordingly.

One such framework, outlined in this presentation, aims to stimulate the US aerospace sector with foreign investment, fill the heavy space-lift gap left by shuttle retirement, support the ISS beyond 2015, and capitalize on work already completed on Ares I and the Orion CEV.

With "seats" aboard ISS-bound spacecraft fetching over $30M on the open market, seats aboard an Orion CEV, bound for destinations beyond LEO could command significantly more. Several of our ISS partner nations may be interested in financing a significant number of "COTS" flights in exchange for a seat (and a role) in an upcoming expedition to the Moon, a NEO or Mars.

The foreign capital injected among COTS competitors would stimulate domestic job growth, while simultaneously amassing the needed resources at an ISS supported depot. If additional foreign capital were required, participating nations could bid on the privilege of historical mission accomplishments, examples including being first to set foot on the destination's surface, or recovering the returning Orion capsule off their native coastline (a public event surely on par with the Olympics).

The essence of this framework lies in NASA’s assets against its inherent weaknesses. For instance, the Orion CEV is being built to support six astronauts, twice what was needed for the Apollo missions. With three Americans and three foreign astronauts from wealthy partner nations, NASA could grow jobs and still meet exploration goals in the midst of a global recession.

Furthermore, NASA is the only agency in the world with the required exploration and high-speed Earth re-entry track record needed to reliably assure mission success and avoid a national tragedy. Potential competitors from foreign space powers (i.e. China or Russia) cannot make such claims.

Finally, contracts and guarantees made under this framework could be assured by the full faith credit of the US Government. When writing multi-billion dollar agreements that hinge on ambitious technical challenges, potential international customers will demand these financial guarantees that protect them against schedule delays or catastrophic failures.
Space Station v1.5
Using the ISS to Develop Technologies and Practices to Improve Utilization

Jeffrey L. Smith

Abstract

With the planned completion of the International Space Station in the next few years, the ISS will move out of its building phase and fully into its utilization phase. While the Space Station will finally be complete, now is not the time plan for wrapping up operations and moving onto the next big project. Instead, ISS should be viewed for what as a testbed for future technologies and practices to improve the productivity of human spaceflight. Without focusing on one specific architecture, the ISS can be used to develop the enabling technologies that will form the building blocks of new human spaceflight missions in the future. These technologies can provide for better utilization of the station now, and make future manned mission more scientifically productive by improving crewmembers’ standard of living. This presentation will examine several ways in which technologies may be used to improve the quantity of science performed on the Space Station, and some human factors issues which can be addressed to improve the quality of work astronauts are able to perform.
ISS Nuclear Systems Testbed

Cody Vandermyn

Abstract

The International Space Station (ISS) represents the culmination of many decades worth of the best human minds’ thought and creativity as human spaceflight is arguably the greatest achievement that has ever been realized in the history of the earth. Close on the heels of human spaceflight is harnessing nuclear power for the benefit of mankind. This is another goal that many countries and scientists strive to achieve. What better place than the ISS to integrate two of mankind’s greatest achievements?

The general public is highly skeptical of nuclear energy due to the publicity of a couple nuclear disasters. Since then, scientists have studied nuclear power and claim it to be a very safe form of energy. To demonstrate to the world that nuclear power is safe, reliable, and absolutely essential for the progression of humankind to expand into the cosmos, the ISS will be used to develop and test cutting edge nuclear research in a phased approach. During the first phase, Radioisotope Thermoelectric Generators (RTGs), a kind of nuclear battery, will be installed to provide backup power for critical ISS systems. By installing RTGs on the ISS first, the world’s scientists can start a massive public outreach campaign to show the public that nuclear power is safe and reliable. After the public more readily embraces nuclear power with RTGs, full-scale nuclear reactors will be integrated into the ISS to become the main source of power for the station and the second phase of nuclear research on the ISS will commence.
Construction International Space Vehicle
Using the Space Station

Dan Roukos

Abstract

The International Space Vehicle (ISV), as described in this paper, is a concept for a new kind of spacecraft that can serve as the platform for accomplishing the space exploration and colonization goals set by the U.S. and shared by the world; namely manned return to the moon and manned missions to Mars and beyond. The nature of these missions demand long duration manned space presence of multiple years yet no vehicle planned or built, with the exception of the ISS, can effectively support life in space for that time.

The ISV will be constructed at the ISS leveraging the facility’s robotic arm, EVA capabilities, and full time crew as well as the experience in on-orbit integration gained by the construction of the ISS. The ISV will be optimized for travel beyond LEO and long term survival in space with the proper radiation shields, artificial gravity, and nuclear power to sustain a closed loop life support system for up to three years. Docked to the ISV will be a lander to bring humans to lunar and planetary surfaces as well as an Orion capsule that will ferry astronauts from earth to the ISV and serve as an escape option in case of disaster. After construction and certification at ISS the ISV will perform a multi-year mission to the moon where it will survive in lunar orbit and support multiple long term sorties to the surface. During this mission all of the systems, methods, and knowledge will be obtained to eventually conduct deep space manned missions using the ISV or its derivatives.

The ISS will be essential for construction of the ISV both as an on-orbit assembly platform and as a heritage design from which to innovate. The ISV will be constructed by integrating ISS-like modules which will be designed and built by a coalition of nations. The scale of this vehicle (comparable to ISS) will require U.S. leadership and international unity but will open unprecedented opportunities for space exploration.