ISS:SOS Saving Our Station
Alternative Futures for the International Space Station

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Space offers the ultimate location for preservation of objects we put there. Satellites from the dawn of the Space Age still roam the heavens, some seven decades after they were lobbed into the heavens. Most of them are long past their intended mission, and many have been mothballed into “graveyard” orbits around the Earth. Some like Voyager spacecraft are still zipping through Space, not to mention, still continuing to return scientific data, even after five decades since they were launched. Yes, we’ve had to do some remote surgery to keep them ticking, but it is amazing how these objects seem to weather the extreme conditions they are exposed to in outer Space.

By some account though, Space offers a much more desirable environment for preservation of artifacts than the dynamic processes posed by climate and weather here on our blue planet. Ironic, isn’t it, that the environment that we think created and nurtures life and our unique biosphere, is also capable of erasing it, along with all the rich history of our civilizations and aspirations?

But, in this 21st century, there is new hope for ISS preservation. Space could be the ultimate site for it. It is in this context that our students at USC are pondering the fate of cherished assets that are already in close orbit around the Earth.

What to do with the International Space Station(ISS) that is in low Earth orbit, some 400km above us, that is host to astronauts from around the world, when the facility is planned for retirement, sometime after 2030? That seems to be the question hovering over us right now. It is the theme the participants pondered in this fall 2024 Astro studio.

One of the hall marks of the NASA of yore was the skill, agility and dare that was evident in missions leading up to Apollo. The trace and circumspect rigor of Apollo program execution can be appreciated in records like NASA SP 287. https://ntrs.nasa.gov/api/citations/19720005243/downloads/19720005243.pdf Now, NASA's reports, like the updated Moon to Mars architecture https://www.nasa.gov/moontomarsarchitecture/ or the deorbit summary rationale for ISS decommission https://www.nasa.gov/wp-content/uploads/2024/06/iss-deorbit-analysis-summary.pdf suggests that the agency vision, imagination,(and budget too) seem to be running dry? It appears through new programs and projects like the lunar Gateway and Artemis, the agency bureaucracy is being hobbled even more by additional human spaceflight programs than it can afford to spend resources on.

Crew and mission safety regulations along with policy overburden issues, imposed from within as well as from external government agencies like the FAA or the State Department cannot be only reason for the glacial progress we see. The easy way out, as in the past, is to eliminate the ISS program, wipe the sheet clean, so NASA can move on to new programs. The agency claims that there have been no credible offers in response to requests of opportunity to transfer operations to another entity.

Evolution of leading edge-edge technologies and the race to master them have proved difficult to rein in and frame into matters of hard policy, just as we see the growth and spread of AI across the globe right now. Colleagues still dream of an independent NASA that is youthful and agile and not under the thumb of administrations or policy instruments of governments. And clearly, there is bipartisanship in Congress to see NASA as a highly effective agency with tremendous appeal and lasting mystique, both domestic and global. Some members of Congress do wish to see

an independent NASA, though the domestic private Space sector seems to be stealing the thunder, outshining the agency in creativity, agility and economics. And that is a matter of concern to all who watch over how discretionary taxpayer funds are spent.

I hope the collective forward-looking vision of our people does not succumb to this seeming vacuum of creativity. The former administration made some deft strides in advancing US Space Policy, and there is reason to hope the incoming one will follow the path set by the recommendations of the National Space Council including the vision outlined in the 2020 White House NSC document "A New Era for Deep Space Exploration and Development" https://csps.aerospace.org/sites/default/files/2021-08/NSpC%20New%20Era%20for%20Space%2023Jul20.pdf and the most recent National Academies NASA at the Crossorads:Consensus Study Report, yet another committee that was chaired by the legendary Norm Augustine, the sage advisor who penned Augustine's Laws https://nap.nationalacademies.org/catalog/27519/nasa-at-a-crossroads-maintaining-workforce-infrastructure-and-technology-preeminence

ISS:Save Our Station(ISS:SOS) is the theme that participants worked on last fall term, for presentation just in time for Christmas! Alternatives for ISS future showed pathways to support deep space missions that impacted NASA reference lunar Gateway, Artemis as well as suggestions for more ambitious endurance-class vehicles. Participants explored transferring ISS management to the private sector and initiating Space Tourism, commencing in earnest, immediately. If the station is recommended to be unsafe for crew beyond 2030, our vision for the future recommends AI technology-assisted fully remote operations of this unique facility in a higher parking orbit assisted by robotic agents and state-of the art algorithms employing deep learning neural networks. That procedure could start to be integrated into the ISS systems control, crew management and mission control loop as early as 2025 with current, conventional mission control monitoring and oversight that tapers as autonomous onboard systems become mature. In this respect, the ISS could play the role to become the ideal and existing space-based, habitable spacecraft to evolve reliable autonomy. Merits and limits of such complex operations could be identified empirically. Ideas discussed include boosting ISS using advanced electric propulsion, use of ISS as an Earth Observation Station from a higher orbital altitude, making ISS the central attraction of an innovative orbital national park, to which other historical spacecraft like the Hubble Space Telescope and the James Webb Telescope, when decommissioned, could be added in the future. A concept to return lunar far side samples to Earth is discussed and the possibility that the ISS could be a retrieving station and quarantine for inbound sample return missions was proposed. The idea to reconstitute alternative configurations from an array of useful ISS elements to build a lunar orbiting platform for a variety of uses is also discussed.

SpaceX, local to us at USC in Hawthorne, California, a city in Los Angeles, has been contracted to dispose of ISS at the end of life. Let us hope that this agile, highly imaginative and innovative private Space Company can offer creative alternative options to sustain and save this facility, that is also deemed a national laboratory by Congress, from a fiery end that awaits it, with bolder imaginative and creative extended lease of life options.

This 2024 fall studio ISS:SOS recommendations include:

Besides the new knowledge that these facilities have gathered, and the recent safe haven the ISS provided for Starliner test crew Suni and Butch, the ISS and observatories like Hubble and JWST have deep meaning associated with them. Their true value far exceeds the science and technology of our time.

As so many thought leaders have resonated, we should find ways to protect and preserve our collective species heritage, not destroy them, and worse, leaving no trace of precious unique artifacts that continue to shape and evolve the view of who we are, and our purpose and place in the Cosmos.

Beyond sheer scientific value or advancement of technology, the ISS holds tremendous "symbolic" significance. Symbolism that lays over the foundation of philosophy upon which ideologies are built and policies of nations are formulated.

The ISS was built and is being maintained through global participation and cooperation among nations with diverse cultural and governance philosophies. As is evidet in the Artemis Accords being promoted today, Artemis Accords - NASA Free World Values and peaceful collaboration is at the heart of the ISS program. The exchange of ideas, technologies and hardware to conceive, create and operate the ISS has weaved bonds in international relations and brought nations, even adversarial ones, together in common peaceful pursuit. Human spaceflight is at the core of this pursuit.

Just take a look at the diverse astronaut crew onboard ISS and global support team that is associated with such an endeavor. Forget the budget. The sheer "elbow grease" by the thousands of scientists, engineers and highly skilled technicians and the policy makers that went into bringing the world of nations together to create, operate and maintain the ISS program far exceeds all the budget woes and associated drama.

Unlike the Salyut missions, Skylab or Mir which were symbols of national prestige, or the Chinese Tiangong station in orbit now, scuttling the ISS would set back our common species cosmopolitan ambitions rather than continue to enhance and enrich the spirit of global collaboration and cooperation.

We should create new orbital stations and extraterrestrial habitats. We should also use our collective imagination to at least continue to service this unique facility till the next generation of stations become real. Otherwise, we'll be faced with the situation like the space transportation gap we faced after the agency retired the STS.

If ISS is truly showing age and unsafe for crew, we should find ways to preserve it unmanned, in a parking orbit, making it the centerpiece for an International Space Artifacts Museum that would include other historic assets like the aging Hubble.

We proposed a concept for such a facility in our Moon book, *The Moon, Resources, Future Development & Settlement.*

The Moon: Resources, Future Development and Settlement (Springer Praxis Books): Schrunk, David G., Sharpe, Burton L., Cooper, Bonnie L., Thangavelu, Madhu: 9780387360553: Amazon.com: Books

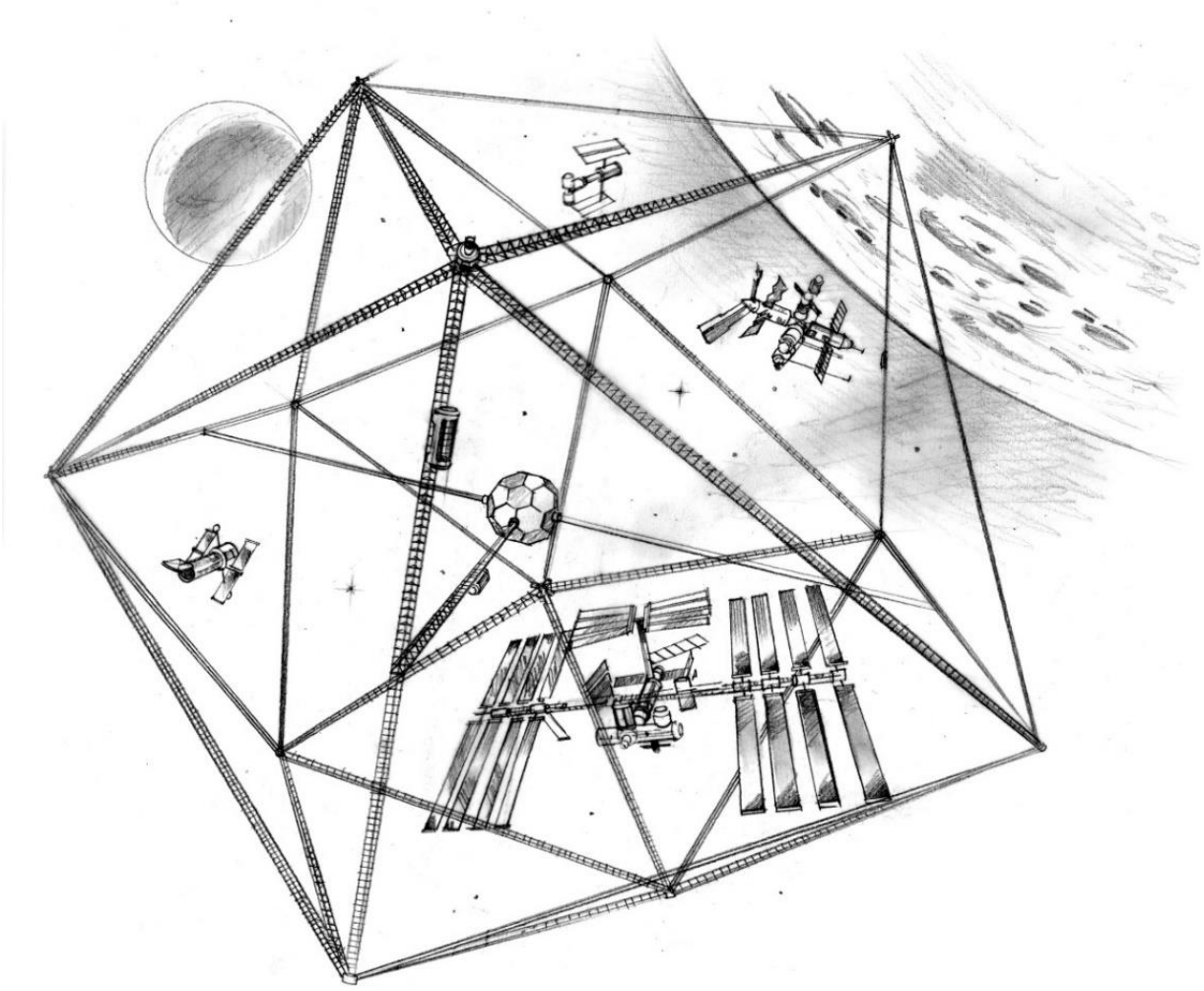

Figure 1. The International Space Artifacts Museum at the Earth-Moon L1 Lagrange point would house the decommissioned Space Stations and Observatories, sparing their fiery destruction as NASA proposes, instead preserving them for future generations to visit and appreciate the march of technologies that is making us a truly space faring species.[credit M.Thangavelu]

Though we suggested the Earth-Moon Lagrange point L1 as the final spot in cislunar space for the Space Museum, [Figure 1.] we could begin to collect and preserve artifacts in a suitable Earth parking orbit until we mature more suitable transportation and propulsion systems to locate it further out.

Yes, there are tough engineering problems to address. But technologies exist that can solve these issues. For instance, advanced electric propulsion currently available such as High-power Hall thruster technology coupled with power from the existing large solar arrays can gently thrust the ISS into a higher orbit where the LEO constellation traffic is much more manageable and debris threat is reduced.{Figure 2} Electrodynamic tethers installed on spacecraft that interact with the Earth's magnetic field have been proposed to alter orbits in the past. Gentle initial thrusting of the fragile ISS truss structure is also possible using small conventional thrusters that employ deep throttling, several being built and tested using state-of-the-art additive manufacturing methods.

Figure 2. Advanced electric propulsion coupled with power from the existing large solar arrays can gently thrust the ISS into a higher orbit where the LEO constellation traffic is much more manageable and debris threat is reduced. The ISS can stay in such an orbit and be a Space museum for future generations. ***ISS:Save Our Station(ISS:SOS****) is the theme that USC Astronautics students are working on this term, for presentation just in time for Christmas! . [credit M.Thangavelu]*

Furthermore, the increased orbital debris threat that the agency points to, mostly from assumptions in studies, can be mitigated by mounting high energy laser systems that are already mature and in use today by the military and

heavy industry. By adopting this line-of-sight speed-of-light(LOSSOL) targeting approach, the ISS has ample power onboard to neutralize any threat posed by debris. Moreover, such a LOSSOL mitigation technology is vital as we plan to execute fast trajectory crewed interplanetary missions using nuclear propulsion. It is time to develop and certify such debris threat mitigation systems and the ISS could play host to this critical technology development.

The harder issues may lie in the modification of existing memoranda of understanding among the partners. Partner nations with deep historical roots also know the immense value of history and preservation. Our nation should lead the effort as we have done all along, and continue to provide the maximum resources to keep the facility in orbit. We should also encourage more partners to join the coalition to preserve ISS just as we are doing with the Artemis Accords right now.

It is good to be reminded that we dearly hold on to and cherish the continuum of civilization by preserving historic artifacts all over the globe. Culture is enriched, and generations to come will value the preservation of heritage of historic artifacts of our era.

And that is why we have cultural heritage sites and museums around the globe, to protect and preserve the continuity of thought and creativity of our species and our civilization, lest we forget how we became what we are today and what our aspirations are for tomorrow; what we hope to be.

And in civil architecture philosophy, we also rehabilitate and service historically relevant buildings and infrastructure all over the world. In fact, some structures in use today date back to the cradle of civilization.

The time is right to start evolving the infrastructure for an International Space Artifacts Museum to preserve our species heritage in Space and on celestial bodies as we explore and settle lands beyond planet Earth. The promise of new technologies for the maintenance and evolution of endurance-class future spacecraft can evolve through such an effort.

The ISS collaboration has paid rich dividends in the past, continues to do so today, and our bipartisan leadership should act proactively to propose a creative plan with the established partners together with emerging space faring nations to establish such a museum when the time comes to decommission this unique facility.

In a final analysis, the world community, especially the practicing professionals thought leaders and visioneers in the progressive civil architecture field, including the educators, continue to seek practical and pragmatic reasons for all that we do in this new global endeavor we pursue in human space activities. They seem to converge on the fact the ISS has been flying the banner high, literally, and around world every ninety minutes to be precise, for global cooperation, highlighting advanced technologies for improving quality of life on Earth. They quote examples of clean, renewable solar energy, recycled potable water, revitalized air and efficient food systems and waste disposal as models to pursue and adopt to enhance the quality of life. These issues are at the heart of the United Nations Sustainable Development goals(UNSDGs) THE 17 GOALS | Sustainable Development and depicted in 17 tiles by the United Nations.[Figure 3]

This issue of inclusion of Space activity in the UN SDGs has been articulated by the Space Renaissance International SRI thought leaders and presented before the UN at various instances, including the 37th UN Science Summit where the author was invited to present some slides including the Space for All tile, hoping that human Space activity will be represented more vigorously in upcoming UN proceedings leading up to the UN Space Agenda 2030. UNISPACE+50 Outcome document: The Space2030 Agenda- Space as a Driver of Sustainable Develoment. [Figure 4]

Incidentally, the National Space Society's flagship International Space Development Conference(ISDC 2026) International Space Development Conference (ISDC) 2026 hosted several pertinent sessions to this topic and awarded the UNOOSA with the Space Pioneer Award that was presented to the current director Aarti Holla-Maini in Washington D.C., [Figure 5].

Commerce is the lifeblood of civilization. Good commercial activity coexists with good and progressive governance practice that the US is capable of and has demonstrated in past projects. Space commerce is paving the way for global cooperation that allow new and aspiring nations to partner with established spacefaring nations at an unprecedented scale.

The current administrator, Jarred Issacman, is a proven business leader who has a vision to breakout of past government funded programs to kickstart a cislunar economy that evolves from space stations in Earth orbit.[Figure 6]. Artemis II is setting the stage for evolving a truly sustainable cislunar economy in a public and private partnership

model starting with cislunar orbital tourism using both governmental and private space assets to accelerate the permanent establishment of an open architecture for cislunar infrastructure that establishes a sturdy communications network and logistics channel in the immediate term. NASA is an administration that charts vision and long range planning based on taxpayer wishes directed by the US Congress, the leadership, who in turn depend on feedback and sage advice from global citizen advocacy groups, devoid of agency, governmental or industry bias, like the National Space Society(NSS), The Planetary Society, Space Renaissance International(SRI) and the Moon Village Association(MVA). Several NGO's like For All MoonKind and Open Lunar Foundation who have UNOOSA Observer status should support such an initiative.

The fate of ISS rests with ALL of us(not only US!) citizens of planet Earth and is not dictated by any single organization or entity. It is vital that SRI and NGO advocacy organizations support and promote the continued operations of ISS, and when the time comes to retire the facility that has helped us understand and evaluate the limits of human spaceflight and astronaut performance in simulated endurance-class missions, to proactively engage NASA and ISS partners to find ways to mothball this unique facility as a museum in a viable parking orbit and not destroy it.

Figure 3. The issues at the heart of the United Nations Sustainable Development Goals(UN SDGs), in order to improve the quality of life(QoL) for the multitude of Earth dwellers, depicted in the tiles above and explained in the url, are closely linked to human spaceflight and the systems operating on the International Space Station for the past quarter century.

Figure 4. This issue of inclusion of Space activity in the UN SDGs has been articulated by the Space Renaissance International (SRI) thought leaders and presented before the UN at various instances, including the 37th UN Science Summit where the author was invited to present some slides including the Space for All tile, hoping that human Space activity will be represented more vigorously in upcoming UN proceedings leading up to the UN Space Agenda 2030.

Figure 5. National Space Society's flagship International Space Development Conference(ISDC 2026) International Space Development Conference (ISDC) 2026 hosted several pertinent sessions to this topic and awarded the UNOOSA with the Space Pioneer Award that was presented to the current director Aarti Holla-Maini at the Hilton in Washington D.C.,

Figure 6. The current administrator, Jarred Issacman(posing with the author and NSS awardees), is a proven business leader who has a vision to breakout of past government funded programs and NASA's defunct 20th century " fund and forget" welfare for engineers program, to kickstart a cislunar economy that evolves from space stations in Earth orbit. ISS could be a waystation for Commercial Cislunar Orbital Amateur Astronaut Space TourismC-COAST) missions, before the facility is retired and made into the crown-piece of an International Space Artifacts Museum(ISAM) that would host other invaluable assets like the Hubble Space Telescope, the Tian Gong Space Station and the James Webb Telescope when the time comes to decommission them.

It is good to remember that at the root of each discipline and profession lies a philosophy. The Sciences hold discovery and data gathering seminal to the underpinnings of their pursuits, while professions like the law, medicine, engineering and architecture hold on dearly to societal applications, while also helping build the tools to extend the reach of the fundamental sciences. And architects, by virtue of their exposure to Humanities and the liberal arts, strive to bring added value to these technical fields, offering critical insight into issues involving human factors, culture, spirituality and religion.

At USC Viterbi School of Engineering we know and practice what we preach. We call it Engineering+, and an interdisciplinary education that aspires to much more than mere competition, striving for excellence.

Our leaders know this, and our architects stand ready to act too!

E Pluribus Unum

Author bio:

Madhu Thangavelu is a long-time resident of Palos Verdes, a small coastal beach city in southern California. He conducts the ASTE527 graduate Space Exploration Architecture Concept Synthesis Studio, ASTE 527 Home devoted to creating concepts for human space activities, in the Department of Astronautical Engineering within the Viterbi School of Engineering and the School of Architecture at the University of Southern California. He is on the faculty of the International Space University, an international organization that trains space professionals globally. He is a director of the National Space Society and the North American activities coordinator for the Moon Village Association. Madhu Thangavelu - USC Today