SPACE STATION 2.0: A TRANSFORMATIONAL ARCHITECTURE FOR SPACE DEVELOPMENT. J. Berk[1], J. Straub[2], A. Nervold[3] and D. Whalen[2], [1]Department of Space Studies, University of North Dakota, 4149 University Avenue Stop 9008, Grand Forks, ND 58202, joshua.berk@my.und.edu, whalen@space.edu, [2]Department of Computer Science, Univeristy of North Dakota, 3950 Campus Road Stop 9015, Grand Forks, ND 58202, jeremy.straub@my.und.edu, 3 Department of Entreprenuership, University of North Dakota, 293 Centennial Drive, Stop 8355.

Introduction: The United States' 150 billion dollar investment in the International Space Station (ISS) has produced only a fraction of the scientific value that was expected. The ISS, despite the best of intentions, is a somewhat esoteric underachievement. Recent successes in commercial launch vehicle acquisition programs, however, highlights a promising alternate approach for developing a successor station: Space Station 2.0. By leveraging a COTS-style acquisition strategy for modular space station components, the next space station could be located at a destination of greater scientific interest and be far more productive than the ISS.

Space Station 2.0 could be built in lunar orbit (or another location of interest to planetary scientisits) to facilitate in-situ data collection by productive human astronauts. In addition to the prospective science benefits, this will also serve to stimulate the development of the heavy lift launch services necessary for deep space exploration and an eventual manned Mars mission. The scientific benefits of a hybrid commercial-government space station along with the public policy benefits it would provide are considered herein.

Space Station 2.0 Concept: Under the proposed model, NASA would utilize a number of Space Act agreements to begin the Space Station 2.0 development process via incentivising the development of multi-purpose modules suitable for destinations beyond low earth orbit. Not unlike the process utilized for procurement of the Commercial Orbital Transportation System (COTS), limited design requirements would be imposed on companies developing flight hardware. Companies would be encouraged to design space station components with both government and commercial operations in mind. Modules that are certified for flight readiness will be purchased competitively, based on cost and performance, as has been done with NASA's existing Commercial Resupply Service.

Space Station 2.0 will be based on a scalable and upgradable architecture. No single module on the station will be designed to last for the full ten-or-longer year duty cycle of components on the ISS. Emerging low-cost, heavy lift rockets have changed the cost equation for module longevity needs. Under the Space Station 2.0 model, it will be more cost effective to plan for recurring module upgrades, than it will be to design and develop a pristine module capable of enduring the hardships of space for an extended period of time. Planning for occasional module replenishment will reduce design and testing costs as well as allow the station infrastructure to be easily adapted to support research and commercial needs over time.

Scientific Benefit: Building the next great space station at a destination of scientific and tourism interest (i.e. The Moon) would allow for a significant range of scientific, commercial and exploration activities. Some intriguing possibilities include routine human sorties to the Moon, persistant low-lunar orbit observation, minerology mapping, meteotite research, resource identification and general purpose exploration.

While construction and operation of Space Station 2.0 would be handled by a third pary service provider, NASA would procure and operate a reusable lunar lander to give astronauts access to the lunar surface. The lander, a resuble craft, would take austronauts to scientifically interesting destinations not visited during the Apollo moon program. For example, according to the National Research Council's Decadal Survey, "the exploration and sample return from the Moon's South Pole-Aitken (SPA) basin is among the highest priority activities for solar system science" [1]. Deploying a long-lived network of geophysical senors would also yield valuble data needed to understand and reconstruct the evolution, makeup and dynamical processes of the moon [1]. Such a network could be installed at ground sites by human astronauts in conjunction with in-situ research and exploration activities.

From orbit, multi-spectral measurements of Earth can be conducted by astronauts and a dedicated remote sensing system can record a synoptic thermodynamic profile of entire hemispheres with high temperal and spaciel resolution. This data is only partially possible to obtain today through a combination of LEO and GEO asynoptic compsits observations [2]. Observations from lunar orbit could, thus, enhance climate change research and facilitate the development of a more robust climate model for the Earth.

Space Station 2.0 Operations:

Access to lunar orbit has historically been a complicated and expensive proposition. The emergence of several disruptive technologies however, are making regular access to a large moon orbiting facility, both practicle and affordable. These technologies, include-ing high-power solar electric propulsion (SEP), low-mass, high-volume crew modules, and the emergance of low-cost, heavy-lift launch vehicles. Logistics and operations of Space Station 2.0 will be serviced by a comination of the above technologies and commercial service providers.

Lanch of station elements will be performed by compeditivly bid heavy-lift launch services to LEO. Companies such as SpaceX are currently developing launch vehicles that lift up to 50 tonns to LEO for an estimated 100 million dollar cost. [1] Modules, fuel for the reusable lander and other consumables can be moved from low earth orbit to lunar orbit via a large commercially operated Solar Electric Propulsion tug. This highly efficient transportation scheme is the most cost effective, and perhaps, practically speaking, the only way to deliver such massive payloads to the moons orbit. [2]

All of the input technology required to build a SEP space tug exist but need to be integrated to develop a service capability. To incentivize commercial devel-opment of such a transporation capability, NASA and commercial partners must make a long term commit-ment to the lunar station and guarantee to purchase cargo delivery services at some price floor. The long-term commitment is advantageous to the planetary science community who would benefit from endrung access to the moon.

Conclusion: The justification for Space Station 2.0 is strong and multifaceted. In the aftermath of the cold-war and in the shadow of a global economic downturn the most critical and compelling reason for building a modern space station, from the government perspective, is high scientific return at a lower cost then legacy systems.

The ISS was expensive to build and provided re-search opportunities primarily to a limited community of scientific investigators. New public-private space partnerships, acquisition and operating paradigms can be leveraged to implement a more capable space sta-tion at a lower cost and with improved research results for a larger community of users. The resulting station would be a down payment on an exploration infrus-tructure that would give lunar and planetary scientists unprecidented access to the lunar surface and beyond.

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