

Space Transformation -- Localizing the Remote and Connecting the Isolated

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ABSTRACT

In motivating the Space Transformation theme for this year's 4S symposium, the organizers provided the following context, "Transformation of economies are driven by a change in values and accelerated by new technologies." These words rang particularly true when I read them at the beginning of the holiday season. Like so many others, I was in the early phases of my Christmas shopping procrastination campaign, and I'd just been reflecting on how Amazon Prime was the transformational tool I'd been waiting for. Basic limiting principles of time and space, supply and demand, were all but erased by the Amazon Prime phenomenon. Coupled with emerging 3D printing and other adaptive manufacturing technologies, a transformation from deliberate planning to "think it ... have it" had occurred, empowering me to procrastinate longer than I'd ever dreamed possible.

The organizers went on to ponder, "Will space transformation also affect society?", just as our team at the Air Force Research Lab's (AFRL) Center for Rapid Innovation (CRI) were working alongside partners within our larger Integrated Capabilities Directorate, NASA's Flight Opportunities and Small Spacecraft Technology programs, and DARPA's Luna-10 program to develop technologies and execute demonstration missions that leverage the space domain to genuinely connect even the most remote and austere domains on the timeline of need.

Picking apart the miracle that is Amazon prime, where does the model fail, and why? More relevantly to the theme of this year's symposium, how can the space domain be used to overcome its limitations and minimize its weaknesses? Perhaps it is best assessed in the context of Use Cases. What are the Amazon delivery cost, schedule, and cargo limiters to the Amundsen-Scott South Pole Research Station, or the Lunar South Pole Research Station?

This paper will explore enabling infrastructure that allows Amazon prime to thrive and assess the transformational enabling technologies that would be necessary to extend that miracle to the truly remote or the truly austere.

Localizing the Remote

- First, it will evaluate the ability of the on-going AFRL Rocket Cargo and Space Initiatives Ringside Seats systems, coupled with Astrobotic's Xodiak and Xogdor capabilities, developed to support the NASA Flight Opportunities Program (FOP), to supply orbital/suborbital delivery to both improved and austere sites on the Earth and Moon.
- Then, it will add the surface terminal distribution leg, with an examination of Lunar Outpost's Mobile Autonomous Prospecting Platform (MAPP), equipped with Mobile Autonomous Robotic Swarm (MARS) software, and Intuitive Machine's Hopper,

developed with support of AFRL and NASA's Commercial Lunar Payload Services (CLPS) program.

Connecting the Isolated

From there, it will focus on the destination, asking what implied destination services are required to support highly assured autonomous delivery.

- Specifically, it will highlight Astrobotic's Skymage mesh-networked publish and subscribe communication and navigation service, as well as AFRL's on-going developments of radioisotope and reactor nuclear-sourced thermoelectric power generation and distribution systems under development under the Joint Emergent Technology Supplying On-orbit Nuclear Power (JETSON) program by Lockheed Martin, Westinghouse, Intuitive Machines, and Zeno Power, to provide the power service to locations well off the grid.
- Finally, the paper will connect to the "human machine". What connects the remote or in-situ human consumer to the remote domain? What connects the diverse international government and commercial services to each other? The former will focus on AFRL's OraCloud feeding their Space Defense Control and Characterization System (SDCCS) and Lunar Station's MoonHacker systems, while the latter will focus on the BlueHalo/Tensor LunX Technology Platform for the Cislunar Commodity Marketplace.

In 1984, Krafft Ehrlicke famously remarked that, "If God wanted man to become a spacefaring species, He would have given man a Moon." This paper is not about the Moon, but is about humans as a spacefaring species, shedding the pesky land/air limitations of the Amazon Prime model ... so that we can all live a procrastinator's "think it ... have it" existence.