Kelli Kedis Ogborn's leadership has played a pivotal role in shaping the trajectory of companies entering the space market. She is vice president of Space Commerce and Entrepreneurship at Space Foundation and leads Space Commerce Institute, an initiative aimed at empowering countries, individuals, and companies to thrive in the rapidly expanding space economy. Her expertise includes a previous role as a contracted congressional liaison to the Defense Advanced Research Projects Agency (DARPA).

INSIGHT: LunA-10 – DARPA's bridge to the lunar economy

For space programs and companies, the Moon looms large as a contested frontier of space access and commercialization. The cadence of attempted Moon landings is increasing, preceding the hopeful launch of NASA's second and third Artemis missions. The accelerating activity around Earth's largest satellite suggests we are on the cusp of a new phase of humanity's journey in space, which could include permanent lunar surface bases, ice mining, autonomous machines, and an orbiting hub such as NASA's Gateway. Yet, these landing attempts are in keeping with the paradigm that carried the United States to the Moon more than 50 years ago. Each mission is a self-contained display of capabilities evidencing a feat of technological accomplishment. This is how the Moon has traditionally been approached, but this will not carry us into the future. If a sustainable cislunar economy is to emerge in the near term, a different paradigm is necessary.

Public and private sector organizations are having real conversations about a future cislunar economy, what it could look like and how it could be developed. In these conversations, the Moon is not a goal unto itself but instead the cornerstone and host of commercially owned and operated lunar infrastructure that powers and enables the cislunar economy. The task is to fundamentally reimagine how Moon technologies and missions are pursued and to drive toward a more integrated and strategic framework for lunar activity.

For private companies, investing in this different, bolder approach to the Moon may be compelling, but it is not immediately beneficial to the business. There is little, if any, short-term return on investment (ROI), and space investors are more attuned to risk and return now than in prior years. Thus, there is a gap in the global space economy as it relates to our future on and around the Moon, and the U.S. military's Defense Advanced Research Projects Agency (DARPA) is already working to bridge it.

Toward an integrated framework for lunar services

In 2023, DARPA released a call for applications to join its 10-Year Lunar Architecture Capability Study (LunA-10). The agency painted a vision for a lunar economy coming to fruition by 2035 and assessed that a new approach is needed to reach that goal.

Take the planned Artemis 3 mission as an example of the "traditional" approach to the Moon. When that spacecraft launches, it will bring all the systems needed to support the crew, the spacecraft and their work (e.g., power, life support and communications). It will be self-contained and isolated from other missions. Of course, Artemis III will be a science

and exploration mission, but when it comes to commercial activity, the existing model is not suited to the rapid development of privately owned and operated lunar infrastructure.

To get there, according to DARPA, what's needed is an integrated lunar infrastructure framework that charts a path from where we are today and where we could be in a decade.

DARPA selected 14 companies to take part in the project, with each researching and exploring a different facet of DARPA's vision for commercial lunar infrastructure. The goal is not to seed technology innovation but instead to collaborate in determining how to best integrate system-level solutions that cut across lunar services, specifically: lunar power; mining and commercial in-situ resource utilization; communications, navigation, and timing; transit, mobility, and logistics; and construction and robotics.

Study outcomes are expected to be integrated system designs and just as importantly, the quantitative identification of technologies and/or necessary innovation, an affiliated cost analysis, and the challenges that might stand in the way. In essence, participants are charged with discovering how to shift the paradigm of standalone, self-sufficient missions and lay a roadmap for building commercially viable lunar services and the infrastructure that enables them.

While participating in the program is prestigious and important, the companies each were awarded up to $1 million for the seven-month effort, which in the aerospace industry is a relatively small amount of money. At the conclusion of the project, participants will enjoy access to all the data and insights resulting from LunA-10, not just a portion of it. The U.S. government and participants retain unlimited rights with regard to the project outcomes, meaning the government has the right to use and share the resulting data with whoever it chooses, as will all participants. The point is collaboration on a commerce-specific endeavor — "creating off-Earth economic vibrancy through monetizable commercial services provided to a wide variety of users intending to operate on and around the Moon."

DARPA's unique role in the space ecosystem

DARPA was born out of the surprise of the USSR's Sputnik-1, the first artificial satellite in Earth orbit. That technical feat was unexpected, and Sputnik's beeping was a nagging reminder that the United States' geostrategic adversary was quickly progressing in space. DARPA was one U.S. answer to Sputnik, with the mission to create and prevent strategic surprise.

LunA-10 needs to be understood in the context of today's space ecosystem.

LunA-10 – Commercial Participants and Project Focus

Blue Origin – Power generation for lunar operations and power transmission via laser light.

CisLunar Industries – A framework for lunar Material Extraction, Treatment, Assembly and Logistics (METAL).

Crescent Space Services, LLC – Multi-Service Modular User Surface Terminals for lunar communication and navigation.

Fibertek, Inc. – Lunar surface optical power beaming and optical communications.

Firefly Aerospace – On-orbit spacecraft docking and on-demand services.

GITAI – Modular, multi-purpose robots with changeable tools for lunar surface labor from construction to maintenance and adaptation.

Helios – Oxygen extraction from lunar regolith for rocket fuel oxidizer.

Honeybee Robotics – Integrating solar power, power storage and transfer, communications, mesh network, PNT, and surveillance into a single infrastructure.

ICON – 3D-printing technologies for lunar construction.

Nokia of America – Reliable, high-performance communications infrastructure.

Redwire Corporation – Strategies for delivering lunar assets from cislunar space, including for high-speed communications and PNT.

Sierra Space – Integrating oxygen extraction, power storage and hydrogen-oxygen engine technology.

Note: SpaceX and Northrop Grumman also were selected to participate but have not released details of their project focus.

Space is more congested and contested than ever before, with 91 nations having some presence in space and multiple countries enjoying human spaceflight capabilities, indigenous launch systems, and growing private sector ambition. In this, the future of the Moon also is being contested. By convening private space companies to explore the questions, capabilities, needs, and risks surrounding lunar infrastructure, the agency advances its mission of driving (rather than reacting to) strategic surprise while mobilizing private sector stakeholders to build a framework toward the future.

DARPA holds a unique position in the U.S. government in part because it is focused exclusively on cultivating breakthrough technologies and capabilities. The agency takes a measured and strategic approach to high-risk, high-reward ventures, in space and elsewhere. As it is often said at DARPA, "If we're not making people uncomfortable, we are not doing our job."

"If we're not making people uncomfortable, we are not doing our job."

Part of the challenge of building lunar infrastructure is that the flightpath ahead is lined with unknowns. The Apollo era was driven by national directives; priorities favored national posturing, and capabilities were vertically integrated. In the era of Artemis, the vision is one geared more toward collaboration and competition, a globally integrated endeavor with science and exploration at the forefront. That requires a different approach. Yet, the missions and plans to this point still take a methodical, step-by-step approach that is challenged to reveal the complex components of thriving lunar infrastructure and services. With Artemis, NASA can plan each mission in elaborate, perfect detail, and while that may lead to a successful mission, what does it yield for the future cislunar economy? It is deliberate but slow, scientifically impressive but economically, only tangentially useful.

To break through this traditional approach, the first step is to identify the many questions that need answers, determine what is scientifically and technically feasible, understand which technologies will be needed in the years ahead, and factor how long they will take to develop. These insights inform a framework for thinking about, investing in and working toward building sustainable lunar infrastructure and economic activity.

By way of analogy, imagine taking a road trip to a new destination. One approach to navigation is to stop at stores and towns along the way and ask for directions. Am I on the right road? Is there a better way? Another approach is to write down directions before you leave and take a map, using those as a guide in finding your way, as well as sometimes asking for help. The latter approach is likely to get you to your destination more quickly, with fewer wrong turns and missed exits because you knew where you were going and how to get there before you ever left home.

DARPA is the ideal agency to promote a future-oriented approach to devising and then building lunar infrastructure. Its risk appetite aligns with investing in collaborative projects that reveal questions, needs and technological feasibility. By setting aside the launch-learn-repeat approach typical of most space missions, DARPA can step out into the unknown to identify and begin to answer questions in a non-iterative way. Not evolutionary but revolutionary.

The benefit of DARPA's investment is not just speed to cislunar activity. It can also influence common narratives about space and lunar access, which has implications for private space investment.

Impact and outcomes from LunA-10

In the space sector, the pressure to deliver ROI is intensifying. Investment trends show greater risk-awareness and risk-aversion. As reported in *The Space Report* 2023 Q4 report:

"Equity financing from sources as diverse as traditional venture capital, alternative investors and corporate venture capital (CVCs), and the public markets (including SPACs) were the fuel that propelled developing of the space sector in recent years. A geyser of funding was unleashed in 2021 but a shift in risk appetite and higher rates sent space deal volumes plunging 41% in 2022."

Firefly Aerospace was selected to create on-orbit equipment for the Defense Advanced Research Projects Agency's LunA-10 initiative that seeks to develop infrastructure plans for future lunar missions.
Credit: Firefly Aerospace

The luster of the modern space ecosystem that prompted eager investment has given way to the reality of space activity, where economic returns tend to come slower than investors might desire. This, along with rising interest rates, economic uncertainty, market volatility, and post-IPO underperformance, is weighing on investor sentiment and hampering the narrative that the space economy is a viable and growing investment domain.

One challenge is that forecasts for the future of the space economy are sometimes grounded in educated guesses rather than clear-eyed analysis. We are often betting on a hypothesis of economics in space, working off the same assumptions that might be correct – but they might also be flawed. There is a lot left to discover and understand about how to shift from isolated Moon missions to integrated and strategic infrastructure development.

Unlike private investors, DARPA does not need to measure ROI in monetary terms. It is positioned to help and incentivize the private sector to not just answer the unanswered questions but to determine which questions to ask in the first place. This puts parameters around the space economy hypotheses, moving past hype and excitement into something that is defined and where risk is more deeply understood. This is attractive to investors, and it is precisely what is needed to reinvigorate the space narrative and inspire those who will invest in the cislunar economy.

Changing narratives and tangible roadmaps can lead to new waves of venture capital and successful IPOs. This can fuel innovation and scale. Scale attracts customers and investors, fueling enterprise growth and the free market development of the Moon economy. And meanwhile, DARPA can continue its mission and invest in catalyzing an even more daring future. The flywheel of cascading value can spin fast, but it takes an organization like DARPA to nudge it into motion.

The next step for LunA-10 will come in April, when participants meet to discuss and finalize their work at the Lunar Surface Innovation Consortium. A final report is expected in June. Its contents and insights will reveal a lot about how we go forward in humanity's fast-arriving future on the Moon. ■