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[00:00:00] **John "Slick" Baum:** Welcome to the Aerospace Advantage podcast. I'm your host, John Slickbaum. Here on the Aerospace Advantage, we speak with leaders in the DoD industry and other subject matter experts to explore the intersection of strategy, operational concepts, technology, and policy when it comes to air and space power.

[00:00:16] **John "Slick" Baum:** So if you like learning about aerospace power, you are in the right place. To our regular listeners, welcome back. And if it's your first time here, thank you so much for joining us. As a reminder, if you like what you're hearing today, do us a favor and follow our show. Please give us a like and leave a comment so that we can keep charting the trajectories that matter to you most.

[00:00:36] **John "Slick" Baum:** This week, we're taking a deeper look at cislunar space operations, which represent the next frontier. For years, we've largely been focused around operations in Earth's orbit. Now it's time to expand to a region we call cislunar, which includes the moon and the surrounding volume. It's a huge amount of territory, and it involves really tough challenges.

[00:00:58] **John "Slick" Baum:** I mean, even the [00:01:00] actual physics are different. And this isn't an optional activity. China and other competitors are headed out there. Just like any form of territorial expansion, we either get there first and set the norms and standards, or we're not going to like what will happen. Just look how China is treating nations that are in the Pacific.

[00:01:17] **John "Slick" Baum:** They bludgeon their way around and seek to dominate through force. That's not what America wants, nor our allies, and we certainly don't want to see that type of behavior replicated in space. It's time we get real about this and that demands launching a new wave of exploration and a change to some mindsets.

[00:01:35] **John "Slick" Baum:** So make no mistake, this is a race and the stakes are high. That's the point of this episode. We are going to talk to some of the pioneers that are charting the next moves in this realm from both government and industry. We've been tracking this initiative for a long time, and that's why Charles Galbraith of our Space Power Advantage Center of Excellence just released a new paper helping explain what's at stake and why the Space [00:02:00] Force needs to be engaged on this front.

[00:02:02] **John "Slick" Baum:** It's called Securing Cislunar Space in the First Island Off the Coast of Earth. And I can't recommend it enough. Trust me, leaders in DC and beyond are reading it for good reason. Charles defines the scale and scope of the challenges and then makes the case for increased growth in the space force and us space command to provide foundational architecture to enable and secure a growing list of national security.

[00:02:26] **John "Slick" Baum:** Scientific and economic interest in the cislunar region. Bottom line, failure to do this risks allowing a country like China to exploit a lack of well established norms and impose the same territorial mindset they've demonstrated in so many places around the world, especially the South China Sea. Just like any successful operation on earth or low earth orbit, starting out on this journey demands situational awareness.

[00:02:53] **John "Slick" Baum:** We need to monitor activities and to identify irresponsible or aggressive behavior. And that's why we're excited about the Air [00:03:00] Force Research Labs Oracle program. It is a lead pathfinder. So with that, we are thrilled to welcome to the podcast, Dr. Jamie Stearns, the AFRL Cislunar lead. Dr. Stern, welcome to the show.

[00:03:14] **John "Slick" Baum:** Thanks. We are also excited to have Bradley Cheatham, the president of Advanced Space. They are leading the team building Oracle, a team that also includes players like General Dynamics and Leidos. Advanced Space also owns and operates Capstone, a spacecraft mission currently in lunar orbit, and is a pathfinder for NASA.

[00:03:34] **John "Slick" Baum:** So Brad, thank you so much for being here. Yeah, thank you very much for having me. And of course, last but not least, we have Charles Galbraith. Welcome back and congratulations on the new paper. Thanks, Lick. Always great to be here with you. All right. This is really a great crowd again. Cannot say thank you enough.

[00:03:50] **John "Slick" Baum:** really exciting time. And Charles, I want to get started with you. this report is incredibly interesting for our listeners. You can find a free copy on our website at Mitchell aerospace power dot [00:04:00] org and click on the publications link on the top of the page where you can download it. Watch the raw video.

[00:04:05] **John "Slick" Baum:** Really has a tremendous lineup, uh, with leaders in this area and download the charts as well. So with that, uh, what's the response, uh, to the paper been like so far and, uh, really to start what prompted you to write this paper Charles? Yeah. So like, so there's a lot going on, in the CIS lunar environment and, and missions headed to the moon.

[00:04:24] **Charles Galbreath:** Uh, you know, we're currently in the throes of, uh, the third mission already in 2024, uh, to the moon, which is incredible. And that's just going to picking up over the next several years, uh, throughout this entire decade with over a hundred missions, uh, by 2030. So that, that really prompted me to try to dig into, uh, this topic a little more to understand what are the challenges of going back to the moon.

[00:04:49] **Charles Galbreath:** why go in the first place? Uh, and, and really that was eye opening for me. And the response has been really incredible. there's been a lot of interest, in going back to the [00:05:00] moon and these missions, uh, I've had a lot of positive feedback on, on the report itself. A lot of people really resonated. Uh, with the analogy of, uh, for size comparing the earth to a basketball and the moon to a tennis ball at the top of the three point arc.

[00:05:14] **Charles Galbreath:** So a lot of folks really appreciated the, sort of the, the simple language I tried to put this very complex topic

[00:05:20] **John "Slick" Baum:** into. Yeah, it really is incredible. Cislunar is huge. I mean, on a scale that's hard to even conceptualize and keeping track of the activities there is a real challenge. And Dr. Stern, given, uh, the race of the moon and the national security implications this entails, uh, how do you describe where the Oracle program and the overall, research AFRL is in with, Cislunar fitting into these circumstances and why the efforts are so important?

[00:05:48] **Dr. Jaime Stearns:** Well, as Charles said that the number of spacecraft going to the moon just keeps growing. Um, I think we're, we're expecting there to be something like 100 objects in space by 2026. Now, that's a mix of, [00:06:00] uh, active satellites and typical, uh, launch related debris like rocket bodies. These numbers are going up fast.

[00:06:06] **Dr. Jaime Stearns:** Um, and if we want everyone to be able to operate in an environment that's transparent, that's safe, you know, we need to be able to monitor all the activity. That's where space situational awareness is really, really crucial. And AFRL's research in this area is really focused on the technical challenges.

[00:06:22] **Dr. Jaime Stearns:** You know, this is the moon is more than 10 times the distance that the Department of Defense is used to having to keep an eye on things in space that ends up being a thousand or more times the volume that we're used to searching for objects. And we have a whole network that we've built out over decades that is really optimized for geo and below.

[00:06:39] **Dr. Jaime Stearns:** So really finding the ways that we can do that more sensitive sensing really deal with the challenges of that distance and volume is a huge piece of it. The 2nd part is just. The chaotic dynamics, um, Charles talked about it well in the paper that there's these 3 body dynamics that lead to, you know, a lot of really unusual behavior that we're not used to seeing, um, just because we're so used to thinking [00:07:00] of simpler orbits closer to earth.

[00:07:02] **Dr. Jaime Stearns:** So, we need to do a lot of S and T in order to develop the technology to track objects under those circumstances. And then finally, the physics is just hard. There's, you know, a week every month that if you try to monitor a spacecraft around the moon from the earth, you're just staring into the sun during that time because of the phases of the moon and the way that works.

[00:07:21] **Dr. Jaime Stearns:** So we built up the Oracle mission in order to actually go out into cislunar space to overcome that solar exclusion challenge so that we can do a better job of keeping track of all this traffic that we expect over the next

[00:07:32] **John "Slick" Baum:** few years. Dr. Stern, thanks for that breakdown. And, you know, with a lot of the.

[00:07:36] **John "Slick" Baum:** quantifiable, things that you just said really, it's hard to wrap your head around how, how big this volume is. And I know we talked about it in the, in the intro and Charles talks about it quite a bit, but, uh, your description really makes it, Really hit home on, on what a challenge this is.

[00:07:51] **John "Slick" Baum:** And Brad, advanced space, isn't just a lead contractor for Oracle. You're also, running the capstone mission. So why is that important in the context of [00:08:00] pioneering, cislunar operations? I mean, you guys are the real technical pioneers.

[00:08:05] **Bradley Cheetham:** Absolutely. So our team has been operating at the moon for over 450 days over this time period, we've been successfully navigating the spacecraft and maintaining a high value three body orbit, uh, in a near rectilinear halo orbit or N.

[00:08:20] **Bradley Cheetham:** R. H. O. And this is the location that's planned for NASA's lunar space station called Gateway. This would be the foundation for our humanity's return to the moon this time to stay. And this is really critical flight Experience that builds on over a decade of development and support, learning how to do navigation, communications and spacecraft operations.

[00:08:40] **Bradley Cheetham:** And as you mentioned, we're really pushing the state of the art on new technologies, things like position, navigation and timing technologies, as well as learning lot of lessons from flying in these orbits. that will inform several subsequent programs, including the Oracle program for AFRL, as well as we're supporting the Draper and iSpace teams to [00:09:00] do a far side landing and we'll be managing the relay orbiters for that mission.

[00:09:04] **Bradley Cheetham:** And so ultimately, cislunar operations, as Jamie mentioned, are very different than more traditional earth orbiting missions. And so part of what we're doing under capstone is we're building that sort of muscle memory and that capacity so that we can efficiently support all of these programs, including the Oracle flight experiment for AFRL.

[00:09:22] **Bradley Cheetham:** All those lessons learned ultimately are buying down technical and programmatic risk so we can push the state of the art for the space situational awareness mission.

[00:09:31] **John "Slick" Baum:** Absolutely. Again, like we said, you guys are just the leading the charge here. and, you know, again, we, touched on this already, but the scale and scope of the cislunar awareness mission is just huge.

[00:09:41] **John "Slick" Baum:** and this is one of the questions we didn't have time to address in the rollout. So we're excited to be able to talk about it here. and, you know, we struggled today to maintain enough domain awareness of things happening in geo and below. So is it really feasible to accomplish this mission for the massive volume of cislunar space again?

[00:09:58] **John "Slick" Baum:** people have trouble understanding the, [00:10:00] the breadth and the dimension that's at play here. And it's like, uh, comparing the scale of a country to a continent. Yeah, I think that's, that's a great analogy and I think it just comes down to priorities. Um, you know, both from a research perspective and eventually, you know, where, where the space force decides to spend its money, the 1st thing that we prioritized when we got into this business was getting as much as we can out of what we have today, right?

[00:10:21] **Dr. Jaime Stearns:** We don't need to throw away the space surveillance network that we already have today. We just might need to make some tweaks to it, figure out how it can be, you know, maybe re optimized. To work on cislunar objects as well. The 2nd prioritization that we focused on was the earth moon corridor. It is the most technically challenging, like, I talked about before, because of solar exclusion.

[00:10:41] **Dr. Jaime Stearns:** It's the 1 place that you just simply cannot do from the earth. And it's also the place that's going to have all of the traffic in the near term. So everything going from the earth to the moon, you know, will interact with. Things in every other orbit on their way out and for sample return missions for human spaceflight on their way back as well.

[00:10:58] **Dr. Jaime Stearns:** So we identified those as kind [00:11:00] of our key priorities within the research program, saying eventually we're going to have to look at the entire sphere that's within, you know, the moon's distance. But we can't do that today. We're going to eventually need to look at low lunar orbit. That's not the place to start either.

[00:11:14] **Dr. Jaime Stearns:** So I think it's just, it's really about prioritizing and deciding where you need to focus your attention 1st and doing the foundational work and then rolling out the

[00:11:23] **Bradley Cheetham:** rest later. And I'll just add, I think it's absolutely feasible to the root of your question. And I don't really believe that we have a choice but to work towards addressing this need.

[00:11:34] **Bradley Cheetham:** There's a lot of areas of awareness that can be improved for lower orbits, LEO to GEO, for example. And at Advanced Space, we have several projects working on scaling the ability to detect, track, and catalog at scales previously unimaginable for those lower orbits. And so they certainly want to improve that.

[00:11:49] **Bradley Cheetham:** But that being said, while we have some coverage, Of these lower orbits, which we certainly can improve, we really have minimal coverage to support safe operations above geo. And so from my [00:12:00] perspective, I think this has to be a high priority to develop this awareness because we ultimately, we need to prevent strategic surprise.

[00:12:06] **Bradley Cheetham:** And I think we also need to set international precedents more broadly. And I also think as it relates to this question, it's important to realize that this lunar is not totally independent. from lower orbital regimes. So the tools we need in space and on the ground for cislunar will enhance our operational resilience for lower orbits.

[00:12:25] **Bradley Cheetham:** And in fact, in advanced space, we're developing some some novel solutions that we think will provide what we refer to internally as over the top resilience to lower orbits. So we believe that cislunar can serve as a high ground in space. To provide not just awareness, but also resiliency in the areas of PNT and C2 for lower orbits and terrestrial users.

[00:12:44] **Bradley Cheetham:** So I think, I think it's something we have to address. And I also think it's important we think of addressing it as a total package. It's not one or the other, but, but I think both will, will improve as we advance these technologies.

[00:12:56] **Charles Galbreath:** Yes, look, I'm just going to pile on to what Dr. Stearns and Brad talked [00:13:00] about.

[00:13:00] **Charles Galbreath:** Um, first of all, priorities, absolutely we have to have the right priorities as we move forward and we're never going to know everything about, everywhere all the time. And so we have to understand where are those key lines of communication that we're going to need to be monitoring? Uh, what are those, uh, key real estate areas, uh, in space that we're going to have to have to watch out for?

[00:13:21] **Charles Galbreath:** And then are there are there specific activities that we're going to want to be monitoring with extra attention? I assume that as we conduct human space flight to the moon, that will probably garner a lot more attention and want to be tracked a lot more closely than maybe some of the other robotic missions.

[00:13:38] **Charles Galbreath:** And then, you know, Brad talked about the, the high ground and, and, uh, avoiding operational surprise and, and that's really one of those other things that, that, uh, prompt me to, to think about this topic is, uh, when I wrote the counter space paper last year, you know, I alluded to the fact that, China could, put a spacecraft on a trajectory around the far side of the moon.

[00:13:58] **Charles Galbreath:** and reenter and an [00:14:00] impact, uh, not, not in a physical sense, but to have an impact on, spacecraft NGO or below. And this would be an unwarned, uh, potential attack. So maintaining awareness of this regime is critical from a national security perspective, as he, mentioned.

[00:14:16] **John "Slick" Baum:** Yeah. And, you know, Brad mentioned, you know, buying down risk and, and what you had just mentioned about, the Chinese potentially going to the, far side of the moon and, and then coming back to, is that something that you see as a direct threat to, to our satellites and in orbit around earth?

[00:14:30] **John "Slick" Baum:** It's certainly a

[00:14:31] **Charles Galbreath:** realistic threat that could be manifest. Now, are they actually planning to do that today? They will of course say no. Having a satellite that can conduct communications on the far side of the moon and so far they are the only nation to have an asset land on the far side of the moon as well.

[00:14:49] **Charles Galbreath:** That sets up the necessary infrastructure to enable that sort of attack. And so anything we can do to improve our awareness of that region where we currently have [00:15:00] basically Little to no eyes is absolutely

[00:15:03] **John "Slick" Baum:** critical. I just want to give the opportunity for Dr. Stearns or Brad to tap in on that one.

[00:15:09] **Dr. Jaime Stearns:** Yeah, I think I would say there's, there's kind of 2 priorities there, you You guys mentioned human spaceflight. Obviously, that's always going to be a top priority, making sure that those extremely high value assets we send out to the moon, uh, make it back safely. So support to that will always be a high priority. And I think beyond that, part of the reason we focused on the Earth Moon corridor is that regardless of the type of activity.

[00:15:29] **Dr. Jaime Stearns:** You know, anything that's transiting in that corridor potentially presents a risk to to the rest of satellite operations. Um, we've seen recently that, you know, space is hard. Uh, a number of missions have not quite made it to the moon or crashed when they got there. And we just need to be able to understand where even those objects are the most well intentioned of operators doing almost everything right, uh, still presents risk.

[00:15:51] **Dr. Jaime Stearns:** And so a lot of our attention is focused on, on just trying to make sure we understand what's going on in that corridor

[00:15:56] **Bradley Cheetham:** today. Yeah, I'll just say we certainly [00:16:00] support AFL's perspective in this regard completely. Um, and, and from a commercial perspective, independently of thinking about this problem, my co founders and I started advanced space over 13 years ago, our goal is very explicit.

[00:16:13] **Bradley Cheetham:** It was purpose driven entity was to enable the sustainable exploration development and settlement of space. So we look at these problems through how, how are, what we're doing now, setting a precedent that will enable that future and critical to that vision, as we've alluded to in this conversation is that we have to have safety of flight and security across all these domains.

[00:16:32] **Bradley Cheetham:** Specifically, we believe, you know, CIS lunar development is only going to be successful from a commercial perspective, from a sustainable perspective, if it's led by. Western values of freedom and capitalism. And so ultimately, as we look forward to what's going on now and how that's setting a precedent for the future, you know, we own a satellite that's flying at the moon today as a company, we own that, right?

[00:16:53] **Bradley Cheetham:** So awareness, security, and transparently is something. And transparency is something that's very acutely important to us [00:17:00] because our commercial asset is operating there. And so I think as we look forward, as it relates to these capabilities, this is really, to me, a fundamental enabler to the future that we want to create.

[00:17:10] **Bradley Cheetham:** And that's why, in my mind, it's not really an optional thing to figure out. We have to figure it out because that's how we're going to get to the future that we're all working towards.

[00:17:18] **John "Slick" Baum:** Yeah, absolutely agree. And great point. And Dr. Stearns, I want to pull on, uh, one of the strings that, you left hanging for me there, you know, speaking of the importance of crewed missions, you know, NASA is a driver, or I'm sorry, in the driver's seat, uh, on our return to the moon.

[00:17:32] **John "Slick" Baum:** But, you know, there's a strong relationship between the Department of Defense and NASA on those efforts, you know, from the government and industry perspectives, uh, how are you working with NASA to ensure that the whole of Uh, government approaches being taken and any observations that you have on what is working well and where you'd like to see some improvement or maybe some efficiencies.

[00:17:53] **Dr. Jaime Stearns:** Sure. I think, you know, we, we work with NASA on a number of different fronts. I think the, the single biggest one is like you said, they, they've [00:18:00] done this before they are doing this today, um, in terms of flying in cislunar space. So drawing on, you know, the expertise that they have at a number of, of the NASA centers.

[00:18:10] **Dr. Jaime Stearns:** Um, As far as guidance, navigation, control, mission planning, things like that, we're looking into ways that we can work on communications together, you know, whether it's, us using it, NASA assets, like the deep space network as needed for our programs. or whether much further in the future, go out and start building some networks together.

[00:18:28] **Dr. Jaime Stearns:** These things are all under, discussion right now, but it might surprise people a little bit. I think the area that we actually work most tightly with NASA right now is the planetary defense coordination office. when I mentioned we started up this research program, one of our highest priorities was figuring out what we could do without having to spend any more money.

[00:18:44] **Dr. Jaime Stearns:** Right. Just what can we do with what we have today? And it turns out, you know, planetary defense has enormous telescopes that survey the sky every night. all year long looking for killer asteroids. And we were able to siphon off some of their data that they they mark as artificial satellites. And we can [00:19:00] pull that in and use that to kind of seed a prototype cislunar object catalog, use that for development of different algorithms, orbit determination, things like that.

[00:19:09] **Dr. Jaime Stearns:** So that has been a really, really successful collaboration that I just wanted to highlight for everyone.

[00:19:14] **Bradley Cheetham:** You know, I'll add, I think as it relates to collaborating with NASA, you know, we at Advanced Space are supporting NASA, both certainly through the Capstone mission, but also directly supporting the teams that are working on Artemis and Gateway.

[00:19:27] **Bradley Cheetham:** And this collaboration has really been seamless in terms of the integration of, of information sharing and lessons learned between our, what we're learning on Capstone and what the NASA teams are working on to develop the plans and the systems to return humanity to the moon. The plans is time to stay, right?

[00:19:44] **Bradley Cheetham:** So that collaboration is really at the core of, of a lot of the work that we do at CIS lunar from advanced spaces perspective. I think also, as we think about humans going into deep space, just like today, the department of defense monitors low earth orbit, uh, in order to protect the safety of us [00:20:00] and international astronauts on the international space station.

[00:20:03] **Bradley Cheetham:** Our expectation, as we look to this problem from industry's perspective, at least, is that we expect that as crew, you know, us and international are going into the cislunar environment, they're going to land on the moon during future Artemis missions, or they're operating on the gateway space station there.

[00:20:20] **Bradley Cheetham:** We believe that the expectation will be that in a similar way. The department of defense will be providing that awareness and that knowledge to protect just American astronauts, but international astronauts as well, I think that's really an important consideration here, right? The idea of having awareness in space is not a new idea at all, certainly, but, but going into the system or domain, I think that requirement will follow as, as we send, you know, our national heroes and our foreign allies heroes to the, to the moon, uh, that requirement is going to flow.

[00:20:48] **Bradley Cheetham:** And so I think as, as it relates to. So Oracle and the programs that AFRL is leading right now, this is sort of the vanguard for that, that safety of flight mission that I expect will be [00:21:00] flowed down formally as we start looking into those future, future areas.

[00:21:04] **John "Slick" Baum:** Yeah. It really has to be an all hands, uh, collaboration to, to take all the assets that we have available to, to paint this picture.

[00:21:10] **John "Slick" Baum:** And, uh, Charles, I've got to ask you, Obviously, you know, I think it's important to highlight that the military component of the mission is really important. So, why is the Space Force's presence essential? You know, if we're thinking about exploration, we normally put that in NASA's job jar.

[00:21:24] **John "Slick" Baum:** So where, where do you see the Space Force contributing here? Yeah. Uh,

[00:21:28] **Charles Galbreath:** thanks, Slick. And I, I think Brad really began to, to hit on this when he talked about the expectation is that the military is going to continue to provide some of that domain awareness and safety of flight. That we've done for low earth orbit and geosynchronous orbit and below the same type of capability is going to need to be, uh, provided for the cislunar environment.

[00:21:49] **Charles Galbreath:** And, and further, additionally, the military has since the creation of our country, really, uh, been able to pave the way for others to follow [00:22:00] in the paper. I talked about Lewis and Clark. I talk about the internet. I talked about the use of GPS, other things. These are capabilities developed. By the military, for the military, but then they have incredible, uh, application or open up new frontiers for others to follow.

[00:22:15] **Charles Galbreath:** And I think in the same way, if the military can provide some of that basic infrastructure that they're going to need to have in order to secure those interests in the moon and in the cislunar environment that, uh, you know, their charter is to protect, then those same capabilities can help accelerate the commercial and the civil activities, uh, that we all want to see flourish.

[00:22:38] **Charles Galbreath:** And so anything we can do from a military perspective to help. Foster that to accelerate. That is goodness, especially when they have to do it anyway, in order to secure those interests.

[00:22:48] **John "Slick" Baum:** Yeah, absolutely. And, you know, I've got to ask as the Artemis Accords, uh, exemplify and and the Mitchell, Institute paper highlights, uh, the United States isn't doing this alone.

[00:22:57] **John "Slick" Baum:** so how are we working with our partners on the [00:23:00] developmental, uh, excuse me, the development of capabilities, architectures, and sharing of information. I've been really happy to see over the last few years, a real emphasis on what I like to, you know, with air quote called getting to yes, foreign, right?

[00:23:12] **Dr. Jaime Stearns:** Let's figure out how to share things with our allies instead of just immediately knee jerk stamping everything. No foreign. it really opens up opportunities for data sharing in both directions. Um, I know one of the tenants on, uh, the Oracle Prime flight program is that we really want to be able to share that data as widely as possible.

[00:23:28] **Dr. Jaime Stearns:** You know, we don't, it doesn't need to be classified. Let's not classify it. Let's keep it as a, at as low of a level as we can make sure that we can, we can share it with our allies. We can help develop their capabilities with it. We can open it up even to the whole research community to start developing that next generation of tools that we need.

[00:23:44] **Dr. Jaime Stearns:** So I think the data sharing, everything seems to be moving in the right direction on the data sharing front. Um, and I'll say just more broadly, you know, we're very interested from a research perspective in working with any other moonfaring nations. It makes sense. We all want to go out there safely.

[00:23:59] **Dr. Jaime Stearns:** [00:24:00] Let's team up and figure out how to do that. You know, those, those things happen, uh, slowly and they happen when they happen, but it's something we're very

[00:24:06] **John "Slick" Baum:** interested in. Dr. Stearns. I have to admit, uh, yes, foreign. I, I love the concept and I'm going to steal that because that, that is absolutely what we need to be doing.

[00:24:17] **John "Slick" Baum:** Um, you know, it's just getting to that. Yes. And starting to, to make this information more accessible to, to the decision makers and not have it locked up, uh, behind some. some sort of security, uh, craziness. Um, but moving on another question from the rollout that we couldn't get to, uh, was a need for technical, uh, workforce with, you know, a strong understanding of the unique challenges of cislunar space.

[00:24:38] **John "Slick" Baum:** And, you know, Charles, you advocated for the growth of about 200 dedicated guardians. Uh, so how deep does this understanding of, uh, astrodynamics need to be for this cadre? Yeah, thanks. Like,

[00:24:49] **Charles Galbreath:** so the growth of 200 guardians to focus on cislunar activities, um, you know, I, I think is really critical because this is a difficult area.

[00:24:58] **Charles Galbreath:** And it's going to require some, [00:25:00] some specialized thinking. So the growth is spread out across acquisitions, operations, staff, and training. And the level of knowledge you're going to need is going to vary from position to position. I think there's going to be a general need for, I think, every guardian to have at least some fundamental understanding of what it is when we talk about cislunar and the three body problem and things like that.

[00:25:20] **Charles Galbreath:** but then for those, uh, 200 or so guardians that are going to, that are going to focus on this, they need to be steeped in, in the understanding, of the complexities of cislunar operations. And I honestly think that there's going to be a smaller cadre of that. That's, you know, at a master's level of understanding, and maybe even a few that are at a PhD level.

[00:25:41] **Charles Galbreath:** Um, understanding what it is to operate in cislunar, how the trajectories work, what are the, um, natural, um, threats and hazards that, uh, our spacecraft and our, and our, uh, crewed, astronauts are going to be experiencing as, as they journey out there and, and how [00:26:00] that all fits together. This is going to help us not only articulate what the military will provide.

[00:26:05] **Charles Galbreath:** But how we can work with the civil and commercial entities as well, um, on a level playing field to make sure that we're all working on this together towards that common objective of success.

[00:26:19] **Dr. Jaime Stearns:** I think Charles has hit on something so important here. Um, you know, it, it, it takes a PhD in astrodynamics to understand a lot of what goes on in space right now, or it takes spending, you know, two years around one to begin to understand and build up that intuition. I think there needs to be a really active effort to get that training.

[00:26:38] **Dr. Jaime Stearns:** Into the Space Force at all levels and kind of throughout, you know, the whole the cadre of guardians, um, you know, groups like AFRL other expert organizations applied physics lab is another one. You know, we provide support where we can. Um, but we need to get our tools and our training. To a point where an operator who doesn't have a [00:27:00] phd in astrodynamics still has an intuitive understanding of what's going on on the screen in front of him or her because that that system or knowledge has just been built in from the beginning.

[00:27:09] **Dr. Jaime Stearns:** And I think the other challenge we have in the near term is, we have a cadre of guardians who have built up a lot of mental habits that are based on normal two body dynamics and more, more rigid earth orbits, and in order to get out into this lunar space and have them thinking the right way out there, there's some bad habits that need to be unlearned.

[00:27:29] **Dr. Jaime Stearns:** So there's going to be kind of that extra hump here in the near term. Um, and in fact, some of that is actually an active area of research within AFRL is, you know, what kind of information should you be putting in front of a. You know, normal operator who doesn't have a Ph. D. In physics. Um, how do you actually train a person like that to understand this correctly?

[00:27:45] **Dr. Jaime Stearns:** You know, in a physics informed way, but where they don't need to be able to drive the equations. Interesting. I think this is so important. I'm glad it's something that

[00:27:51] **Bradley Cheetham:** Charles brought up in the paper. Yeah, let's echo that. I think the inclusion of this topic in the paper was so important [00:28:00] because I don't think this is a topic that can be overemphasized.

[00:28:03] **Bradley Cheetham:** So fundamentally, as I see it, our ability to support space operations in any region of space, but in particular insists lunar, uh, this is going to be constrained by the availability of trained and equipped people that have the experience and capacity to support those operations. Right? So an advanced space are, Sure.

[00:28:20] **Bradley Cheetham:** All of our success, all of our work has been enabled by the incredible team that we've assembled, which includes people with PhDs and master's degrees and decades of experience, right? And all of that knowledge and wherewithal and experience has been deployed to overcome a lot of challenges that we've encountered on our capstone mission and on other projects.

[00:28:39] **Bradley Cheetham:** But with that in mind and thinking towards the future, thinking, how are we going to see these operations scale? We're also investing in the technologies and they're intended to be built, to be resilient. At scale. And so we think another key part of this, once you have the right people that are well informed and intentioned is that you need to have automation and autonomy, both on the ground and onboard [00:29:00] spacecraft in order to do safe and resilient future mission operations, because the scale that with which these things are going to grow in numbers and in complexity is only going to increase.

[00:29:09] **Bradley Cheetham:** And so, as I think about, like, how do we attract the The right people and motivate the right people. I'll say for a personal example, for me, I have something I call the toddler test. This is, you know, something for me that works. I have three young children and most days they'd rather me just stay home and play with them instead of going to work.

[00:29:26] **Bradley Cheetham:** So for me, the toddler test boils down to what's the reason that I'm going to tell my, my toddlers that I have to leave to go to work. And it's got to resonate with the toddler, right? It can't be this esoteric complex explanation. And so for me, that explanation is it. No daddy goes to work to help people go to the moon.

[00:29:43] **Bradley Cheetham:** And so far that seems to satisfy them most of the time. But I think it gets the root about what we're talking about here, right? We're talking about the future of humanity. And I think, uh, that's a heck of a motivator. And I think as we really say that out loud and are very explicit in our goal of, of leading the future of, of where our [00:30:00] species is going to go in space, I think that will help us to bring and identify the right people and motivate them through, because the other thing here is, is none of this work is easy.

[00:30:09] **Bradley Cheetham:** Right. This is really complicated. I think Jamie said earlier, right? I think if space is hard, this lunar is harder and we've seen that over and over again, and that requires really capable people, but they also have to be motivated. Right there. This is not the easy button of a career path for anybody, whether they're in the space force or civilian or commercial.

[00:30:26] **Bradley Cheetham:** And so we really have to pull that together. Uh, so that's how I think about this. It's really all about the people and then build, giving those people the right tools.

[00:30:33] **John "Slick" Baum:** Yeah, and, and just really to hammer that home, when Dr. Cern said, you not only need to have the PhD, you need a year or two hanging around somebody else who's been doing the work for a while, really just to get, you know, the broader understanding and application.

[00:30:47] **John "Slick" Baum:** So, uh, it is a long road to get there, but, uh, to your point, it's super important if we want to get our species, uh, you know, to be in. Cislunar and beyond, uh, we need dedicated folks that really, uh, just care [00:31:00] to want to get, uh, you know, to go to work and do this for humanity. Um, and that kind of as the baseline, this goes into my next question for all of you.

[00:31:08] **John "Slick" Baum:** Um, if we look at things 10, you know, 20 years into the future, what does success look like? And what would failure entail? You know, just so we really can understand, um, what's at stake here, especially considering how tight our resources are for

[00:31:24] **Dr. Jaime Stearns:** this. I'll jump in and say, I think I think success is that the moon is a stable and transparent.

[00:31:31] **Dr. Jaime Stearns:** Hub of activity, and our eyes are starting to turn to Mars or asteroids or whatever the next step is. I think failure is. Something bad happens that would've been avoidable Had we made different decisions today and would we get scared and back off the exploration in the

[00:31:47] **Bradley Cheetham:** commercial development? Yeah, I'll say that.

[00:31:51] **Bradley Cheetham:** And it may be cliche, but, but I think failure is not an option in this regard. Uh, I refuse to hand over. You know, a world to my children where we have [00:32:00] not been successful in these efforts. And so I think to me, the focus needs to be on what's it going to take to be successful as Jamie mentioned. And I think that looks like security and transparency in space everywhere, including cislunar.

[00:32:11] **Bradley Cheetham:** I think it looks like a sustainable economic expansion from earth to include the moon. And I think that will result in dozens, if not hundreds of concurrent missions in cislunar space at any given time. And that's a massive step function increase. From what we're seeing today. And so I think to think about that, we're going to have to have, uh, you know, earth independent position, navigation, and timing and comms that have to be able to scale, we're going to need those highly automated flight operations tools.

[00:32:38] **Bradley Cheetham:** Cause we're not going to have enough people to do all these things manually, like we do it today. And I think also what we're going to see, and hopefully in the 10, 20 year time horizon is we're going to see us commercial companies. Deploying infrastructure that can be utilized not just by commercial users, but by NASA, by national security customers and by allies.

[00:32:57] **Bradley Cheetham:** So I think what we'll hopefully get to is, [00:33:00] is a very robust architecture that is, is, is interoperable. And that is really laying the foundation for that step beyond the moon. As Jamie mentioned out to March. Yeah,

[00:33:11] **Charles Galbreath:** I agree with your, Positive vision of what success looks like in 10 to 20 years.

[00:33:16] **Charles Galbreath:** maybe I'm a little more pessimistic about what a failure might look like. Because to me, a failure isn't just that we haven't succeeded, but that we have been unable to create the infrastructure that we need to monitor activities. Meanwhile, a potential adversary like China has succeeded, uh, and they are able to exploit those resources, take advantage of that gravitational, uh, assist around the moon, uh, and can do things in cislunar space without us, uh, even being aware of it, that not only affects cislunar, uh, but, but geocentric and below and therefore everybody on the planet.

[00:33:51] **Charles Galbreath:** And basically we would be seeding. Uh, not just the moon, but ultimately the whole space, uh, enterprise, uh, to a potential adversary. If, [00:34:00] if we don't get this right. Uh, in the cislunar environment, you know, something that's, that's been constant since, uh, the right stuff, the quote, you know, no bucks, no buck Rogers.

[00:34:10] **John "Slick" Baum:** Right? So it just seems like everybody is tight on resources these days, especially with the budget caps and continuing resolutions and so many competing demands. Uh, you know, the space force says it all the time that they're slammed handling missions closer to earth. So, Is this a mission where we can grow our way, you know, from a crawl walk, run type of fashion.

[00:34:31] **John "Slick" Baum:** And, you know, Charles, I think you've referred to this as a, as running a marathon. Yeah. It's one of those activities that's a marathon because you have to stay there the longest and be able to endure. Uh, but there is also the, the sprint, uh, aspect of this. And that is the nations that get there first will help establish the norms of behavior and the policies, the going forward.

[00:34:54] **Charles Galbreath:** And is that going to be transparency? Uh, through the Artemis Accords. Or is that going to be secrecy through, you know, [00:35:00] some coalition between China and Russia? and so there's, there's a combination of both. And for those that are concerned about the cost, yeah, cost is always going to be a factor. but let's take a look at the cost of taking these incremental steps to establish the capabilities that we need, uh, versus the cost of, uh, sitting back for a while, uh, letting someone else take an advantage and then trying to catch up Later, that's gonna cost a lot more money.

[00:35:27] **Charles Galbreath:** it's gonna take time that frankly, we won't be able to get back. and so for me, cost of doing nothing far outweighs the cost of moving forward in a smart way today.

[00:35:40] **Dr. Jaime Stearns:** I totally agree with that. I think. Crawl, walk, run, you know, iterative approaches are, are almost the only way we can start solving this problem because it is so big.

[00:35:48] **Dr. Jaime Stearns:** I talked earlier about, you know, priorities that we have at AFRL through a couple of different lenses, um, just using what we have first. Like, let's just see what we can do when we have nothing. And then let's start to spend little bits of money [00:36:00] smartly. Um, we've been talking about, you know, Brad and Advanced Space are building the Oracle satellite for us.

[00:36:05] **Dr. Jaime Stearns:** We really call it Oracle Prime in house because it is the prime mission that's meant to go to space. You know, it's designed to go study how to do space situational awareness out in cislunar space. But it has a predecessor mission that we call Oracle Mobility. And this was kind of a convergent evolution of a couple of programs at AFRL that, uh, both decided to go after the moon at more or less the same time.

[00:36:27] **Dr. Jaime Stearns:** Uh, Oracle Mobility was really meant, like its name suggests, to go out into cislunar space and just see what maneuvering around is like, learn how to operate, learn how to communicate, build first generation mission planning tools. Um, it will also do some SSA, but it's not custom built to do that the way that the way that Oracle Prime is.

[00:36:47] **Dr. Jaime Stearns:** And so we're even trying that iterative approach just with what we can pull together, uh, on the flight experiment side at AFRL. And I'll

[00:36:54] **Bradley Cheetham:** just add as it relates to the resources, I think one of the [00:37:00] Key for space force working with industry and whether our industrial base here in the United States, which is unmatched in the world.

[00:37:06] **Bradley Cheetham:** We need to be able to unleash that and unleash that we need to have clear congressional direction in terms of authorizations and appropriations and budgets. I think 1 of the challenges we have in a lot of these programs broadly is the sort of. Hit and miss, hesitation on allocation of budget and proceeding with new programs that is caused by that uncertainty at the top.

[00:37:27] **Bradley Cheetham:** And so from our perspective, we need clarity there. We need priorities there from Congress. That's their, their job here. And then industry and government need to work together. To go do and get at these missions. And I think as we proceed with those missions, we have to have a real sense of urgency because I think this is a time sensitive mission need, but I also think we have to be realistic that, you know, resources in terms of time and money are not, uh, you know, in abundance.

[00:37:51] **Bradley Cheetham:** We don't have the time or the luxury of reinventing the wheel. And starting these things on, you know, independently and having all these bespoke solutions. So I [00:38:00] think Space Force must, and I think to their credit, they have, uh, leverage. We must leverage these existing capabilities in order to amortize and buy down schedule, technical and budget risks.

[00:38:10] **Bradley Cheetham:** I think that's through direct and indirect collaborations with other users. We've seen these experiences from capstone or feeding NASA. They're also feeding Oracle and other programs. I think we have to get to a future very quickly, uh, where we have solutions to these problems. And I don't think we have the luxury of having a space force solution and a NASA solution and a commercial solution that all get at the same problem and are all developed totally independently.

[00:38:35] **Bradley Cheetham:** We really have to come together. And it has to be a team effort across the whole industrial base to get at these problems, because I really think we have to move forward with a true sense of urgency. I think, as I alluded to earlier, right, this isn't a nice to have capability. I really think it's a need to have capability.

[00:38:53] **John "Slick" Baum:** And Brad, you know, having you here with your experience, I just really want to continue that, uh, that thought, you know, but, but from [00:39:00] an industrial based vantage point, you know, why is, uh, steady and sustained investment so important if we want to realize the operational system and our capabilities.

[00:39:09] **Bradley Cheetham:** Sure, maybe I'll kind of build on that, that team sport mentality, right?

[00:39:12] **Bradley Cheetham:** I think steady and sustained investment is absolutely critical for maintaining the teams and the individuals that have demonstrated the capacity to overcome these challenges and operate in what are very complex environments. And so, you know, maybe a slightly corny analogy, but I like to think of it sort of as like the Super Bowl winning team, right?

[00:39:31] **Bradley Cheetham:** You know, these exist in our industry, uh, specifically in advanced space. We overcame a lot of challenges to get Capstone to where it is operating today. So I would argue in some analogous way, we sort of won the Super Bowl of sooner space. But right, if, if we won the super bowl system in her space, uh, you know, and we do not get to play the next season, right?

[00:39:50] **Bradley Cheetham:** If we don't have the opportunity to keep that team together, then I think not just as a company, but as a, as a country, we lose that. Some of that industrial base advantage that [00:40:00] we've built up, right? that muscle memory I alluded to those, those experiences, scar tissues from, from spacecraft operations.

[00:40:06] **Bradley Cheetham:** And so if we need it in the future, we have to reconstitute it. And hopefully we get it right and we get the right people and the right skills. And obviously that becomes more expensive, right? So I don't think from where I sit, we have the luxury or the time or the ability to waste resources. So I think it's really important that we have that stability and that steady, consistent.

[00:40:25] **Bradley Cheetham:** Support and then an approach moving forward so that we can build on these lessons learned and continue just like we did during the Apollo program, right? Continue to mature the capabilities and do great things as opposed to starts and stops and pivots. And I think that's a very inefficient way to do things.

[00:40:41] **Bradley Cheetham:** And I don't, I don't think we have the luxury of inefficiency

[00:40:43] **John "Slick" Baum:** right now. No, great. And thanks for expanding on that. And, you know, we were getting a little short on time here. Um, Jamie, I want to ask you, you know, about the valley of death. So how do we work, uh, to transition these programs into the operational space

[00:40:59] **Dr. Jaime Stearns:** force?[00:41:00]

[00:41:00] **Dr. Jaime Stearns:** Well, the boring, but true answer is community early and often, right? I think, uh, there's been a few leaders in the space force who have been talking about cislunar space. Um, for years now, at least as long as, as we have, um, and the standup of the 19th space defense squadron who was handed the CisLunar SSA mission last year, uh, was a great step forward.

[00:41:19] **Dr. Jaime Stearns:** And we have really worked with the 19th to go out and just educate people on why CisLunar space is hard, why CisLunar space is important, why CisLunar space is something that they need to be thinking about. So we have kind of a CisLunar 101 brief that we've been doing for the last couple of years. They have a really great mission brief on how.

[00:41:37] **Dr. Jaime Stearns:** You know, they have this really hard problem to solve and don't necessarily have all the tools they need to solve it. Um, but really just conveying the importance of that across the Space Force for a couple of years. And really, what's the message that I think everyone else has said here in the last 45 minutes of we have a chance to actually get a little bit of head of this problem right now.

[00:41:53] **Dr. Jaime Stearns:** If we don't do something about it now, we're going to be looking back in 10 years wishing we had. So being realistic that [00:42:00] it isn't going to be, you know, the top priority, we understand that it's not the top priority right now, but it needs to be on the priority list somewhere. And I think that's the huge win that we've had over the last couple of years with a broader recognition that this is an area that needs to get solved.

[00:42:14] **John "Slick" Baum:** Yeah, I could not agree more. And I think that that's really what, folks listening to this podcast are going to walk away from, you know, the fact that, we were talking about exploration and everything that entails, uh, in a way that we haven't had to think about in over a century. And this is so impactful.

[00:42:29] **John "Slick" Baum:** Uh, and I really appreciate your insights here. I just want to give everybody the opportunity for any final thoughts before we sign off.

[00:42:36] **Dr. Jaime Stearns:** I just want to say thanks for having me. This is, you know, the most interesting and impactful and exciting stuff that I've ever worked on in my 15 years at AFRL, and I'm really happy to come on and share it with you and your

[00:42:45] **Bradley Cheetham:** listeners today.

[00:42:47] **Bradley Cheetham:** Yeah, I'm happy to wrap up with just sort of saying thank you for this podcast opportunity for covering this topic and for the great report that it's referring to, I think this is a really critical topic to the future of our industry, to our [00:43:00] country. And I kind of, my closing point would be to reiterate that cislunar awareness is a today problem.

[00:43:06] **Bradley Cheetham:** It's not a hypothetical future issue. It's something that we need to address now. And from that perspective, I think we need to continuously, uh, you know, reiterate the importance of moving out with urgency to deliver the capacity to our national security users, to our civil NASA exploration partners, and to our commercial industry, uh, to, to get at this problem and to deliver capabilities for our nation.

[00:43:29] **Bradley Cheetham:** So thank you so much for the opportunity.

[00:43:31] **Charles Galbreath:** Yes. Like I wanted to add my thanks to, to our guests for, participating in the discussion, uh, today, found it very insightful and, and, uh, I look forward to continuing the discussion with you and for our listeners. Uh, the plan is to do a couple more podcasts throughout the year, talking about different aspects, of the cislunar, uh, mission and why it's so important to remember that the failure to take the steps that we need today.

[00:43:55] **Charles Galbreath:** we'll limit the capabilities and, and, uh, options that we have in the future [00:44:00] and potentially put at risk, uh, to, to the growing threats, uh, our interests, not just here on earth, but, but in space. So thank you all for listening.

[00:44:08] **John "Slick" Baum:** With that, I'd like to extend a big thank you to our guests for joining in today's discussion.

[00:44:14] **John "Slick" Baum:** I'd also like to extend a big thank you to our listeners for your continued support and for tuning into today's show. If you like what you've heard today. Don't forget to hit that like button and follow or subscribe to the Aerospace Advantage. You can also leave a comment to let us know what you think about our show or areas you think we should explore further.

[00:44:31] **John "Slick" Baum:** As always, you can join in on the conversation by following the Mitchell Institute on Twitter, Instagram, Facebook, or LinkedIn, and you can always find us at MitchellAerospacePower. org. Thanks again for joining us and we'll see you next time. Stay safe and check six.