AMERICAN FOREIGN POLICY COUNCIL

SPACE STRATEGY PODCAST - EPISODE 41

General Simon Peter 'Pete' Worden, PhD
[Intro Music & Podcast Introduction]. [Edited for Clarity]

Peter Garretson: Welcome to the Space Strategy Podcast.

Today, my guest is Dr. Simon 'Pete' Worden, Chairman of the Breakthrough Prize Foundation and executive director of the Foundation's breakthrough initiatives, and I will say one of my personal heroes and mentors.

His career has been unique, touching nearly every aspect of civil, commercial and military space innovation.

He has been an Air Force general officer, a NASA Center director, a professor of astronomy, planetary sciences, and optical sciences. a consultant to DARPA, a Congressional fellow and advisor on space issues to the Senate, and a military commander. He has served twice in the White House, first in the Office of Science and Technology Policy, and later as director advanced concepts, Science and Technology of the National Space Council. His military career included technology, development operations, requirements, strategy, policy, and even arms control negotiation. He has served as the deputy for technology for the ballistic missile Defense organization, the director of Analysis and engineering for the Space Warfare Center. the Deputy Director of Requirements for Air Force Space Command. the Deputy for Battlespace dominance at Headquarters Air Force, the Deputy Director of Operational Requirements for Headquarters Air Force, the Vice Director of Operations at Headquarters, US. Space Command. the Director of Development and Transformation the Space and Missile Systems Center, an Air Force Space Command, the forerunner of today's Space Systems command and he commanded the 50th Space Wing, which operated most of the nation's military satellites, and which has evolved and split into the Space Force's Delta 5 [CSPOC, SSN], Delta 8 [SATCOM & PNT], and Delta 9 [Orbital Warfare]. At the time General Worden was responsible for more than 60 department of Defense satellites, and more than 6,000 people and 23 worldwide locations.

He was among the earliest spacepower advocates and advocates for a separate Space Force and as well as one of the earliest spacepower theorists. Worden has played a key role in

building the modern space ecosystem we take for granted today and continues to build technologies enabling an exciting far-term future.

Throughout the 1980s and early 1990s, Worden served in every phase of development. including international negotiations and implementation of the Strategic Defense Initiative.

Worden was a key early innovator and proponent in the area of small satellites. While at the ballistic missile defense organization and its predecessor of the Strategic Defense Initiative organization, he played major roles in the development of the DC-X. The precursor to today's reusable rockets and the Clementine Mission, a small low-cost and rapidly developed satellite which mapped the Moon and found water as well as tested sensor and propulsion technology for space-based and exo-atmospheric missile interceptors as the Vice Director of Operations for Headquarters US. Space command. He testified to Congress on the relationship between asteroids, Planetary Defense strategic stability and preventing an accidental nuclear war.

As Director of Development and transformation at the space of Missile Systems Center. He was responsible for policy and direction, for force enhancement, space support, space control force application and computer network defense. While there, in 2003 he outlined a vision for usable launch vehicles, responsive space microsatellites and Cislunar space domain awareness and Planetary Defense that is only now being realized

As a professor of astronomy, optical sciences, and Planetary sciences at the University of Arizona. His primary research direction was the development of large space optics for national security and scientific purposes and near-Earth asteroids. There, he developed ideas for an L-1 Sunshade for geoengineering, a solution to mitigate climate change and the mission concept that would evolve to become NASA's planetary defense, Double Asteroid Redirect Test or DART.

As a DARPA consultant. Worden played a key role in starting the reusable rocket and responsive space evolution now being taken forward in our National Security Space Launch and Space Development Agency [as well as DARPA's first foray into interstellar and starships, DARPA's '100-Year Starship].

As the NASA Center Director Worden was behind the "GEOINT singularity" and large LEO smallsat revolution, including the efforts that eventually became Planet Labs and Planet and oversaw the Lunar Crater, observing and sensing satellite or LCROSS which confirmed the presence of water on the Lunar poles. As a precursor to NASA's return to the Moon, [and hada key role starting the international push for asteroid mining.].

He has authored or co-authored more than a hundred 50 scientific technical papers in astrophysics, space Sciences, Strategic studies, and at least 2 books with one forthcoming [*Whither Space Power* with Maj Gen John Shaw, and *SDI and its Alternatives*].

Now as chairman of Breakthrough, Worden has initiated efforts to search for life in the universe, search for techno-signatures of intelligent life, and is developing interstellar

spacecraft and propulsion systems, to send probes to survey exoplanets and neighboring stars.

There is virtually no aspect of 'SPACE 2.0' that Dr. Worden has not touched or pushed!

Please enjoy our far-reaching big ideas. Conversation on Cislunar, the Moon, NASA Space Force, DARPA, Asteroids, Interstellar Aliens, Planetary Defense, John Boyd's Philosophy, Officership, and advice to Innovators. Now I give you Dr. Simon Pete Worden.

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Peter Garretson: Dr. Worden. Thank you so much for taking time to come on the podcast. So, I want to start with a little bit of self-introduction. How do you describe what you do and your role in the space ecosystem?

Pete Worden: Well, I guess I probably the best description is "*space iconoclast," that I believe that that there's a better way to do things, and we need to find it*. But secondly, I'm also a bit of a Futurist, in that I think that *humanity's future is in space, and that--as you'll find out--the further in space, the better*.

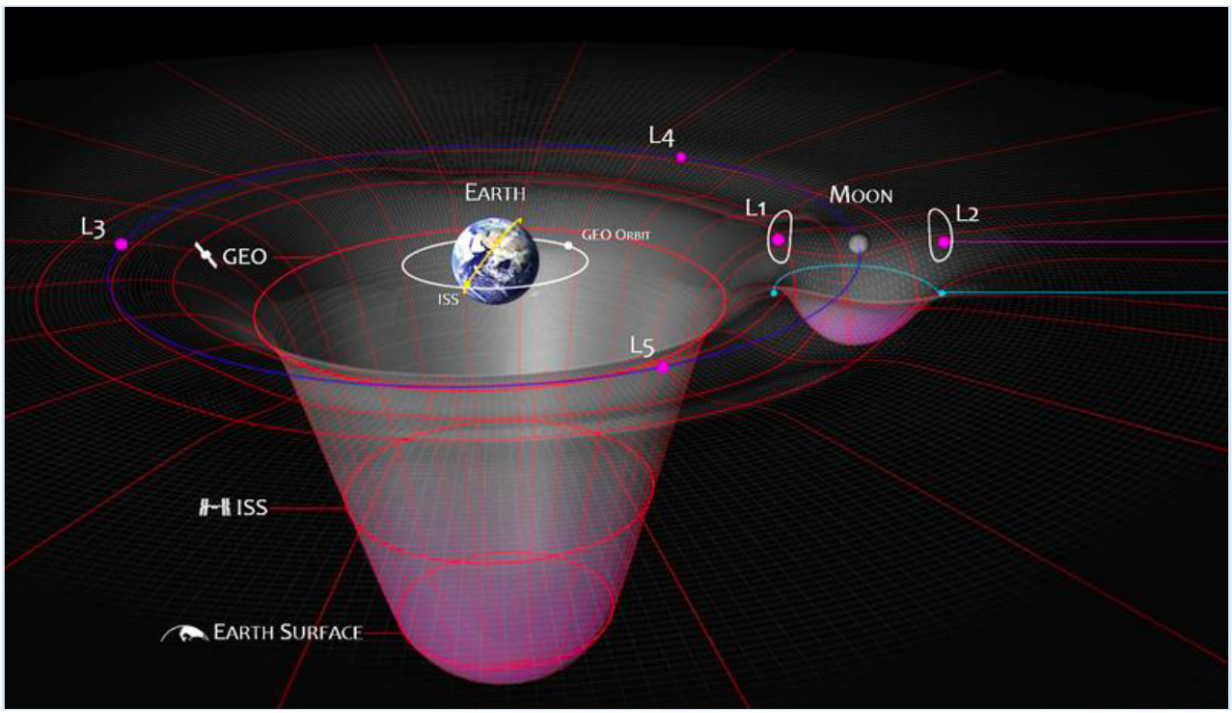
Peter Garretson: So, you know that's a great start. Let's jump right into that. Paint me a vision of how you see our future, and what we ought to be striving towards.

Pete Worden: Well, let me say at the start that: I don't think we've really entered space yet. I mean, I consider Low Earth Orbit… not even 'space.' *We're fooling around in the harbor*. Cislunar space is sort of like a…you know, playing around an inland sea. 'True space' is in the Solar System, and real 'true spaces' lies beyond and in interstellar space. So, I think at the start, it's really to say that *I believe in an unlimited future for humanity*, but that not only necessitates, but *requires, that we go beyond our solar system*, and as far beyond as we can—for a lot of reasons. One is that there are risks in a certainly one-planet species. But in even one-solar system species. Ultimately, there's probably a risk in one-galaxy species. But, *I've always been kind of a fan for an unlimited future*, and I think that that, you know, *it's alright to be focused at Cislunar space, because the first offshore island is the is the Moon, but the real focus should be on the entire solar system and then try to really focus on how we get to the nearby stars*--and what's there. So, that's sort of always been my objective. My…you know my father just died a few years ago. He was 98. And as fathers do, he kept sort of clippings of, you know, the newspaper, and other clippings of when I was a kid. And when I graduated from the University of Michigan in 1971--began to date me a little bit--there was a local newspaper. Somebody, you know, did an interview with me. And it starts out, it says: "this kid believes we will be doing interstellar probes in his lifetime" and my dad looks at me and sort of grins and says, "well, at least you're consistent." That, you know, that was about 70 at the time. And so, that's always been my focus.

I've always felt this solar system is boring. You know, if there's other life here, it's sort of microbial. And…ever since, again, I was a little kid. I had…my mother gave me two books to

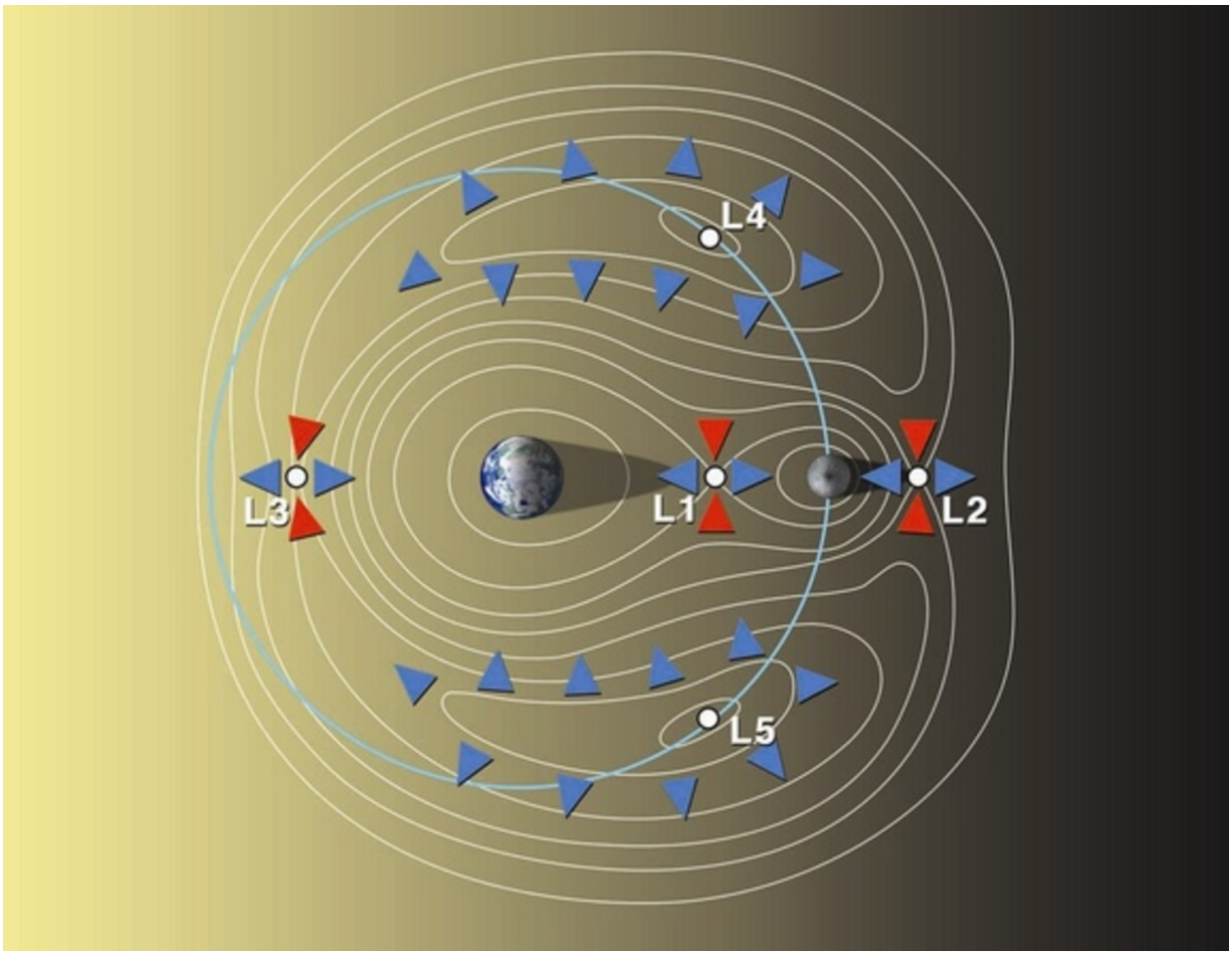
read when I was about six years old. I think it's probably the first book she bought for me. And one of them was called *Planets*, and the other was called *Stars*. And I thought the *Planets* one was boring, because I couldn't see any evidence of--you know--*there's no exciting aliens or anything.* But it mentioned in the in the *Stars* one, there could be aliens on planets orbiting the nearby stars! So that's been my sort of life's work. And as my dad said: I am pretty consistent.

Peter Garretson: So, you've given us already, you know, a ton of hooks to get into. You've given us 'Cislunar.' You've given us 'interstellar.' You've given us 'aliens.' Let's start at the beginning, because I think many people do not actually appreciate why Cislunar is important, and what it can offer to humanity. So let me let you give the spiel on why Cislunar is important.



[Source: National Cislunar S&T Strategy]

Pete Worden: Well, I think that, you know, as a physicist the most important thing to worry about in space is gravity. And you know, *real space doesn't begin until you start to get really free of Earth's gravity*. And then Cislunar space is defined as the region that's dominated not just by the Earth, but the sum of the Earth-Moon gravitational system, which is in itself a rotating system, it rotates with the Lunar orbit.



[Source: NBC]

Pete Worden: But that's a… you can kind of think of that as, again, I called it sort of an 'enclosed lake,' a large lake. And I think, first and foremost, it's *important to operate inside your lake. Or you know…you might expand a little bit*. Say, for the Roman Empire, it was the Mediterranean Sea.

[On Cislunar Space]

And, there's clearly a large object… I mean, you know… *it* [the Moon] *has the area of a continent on Earth*. *So, it's really the additional continent* that has a couple of key features. One is, it has lots of resources. But more to the point, it's really closer to the edge of getting into the solar system than the Earth's surface is. So, I feel that it's really critical.

The other thing is that that when you operate in Cislunar space… and it really begins, you know, somewhere fairly close to Geosynchronous Orbit, your propulsion requirements and so on are dictated by this Earth-Moon gravitational system, which is classically what's a Roche Geometry. It has equilibrium points and unstable equilibrium and stable equilibrium.

Those are kind of equivalent, maybe, to the sea choke points of centuries past. So, I think the point is that *once you're in this sort of Cislunar space, it's relatively easy to get any place else, particularly if you're at some of these equilibrium points. So, it doesn't require a lot of energy*. And it…you know, I think that, you know, quite often we're used to thinking of, well, something is close in number of kilometers. *But you really need to think it's close in terms of gravity. It's how much energy you need to move from one point to another. So, it's in Cislunar space that geometry, and those dynamics, particularly related to propulsion, are going to dictate our ability to move around. It'll dictate national security and international security. You're going to have to know what's going on in there, because somebody sitting on the other side of the planet is actually much closer to you than somebody that might only be a few thousand kilometers away, depending on where they are.*

And so, I'd say that good that *the very first thing that we need is to have space-based Domain Awareness or Domain Awareness of the Cislunar space*.

We need the ability to move around in it. And those are *different propulsion systems than the chemical rockets that get us off the surface of the planet*. I think, you know, the higher efficiency systems, whether they're **solar electric,** or even **nuclear thermal** or nuclear electric. And my particular favorite is solar-driven light sails. I think we'll be entering a new era of sailcraft that makes it quite easy to get around the system or space. Using sunlight is just like using wind. You don't have to spend any energy.

Peter Garretson: Now you also mentioned early on, as the Moon…sort of being this first 'island.' So, let's talk a little bit about the **strategic importance of the Moon**.

[On the Strategic Importance of the Moon]

Pete Worden: Well, it's, you know, as an 'offshore island', it sort of dominates everything. I mean, it orbits the planet and the planet rotates underneath it. So, it's always accessible…from really any place on the planet…*which means that any place in the planet is accessible from it*.

But, probably more to the point is that: it's an **immense resource** in terms of mass. I mean, it's, you know…it's a planetary mass object. *It's a lot easier to take material from the Moon that is to bring it from the Earth from an energetic standpoint, even and including bringing it all the way back down to Low Earth orbit*. So, it's a huge resource. As we're learning, increasingly, it has all of the…you know, the resources the Earth does, including volatiles such as water. The [Indian] landing at the South Pole this week was significant, because it's near the poles that those water resources are confirmed--and they may be much larger than we originally thought. And I think *one of the key objectives of the Chandrayaan Mission is to start looking at those resources.* And it will be followed by other missions. including US and no doubt Chinese missions as well.

So, it's *resources that are incredibly important…they were the things that dominated, you know, economic and great power politics of centuries past. And the easily accessible resources are gonna be a key aspect*.

Another one I mentioned is the ability to get places throughout Cislunar space from a certain point. with minimum energy. *And from some of these points, everything else is downhill. And you know that's…that's a critical aspect. If you don't require much energy to get to some other place in the system…and those other places could include places that are critical for communications, surveillance, and so forth, even on the Earth*.

Peter Garretson: So, you know, you were talking about Cislunar before. I mean, today, Cislunar is a buzz word across multiple communities. But, you know, you were talking about it in your book on space power theory and scenarios with General [John] Shaw in 2002. And you were briefing it at NIAC seminars at about that same time, when you were in charge of transformation for the Space and Missile Center (today the Space Systems Command). And when you think about Cislunar, how closely is that tied to Near-Earth Objects in your mind?

Pete Worden: Well, the Near-Earth Objects are the next step out. And these are, you know--okay, we have a large offshore island [the Moon]. *We have, you know, hundreds of thousands, if not millions of small islands scattered throughout the inner solar system. Some of them are actually easier to get to than from the Lunar surface, from an energetic standpoint.* They may take longer to get to, but I think in *space people need to think in terms of energy it takes to move places…that it's in some sense that's more important than time*. And it's, you know, these small islands, that in some cases they may be much more accessible than the Lunar surface is. There are some of them, for example, that are nearly pure volatiles, including, you know, maybe 50-60% water--these are the sort of icy asteroids.

Peter Garretson: Just to backup, for the audience, who maybe not all of the audience wouldn't understand the term 'volatiles.' What does that mean?

Pete Worden: Volatile typically means a compound of carbon, usually one that's liquid or gas, but water is usually included as a volatile, even though it's not a carbon molecule. But generally, volatiles are, I mean, for example, things like gasoline, methane…a lot of the fuels that we understand, and water. So, it's more correct to refer to these sorts of, you know…and they're called 'volatile compounds' because they tend to be--at very low temperatures--ices, so they're sort of a solid, but they vaporize at sometimes, you know, negative temperatures Fahrenheit, but sometimes--I mean obviously 32 degrees is when water volatizes. Some of them have an intermediate phase, depending on the pressure of a liquid, so they can be pumped and stored as liquids. The…particularly the carbon volatiles, have a lot of energy to burn them, with oxygen. That's the basis of all of our fuels…whether it's methane or breaking water particles into hydrogen and oxygen... or kerosene, for that matter, and…those are all volatiles. And the volatiles are also critical for life--because they have carbon. *And having a*

large store of volatiles is going to be necessary to creating a stable ecosystem off the planet. Most of what we're made of are volatiles…with a little bit of trace of other elements.

Peter Garretson: And do you see that possible? I mean, many people are skeptical that we will ever have a foothold off planet Earth and the solar system. How do you see that developing?

Pete Worden: Well**,** *I think people are skeptical are idiots*. But they…you know, not understanding that: people go where they can go. I mean, they like to say, "oh, well, we don't know whether people could live at one third or 1/6 gravity." I suspect they can. *I mean, that's unfortunately one of the things that NASA should have done but hasn't*. But you know, the Lunar gravity is 1/6, I'm almost 100% certain that life, Earth life, will be able to thrive on it…that there may be a few minor things that have to be changed. And you may, in some cases, re-engineer life with genetic engineering. I mean…it'll happen naturally, after a period of time.

But if you have the resources--and it's primarily volatiles, I mean there's traces of other things…that all exist on the Moon, by the way--then you have everything you need for life. Now, people say, "well, there's a high radiation environment." Well, there's a high radiation environment if you're sitting out on the surface. There's, you know, *many parts of our planet aren't very hospitable* if you're sitting out on the surface. And you build shelter…to my mind, one of the most exciting places on the Moon for large-scale habitations are the so-called lava tubes. The Moon was formed, you know, about the same time of the Earth, maybe slightly thereafter--so some 4.5 billion years ago. About 4 billion years ago there was probably what we call the 'late heavy bombardment.' There were large asteroids that hit both the Earth and the Moon, but those sort of created huge seas of lava on the Lunar surface. They probably get on the Earth, too. But as those cooled, the lava flowed out of the certain areas of this, and made what they do--like lava lakes on the Earth--lava tubes. And these things cool after a while. We can see the remnants of the lava tubes and some places on the Moon. They're called sinuous rilles. These are where they've collapsed. But we also see places that they haven't collapsed. And there's a couple areas where there's so-called skylights that you can see that down *below the skylight is a huge empty area which probably runs for many, many kilometers*. *Those are sort of natural places to put human habitations because they're already underground. So, they're going to be protected from radiation*. You could build a city and seal it, and then you can provide with power from the surface or nuclear power--everything one needs. So, I don't believe this is a terribly difficult thing to do. And these lava tubes--people think of little things that are 5 or 10 feet across. If you look at an artist's conception of the one or couple that we know of, *these are big enough to put the whole city of Philadelphia in them*... which might be a better place to put Philadelphia, but you know.

Peter Garretson: So, we have... we have billionaires that--I think you, in at least a couple of your jobs, have been able to rub noses with--who have visions of becoming multi-planetary [species, life], of creating a city, and perhaps even terraforming Mars, and of creating free-

flying space habitats for billions or trillions of human beings in the solar system [Video]. What are your thoughts on those?

Pete Worden: Well, I mean... *I can't think of a better goal to do*. I may differ on the location and the timing, but I mean, it's not my money, it's theirs. But I think it's important to have visionary individuals--high net worth people.

And I think *this is very much consistent with history, that throughout history new settlements were financed by individuals or small groups of individuals that had a lot of resources*. In some cases, they controlled the government, and other cases they had, you know, what we call private wealth. But virtually all of the expansion--and I suspect this extends to expansion, that isn't written about--you know, like the Polynesian expansion, you had some individual that had a bit of power and influence, and decided that he or she wanted to go someplace else, and finance building the ships and so forth. So, I think it's a very positive thing. You know, obviously, you know, some people have talked more about it than others. And I don't think because it's a private individual that maybe the initial impetus--that it doesn't also involve, you know, governments and public organizations as well. I think that we're gonna see the sort of an expansion that's funded by, in some case wealthy individuals, in some cases, you know, visionary aspects of governments, other cases consortia, and probably ultimately private corporations.

Now, does that give us complexity? Yes. And conflict? Possibly. But that's our challenge--to do that in, you know, a peaceful, mutually acceptable sort-of manner.

Peter Garretson: So, you've twice served at the White House, trying to revitalize America's Civil space program, and we are finally focused on the Moon. And we have Artemis. So *how do you evaluate our current efforts and focus on the Moon, and how does it stack up against the vision of where you'd like to see us go?*

Pete Worden: Well… most people know that I'm sort of a critic of NASA. You know, there's probably a lot of quotes--some of them fortunate, some of them unfortunate--that I've made. *And when I was a NASA employee, this was the kind of things I was pushing for, and it's good to see that you can teach an old dog new tricks*.

I think the Artemis program is very well thought out. I mean, there's certainly, to be sure, there's things that I would criticize. Those are more in the details than in the fundamental direction.

One of the most important things of the Artemis program is the Artemis Accords, where they're really trying to build an international framework--*that this expansion can happen in a in a peaceful way; that does allow, or even emphasizes private and collaborative public-private development*.

I mean to me one of the great accomplishments here was just before India lands on the Moon, they sign the Artemis accords. And so, we now have, you know, most of the countries that are

able to get to the Moon, that have signed it. I mean, one would hope that the few holdouts, particularly China, eventually sign it…and I suspect they will. It's more in their interest to collaborate than not.

But the other key thing about the Artemis Accords is the emphasis on public-private partnerships and private efforts. You know, obviously, the **SpaceX** transportation one is a big one, plus you know, Blue Origin, and others that are also involved in this.

To me, though, one of the most important aspects--which I was very pleased to see--is the Commercial Lunar Payload Services; the CLPS program, that is quietly developing and funding the ability to put payloads on the on the Moon: 100 kg or so, for $100 million or so. In fact, one of these--my own foundation is very excited about this because we're looking at potentially putting a radio observatory on the far side of the Moon. That's an area that's shielded from interference from the Earth. And it's our best shot of being able to see if there are radio signals from other civilizations that we might be able to detect. It's awfully hard to do it on the surface of the Earth, just because there's so much interference.

Peter Garretson: So that's fantastic. And I think there are folks across our government that are helping with that. So, you know, you used to be a consultant at the Defense Advanced Research Projects Agency--or DARPA--on space, and I remember having you out to the Pentagon during that time period when you were working on a diversity of things, including standing up what became SpaceX and Falcon-1 under the Falcon program. Today, DARPA has a number of programs that seem to be tending towards creating this kind of ecosystem and industrial revolution in space, such as the NOM4D program, the DRACO program, the B-SURE program, and the brand new LunA-10 that aims to create scalable commercial infrastructure. What do you think about DARPA's entree into this, and what role do they have in building out this ecosystem?

Pete Worden: Well, DARPA is a unique asset for the United States. I know other agencies and other countries have tried to imitate it. The key to DARPA is that it has no corporate memory--that there's no permanent staff. I mean, it has a few support people that write contracts and so on. But the director is usually only there, you know, one administration. The program managers are only there for a few years, typically four. The only way they can stay longer if they get made an office director, which is then eight.

So, you have an organization that, first of all, as you and I probably have known--you go and talk to the big boss at most organizations, and the big boss tells you to come up with some new ideas and say, “why don't we do this?” “Oh, we looked at that 20 years ago. That's stupid.” And so those kinds of things get dismissed. At DARPA, there's nobody to do that cause nobody's been there 20 years to say, “we tried that 20 years ago.”

The second thing is, it has a lot of money... I think its budget is $3 or $4 billion. Now, that's like, you know, real money.

And the third thing is it empowers their program managers. The program managers come from all over. They come from academic backgrounds, corporate backgrounds, civilian government backgrounds, and military. And so… *I never was a DARPA program manager. But it's sort of the coolest job in the world*. You get there, and you've been hired for 4 years, and you've been told you're going to go away after 4 years. So, for the first 2 years, you're given somebody else's program to finish, you know. And those are usually cool programs, and something you're interested in. *But the first 2 years you're there, you are able to start a number of **seedlings**. These are sort of million-dollar-class things*. You go to somebody and say, "Hey, I'm really interested in fusion propulsion." And it's pretty much up to you--I mean, you've got to answer a few of the Heilmeier questions, these are kind of the critical questions. Is this completely stupid, or does it have any use? But those are usually pretty straightforward. *Assuming that's the case, if you're a program manager, you say, "okay, here's a million bucks." And then in two years, if it looks promising, you can start a new major program that may have hundreds of millions, or even a billion*. *And that's a unique thing where one person can do stuff.* (The only other place that one person can do things is if you made the billions yourself--I mean, like some of the some of the private rocket companies have.) But it gives a chance for particularly a younger expert to really have a grub stake in starting something really new. So, I think it's a unique organization.

Probably another reason it is successful is because it's not over managed. There's a tradition that both Congress and the DoD bureaucrats are sort of chased out, and say, "Look, you know, if you want new stuff, give us the money and go away. And yes, understand we're going to make mistakes."

I mean, some of the big DARPA successes are always touted, but there are big DARPA failures, too. I was told there was one a long time ago called 'Hush-a-boom.' It was some Air Force nutty idea that some DARPA program manager--"can you make a quiet explosive?" And, you know, which violated some laws of physics. But they spent a few hundred thousand on that and decided, "okay, this violates too many laws of physics."

Peter Garretson: So, you were one of the earliest, most vocal, and most consistent voices for Space Power or Space Force independence, and you consistently mentored many of the advocates. You held key positions at both Air Force Space Command and the earlier Space Command. And you know, you mentored students for what became today's Space Force Schriever Scholars and boy back in like 2015-2016, you gave a quote that starts off a student paper, called **Movement and Maneuver in Deep Space**, that I'll post as a link. And the quote is that essentially:

> *"[the DoD] needs to focus on true strategic objectives in space... these are objectives for the coming century. True space operations will spread across the solar system in the decades ahead, and the nation that controls them will dominate the planet. Focusing on low Earth orbit is akin to having a Navy that never leaves sight of the shore. The U.S. military needs to focus on "blue-water" space operations, GEO and above. U.S. military*

> *space operations need to be in deep space, initially all of cislunar space, with an eye toward the entire inner solar system. To operate in deep space, one needs the resources there, starting with fuel from the asteroids. Once this is recognized, the military-economic imperative of identifying and protecting these assets becomes clear. The focus should be to be sure on low-cost access to real outer space--with space beginning at GEO. New means of moving around in space are more important than just getting off the ground."*

How is our Space Force doing?

Pete Worden: Well, that's a good question. Good start they've got. You know…*one of my concerns is that there's still too much interference from the Air Force*. There's a lot of view, I think, on the other services, particularly the Air Force--"Well, you're there to support us"--which is baloney.

In some sense, I think the Space Force would've been better if it had come out of the Navy--says the former Air Force guy. The reason for that is that if you go back to the U.S. Constitution, it specifies two kinds of military, and it's very explicit. It says that the government has the authority to raise an army from time to time, but will provide for a navy. There are a couple reasons for that, and I think those are valid today.

First of all, armies usually have the possibility of being an instrument of suppression, and that was clearly the Founders' concern, and I think it's a concern that maybe isn't great, but it's still, you know, instruments of suppression of open public discourse are always a possibility. But more to the point--that having a large-standing military tends to encourage foreign adventurism. And so--not to get into all of the politics, but I think smaller-standing armies are a good idea, and I include air forces as a part of that. It always encourages doing something unilaterally, which I think is a bad idea.

Now, the second thing is that the Navy was stood up--and why did they say 'provide for'? And the reason is**:** *they felt that a navy was critical to protecting commerce. And so, it was really a commercial thing. And to my mind, the Space Force has that function much more than fighting wars and carrying on, you know, foreign adventures*, and so forth. *So, I think it's really important that that that Space Force understands that. That, as we see greatly increased commerce--particularly in Cislunar space and beyond--that it's their job to work with other nations to provide a secure, predictable environment.*

You know, this is what navies do on the surface of the ocean and underneath the ocean. And if you have *a number of navies, there've been very few naval battles in the last, you know, three quarters of a century*, and I think that's partly due because the navies are really there for protecting commerce, protecting economic security. So, I would say that *the Space Force, I would look at it much more as an instrument of economic security rather than an instrument of war fighting---and the more we do that, I think the better*.

There's some of that certainly in the people I know in the Space Force, but I'm not sure that the broader Pentagon and National Security community understands that.

Peter Garretson: So, some of the things that they do seem to understand are things that you've been championing for an extremely long time. So, *it finally looks like the Space Force is starting to embrace reusability and these proliferated, large, small satellite constellations*. And you know, I encourage you to add some color and history, but I'll at least mention that you were in the Space Defense Initiative Organization that pioneered the DC-X, I know you were behind that. Then at DARPA, I know you had a big role in the FALCON program that became Falcon-1. You were also part of the Smallsat Revolution trying to get us to do responsive space for decades. And then, of course, the Clementine Mission, *which is, I think, a piece of history that almost no Guardians today know about.* So, you know, talk a little bit about the history of these ideas that now the Space Development Agency within the Space Force is pursuing. Let's talk reusability and proliferated-LEO. Where did those things come from?

Pete Worden: Well, there's a lot of different sources of that. But, you know, I think that my interest in small proliferated satellites really started in--you know, I was at the White House in 1989-1991 at the National Space Council. And my responsibility was to work the Space Exploration Initiative, which was a failed **attempt to revitalize** civil space. And our big challenge was that: a lot of people wanted to put money into something called 'mission to planet Earth.' And now, *I don't consider anything that deals with the Earth have anything to do with space*. So, people say, "oh, we do want to do Earth science." Okay, you can do Earth science. That's not space stuff. That's just high-altitude airplanes. But they were gonna put, you know, tens of billions of dollars into this giant space station that had all these sensors, and they were going to cost a few billion each--in 1990 dollars. And why, rather than have a single satellite with 46 sensors on it--why not put one sensor on each satellite? And you know, of course, that was heresy! And in the end, that's kind of what we did. And so, it began to push that.

But at the same time, I was involved in the Missile Defense Program, and we've been looking at different ways to do effective missile defense. One of those is giant laser battle stations. You know, another one was taking a nuclear device and converting energy to X-rays or some X-ray laser. Various kinds of things that really were 'Star Wars.'

But the best idea came through: why not just have little missiles, little small satellites that could hit another missile? They were called Smart Rocks. And there was a group at Lawrence Livermore Lab that was run by a brilliant physicist--bit of a character--Lowell Wood, who said, "well, these should be even smaller". He'd been a protege of Edward Teller's. And so he developed something called the Brilliant Pebbles that were even smarter and smaller. Now some wag said, "Well, the next thing will be 'Genius Sand'"--but that's probably right. *But the ability to build, you know, capabilities in tens of kilograms means you can proliferate them. They're survivable and they're cheap*. And it really, I think, gave rise, to the smallsat movement.

Smallsats are sort of hundreds of kilograms, but by the end of the nineties, people started to say, “why can't you build things in kilogram class?” And I was an early adopter when I went to NASA in 2006. CubeSats, of course, initially everybody regarded those as toys. They initially were just sort of ways to teach students how to build spacecraft that didn't cost a lot of money. But now that's the mainstay of Earth observing is Smallsats and CubeSats. I think the revolution that's just starting is--how do you get those things deeper in space?

You know, that's beginning--of course, the next step, in my view, you know, the ‘genius sand’ level rather than kilograms. *Why can't you make these things, you know, tens of grams or 100 grams*?

And that’s started, although that's being resisted by idiots in the U.S. Government that don't like the idea of these little things…they're trying to say, “well, it's very difficult to get communications licenses.”

Of course, at the same time, my foundation--we're trying to do interstellar probes. The only way we can figure out how to get something to 20% the speed of light is if they only weigh a few grams. But these are *revolutions that you have to understand where technology is going and what it does and how it could help*.

The first thing was, you know, small, cheap, proliferated. The second question is, “now, how do you get the stuff there?” And I've been a big advocate of small launchers, but reusability is… I mean, I don't understand why people didn't get this, but the best analogy that was used from 40 years ago was: “Look, if you build an airplane that could do one flight across the Atlantic... you know, that the wings fell off, and the engines, and so on… and you end up just getting the passengers there. There wouldn't be intercontinental air transport. You can't build a new airplane every time, so why not do it in space?” Now, you can only carry that so far. The issue is that sometimes there are premature efforts... that NASA's--what is it, Delta Star, or whatever they called it? It was a hypersonic...

Peter Garretson: VentureStar.

Pete Worden: VentureStar--and a few others, that, you know--you can only expect so many miracles in a decade. And there were too many miracles in series that had to happen. But we are seeing now that *reusability is clearly what is giving us cheap access to space*. I think, to my mind, *one thing I didn't foresee, which is really cool, is that it probably makes sense that you can actually do bigger things even cheaper, and do them reusable.* Like the *SpaceX Starship is incredible because I think it gives us the ability to put a lot of mass up.* And now as they're already doing, those are proliferated small satellites in many cases, but in some cases they won't [be small].

Peter Garretson: So, you had this important role in the Strategic Defense and Space-Based Missile Defense, which, of course, has not come to fruition. But you even wrote a book, *SDI and its Alternatives*. You know, I'm curious whether or not, you still are a proponent, or see

the relevance of it given that this 'force application' that at one point you were in charge of requirements for. Now, we have competitors who are actually launching Fractional Orbital Bombardment, you know, system tests. *What do you think is there continuing relevance for the idea of space-based missile defense?*

Pete Worden: Well, *I think there's maybe a stronger need today than there ever was to base security on dissuasion--which is a step before deterrence. And to move away from offensive capabilities*. I think that the war in Ukraine is raising, again, the specter of nuclear warfare. *Now the purpose of the missile defense program 30 years ago wasn't to eliminate the ability to get a nuclear weapon through--it was to make it incredibly difficult to accomplish anything militarily with it*. And I believe that the ability to say: "if you want to do something offensively and aggressive, you're very unlikely to succeed. You may cause some damage, but it'll cost you a lot, and there's a high barrier to your succeeding. So isn't it better to figure out some other way to get your objectives than to attack somebody?"

I think that's more valid today than ever. And it's the essence of security. *I've always liked to emphasize that the purpose of a military is prevent wars, not to fight them*. And once you have to fight something, you've failed.

And… *I hated that term the 'warfighter.' I mean, you're supposed to be a war preventer, not a war fighter. And that's why I felt that that, you know, having a very strong ability to protect your economic assets, including assets that are in space--particularly in space--the ability to minimize the ability for somebody to attack long distances, especially through space, is critical to that*. Again, I haven't paid a lot of attention to the details of national security, other than reading the newspapers, or listening to blogs, and so forth. But I think now, more than ever those are critical.

Peter Garretson: So, I wanted to come back to **Clementine** because it's such a fascinating story, and I will routinely hear people in the Department of Defense make claims that it's not the role of the DoD to do science or to support industry, and the cleverness of what was accomplished. Or the other thing that's kind of involved in this is: in rereading your Bio, I see that you were involved in like all phases of arms talk negotiations during SDI. And so it does not seem to me that there is the same level of strategic savvy and engagement, in terms of 'setting the conditions for the entire domain' to include both the development of threatening technology and the negotiating of it. *But tell the story of Clementine and what it accomplished*.

Pete Worden: Well, maybe I can start by talking more about what was the purpose of the Missile Defense Initiative--The Strategic Defense Initiative, or sometimes called Star Wars--which wasn't a bad name by the way, it was applied to it by Teddy Kennedy to be insulting. But the whole objective of that was to 'change the game.'

And I guess our competition with the Soviet Union was two different approaches clashing. And I think somebody wrote that the Soviets… as the Russians are today, are good chess players.

And if you let them freeze the rules, they'll eventually beat you as they're good at multiple planning ahead.

On the other hand, you know, the West, and particularly the United States, is damn good at poker. And if you can change the game frequently and particularly change the game in areas where you've got a very strong hand, then you're gonna win.

So much of the Cold War was, I saw, seeing the Soviet Union trying to freeze the rules and get us to play chess--and we were stupid enough to do that for a long time. And I think Ronald Reagan and his advisors understood that we really needed to change the game, because we're gonna lose. And so, they decided to change the game.

And I don't think initially it was that changing the game was necessarily space--although it turns out that, in my opinion, and the more we looked at it, that was what changed the game so strongly--I sort of liken this to that. In fact, I sometimes refer to it as "*the Great 50 Year Space War"* that started with V-2s.

And it was really a 'one-two punch.' The Soviets saw that the U.S., when we went into space with the Apollo program, beat them decisively. And then they went back to, "well, let's see if we can freeze the rules again with arms control and other things." But the Missile Defense Program increasingly was, "let's change the game by using space". That was an area that that the Soviets tried to compete with us.

But *I think it was the straw that broke the camel's back.* And so that that it was clear to me, having been in Geneva and talked to a lot of the Soviets, that *it was the space stuff that scared to Bejesus out of them*. And because they said, "Okay, the U.S… if they really put their mind to it can really beat us badly there." And the fact that *we never actually had to build anything and we ended the Cold War*--now there'll be a big argument: "What was the key factor?" *I'm convinced that the space part of the Missile Defense Program was a major factor, maybe the major factor, and I know a lot of experts think I'm wrong, but they're full of shit. And they weren't there*.

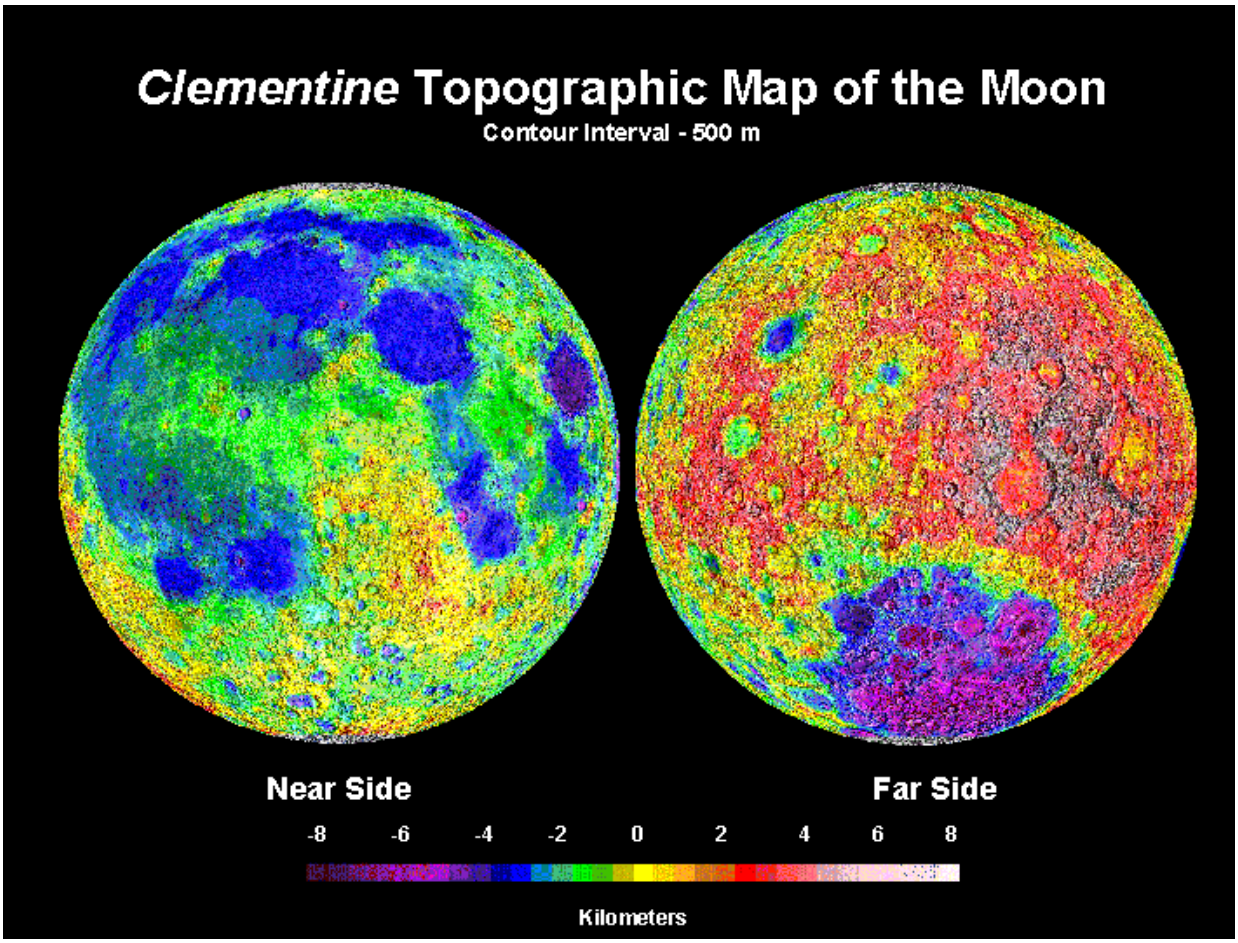
And so, that having been said, one of the things we looked at was: "What can we do in space? ...and in some sense recalls Apollo and shows that 'okay, deeper and deeper in space, you're gonna see us beating you."

And so the idea was, as I said, we're looking at these small satellites. At the same time when I was at the White House, they were--NASA was trying to restart the Moon program, but they wanted to do it by tripling the size of the space station and building a dozen more space shuttles. A more ignorant approach I can't imagine. And so our point was: why don't you look at the new directions? Small, cheap things? And so--in fact, the concept was actually *hashed out in a bar near* the White House with a colleague of mine, who has had a somewhat checkered career since then—that's Stu Nozette, a brilliant guy. We were there--I think it was called Quigley's--to meet a Congressional staffer. I think Jeff Tudor was his name. He was late.

So, we started bemoaning NASA's inability to do things. “Why can't we just modify these brilliant pebbles we're making and send one to the Moon?” And so Stu actually *sketched that out on a napkin.* And so, we went back and told him, "this is a good idea". Mike Griffin was the was the head of technology at the Star Wars program. And so, he started a study and about a year and a half later I took over his job. The study was kind of collecting dust. And I said, "Let's go do this." And of course, the problem was, people said, “well, it might violate, you know, things that we would do in space. That looks like weapons that could violate the anti-ballistic missile treaty.” So, we had some clever lawyers and said “well, if everything we tested on missile defense was done in Lunar orbit, not in Earth orbit, does that violate it?” And they sort of scratched their heads and [said] “no, actually, not.” So, we got the program started. Now, I will say we kind of slipped it through Congressional oversight. Because I figured if we'd actually put something in there saying “we're going to do a Star Wars probe to the Moon” that probably would have got zeroed. So, there was something at that time called… you had to put ‘descriptive summaries’ in, and these were like--I was the head of technology--and there was probably 300 pages of descriptive summaries. Deep in the sensor area, we had the sensor integration experiment. We said, “we're going to test these sensors in Earth orbit and in deep space, including Cislunar space” and the staffers on the Hill didn't understand what that meant, so they didn't knock it out.

So, after we started this program, one of the Congressional staffers there called me up and said “You are ordered to stop this program! It wasn't approved!” and I said “Yes it was, it was in the descriptive summaries. It was passed by both Houses of Congress and signed by the President. It's in law.” And so, we actually got the thing through. Now, it ended up sitting on the launch pad when the change of Administration--the Clinton Administration--came in, who wasn't very happy about space stuff, but I think they didn't pay much [attention]. It took them a year to get their act together, and I don't think they even realized what this thing was. It was sitting on the launch pad at Vandenberg Air Force base to go to the Moon. So, nobody stopped it. So it went to the Moon, and to my mind it was not just that *it was a critical strategic item, but it also began to focus our overall attention, including national security attention, on Cislunar space and beyond.* The second part of it *was supposed to go and intercept an asteroid.* But we had a software on that stop that failed it. But that was a really cool mission.

Peter Garretson: So just because you didn't mention it, correct me if I'm wrong. This *tested most of the components that were needed to space qualify the brilliant pebble system*, and it was the *first indication, or the first discovery of water, on the Moon* that *completely changed our view of the Moon as a strategically logistically important body*.



Source: Planetary Society

Pete Worden: Yeah, that's correct. It basically demonstrated the key capabilities to do affordable space-based interceptors. But it also got the first full 7 color map of the Moon for a lot of useful resources. But probably one of the most significant aspects is it was the first positive indication of that there are substantial quantities of water in the Lunar polar craters. That was kind of an added benefit. So yes, it was, to my mind--you know, I kind of got fired over it, but it was worth it.

Peter Garretson: And why was it called Clementine?

Pete Worden: Well, again, the people that started it--we had a lot of drinks in bars and we said, "Look, NASA keeps naming things after some ancient Greek or Roman gods. You know, why don't we use a good American name? And so, one of my favorite songs was 'My Darling Clementine.' And I said we should name this mission Clementine, and as it turned out, it was going to be lost and gone forever, which it was. And so it was an appropriate name. So, I kind of like the idea of using something out of American history, not ancient Greek history.

Peter Garretson: So, let's pivot now to the farthest reaches and talk to me about Breakthrough and interstellar and both Breakthrough Listen and Breakthrough Starshot.

Pete Worden: Well, you know, when I was at NASA, I was frustrated that we didn't really do a lot beyond the solar system. I mean, one of our neatest missions was the Clementine Mission. So, in the Science Mission--or not Clementine Mission, Kepler Mission--*which basically found that every star in the galaxy essentially has planetary systems*, at least in a statistical sense. And a lot of them have planets like the Earth in the habitable zone. But most of those stars are pretty far away. They were hundreds or thousands of light years away. So, I had a strong interest in, you know, why don't we look at the nearby star systems? Because those are things that are in our future in the next century, or even less. It didn't get very far with NASA. We did studies, and so on.

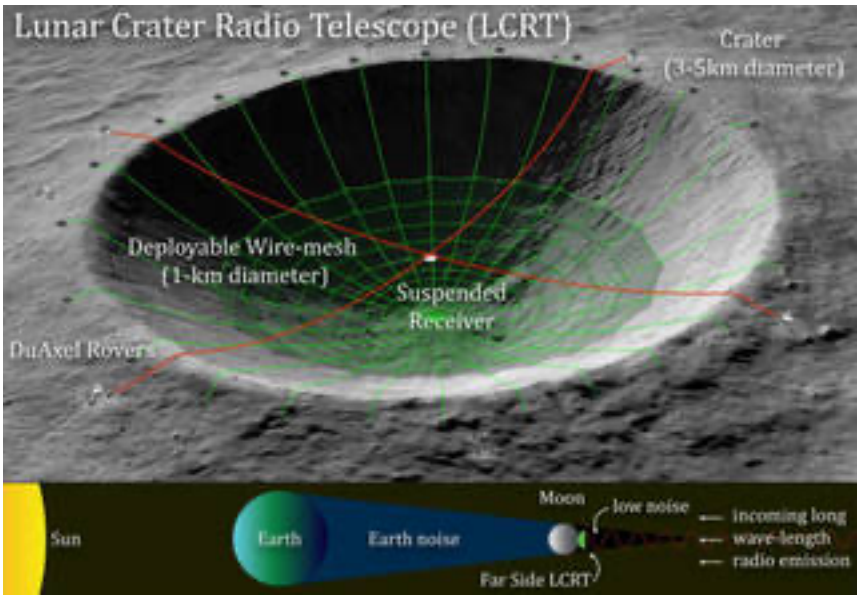
But being in Silicon Valley, I was the senior Civil servant in Silicon Valley. So, it meant I got invited to a lot of billionaire parties… mostly as entertainment. But so, I met a lot of these folks, and as an astronomer, I was well aware that in the nineteenth century, and the twentieth century, most big telescopes were built privately. Including today, most of the big telescopes have a substantial or even majority private funding. So, I kept hitting up the billionaires. And finally, one of them got excited about it: Yuri Milner.

And so, I got to talking to him, and by this time it was clear that that I wasn't going to stay at NASA forever. I'd caused enough trouble. And Yuri had been the principal founder of the Breakthrough Prize, which is the largest science prize. It's three million dollars. Basically, it's an attempt to highlight the accomplishments of basic scientists.

But he also wanted to do research on the big questions, the big questions of life in the universe--and they're really **3 of them**. And the first one is: *is there any life elsewhere?* And the second one is: if there is, is there any--I hesitate to use the word intelligence--I call it…*Is there a techno signature somewhere, or techno civilization somewhere else that we can detect*. And the third one is: *can we really think about sending probes this century to the nearest star systems?* So, we started the program and *Mr. Milner has dedicated several hundred million [dollars] to the three programs:* the life in the universe is, in general, Breakthrough Watch. The search for extraterrestrial intelligence or techno signatures is called Breakthrough Listen, and then the interstellar probe is Breakthrough Starshot.

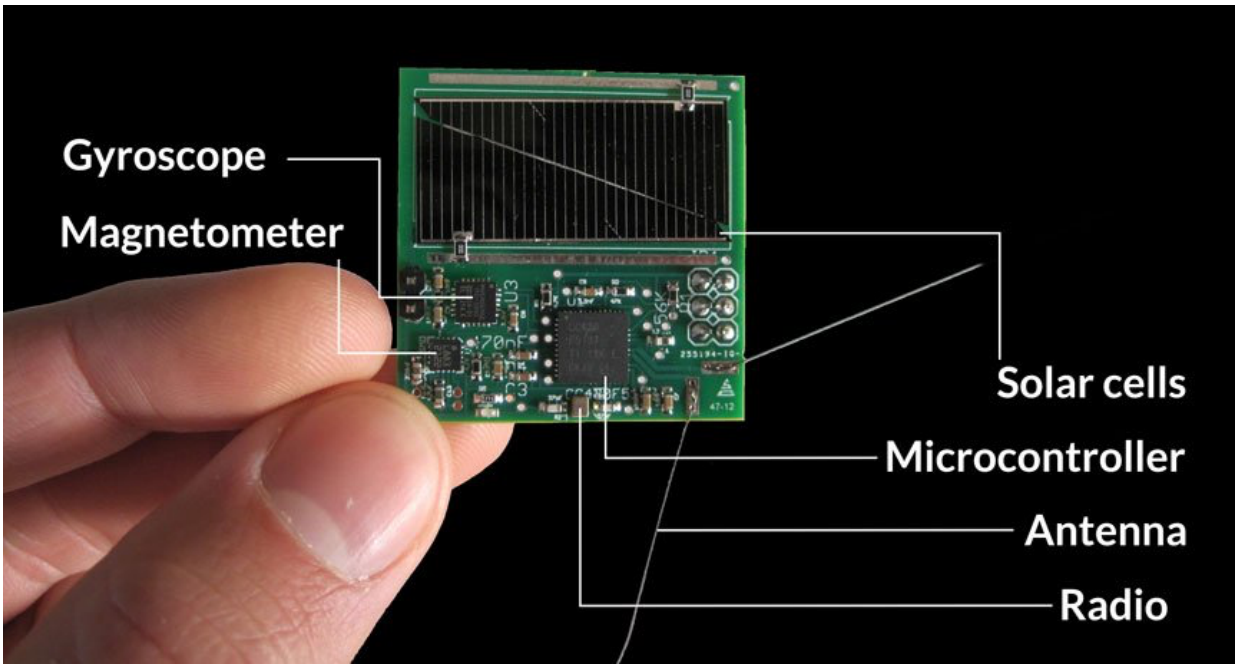
And those have been going on. On Breakthrough Watch, we were about to fund some more programs. The first one we funded was a joint program with the European Southern Observatory, and we were able to tentatively detect a giant planet orbiting in the habitable zone of one of the stars in the Alpha Centauri system. The Alpha Centauri system is 4.3 light years away. It has three stars. Two of them are about the size of the sun. They orbit around each other over 80 years. The third one is very distant, but we now have tentative indication of a planet in the habitable zone of one of the most solar-type stars. By the way, that's the same scenario that was in Avatar. So, James Cameron has been quite excited about this. There was a giant planet orbiting in the habitable zone of Alpha Centauri A that has moons, one of which is called Pandora in his movies. So, we're glad to kind of prove that science fiction may be real. But we also did some studies on looking for life in our own solar system--a couple of

places looking at the moons of the outer planets, but also on Venus. And there's some tentative evidence of life in the upper atmosphere of Venus, although it's quite controversial. So, we did some studies, funded some studies, by Professor Sarah Seager at MIT. She now is working with Rocket Lab to send a probe there in a couple of years that can begin to look for life. Another foundation has actually funded the instrument, but we've worked closely with them. And so, we're about to start more programs to look particularly at Alpha Centauri and some of the nearby stars. So that's very exciting. The second program, Breakthrough Listen--we're just in the process of opening a European office of it. There'll be announcements pretty soon on that one in the UK--and I guess that's not Europe anymore. So, that one we've got time on most of the world's large radio [telescopes], and many of the large optical telescopes. *We did, three years ago… [we] had the first tentative detection of a signal. It looked like what we call a techno signature. We're now almost 100% convinced it was caused by radio interference*. It's very hard to do these in the surface of the Earth.



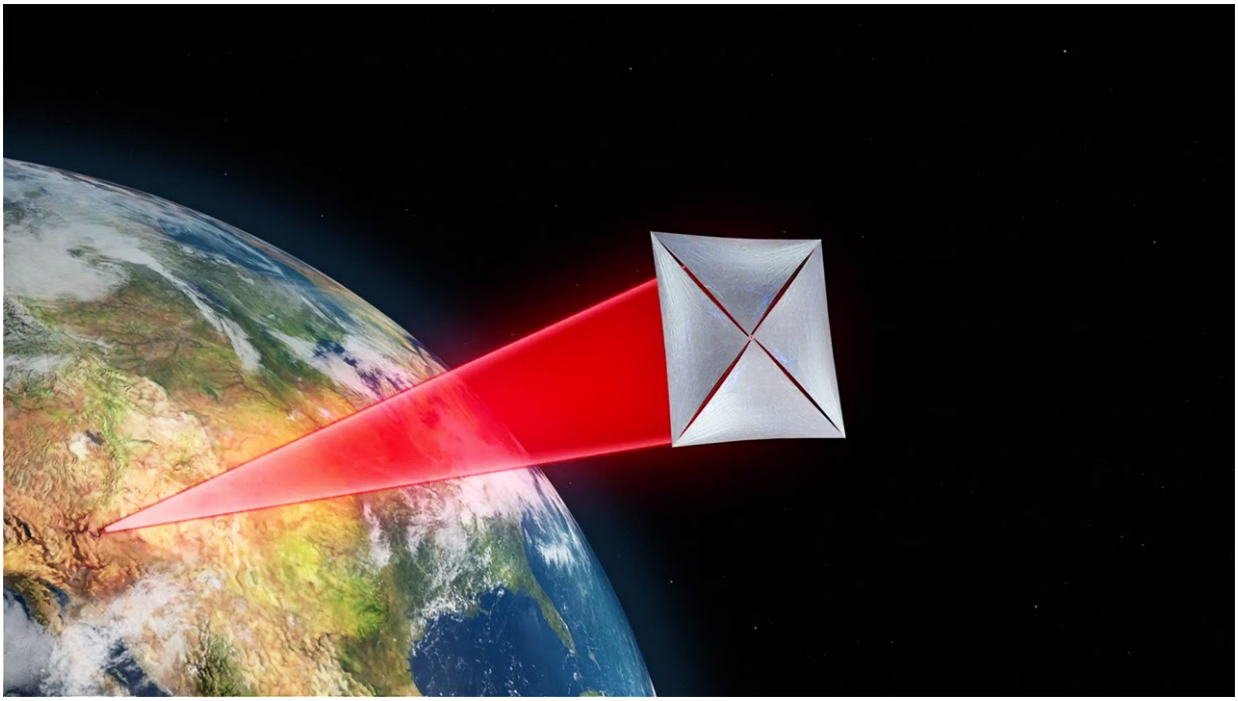
Source: NASA

So, we're starting to look at--can you put a sensor on radio telescope on the far side of the Moon? But that program is going very well. We're now convinced if there is a signal to be seen, we can see it.



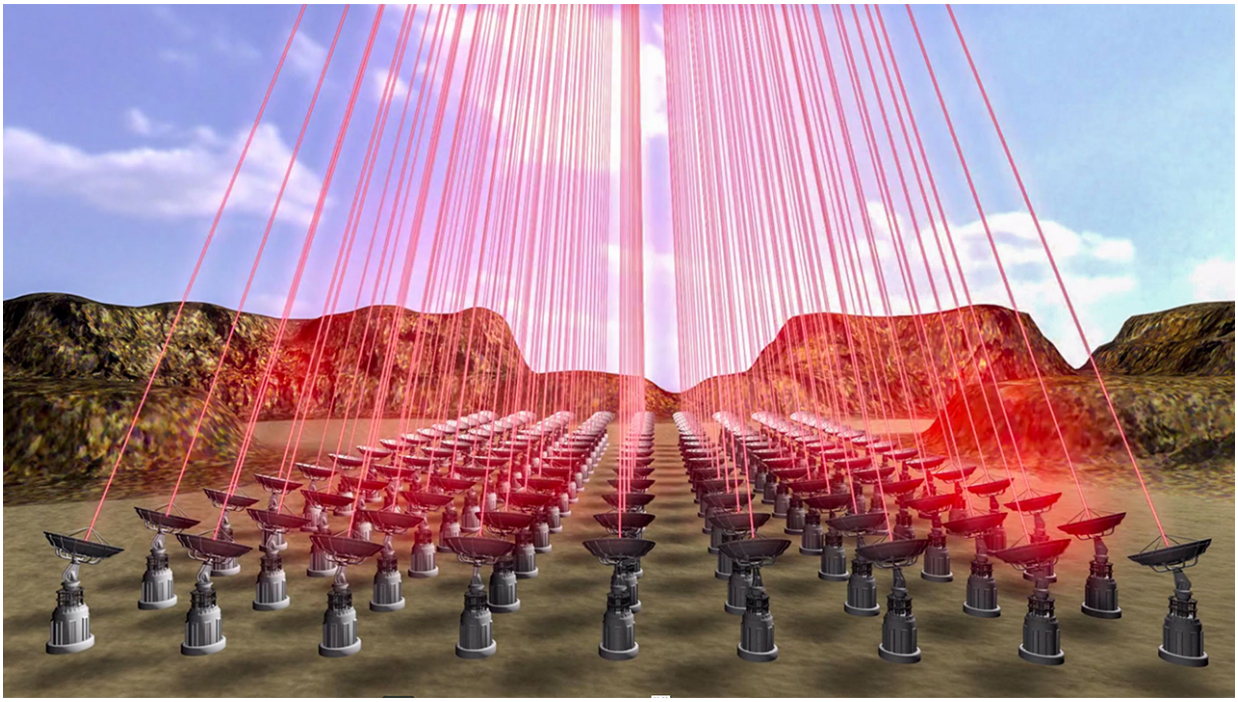
Source: Breakthrough Initiatives via Spaceflight Insider

The third one, **Breakthrough Starshot**. We are just completing the first phase of that. The only way we could figure out with technology we understand to send a probe to the nearest star is to have the probe only weigh a few grams and attach it to a light sail, which is, you know, 4-5 meter diameter.



Source: Breakthrough

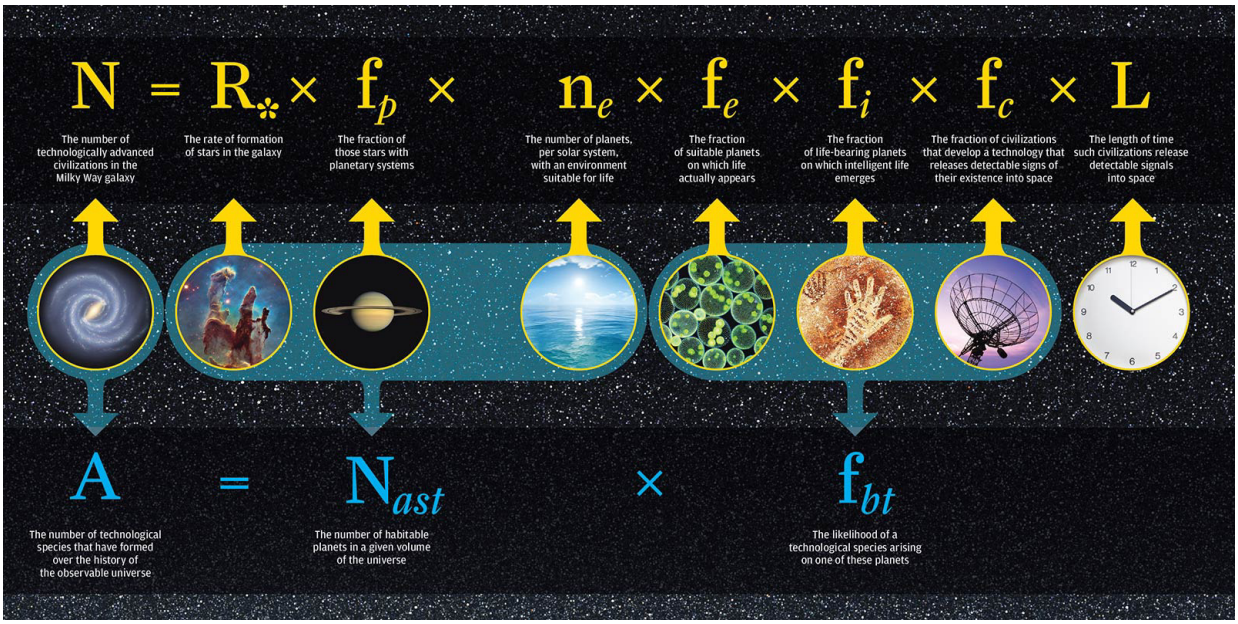
Very thin material, which you then erect in space, and you hit it with a *100-gigawatt class laser*, which is a really big honking laser! And you hit it for about, you know, 10-20 minutes, which accelerates it to 20% light speed, and then it coasts through interstellar space for 20-25 years, flies by planets in the Alpha Centauri system--and we now know of several--and takes images and other data and sends it back via laser beam. The first phase looks pretty promising. This is a long-term program--these things probably couldn't be launched until later this century.



Source: Breakthrough

But to my mind, it's the first evidence that we have that our civilization can actually reach interstellar distances. So, I'm very excited about those three programs. You know they really are addressing, you know, my life's interest is the nearby stars, finding life, and finding aliens.

Peter Garretson: Are you optimistic? If you were to plug in numbers in the Drake equation. Are you optimistic that there are other living [alien] civilizations. And if so, as somebody who thinks both on the civil and national security side, how do you see that?



Source: NASA

Pete Worden: Well, I'm optimistic. Let me say *I'm optimistic that probably even this decade, we're gonna find life elsewhere*, whether it's in our solar system or life-bearing planets. *I think the galaxy is infected with life. Life is everywhere. Now the question is, does it develop into what we call 'intelligence?'* I have to say as the scientist, I haven't the slightest idea, and that's why we're looking at it. The interesting thing about the Drake equation is it's a multiplicative equation--any one of those factors is zero or almost zero, the whole equation is very small, not zero. But we need to march down those terms. The first one is: find out where else life is, how common is it? Now, I suspect that there may be something that you would call alien intelligence, but I'm not sure we'd recognize it if we see it. And it may operate in vastly different timescales, it may be machine intelligence. Who knows? But I think that if you don't look, you won't find it.

Peter Garretson: As someone overseeing an organization that's devoted significant resources to listen for traditional radio signals, how do you evaluate… what do you think about these UAP hearings [2022, 2023] and the whole UAP phenomenon right now? One of your advisors, Avi Loeb [see AFPC Podcast with Avi Loeb] has started this Harvard Project Galileo. [See also NASA public Hearing and DoD All-Domain Anomaly Resolution Office (AARO) investigating 650 cases]

Pete Worden: Well, this is always an interesting question, and it's always fraught with opinions. Avi Loeb is doing what I think is one of the most important things, which is: 'let's try to apply science to that.' And the key thing in science is, you know, to detect real things and have them be repeatable. I mean, that's the essence of science. So, if somebody says, "I saw an alien phenomenon," somebody else can go observe the same thing. *So far, it's all been hearsay.* It's "somebody saw something," I mean, I listened to those hearings, and it's *just*

somebody says they heard somebody say that it was real. Now that's…you know… that doesn't mean it's wrong, but I'm very suspicious, and so I think that the obvious point is that we now know there are interstellar objects that go through our solar system. Some will hit the planet. Let's go find some of this material. And is there anything weird about it? And that's an important area. Now, I also have to remind everybody that what Carl Sagan said, "*that extraordinary claims require extraordinary evidence*," and I have seen nothing that would qualify as extraordinary evidence, but I've heard a lot of extraordinary claims. So, I suggest that people continue to be skeptical. I'm skeptical.

Peter Garretson: So, more in the realm of verifiable things, we've had an amazing last few years, when it came to interstellar--two interstellar objects [Oumuamua, Comet Borisov], and then the confirmation of the first interstellar meteor that I believe you had a role in getting the U.S. Space Force and U.S. Space Command to acknowledge. Is that right?

Pete Worden: Yes, watch carefully: my fingers never left my hand. But the certain colleagues helped get that out through. But yeah, I mean, I think there are… what's exciting to me is that there are, you know, *lots* of interstellar objects. Now, *I see no evidence that any of [the] things are other than natural phenomenon*, but unless you look, you won't find out.

Peter Garretson: It is curious, though, reading Loeb's book, that the light curve of this does seem like it would match exactly the kind of solar sail that you guys are attempting to build and launch on Breakthrough Starshot.

Pete Worden: Yeah… with big error bars! I mean, I was quite excited when Avi wrote that paper initially, and they asked [for] physical journal letters. And I think it kicked off some very good discussion. You know, I certainly am probably a lot more skeptical than he is. But on the other hand, he's a good friend, and I respect his great scientists. I respect his judgment on it. *If you don't ask the question, you're never gonna get the answer*.

You know, I'm very excited about--in fact, I worked with him a little bit on his expedition to recover those fragments. It appears that he's recovered meteorite fragments from his expedition. He's got material now that can be tested in various laboratories. I mean, there are people that claim, "well, that's just terrestrial material that was on the bottom of the ocean." All right, well, *if you got real stuff, you can test it.* And there's another meteorite that apparently is interstellar, that hit off the coast of Portugal--potentially [with] expeditions to collect that material as well.

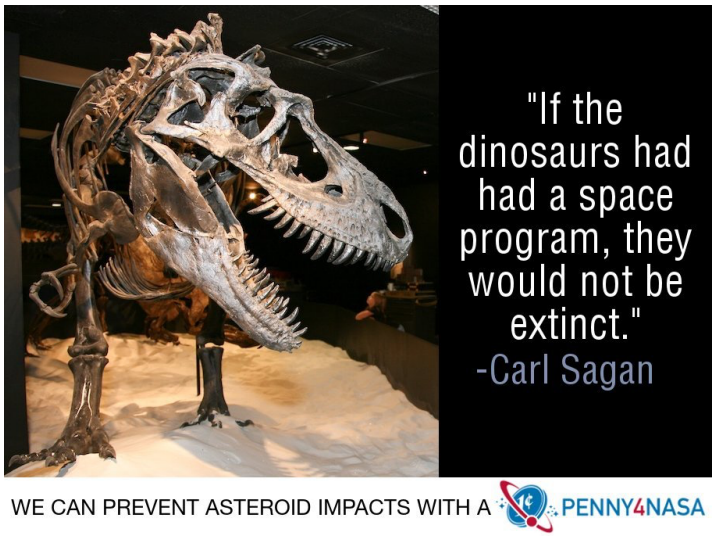
Now, what people need to understand: that isn't really fragments of the original object. When the original object came in the atmosphere, it vaporized. But then the metal in it is sort of a vapor, [it] re-condenses into little droplets, and the droplets come down to the surface. So, there is always a question of, well… you know, "when you vaporize them and recondense them. Did you do something to it? Are you really looking at what this object looks like outside the atmosphere?" We don't know. I'm a great fan of that if there's a lot of these objects--if we have better space surveillance capabilities--we can find them, and then go send something to

one and rendezvous with it, and you get stuff [from] what it looked like in space. Now, you know, again, my assumption is that *even if there are alien origin stuff, that it's highly unlikely the first few we see are of alien manufacture--they're probably just rocks*. But it's always important to ask the question of "if it behaves strangely…" One strange explanation is it's the product of an intelligence.

Peter Garretson: Now, as you have alluded to multiple times, you are a scientist, and you have a very unusual pedigree, especially for someone who has served as a general officer in what was at the time our space forces. And I think that brings a different kind of awareness. So, as an astronomer, and as an innovator, going back to Clementine's attempt to go to an asteroid, and the Clementine-2, which never launched, [to] actually go and impact an asteroid--you had been behind what this recent success of dark, when it had a different name, I think 'Don Quixote,' or something like that. But you have been among the earliest and most consistent voices on the importance of planetary defense, including testifying to Congress. So, tell us a little bit about planetary defense in the big picture.

[On Asteroids & Planetary Defense]

Pete Worden: Well, I think it's that I find the asteroids--particularly the nearest asteroids--fascinating from three perspectives. First of all, they're left over from the formation of the solar system. So, they're primordial material. So, they tell us about the formation of the solar system. Second, there are resources. And some of them are pure metal, or almost pure metal; others are ices and volatiles. You know, if you go get these things to the Moon, you have to mine them, but if you get them from an asteroid--if you find the right asteroid--they're pretty pure material. So, I find that that *from a resource standpoint they're very interesting*.



Source: Penny4NASA

The third one is that--I like what Carl Sagan said several decades ago, he said: "*If the dinosaurs had a space program, they'd still be with us*." You know, indicating that if they had been able

to find the asteroid that killed the dinosaurs 65 million years ago, they might have been able to divert it. *We now, for the first time, have the ability to protect the current life on Earth--so, it would be stupid not to do that*! And unless we want to be replaced by something else in another 50 or 100 million years. So, to me, there are scientific reasons; there are economic reasons; and there are survival reasons. That's a very strong set of reasons to focus on near-Earth asteroids.

And there's always an argument, "*Okay? Which bureaucratic organization should do this? Should it be NASA? Should it be the Space Force? Should it be some international organization?*" And I said: "I don't care." I mean, when I worked for NASA, I wanted NASA to do it, and when I worked for the DoD, I wanted [the] DoD to do it. You know, if I worked for the UN, which is unlikely, I'd probably want the UN to do it. *But I think it needs to be done. And that's really a critical effort.*

And, by the way, I'm really fascinated, not only by the asteroids that come near the Earth, but the ones in the main belt. You know, I believe *one of the best places in the solar system for human settlement is the asteroid Ceres,* which, by the way, as I get into that TV series, The Expanse, that was the headquarters of the asteroid Belt. But it's about 1,000 kilometers in diameter. It apparently has a lot of volatiles and other things. The gravity would be about 4% Earth-normal. So, for fat old people like me, it really feels good.

But I think that *planetary defense is a very serious thing. We… when I was on active duty, we tried to push it, and almost got it as a new mission*. Although I understand in the final discussion in the Joint Chiefs Requirements Council, that the Marines thought it was some sneaky Air Force trick to get more money, so they vetoed it.

Peter Garretson: I mean, that is a fascinating piece of history--was that *U.S. Space Command that took it as a proposed Joint Requirement?*

Pete Worden: I normally like Marines, but in this case, they were being jerks. I mean, the Air Force didn't want it, either. They just didn't say anything about it, cause they knew they'd have to pay for it.

Peter Garretson: So, let's talk for a moment about--well, actually, before I do that, I think it's interesting to note that *in Space Command 1.0, planetary defense was championed*. They actually paid for a CONOP to be developed.[1] They submitted it as a Joint Requirement. They thought about it as part of their strategic plan. And, in fact, the Air Force at the time developed the term Planetary Defense, wrote about it in Spacecast 2020 and Air Force 2025. But you know, it's amazing that *there appears to be like no advocacy by Guardians today, either in the Space Force or U.S. Space Command. Why do you think that is?*

[1] SAIC (2002). Concept of Operations for Natural Impact Warning Clearinghouse, prepared for Headquarters United States Space Command, Contract# F04701-00-C-8029, CDRL A005, Task Order 21-S, EADDII-21-10152.

Pete Worden: Well, it takes some advocates in the system. I'm happy *if I find some young officers that want to talk to me--I'm happy to help encourage them to push it*. I think there's certainly number of people that would. There's a lot of other challenges, too. You know, the argument that actually was used when I was doing this, trying to get it through is… and a couple smart and very senior people said: "Well, look: how many people have been killed by asteroids?" I said, "Well, I don't know, maybe one or two,"--and that's stretching the point, in the last... you know, the whole planet. "And when did this thing happen? The one that killed the dinosaurs?" "Well, that was 65 million years ago." So, the answer was: "Do you think we can defer this particular problem until next year's budget? You know, what's the risk of doing that?" And you can say, "okay--you could say that about anything that's long-range, until it happens." But I think the conclusion was that what we really probably need to do is, rather than push it is an independent mission right now, given all the other arguments*, is to is to tack it on to the requirements for Space Domain Awareness*, and say: "*Look, the system that will figure out what's going on in Cislunar space will also find these asteroids*", because, I mean, that *should be explicitly part of that mission*. And I think that's quite feasible to occur. Again, they haven't asked me [for] my opinion. You know, as I said, I'm an old retired guy living in Europe most of the time, so they probably won't.

Peter Garretson: Speaking of Europe, I think that you have been part of establishing the whole idea that '**asteroid mining** could be a thing' and encouraging that. So, talk to me a little bit about your role in advocating for us mining asteroids.

[On Asteroids Mining & Luxembourg's Role as an Ally]

Pete Worden: Well, that's an interesting long story--I can probably give you this, and then I probably need to sign off. But when I was the director at NASA Ames, I was a big enthusiast for bringing a lot of people in from around the world--[from] International Space University and other places.

And so, we actually had, I'd met a fellow that was at the International Space University in 2009, and we had at NASA Ames--he was a Luxembourger and he had a Ph.D. in astronomy--and so we hired him in our mission design center. And one thing I soon discovered about Luxembourgers is they love good wine, as I do. So, he was over at my apartment, having a glass of wine with some of the other students and young people, and he said: "Well, you should go visit Luxembourg." And I said: "Isn't that that little country between Germany, France, and Belgium that has cheap gas and low-cost booze?" and he said: "Yeah, that's it. But they're also a very rich country. And he said they were interested in space," and I said, "oh, come on, now--600,000 people." And he said, "No, really." And he pointed out that in the eighties that Luxembourg had sponsored the SES, which is now the world's largest COMSAT company, and it's actually based in Luxembourg. So, I said, "All right." I went to visit, and there was enough interest. They invited me back to meet some of the ministers--one of the ministers was the minister of the Economy, who was soon to become the Deputy Prime

Minister. He said, “Look, we're very interested in working with NASA. Let's talk about various ideas.”

And so, I talked about a number of things, and now he claims he thought I was nuts when I talked about space mining, but actually I found out his family had been involved in mining in the last century, so he was more interested than he said. So, we agreed eventually to do a series of workshops on mining asteroids and the Moon. And so, we had three of them: two of them at NASA Ames, and the third one in Luxembourg.

This was right in 2014, 2015, when I was leaving NASA, but the second workshop was held at NASA Ames, and he showed up, the Deputy Prime Minister--the Prime Minister showed up as well as the Minister of Justice. And these workshops, it was pretty clear there was a real [interest] there in the next decade or two, and I got sort of a frantic call from the NASA administrator, Charlie Bolden, who said: “I understand you have the entire government of a NATO ally at your center. How come I didn't know about it?” and I said, “Well, your head of external affairs OK'd it.” he says, “Really?”. And so, I quickly sent him the email. He says, “Alright, alright.” You know, because he was always concerned that I was out of control. But they decided to go ahead and *start their space program, which is really an investment agency, not a traditional space program*. And after my year was up, the Luxembourg Government asked me to be an advisor to them on the space resources. So, I'm the American advisor--still am. The Deputy Prime Minister became one of my best friends. I bought my apartment from him--Etienne Schneider. But they’ve done really well. *They've got over 80 startups. About 20 of them are related to space resources.* They expect by the end of this decade [for] some *10% of their GDP to be space-oriented*. They've worked a global consensus that we can do space mining--very effective ally and friend of the U.S.

And it's a really neat country.

Peter Garretson: So, I know you've got to go. If you have time, I actually want to ask two questions. One was, we had a conversation a while ago about the attempt, circa 2000, to start a Space Force, and why it didn't happen--and I wanted to give you a chance to broadcast that to a larger audience, because I think that's a particularly interesting story. And then the last question will be about your message to young people. But let me ask you first about Space Force. Why didn't it happen [in 2000]? How was it about to happen? What happened? [see also Slate & Substack]

[On the Attempt to Create a Space Force in 2000]

Pete Worden: Well, I think, *I was a strong advocate of it*, but I think that, you know, these are the kind of things that if they're quiet, then you get almost to the point, and then the elephants wake up--or the dinosaurs more likely--and they begin to get very concerned about it. It is about money and budgets. I was at that period a brand new one-star in the senior leadership of the Air Force. *When they finally figured out I was about to do something that Billy Mitchell did to the Army, I was effectively gotten rid of as well*. You know there's a lot of

other things to that. But bureaucracies are bureaucracies, and I think most bureaucrats regard that any budget is a 'zero-sum game.' And so, you can get *almost to the point where they let you do something*, and then it's like, "well, wait a minute, it's gonna cost us something. Where is this money coming from? Congress isn't going to give us more money." And then you begin to have *people that just don't like new ideas and start making fun of it, you know: "this is sort of science fiction*."

[Advice on Changing the World: Never Give Up]

But I think that each one of these attempts--it takes four or five times before something works. So, I guess *my advice to somebody that wants to change the world is*, first of all, *you gotta be ready to be fired a lot of times*. *And what doesn't kill you makes you stronger, although occasionally they might actually kill you, at least professionally. But so, my advice is, never give up*. And *if you can't punch through something, find another route*.

[On John Boyd's 'Roll Call']

I guess the other thing is: There was…probably the most famous, not-known Air Force strategist was John Boyd. He was a fighter pilot in the fifties and in the sixties. He was responsible really for the F-16 and the A-10, and he retired from the Air Force, and he came up with something called the OODA loop. If you can do your Observe-Orient-Decide-Act inside the adversary, you're always gonna beat them, whether it's in business or military or whatever. But there was one thing that he did that I thought was very important, and *when somebody wanted to work in his little group of troublemakers, he'd ask them*, "*do you wanna be someone or do something*?" Amen. Do you want to be the Chief of Staff of the Air Force, or the Chief of Space Operations, or the secretary of this, or the CEO of that company? *Or do you want to do something? And you wanna change the way we do things*? And I mean, it's nothing wrong with whatever you decide. *To my mind, the people that are gonna do something are much more important.*

And so, consistent with that is that: *decide what you want to do with your life, and don't never give up*.

If you want to be someone, there's not much advice I can give you. Talk to Elon Musk, or you know, President Biden or somebody.

Peter Garretson: Well, that's a perfect segue into my last question. So, I've often looked to you as an inspiration. And your leadership style, which seems to always be to 'look out at what's important and not always urgent,' to constantly be building a network. And you've been particularly open, you know, you create these flat organizations [that] are very accessible. You're always open and are known for mentoring young people and starting up educational organizations. I know you had a role in the International Space University, and I remember when I was a major and I met you at the STAIF or ISDC, introduced by Brad Blair, who unfortunately has passed away recently. But I remember you told me at the time that

writing was important, that *you needed to write*. And you also were very encouraging to get involved. I think we were in probably a thousand people, there was you, a general officer in uniform, and there was me, a major, and there was basically nobody else at the time.

So, I think we have a significant *young audience. So, what is your advice to them*? What is your mentorship to somebody who wants to do things?

[Advice to Somebody who wants to do things]

Pete Worden: Well, if it's moving us interstellar, then I'll be happy to help you, and there's a lot of different ways that you can do things. I mean in some sense, Elon might be a good example. I think he made money because he *does want to do something*: he wants to settle Mars. So, you know, he's probably not a good example of one somebody that wanted 'be someone.' He wanted to do something.

But it's doing the best you can to develop your professional capabilities. You know, *I'm a big believer in advanced degrees, particularly PhDs*. It doesn't have to be in a technical area. My current staff--there's only one engineer. The rest of them are all sort of humanities and social sciences, and my assistant is a lawyer, a space lawyer. God, I hate lawyers, but he's done a good job in helping me.

But I think the other one is: *Figure out what your vision is. What is it that gets you out of bed every morning?*

And like I said, if it's interstellar, I'll help you.

But as I told you, *write things down*. You know, *you can only talk to so many people, even on the Internet. But if you write things down it's forever*.

Peter Garretson: Well, Dr. Worden, thank you so much for your time. I think we'll have to leave fusion and geoengineering and starships and a lot more for a future conversation. But I really appreciate you sharing this. This big picture overview of everything from Cislunar to asteroid mining to planetary defense to interstellar.

Pete Worden: Sounds good. Happy to chat again. Have a great weekend. Bye-bye.

[Podcast Outro & Outro Music]