Space Capital Podcast S01E15 - Pinpoint with Greg Milner transcript

"It just simply cannot be done with GPS. If GPS went down, those companies would be- they would be out of luck."

Welcome to The Space Angels Podcast, episode fifteen, Pinpoint. I'm your host, Chad Anderson, CEO of Space Angels - the world's leading source of capital for early stage space ventures. You can find us on social media at Space Angels. In this podcast, we explore what's happening at the bleeding edge of this new entrepreneurial space age, and speak to the founders and thought leaders at the forefront. Today, we're going to be talking about GPS, which is integral to our investment thesis. Space-based technologies are the building blocks of innovation. They are what enable our global economy. GPS began as a military technology, which quickly became an economic one. Those early infrastructure investments by the government were leveraged by pioneers, Trimble, Magellan, and Garmin, who not only made the signal more useful and accessible by military troops but also for commercial purposes. The importance of this space-based signal cannot be understated and is now ubiquitous in our everyday lives through applications like Google Maps, Lyft and Uber, and Pokémon Go. Which have accounted for some the largest venture outcomes in history. This is why I'm so excited about today's guest, Greg Milner, the author of Pinpoint: How GPS is Changing Technology, Culture, and Our Minds. Named the best book of 2016 by Wired, The Financial Times, and others. He's a copywriter and editor featured in The New York Times, New Yorker, Bloomberg, The Guardian, Time, Rolling Stone, and more. He also gives talks and lectures related to GPS and other geospatial-related subjects at Columbia University, Stanford, Schriever Air Force Base, and The National Space Security Institute. Greg, super excited to have you here. Thanks for taking the time to speak with us.

Greg:
Great. Thanks for having me.

Chad:
Okay. So, we have a lot to cover today and I can't wait to dive in. But to start us off, can you first tell a little bit why you are personally interested in space technologies and geospatial issues?

Greg:
Well, it actually started with my interest in GPS and that started with the - this about almost ten years ago at this point - I just started noticing that GPS was seemingly everywhere. It was migrating onto our phones, it was something everyone talked about, but nobody I talked to seemed to know what it was. And that I didn't know what it was. I didn't know if it was a specific technology, or just kind of whole suite of geospatial technology. So, I decided to find out. And it was like peeling an onion. I mean, just when I thought I'd figured out, you know, all that GPS does, there would be another thing until I basically encompassed pretty much every aspect of modern life. And so, that's what got me interested in that. And on a larger level, just geospatial issues. I'm fascinated by the idea of how we define even what here and there is. I mean, it's all subjective in a way. There's no such thing as right now, right here. It's something that we define. So, that's on a larger level. That's why I'm interested in geospatial stuff.

Chad:
So interesting. So, we're gonna dive into some of those points a little bit later. So, in the book you start by discussing the Polynesians navigational and seafaring prowess, leveraging etoc, and the celestial techniques used by various cultures. And I was just telling you, earlier, your book is actually required reading in our office. And so, we all felt that this was an excellent way to establish both the importance of navigational tools but also the need for a system like GPS. So, this is a big, broad question. But can you help us understand what makes GPS such a powerful tool, and how it addresses the limitations of previous navigational methods?

Greg:
Well, basically, GPS is powerful because, well, on the most basic level, no matter where you are in the world, it works. And it's something that, you know, from pretty much every point on the globe, you've got a direct sightline to enough GPS satellites for it to make it work. Now, it's powerful though, also, because it's such a big source of timing. And in a way, that's what makes it even more important, or at least as important, as it is for geolocation. The fact that it's pumping this time signal that's very, very accurate, and so can be, you know, with these incredibly synchronized clocks on these satellites, synchronized with, I think, within a billionth of a second that it creates like a really, really enormously powerful timing source. So, the fact that, from a geolocation standpoint, I mean, what it does is it basically gives us a way to always know where we are. And that sounds really banal, because maps could do that. But this is like an overarching way to like, no matter where you are in the world, to know where you are. And that's really, really powerful. I mean, in a way, GPS, I guess, from a geolocation standpoint, doesn't do anything that paper maps didn't already do. But it does it so much more powerfully. Almost too powerfully in some way. I mean, it can be seductive how well it works. In a way, as much as it prevents you from being lost, it also creates sort of new ways of getting lost.

Chad:
Yeah. And I was fascinated to dive in and to- when you compare it to seafarers and the three different pieces, the navigation, wayfinding, and dead reckoning. Which, you know, people don't use in everyday language, but, I mean, they perform these functions in everyday life.

Greg:
Right. Exactly. I mean, wayfinding is kind of a tricky concept to describe. But it's basically, you know, the idea of how we are aware of our surroundings and how we move through them and know where we are in relation to everything else. And the reason I started out the book talking about the Polynesians is, well, I mean, first of all, the fact that they found these little dots in the Pacific, which is so big, you know, every other landmass in the world could fit within the Pacific. And over, you know, a few thousand years, the Polynesians found these tiny little dots and they did it through trial and error, to some degree, but they also developed these incredibly sophisticated navigation techniques that didn't require what we, you know, the things that we use. I mean, in a way, if I could just go back to GPS, it's kind of the apotheosis of this whole Western way of looking at the world, because it gives us latitude and longitude. Which is ultimately what we're getting. We don't think of that, because we always see the blue dot on a map. The Polynesians didn't need that. They didn't need latitude and longitude. They had a different way of looking at the world that was almost unfathomably complex from the way we think of the world. It's a completely different belief system in a way.

Chad:
Yeah. I want to pick up on something that you mentioned. So, time is funny thing that I think a lot of us take for granted. I learned recently about railway time. And so, the idea that, prior to 1840 in London and the train system there, in 1840, the great western railway had established railway lines between two cities, and this was the first time that they synchronized two local times. And it's super interesting to me, because before that, time was just local.

Greg:
Yeah.

Chad:
And when you turn on the news, even today, they say, "Hi, I'm, you know, Brian Williams. Today's November 21st and its 5 PM." Or whatever, you know. And they always do that. And the idea behind that at the news hour was to synchronize your time. And the idea of synchronizing time has eluded us for a very long time, and it's actually a relatively new concept. And in your book, you assert that, you know, first and foremost, GPS is a clock.

Greg:
Yes.

Chad:
Even though you and I, you know, mostly use it to find our way places. And so, can we talk a little bit about that and the importance of that?

Greg:
Sure. I mean, first of all, GPS is weirdly hard to define. When people ask what GPS is, and what I always say is it's the signal that comes from the satellites and that signal is ultimately based on time. And by the way, what's interesting, you said about railway time, because not only was time not always synchronized but even distance and location wasn't always synchronized. Every country used to have practically its own datum, which is, you know, the sort of ground zero by which all other points were defined. And one thing that GPS does, it didn't do this singlehandedly, but it kind of created one grid for the whole world that we all follow. I mean, again, that was sort of a gradual kind of post-war sort of thing. But getting back to time. Yeah, I mean, the entire system works by timing. And that's why when I say, GPS is a clock, it can't function unless all those satellites are synchronized in time. And I don't know if your curious- I mean, I can talk about the nuts and bolts of how that works. I don't know if that's something you want to talk about, but...

Chad:
I do want to get into a little bit of it, just because, again, it's a signal that I think everyone uses and everyone sort of takes for granted at this point.

Greg:
Right.

Chad:
I don't think they understand how it works, you know? The space segment, control segment, the user segment.

Greg:
Yeah.

Chad:
And all of that. I mean, it would be great to dive into that a little bit.

Greg:
I mean, the way to describe what GPS does is, first of all, you have to understand it's what's called a passive navigation system. Meaning that we don't have to transmit anything for the satellites to send back information and tell us where we are. Which is why when people say GPS is tracking them, I say, "No. No. GPS can't track you anymore than when you turn on a radio, the radio can track you." Other things that you do are letting people track you. But basically, the way it works is that every spot-on Earth has a line of sight to at least four GPS satellites in a constellation of twenty-four active satellites orbiting, I believe, twenty thousand kilometers above the Earth. If... if you... if your GPS receiver, and that can be in a phone or in a nuclear missile, doesn't matter, it all works the same thing. If it can measure the transmission time from one satellite, it can tell how far away it is from that satellite in the same way that if I threw a baseball to you and you knew exactly, like, exactly the speed that it was travelling, you could figure out where you were- how far away you were by how long it took to get to you. So because the signal is travelling at a constant speed, at the speed of light, your GPS receiver can tell, because the signal has a timecode in it. "Oh. The signal left the satellite at this time, and now it's reaching me at this time. So, I'm this far away from that satellite." Now, if your receiver can do that simultaneously for at least three satellites, it can define its location in three dimensions. And it actually, technically, needs four to like iron out some inconsistencies. But, essentially, if it can do that with these satellites simultaneously, it can figure out, "Okay. I'm this far from this satellite, I'm this far from that satellite, I'm that far from that satellite. That must mean I'm here, in terms of latitude and longitude." And that happens every single time we get a position fix. And what's incredible about that time signal is that the signal from the satellites is almost unfathomably faint. By the time it reaches us, you know, I think it's a few milliseconds after it leaves the satellite, it barely exists. And one of the amazing things about our GPS receivers is that we can sort through all the electronic crackle and noise around us and pick out just enough information we need from this tiny little signal coming at us from four satellites.

Chad:
Tiny little signal, but infinitely scalable almost, right?

Greg:
Yeah.

Chad:
So, you've got the space segment, which is the satellites that are in orbit.

Greg:
Right.

Chad:
You've got the control segment, which is the tracking stations on Earth, and then you've got the user segment which is every one of the world's GPS receivers. And you also mention in your book that you could double that, triple that-

Greg:
Yeah.

Chad:
...and it wouldn't have any effect on the signal.

Greg:
There are two things that I find - well, there's many things I find amazing about GPS - but two that stick out is that, first of all, I can't think of another technology that hasn't changed really in fifty years. And that's a plus, not a minus. You know, I mean, GPS has been tweaked, but essentially the system is exactly the same technology as they figured out in 1973 when they began. But also, as you say, it's infinitely scalable. I mean, because all it involves is us receiving a signal, you know, the number of receivers could double, it could triple tomorrow, and it doesn't matter because all we're doing is taking in a signal. In the same way that you could triple the number of radios in the world tomorrow, and it wouldn't matter because all you're doing is receiving the GPS signal. It doesn't matter how many receivers there are in the world. And so, like you say, it's infinitely scalable. And that's one of the things that makes it so powerful is that we'll never be able to overwhelm GPS, it's impossible to do that. And so, we'll never have to beef it up in that way. We have to improve it in other ways. To, you know, improve the timing a bit, to increase some security issues. We change the satellites from time to time. But we'll never have to say, "Oh, you know what? There's too many people using GPS, we've got to do something." And by the way, when I say we, we is the United States Department of Defense. Which I think is another thing people don't realize. You know, the space segment and the control segment are both handled by the US Air Force, which kind of administers the system, and a series of tracking stations around the world. Some of which are controlled by the Air Force, and some of which are controlled by the National Geospatial Intelligence Agency. Probably the least well-known wing of the US intelligence community. So, that's the control segment and the space segment. The user segment is all of us. And that's, you know, that's the segment that's bigger than anything else. And because the signal is relatively transparent which is part of the... part of its structure, we can always figure out new things to do with it. I mean, when people say, "Oh, my GPS failed." Ninety-nine percent of the time, they're wrong. GPS didn't fail. And I've talked to, you know, people at the GPS control center at Schriever Air Force Base in Colorado and they're very intent on this. They say, you know, "We're responsible for the satellite and the signal coming off of it. Once the signal leaves the satellite, it's yours." You know, and so when something goes wrong- I mean, GPS is a very robust system, in terms of how it works. So, when you say your GPS failed, it's probably the map program in your phone, or whatever, that gave you weird directions. It wasn't the signal itself.

Chad:
Fascinating. And GPS has been called the world's only global utility. It's universal, free for all, accessible by anyone, and influencing everyone.

Greg:
Yeah.

Chad:
And you say in your book, also, "Although less visible, GPS's influence on the world equals or exceeds that of the Internet." And in fact, you point out, that the Internet could not operate without the precision timing controlled by GPS.

Greg:
Right. I mean, it's a little hazy because not every computer network is taking GPS time, but a lot of them are.

Chad:
Yeah.

Greg:
But yeah, I absolutely- I mean, when I say that it's more- it's importance rivals, if not goes above, the Internet, it's because there's really no aspect of modern life that it doesn't affect. I mean, GPS is just- it's always there in the background doing things that we're not even aware it's doing. Like regulating the electrical grid. Or regulating mobile phone networks. Or regulating financial transactions on the major exchanges. Because all these things rely on timing, and GPS is a great source of timing and it's free. And yeah, I think it's- the point really can't be made enough, that this is free to everyone everywhere. I think some people feel like when they're in another country, they're using something else. And in some countries, there are a few systems that are like GPS, and they're getting more powerful, but GPS is still the, sort of, the bedrock of all of them. And, you know, I always say, if an ISIS terrorist is getting a position fix, he's doing it courtesy of the Pentagon.

Chad:
Right.

Greg:
Because he's using GPS. In theory, the Pentagon could decide to turn off GPS tomorrow. There's, I think, by US law now it couldn't do that, but in theory it could. It'll never happen because GPS is too important now. But if there's such a thing as American soft power, GPS is the best example of it.

Chad:
It's hard to compete with free.

Greg:

Exactly. It's hard to compete with free. And that was the problem that, I think, Galileo, the European system, made at first. It's not like that now, but they were gonna, you know, charge for it. And GPS being free is a huge part of its appeal, obviously.

Chad:
Yeah. And GPS has become our heartbeat, as you mentioned a few times in the book. So, we've established that GPS enables our global economy. It's what ties us together. The precision timing plays a really key role in that. The estimated value of the GPS market in 2011 was around nine billion. It had tripled by the time your book came out in 2016. I've seen reports that say thirty-eight billion in 2017. The US Department of Commerce recently published a report saying, just a couple months ago, that GPS had generated a trillion and a half dollars of economic value in the US alone. Certain early GPS entrepreneurs rank among the wealthiest individuals-

Greg:
Yeah.

Chad:
...among the world's wealthiest individuals. But the true economic influence of GPS resists quantification, you say.

Greg:
Yeah. One of the people I talk to, who was one the early, you know, involved in the early GPS team, he's become sort of like an amateur GPS historian. And yeah, he set out, he said, you know, he tried to figure out the economic value of GPS, and he gave up. Because he just kept getting numbers that were so large, they were almost meaningless. You know, like in the trillions of dollars. I think the way he put it is like, they're meaningless only to everyone but scholars. Like it just didn't actually make any sense. So, he kind of gave up. And, you know, that was before things like, off the top of my head, Pokémon Go. It was before companies like Uber and Lyft came on the scene. There's always people who are figuring out a way to increase the economic value of GPS.

Chad:
And it's becoming more and more difficult to untangle the worth of GPS from, you know, the worth of everything.

Greg:
Yeah. It's like saying, like, what's... what's the value of telephones? You know, like in the twentieth century.

Chad:
Yeah.

Greg:
Like that kind of thing. I mean, you couldn't in other words like, how do you explain how valuable oxygen is the respiratory system?

Chad:
Right. For as much as we rely on GPS today, I think it would be surprising for most people to learn that from its birth in the Cold War into, arguably, the Gulf War, GPS wasn't really accepted by the government as the positioning and navigation solution. Can you help us understand what happened in the Gulf War and the years leading up to it that led to GPS being accepted and eventually celebrated by the government?

Greg:
Yeah. It's one of the weirdest facts of GPS history that the Air Force, which... It was basically an Air Force program. It was kind of done with the help of several services, but it was essentially an Air Force program. And they tried to kill their own program on several occasions, because there was just a feeling... part of it was an institutional thing. Like the space segment of the Air Force, at least back then, as opposed to the operational segment. The people who fly airplanes, or repair airplanes, or design airplanes. The space segment was very small, and they were looked on with suspicion I think by a lot of the operational side of the Air Force, who kind of saw them as like weird pie in the sky people.

Chad:
And it still is. I think the space part of the Air Force makes up ten percent of the budget and the workforce.

Greg:
Is it even? Yeah. It's- Which I think it was probably much less back then. I'm surprised. It's interesting. I didn't realize it was still that low. I figured in this day and age it would be bigger. But besides the fact that it seems crazy to us that they didn't want GPS. It's interesting to kind of dig in a little bit into what they said, because what people would often say when the GPS proponents would try and explain is like, "Why do I need another navigation system? I already know how to get from here to there." And they would say, "Well, it's not a navigation system. It's a positioning system." And that's a subtle but important distinction, you know? It tells you where you are right now. And so, that become... It was originally thought, like this is gonna be a way to drop bombs more precisely. Brad Parkinson who, more than anyone, deserve the title of godfather of GPS, although there are a lot of people. He was, you know, a disillusioned Vietnam colonel, I think, when the Vietnam War happened. And he helped design airships. And he went to Vietnam to kind of see how they were working. And there are bombing campaigns there, he was so disillusioned and disgusted by how random they were this his feeling was like, "Well, GPS will be a way to drop bombs more precisely." So, in his way, it was a more humane way to fight a humane war. What happened, by the time you get to the Gulf War is that it'd been slowly gathering, you know, sort of momentum within the military. But what happened in the Gulf War is it was... GPS was used in some of the early bombing runs, and that was important, but the main thing that GPS did is that it allowed the US Senate's allies to basically barnstorm across a featureless desert. The Iraqi's assumed that that was gonna be slow going for the US, because it's feat- you know, there's no way to know where you are, or so they thought. With GPS - and the funny thing about this was - is that a lot the receivers they used were civilian grade, because the military receivers that were being built were just taking so long to build that they ended up buying some civilian grade receivers. And so, that was what allowed the tanks just to go right

across the desert. And you could make an argument that GPS, as much as anything, was responsible for that war being over so quickly.

Chad:
It's so funny, in the book, you have a few quotes and it says, "You know how many times I've heard, what does it do? It tells you where you are. I know where I am. Why do I need a damn satellite to tell me where I am?"

Greg:
Yeah.

Chad:
It's so funny. And then also, the other quote that just always stick with me is, "We're the Navy. We know where we are."

Greg:
Yeah. Yeah. I mean, that's the thing, it's like especially if you were someone involved in anything piloting or being on a ship. You already had navigation systems that were basically, I think, based on dead reckoning. And they worked okay, they worked fine. So... in the mind of someone like that, they're thinking like, "Why do I need another one?" And nobody, not even Brad Parkinson, could foresee how much it would essentially eclipse even being- Not only would it become important to the military, now it's part of, I think, pretty much every weapons system in the military. But the military use now is actually kind of a tiny percentage of all GPS use. It's been eclipsed by civilian usage. And people like Brad Parkinson, they kind of knew that that was gonna happen. I mean, there was always a civilian signal, and they thought maybe it'll be helpful for like airplanes and aviation. But they could not have foreseen- because, you know, back then a GPS receiver was a big desk like with a computer. And it's now- it's a chip.

Chad:
So, the Gulf War was also important from an entrepreneurial perspective, because it introduced commercial GPS companies, like Trimble and Magellan to the world, as you mentioned.

Greg:
Yeah.

Chad:
And, in fact, in your book, you describe the families of soldiers in the Gulf War frantically calling Magellan looking for GPS devices, ready to pay out of pocket for this technology.

Greg:
Yeah.

Chad:

So, it wasn't just that they were using commercial handsets, that they were actually- their families were going out looking for them, saying, "Please." You know, "Equip my family member with the best technology."

Greg:
Well, and the funny thing was, it actually wasn't even the best technology because the Trimble sets were the ones that were really made to be really exact. Magellan's... Magellan had a slightly different business plan, which was that we can figure out how do we get people to where their car is in the parking lot, but we don't need to get them to the exact, you know, square foot where their car is. So, but... but Magellan's, I think, were a little cheaper. And yeah, people were calling. They were like clearing out electronic stores just to get these Magellan sets to soldiers in the war. So, in a way, that was kind of how GPS... It was almost like its debut on the world's stage. It was what introduced a lot of people. Now, it wasn't involved in, for example, those famous Gulf War shots of the missile going down the chimney or whatever. That wasn't GPS. Nonetheless, GPS was so important and just so ubiquitous that it just kind of started to plant the seed that, "Oh. Maybe this is, you know, important entrepreneurially." And I might be getting a little ahead of us here, but then by the end of the nineties when the US government turned off what's called selective availability, which was the military's way of scrambling the GPS signal for civilians a little bit, because they were afraid of people figuring out how to, you know, bomb the Capitol or the White House. When they turned that off, all the sudden GPS became so accurate that the industry could really boom.

Chad:
Yeah. And, I mean, I definitely want to talk about that because like any advanced technology, any technology period, I mean, it can be used for productive or destructive purposes, right?

Greg:
Yeah.

Chad:
And so, that was actually a really important piece of all of this. And it wasn't until 2000, that Bill Clinton officially ended that practice, right?

Greg:
Yeah.

Chad:
So, what impact do you think that that had on the commercial market, and the increased usage of-?

Greg:
Oh, I mean, it was massive. I mean, it's like if the, you know, the power company finally said, "Okay. Now electricity's gonna be twenty-four hours a day." And then people, "Okay. Good. We can build all these consumer goods that require electricity." I mean, it went from being, GPS for civilians, not the military, but GPS for civilians went from being, I think, about as accurate as like a football field to something that would accurate within a few square meters. And that was

huge. Because that meant that you could come up with all these applications that required something... that required a little bit more precision than just the size of a football field. The reason it took so long for selective availability is that, I think, the military- just no one wanted to be the one to finally pull the plug. And Clinton in, you know, in consultation with the military finally, you know, finally did it through an Executive Order. But the reason it finally had to be turned off is there were all kinds of like hacks and workarounds that you could figure out how to like- If you really wanted to and you had the right equipment, you could figure out ways to get around selective availability. So, in a way, it was kind of pointless to even keep it going. Although, I think people who are really- who were really into GPS at the time said that, when there would be like a military... like some sort of military campaign going on, they'd notice that... that they're own GPS would get less accurate because the military was turning it back on. I think when the Haiti campaign began, I can't even remember what year that was, people said- Or also, people say like whenever the President would visit, you know, their area, they would see their GPS like, you know, get- That's anecdotal, but who knows.

Chad:
Fascinating. I want to take a half-step back and talk a little bit more about the distribution of the signal, because I think that that was a really key piece of this. You know, of getting it out into the user segment's hands. And in the 1980's, the first movers, Magellan and Trimble, they were at capacity, as you said, filling military orders. And this allowed Garmin an opportunity to get into the market. But there was a number of things coming together at the same time, right? You mentioned that solid state memory also allowed for the Garmin system that you'd put in your car to also not just have a local map, but also the whole country.

Greg:
Right.

Chad:
You know, in one system. And that's really when it started to take off. And I've got some facts here from... By 2006, Garmin controlled sixty percent of the US market for navigation equipment, which was about just under two billion in sales, and it was growing a hundred and forty percent annually. So, Garmin came in and made a huge splash in the consumer segment. People started putting these handsets in their dashboards, in their cars, and then we were really off to the races, right?

Greg:
Yeah. Garmin was, well, they were in the right place at the right time, and they had really good technology. They were really smart about it. And yeah, the growth, as you say, in the mid-2000's was just, you know, exponential. Both in, you know, in sort of GPS use, but also specifically with Garmin. They really capitalized on it in a big way.

Chad:
Yeah. In addition to the discontinuation of selective availability, we also think that Qualcomm’s work in improving GPS signals on mobile phones. And the launch of the Google Maps API was key in the development of what we now call location-based services.

Greg:
Definitely.

Chad:
Can you tell us about the influence on GPS like companies, like Uber, and Lyft, and...Bird, Snapchat, all of these things that we know and love?

Greg:
Well, if I'm understanding the question correctly. They can't operate without GPS. They literally cannot operate without GPS, because it's all... it's all based on location from drivers knowing where to go, to also all the things that go on behind the scenes, the analytics and, you know, where they all do, you know, very, very, sophisticated, I assume, location analytics to figure out things like how to price and rides and how to measure traffic. Things like that. There's- It just simply cannot be done without GPS. There's no way. If GPS went down, those companies would be... they would be out of luck.

Chad:
Most people know about Google Maps and using GPS for navigation. Again, that's the way that we use it daily.

Greg:
Yeah.

Chad:
But there's lots of competing technologies out there. We mentioned, you know, that the Navy was using cutting edge stuff back then, but also in every other aspect of our lives we had technology. And there was actually some competing technologies around the same time as GPS that we were using for different applications. So for cars, we had a number of different beacon systems and things like that.

Greg:
Yeah.

Chad:
And the military had their own systems. And so, why do you think it is that GPS won out in all of these? And, I don't know, maybe the Alaska Airlines and like the usage of it in aviation is a good example of this. I don't know.

Greg:
Yeah. I mean, well, one of the turning points was when that plane was shot down like in 1983 that strayed into Russian airspace. That probably happened, the accident probably happened, because they had input some wrong figures into their dead reckoning navigation system. And I'll just give a quick definition of dead reckoning, if you want to include it. I mean, a dead reckoning system basically means that you measure where you are now, in relation to somewhere you were in the past whose position you know. And that's the most basic form of navigation systems. So,

after that accident in 1983, Reagan basically issued, I think, and Executive Order that said GPS is now here to stay. And in a lot of ways it was symbolic because it took a long time for it to be really adopted by aviation, but that was a big symbolic step. Like GPS- It sort of told the world, we control GPS but we're not turning it off and it's always going to be available. And that was a big thing. And yeah, there were other sort of attempts to do things like in cars, but the simplicity level of GPS just won out. The fact that you didn't have to worry about like beacons here and there. And for the military, GPS won out because it was a way, you know, to get a position fix without- and because it's passive, because you're just taking in a signal. You're not having to transmit a signal that then tells you where you are. It was undetectable, you know. And that was a big, big reason why, you know, the military finally figured out that GPS was a good thing. But in general for non-military uses, there was just nothing as simple as GPS, nothing as easy to use.

Chad:
Okay. So, we've been talking a lot about the positives of GPS, but your book also delves into the darker side. And can we talk a little bit about the vulnerabilities? Jamming, spamming, spoofing.

Greg:
Yeah.

Chad:
And what those things are, and what we're doing about it?

Greg:
Well, I should start by saying that earlier GPS was very robust. And it is. It's a very strong system. However, the signal is so weak that it's easy to overwhelm, and GPS has become so ingrained, so quickly that it almost happened before people could really figure out the security implications of what was happening. There's two major ways that you can mess up a GPS signal. One is jamming. And that's just what it sounds like. And you can get little portable GPS jammers that will jam, you know, all GPS receivers in your area and basically just cut the signal for them. That's bad, but it's not as potentially bad as spoofing is. And what spoofing is is when somebody transmits a signal from the ground that imitates the GPS signal. And so, GPS receivers nearby are convinced that that's the signal they should follow. And that can have huge implications. When people talk about GPS going down, they often thing about some worldwide shortage. Now, those satellites are far away and they're moving very fast, and I've been to control in Schriever Air Force Base and you're not getting in there without [laughs] I mean, there's doors that say, you know, like, "If don't come in through in three seconds, we use deadly force." I mean, it's a really fortified bunker. But what the fear is, especially regarding spoofing, is that because GPS is used to regulate systems that are spread out over a very large geographic area, if someone were to do a successful spoofing attack that would effect, say, a few nodes of the electrical grid, all the sudden it would start following wrong timing, it would get confused, and it would start allocating power, you know, in wrong ways and you got blackouts. Or in the financial exchanges, if a spoof signal were to confuse the automatic trading computers. They pull out of the market, and all the sudden, you know, there's a huge crash. In 2010, there was something called the Flash Crash, which wasn't caused by GPS spoofing, but it was the kind of idea. In that, automatic trading programs just pulled out for some reason, and that created a chain reaction. So, it's a chain reaction kind of thing that people are really worried about. I guess, a

jamming is bad. And bosses who use GPS tracking systems to follow their employees, especially truckers, don't like them. I mean, there's so much- there was so much GPS jamming use on the New Jersey Turnpike around here, that it was affecting the landing system at Newark Airport which, you know, runs right alongside the freeway. But spoofing is the big fear. And there hasn't really been, at least that we know of, a major spoofing attack. But you talk to security experts and they basically say like, "It's inevitable. It's going to happen at some point, and we have to figure out what we're going to do about it." I mean, a few years ago, there was a slight timing error in one of the GPS satellites. I think just one. Just a few milliseconds off, and it caused all these problems throughout Europe because that happened to be where that satellite was over at the time. Because all the sudden, the clocks were just a little bit off and they couldn't really synchronize each other within the satellites. So, you throw the timing off and, you know, it's bad news.

Chad:
And one of the reasons why we're so confident in this system and the security of this system is mutually assured problems protection.

Greg:
Yeah.

Chad:
Like in the sense that everyone relies on this.

Greg:
Right.

Chad:
It's the bedrock. And so, you don't imagine that someone else would come in and really fundamentally, you know, mess up the system because they rely on it as well. But that's changing, right? These systems are complex, and they're very expensive. And so, mostly it's nation states that are building these.

Greg:
Yeah.

Chad:
But we've got a lot of them. GLONASS is the Russian one. Galileo is the European that's being built. BeiDou by the Chinese. Japan, India, others.

Greg:
France for a while was doing one. I don't know why, since the EU had Galileo, and I don't know what happened to that. But yeah, as you say these-

Chad:
And the UK's talking about doing their own one now with Brexit and stuff-

Greg:
Oh, right. I forgot all about that. That's right. I mean, as you say, these global navigation satellite systems, there's only a few of them in the world because they're very expensive to produce. It's not, you know, like you said, it's really limited to nation states. And I think the reason why some nation states build their own is sort of... it's so that they know they've got- they don't have to depend on the US. Except they still are, because GPS is more powerful than any of these. I mean, for a long time, this may still be the case, GLONASS was the only other global navigational satellite system that was like GPS, in the sense that it had complete coverage and a full satellite constellation. At this point, I think Galileo may have caught up. But what's going to happen in the future is that GPS is always going to be the bedrock. I mean, the more systems you have up there, the better, the more accurate you can get geolocation services. You talk to farmers, for example, and they use some of the most sophisticated GPS setups of anyone because, for example, you want to land a plane, if you're a millimeter off, or a few millimeters off, it's probably not gonna be a big deal on the runway. But if you're a few millimeters off and you're trying to use a GPS system to harvest beets, for example, you'll split the beet in half. So, when there's been problems with other satellite system, like farmers I've talked to, they can tall when GLONASS is having problems because their systems are relying on GPS and GLONASS, and even some other satellite things. And when some of those go down, they can see that it's a little jittery. You know, that their position is not quite as exact as it is when everything is running smoothly.

Chad:
So, more about augmenting the signal than-

Greg:
Right.

Chad:
Then... yeah.

Greg:
That's what's gonna happen, I think, in the future. And I think that's sort of the official part of this, our space policy now, I believe, in the US. Is that GPS is always going to be there, and it's going- we're going to work with other systems. Cause the more you have, the more satellites you can take readings from, the better your position fix. And so... But GPS, I can't imagine a time when GPS isn't the sort of bedrock, the foundation of all this geolocation stuff.

Chad:
Okay. So you're book was originally published in 2016. Just a few years ago, but a lot has happened since then. Is there anything that's come about that's surprised you?

Greg:
Well, one thing I think I gave a little bit of short shrift to in the book, just because it didn't seem like as big a deal was autonomous vehicles. I mean, self-driving cars are a huge thing. And like a lot of navigation systems, they're not only going to use GPS, but they will use GPS. And I didn't see that coming. And I'm skeptical of the development of that industry for a lot of reasons, but as

it's developing, it's always going to need GPS. I mean, GPS is always going to be a function of it. So that's something that- You know, that's a huge segment now, or potentially huge segment that I just didn't see coming.

Chad:
Greg, on the show, we like to say that there's never been a better time to get involved in space investing. Given your position here, and like your understanding of the GPS segment, can you give us your perspective on that? And which areas are exciting for you?

Greg:
Areas within GPS?

Chad:
Areas within, you know, what you know in geospatial intelligence and what's happening. Data from space signals, I guess is a better...

Greg:
One thing that I heard. I mean, we talked a little about this at the beginning, is that, as I understand it, there's been somewhat of a little bit of a revolution in small lightweight satellites that don't fly that high above the Earth that can do things like, for example, take all the data from the ships, all the automatic identification systems from ships. And that data, from what I understand, as it's repackaged and sold, is very, very valuable. Because just that ship data alone, now they can tell you like how shipping lanes are functioning, but it also, because they have to do things like... the signal has to have what their cargo is and how much they're- You can actually do things like study trade imbalances. And so, that stuff, you know, really... if you excuse the expression, like the sky is the limit, because the more data we can get from things like that, the more valuable- it just adds value to so many other things.

Chad:
Fleet management was a big area of growth in your book.

Greg:
Yeah.

Chad:
And it continues to be, in terms of tracking the movement of goods. And essentially, you know-

Greg:
Supply chains.

Chad:
Yeah. Exactly. And the Internet of things.

Greg:
Right. Actually, the Internet of things is a huge... I mean, it's a huge, huge thing because so much of that depends on location. If blockchain systems continue to develop, a lot of them- there's

some of them are gonna rely on location. It's actually a big problem, is how do you verify a location within a blockchain system. There's... People are working on that. But yeah, fleet management continues to be a huge thing. It's amazing how many people figured out, "Oh. You know what we can use GPS for? Is to track other people." And it's, you know, and so many- Employers will say that it's... it's inflation proof because they see the savings immediately after adopting these systems. When people know they're being watched, it's sad to say, they do things like- I mean, UPS, for example, has incredibly sophisticated location logistics, and probably FedEx as well, that, again, don't only rely on GPS but they often- you know, GPS is in the mix. And they figure out ways then to optimize routes to have fewer missions. Especially as cities continue to grow. You know, everyone's moving into cities. These companies are gonna have to figure ways to get routes that are efficient within crowded cities, you know, have fewer missions. That kind of thing. So, knowing location stuff is just really, really powerful in a lot of business areas, and it all goes back to GPS ultimately. None of it could function without GPS.

Chad:
Fascinating stuff. So, in the show notes, we're gonna have a link where you can go find the book, Pinpoint: How GPS is Changing Technology, Culture, and Our Minds. Greg, this has been a fascinating conversation. Really appreciate your time today.

Greg:
Oh, thank you for having me on.

Chad:
Thanks for tuning into The Space Angels Podcast. If you enjoyed this episode, please leave us a review on Apple Podcasts or wherever your get your podcasts. And subscribe to make sure you never miss an episode. If you're interested in learning more about investing in space startups, I invite you to visit our website, Space Angels dot com, where you can learn all about Space Angels membership and how you can invest in this exciting new innovation economy.