Constellations Podcast

Episode 18 – Satellite Refueling, Deep Space Assembly Lines and Five Ball Constellations

Speaker: Greg Heckler, Telecommunications Systems Manager, NASA – 21 minutes

John Gilroy: Welcome to "Constellations", the podcast from Kratos. My name is John Gilroy. I'll be your moderator today. Our guest is Greg Heckler, Telecommunications Systems Manager at NASA. Greg, how are you?

Greg Heckler: Great. Thanks for having me today, John.

John Gilroy: I'm taking down these notes, and I went to your LinkedIn profile. Telecommunications Systems Manager. Boy, for a big company, that could be the phone guy down the hall, but when you have that title at NASA, that kind of means a big deal, isn't it?

Greg Heckler: Yeah. Yeah, it's a little bit different, but it's a little bit the same too, right? A big part of our missions is making sure we can talk to them at all times, and just like your cell phone, we have users that like a lot of data. So being a Telecommunications Systems Manager, we're making sure we're building and deploying systems to provide data connectivity to all those satellites in orbit.

John Gilroy: Yeah, that's really good, and it looks like you focus on a couple big projects. One's called Restore L, another one's called the SGSS Project, is that right?

Greg Heckler: Yeah, that's correct.

John Gilroy: Let’s go back to your background, I see you have a master's degree in aerospace engineering, so you partially qualified for these titles. I mean, you have a real strong background. So let's just jump right into this thing called Restore L. Nothing to do with Restoration Hardware downtown. So what is Restore L? What's it all about?

Greg Heckler: Well, the goal of Restore L is actually to service an operational spacecraft, and most importantly refuel it to extend its lifetime. This has been a technology that's been in development for more than a decade, and actually traces back to some of the Hubble servicing missions you might have heard about in the last decade. You know, the point is: spacecraft use fuel, and they have gas tanks, effectively. And a lot of times they run out of the station-keeping fuel before the satellites' electronics actually die. So NASA sees an opportunity where if we go have another spacecraft go autonomously rendezvous and dock with an operational satellite, and then refuel it, you'll be able to extend the mission's

lifetime and continue to provide either science observations, or if it's a communications satellite those relay capabilities, for a much longer duration.

John Gilroy: Boy, it sounds like sci-fi movie: "autonomous docking in space", wow. That's pretty cool, isn't it?

Greg Heckler: Yeah, you can kind of think of it as your autonomous car, but an autonomous spacecraft. We have very complicated vision systems, right? If you think of analogies for you autonomous car, we're using cameras and laser ranging or LIDAR, to sight those targets. And to kind of line up and then capture them. And we have ... it's challenging, because we can't assume that that spacecraft is necessarily under control. We call it a non-cooperative target. So it may be tumbling in space and so the Restore L spacecraft will have to observe it, measure that tumbling, and use its thrusters to line up and then capture the spacecraft. So it's a very challenging problem.

John Gilroy: I went to YouTube and typed in "Restore L", and I saw this little 2 minutes [sic] and it really is a nice little visual, exactly, it's got this dexterous mechanical arm, or a couple different arms, where it can, it looks like it can approach a satellite, and then mirror that satellite, and then connect in and fix it. it's pretty Star Wars-y.

Greg Heckler: No yeah, it very much is. You can kind of think of it as it's having those really complicated tools that a human surgeon might have, right? We have to go in, we have to cut blankets on the spacecraft, expose some of the propulsion hardware to access it, take off caps that weren't meant to be taken off, and then connect our fueling system and refuel the spacecraft. And it's not just refueling right, these advanced robotics, we see a need in the future as we do things like as you might have heard the Deep Space Gateway. Assembling that in Deep Space. We may not necessarily have astronauts go there to assemble it, like we did with the ISS. So having these robotic tools and technologies to assemble larger spacecraft in deep space is another application of this technology.

John Gilroy: Yeah. So what it enables organizations to do is to manage their fleets more effectively, I think that's what we're saying. So if we have an asset out there, and we're running out of fuel, if there's a way to take refuel all of a sudden we extend the value of that asset.

Greg Heckler: Right, longer lifetime, and in the commercial industry for commercial comm relays, it's all about how many bits they can squeeze though the satellite for the cost. And so if you double a mission, a satellite's lifetime, right? And most of the cost is in building and launching it, then you've produced a higher return on dollar for that company. So, you know, NASA's doing this, we're trying to blaze

the trail. DARPA has a mission that's similar. And there are a couple of commercial companies, including Space System/Loral and Orbital ATK, that have their own private programs to do this.

John Gilroy: Good. You know a few weeks back we did a show with Dr. Michael Simpson, talked about space debris. And when I saw this little video of these two arms, I'm thinking to myself "Well, this could mitigate some of the problem of space debris using some of this technology as well, couldn't you?"

Greg Heckler: Yeah. Capturing any large uncontrolled object in orbit, and actually safely deorbiting them, yeah that would be an immediate application. You know, some of these orbits are very sensitive. If you've ever heard of what's called a polar sun-synchronous orbit, where most of our earth observing satellites are in, orbit debris in those can create real problems because they're such high demand. They're high traffic areas. So being able to go up there and clean out some of those larger objects is an important benefit.

John Gilroy: So the target's 2020 to be out in space and do this with Restore L? Is that the target date?

Greg Heckler: Yeah, depending on the budget, right? You've probably heard the budget is under question, and Restore L is one of those higher-line items in NASA's overall portfolio.

John Gilroy: So what other benefits do you see Restore L for besides space maintenance and possibly debris cleanup?

Greg Heckler: Well, it's just one of those fundamental capabilities that you don't quite know the long term benefits. We know some of the near-term benefits. Just go extend the mission duration of certain missions, or clean up orbital debris, or do in-space construction. But such a fundamental thing, right? Not having to design your mission around necessarily a fixed quantity of fuel, will allow people to have more flexibility in what they want to do. And certainly we've talked about the possibility of fuel production on the moon or Mars. Once you have fuel, a kilogram of fuel outside of the earth's gravity well, it's actually worth a lot more, right? Because you have to put 10 pounds of fuel on your rocket just to get one kilogram of fuel up in orbit. So being able to capture that and ferry it around, effectively, the solar system. You'll be able to reap the benefits of this possible fuel production as well.

John Gilroy: Yeah, and from the perspective of [sic] you mentioned earlier this idea of getting the most bang for the buck, especially for communications. I mean, this really is a strong, strong argument to fund Restore L, in fact Restore L may

inspire other organizations to do the same thing, for-profit organizations I would think.

Greg Heckler: Right, yeah. And NASA is always… one of our main charters, what we do is commercialize technology that we develop. We do things that industry may or may not have interest in funding, and then once we go make it a proving concept, we then release those patents or that intellectual property for other people to build, and hopefully profit on.

John Gilroy: Well, another project you work with is something called the SGSS project. So what kind of application is that? What does that do?

Greg Heckler: So, NASA maintains three large communication networks under the Space Comm and Navigation Program, SCAN Headquarters. One of the main ones is called the Space Network, and that's actually composed of a space segment and a ground segment. We now have ten TDRS satellites, Tracking and Data Relay Satellites, in orbit. And then SGSS is really about the ground side of the space network. The last time it was basically updated or installed was in the early 90's with basically late 80's technology. And the ground segment is old and aging. So as part of extending the lifetime of the Space Network Project, we're overhauling all of those ground systems. So we're installing the latest and greatest IT technology, and advanced signal processing, to really revitalize and upgrade the space network and maintain it through the next decade.

John Gilroy: When I talk to people about information technology they throw out these terms "extensible, flexible, scalable," and that's exactly what you're doing to this system, it looks like.

Greg Heckler: Right, exactly. We're replacing, if you've ever worked with what we call RF Waveguide, or microwave plumbing, that was all a 1980's what you would call "architecture." For SGSS we're applying digital signal processing, and we're distributing data and spectrum and bandwidth over ten gigabit Ethernet. So when you want to go upgrade the system for a new mission or a new type of communications standard, you can basically "plug and play" in new modems or computers to this 10 gigE backbone, and you'll very easily be able to do that. And of course we're using modern software, the old system was based on 1980 VAX technology, which is hard to maintain. And that will just allow us to maintain the system through the next decade.

John Gilroy: It's hard for me to convince my kids that it actually existed. So that's the hard part. Maintain is one thing. Oh it really happened. Oh no, up in Boston, yeah? No. Let's talk about something else. It's pretty crazy. So what it sounds like is you're positioning yourself to have some highly available services for a wide range of NASA customers.

Greg Heckler: Right, yeah. The Space Network and all of NASA's communications networks have pretty stringent what we call "availability requirements." I think specifically for Space Network it's a 99.5 percent. But again, the aging grounding infrastructure makes that a challenge. And you know, some of the new technology we're using has, in terms of redundancy, right, so you're always going to have failures in a system. And instead of having what we call at NASA like an "AB side" where you have two sets of redundant equipment and you can detect errors and fail over, the SGSS is deploying what's called a "pooled architecture." So you have a large pool of hardware, maybe your modem or other electronics, and the system is smart enough to detect an error and then go get an additional resource from that pool as needed.

So you're able to meet this high availability with less equipment than there is today. In fact if you've ever been in a data center, going out to the ground station the main floor is like a big data center. Racks and racks and racks of equipment. The SGSS project is going to decrease that footprint by about ninety percent. So these big cavernous, football-field-sized server rooms are going to be much emptier and much quieter in the future.

John Gilroy: Yeah, I was in a data center about a month ago. And it was cavernous, I have to tell you. It's designed now to have racks come in stacked up, where they just roll them off the truck, roll them into the data center. It's just [sic] the technology innovations coming up are just [sic] it's almost hard to believe what they're doing as far as making things more efficient. They're applying artificial intelligence to managing some of these larger systems. TRDSS? Tell me about TRDSS, what exactly is that?

Greg Heckler: So, TDRSS is what the space segment of the Space Network ... it's the actual communication satellites themselves. The project goes all the way back to the shuttle era. One of the main challenges during Apollo was astronauts could only talk to the ground or talk to Mission Control maybe about 10 or fifteen percent of the time. So in the 70's, NASA wanted to change this for shuttle program, and they started the Tracking Data Relay Satellite Project. And the goal of that was to put communication relays up in to geosynchronous orbit to provide kind of 24/7 global connectivity to the astronauts on the shuttle. And we do that and we've continued that since the late 70's. The first satellite was launched in 1983. And we just finished accepting, launching and accepting, TDRS-M. Which is now TDRS-13 in January.

John Gilroy: So I think it's like six separate satellites aren't they, in geosynchronous orbit, is that right?

Greg Heckler: Actually right now there are ten operational satellites-

John Gilroy: Oh, ten?

Greg Heckler: Yeah, so some are in storage. We maintain what we call a "five ball constellation". So we have two satellites in the Atlantic region, two in the Pacific, and then one we maintain that's above the Indian Ocean, on the other side of the earth.

John Gilroy: So the biggest goal for this project is communication with our existing satellites, so what are the goals? There've got to be more than just these satellite communications with the shuttle?

Greg Heckler: Oh, well yeah. That was the driving customer in the time, right? And of course the shuttle program has been ended. One of our main customers is now of course the International Space Station. All of the connectivity to the ISS is done through TDRSS. I think we just ... at the Super Bowl, live-streamed it for the astronauts, for some of their downtime that they actually have. We support a lot of the Earth Observing Fleet, or EOF missions. Those missions looking at weather and climate data, and then we even support some odds and ends. We actually deliver data services to Antarctica, and the South Pole Station for the National Science Foundation. And we support all American Launch Vehicles, so the Atlas Fives and the Delta Fours that launch either out of Florida at Kennedy, or Vandenberg in California.

John Gilroy: NASA's getting to be a stronger and stronger reputation in the community. I was at a trade show 2018 [sic] (SATELLITE 2018) last week, and I was posing a question to some executives. I talked to an executive by the name of Kay Sears, and I said "well who's going to go to Mars first?" Is it going to be Elon, or is it going to be Jeff? Is it going to be Amazon? And she said "neither one." I said, "okay, who's it going to be?" And she said "NASA. N-A-S-A." And I said "whoa, Greg's going like to hear this in ten days." She's betting on you there, Greg.

Greg Heckler: Yeah, and certainly our eye is turning to the outer reaches of the solar system, beyond low earth orbit. And whether the presidential direction is "direct to Mars," or "let's stop at the moon along the way," there's a lot of opinions about whether that's the optimal strategy. We're trying to get out of the business of regular operations in low earth orbit and again develop those technologies, capabilities, techniques, scientific knowledge that we need to actually sustain humans on the Moon or beyond.

John Gilroy: And there's a new current argument about going to Venus because it's shorter. We'll just float above Venus. So many new things. It's almost as exciting as in the mid-sixties, when people were going to college and they were real excited about these, and now it seems to be heat up now especially in the university world. I know it's true with my students over at Georgetown. So tell me about

public and private collaboration and working together. So it looks like a lot of the stuff you're doing is really at the leading edge of technology, and many start-ups are looking at these and saying "well we want to partner with NASA and get together and use some of this technology." It looks like it's a new phase of public-private cooperation as well.

Greg Heckler: Yes, certainly. And you know, I really see the next decade, the 2020's, it's going to be the Wild West. We took this initial step into the inky darkness, to the moon in the sixties and now the technology has really caught up. Everyone knew those were high-risk missions, to put astronauts on the moon. But all those fundamental things we need: long-term life support, how do you shield astronauts from radiation? You're not going to be able to go to Mars and do that on a one kilobit data link, like your 1990's modem. You need broadband. And so we're investing in capabilities like laser communications technology to deliver that. And I think a real source of fundamental change will be if the SpaceX and Blue Origin are able to fundamentally alter, basically the cost of a kilogram of payload to orbit. If that comes down by a factor of ten, NASA and a lot of other space agencies and private companies will have to just fundamentally change the way they design space missions, right?

Right now, we design the heck out of our missions to have a really high probability of success. Well, if it's cheaper to not invest all that time and money, and accept a lower risk but understand every once in a while you're just going to have launch another one because the first one broke, that's another way of doing business. These large organizations adapting to that new strategy or way of operating, that's going to be a challenge. But again, I'm in the satellite building business. For a ten-times cheaper cost we're going to be putting a lot more assets into space and that's very exciting to me.

John Gilroy: So your title, telecommunications systems manager, boy has so many more applications and I mean I'm looking at new ways to maintain satellites, I'm looking at new ways to maintain ground systems, and it looks like it's preparing the groundwork for the next step. Maybe all these little details like maintaining ground stations, improving throughput, and maintaining existing satellites and ... it's setting the stage for the next step and the next step might be some really exciting missions. It looks like you're laying the groundwork, is what it sounds like.

Greg Heckler: Yeah. And again we're doing these fundamental things, where any time you get orders of magnitude improvement in a technology you have a good guess of how you might use that in five years, but you really reap rewards and benefits in ten or fifteen years. Just think of the fundamental way cellphones, or smart ... not just cellphones, smartphones have changed the way we lived. And the benefits, with some drawbacks of course, have changed. When Steve Jobs launched that new technology, what in the mid-2000's? I don't think anyone

would have ... Uber or Lyft would not have happened without the smartphone. And the fundamental things there are the processing power, you know these CPUs in your phone that are more powerful than all the computing power we had on the Apollo Mission. That always on, available data link to the cell network. And then of course GPS, knowing where you are and how to get there. So those three things packaged together for the first time really changed things. And again, ten and fifteen years later we're only understanding the impacts of that at this time.

And so yeah, we're working on those technologies, and we'll see where they go.

John Gilroy: I deal with a lot of startup technology. In fact at Satellite 2018 there are tons and tons of startups. Are there geographic areas in the United States you see where there seem to be clusters? I mean, there are groups in Atlanta that are doing innovations in space. There seems to be people in Austin. Are there geographic areas? It's not just in Seattle anymore is it? It seems to be in many different nooks and crannies across the United States, there is creativity and new ways to do this space technology.

Greg Heckler: Yeah, I think a lot of that ties back to the whole CubeSat or SmallSat revolution that's going on, too. You know a lot of that was driven by universities, they turned a Senior design project from "build a UAV" to "Go build a CubeSat" and hopefully get it launched. So you see all these young people getting trained, and are knowledgeable on space technology and components, and how to design for space missions. And them being young and idealistic, they think... not just think, they know they can change the way we operate in space. So you see it clustered around some of the more premiere universities, and then of course there is a higher interest in Silicon Valley, right? Some of the Googles and the Apples and the SpaceX, they're investing and want to join the space game. So you see that as well.

John Gilroy: Wow, you're at the cusp of a brave new world, I think it's going to be very exciting in the next few years. Unfortunately, looks like we're running out of time here, Greg. I'd like to thank our guest, Greg Heckler, telecommunications systems manager at NASA.

Greg Heckler: Thank you, John. It was a great time.