Constellations Podcast

Episode 31 – Open Systems Architecture, Henry Ford, and Standards Enabling Growth in New Space

Speaker: Stanley Kennedy, Jr, President and Co-Founder, Oakman Aerospace – 27 minutes

John Gilroy: Welcome to Constellations the podcast from Kratos. My name is John Gilroy, and I'll be your moderator today. We are recording this podcast from the floor on the 32nd Annual Small Sat Conference in Logan, Utah. Our first podcast today, we will be discussing how small sats have evolved from a novelty to a norm in the satellite industry. The key to this transition has been a change in practice from customs spacecraft to a Henry Ford approach. Interoperability standards allow a much larger volume of rocket builds. We will explore the cutting edge techniques to space systems architectures, as well as the design and development of spacecraft and satellites.

With us today to shed some light on these topics is Stanley Kennedy, Jr., Chief Systems Engineer, Co-founder and the president of Oakman Aerospace. Stanley has over 30 years of direct hands on experience in aerospace and engineering, and is uniquely able to address the architecture design and development challenges in the small sat industry. Well Stan, We're just going to jump right in here.

Stan Kennedy: You bet. Thanks for having me.

John Gilroy: Now traditionally, spacecraft has been hand tailored, kind of like the old school Volvo's, made by hand with lots of heavy duty design. How is that changing in today's small world?

Stan Kennedy: Well, I think the short answer for that is a lot of interoperability. The standards that were started with CubeSat, and CubeSat standard development, and then modular open system architectures. Having a set of standards that everybody can work to, that inner operate together, are what allows people then to innovate on those systems while still making them play in the larger system of systems.

John Gilroy: What's amazing, Stanley, as you walk around this conference, there's a lot of young people here. I mean, you and I are the gray beards, you know?

Stan Kennedy: Oh yeah. Yep.

John Gilroy: There's a lot of young people. This is a very exciting concept with CubeSat, and the whole idea of small sat.

Stan Kennedy: It is. I'm actually very honored to be the student competition technical chair. This is my 10th year doing the student competition here at Small Sat. The young generation is incredibly excited about it. I think it's akin back to our times back in the sixties when the Apollo program was going.

John Gilroy: It's exciting.

Stan Kennedy: Everybody had an eye on what's next. I think there's a secondary effect of it also, in terms of as the STEM: Science, technology, engineering, math outreach continues to excite the next generation. That then spawns new innovations, new adjacent markets, and products and services that we haven't even begin to even dream of yet.

John Gilroy: So we got a lot of smart young people in this business. How has this industry been able to lower the development and build costs, and make small sats such an attractive option? How have they done that?

Stan Kennedy: Again, I think it goes back to a set of standards, the ability to do building block systems. What we see interesting is the CubeSats started out as when you, a 10 centimeter on a side cube, and then very quickly the performance increased to 3Us and 6Us, and now we're talking 12Us and 27Us. On the other side of the equation, you've got large systems that used to take 1500 kilos, or 1000-kilo systems to be able to do those types of missions. Those are coming down in size, and that coupled with the launch segment, new entrants coming in that can launch dedicated payloads in those classes of mass ranges, are really what's fundamentally changing the dynamic in the equation.

John Gilroy: 1U, 2U, I thought you were going to say USU.

Stan Kennedy: There you go.

John Gilroy: That's part of this equation too, isn't it?

Stan Kennedy: Most definitely.

John Gilroy: Utah State University. Wow. What a fantastic program here. Really exciting to be here. You know, small sats bring in a whole new scale dimension. Instead of creating one spacecraft, thousands may be needed. You've stated that with that kind of volume, you have to get into this Henry Ford mentality of interoperability standards. So what does that mean for the people walking around this conference today?

Stan Kennedy: You bet. I'm a real strong history buff, and there are very close similarities between automotive manufacturing. In the early days they were hand built,

onesie, twosie, the Stanley Steamers, all of those types of things. Henry Ford got into the standards, the interplay of parts and pieces. We see that also in the airline industry. Back in the early days, airlines were all custom. The airplanes were onesie, twosies. As we got into production capabilities, the standards, the open system, compatibility, physical protocol, layers, things like that, those are all the things that are going to continue to allow us to build out 200 or 2,000 vehicle constellations.

John Gilroy: Innovation is a very, very easy word to toss out but really hard to actually put in working boots, you know? What innovative techniques and approaches are being used for space systems architecture and spacecraft design?

Stan Kennedy: I think a lot of the work that's going on right now is being able to very rapidly compose systems of systems, and then making sure that those systems are not only backward compatible with either the ground or the infrastructure that you've already developed, but then can roll, block upgrades over the life cycle or the life of the program. Again, getting into modular open system architectures, things that can come into a system or out of that system without fundamentally changing how the communication, either the protocols or the communication interfaces operate, those are what is going to be important in the future.

John Gilroy: Back in the mid 90's, I'm sure you remember this concept of plug and play came in with architecture for personal computers. It was a big deal because you could have interoperable video cards and audio cards, and this concept of plug and play architecture. I guess you're trying to apply it to the world of space satellites, aren't you?

Stan Kennedy: Yeah. Most definitely. And in fact, plug and play originally came into being in the computer industry, very similarly in the spacecraft industry, making sure that those systems can plug in, can sense, can load either their bios, or their interfaces, their meta files back and forth, without having a PhD guidance, nav, and control guy, or a really super smart propulsion young lady that's putting that stuff together. I think that's what's enabling more people to get into this business. There are just a plethora of folks out there that have really great ideas. They're not necessarily space people. How do we make space easy to use and be able to implement those concepts very quickly, but maintain that mission assurance and mission success because space is still fairly expensive?

John Gilroy: I talked about motherboards, and personal computers, and plug and play, and that's one thing to slap on a new video card or something. However, advanced components and subsystems, that's at the next level, isn't it?

Stan Kennedy: No. Yeah. Again, I think the really neat thing that's happening is there are a number of companies on the floor here today, and across the industry, that are

working very, very hard on making those things easily integrated. Case in point, some of the open system architectures that we're working at at Oakman are bringing in API interfaces, and very rapidly configurable systems, and they're tying back to openly releasable databases of components or subsystems that allow you then to very quickly put those systems together and know how they're going to operate in a true design reference mission.

John Gilroy: You put a satellite up there, sometimes they last 10, 15 years, sometimes longer. You know? My question's about this interchangeable characteristic again, so these modular components from different suppliers, can that actually help extend the service lifetime of a satellite?

Stan Kennedy: Yeah, I think there's two fold. I think it can extend the service life, and I'll come back to that, but I think it really helps in reducing your supply chain costs over time. In the past, when you would target a certain system and put very specific one of a kind software on it, trying to re-host that on a new platform, either due to obsolescence or due to cost increases from your supply chain, became very untenable in terms of the cost equation. Having open systems allows you to really commoditize your supply chain. That in turn then comes back to the lifetime issue, so you can go find things that are having either a graceful degradation, or disparate fault backups, redundancy, those types of things. So it becomes, again, part of that equation in the lifecycle costs.

John Gilroy: You know, I'm very comfortable here at Utah State University. I teach in the classroom myself, and I tell my students in order to be terrific, you got to be specific, so I'm going to push that one on you.

Stan Kennedy: Sure.

John Gilroy: Give me a real world scenario where you're able to provide an innovative solution for a customer.

Stan Kennedy: Oh, let's see. I'll look back to one of our first ACORNs we delivered. We had a standard product. We had a simulation version, a hardware in the loop version, and a full up what would be normally considered a flat sap. A customer came in. They sort of wanted something between a simulation version and a rack mounted hardware in the loop version. In two months we actually procured all the hardware, targeted new flight software to a new processor that we've never had. It took us about two and a half weeks to target the software, and that's because of those open system constructs that we've developed over the years. So, between November of 2014 and delivery on the first unit in February of 2015, it was a two and a half month, light your hair on fire program, but they've been using that system ever since as a full design reference mission mod and sim environment.

John Gilroy: At least you have hair to set on fire.

Stan Kennedy: Not much left, but that's good.

John Gilroy: I know you're from Colorado, and maybe they have a crystal ball in Colorado that works. I don't know, but I'm going to ask you that crystal ball question here. Are there any advances in the design simulation and testing process coming up the next few years that's really going to impact this industry?

Stan Kennedy: Yeah, there is. In fact, just before-

John Gilroy: So, the city, they have crystal balls in Colorado?

Stan Kennedy: ... we spend a lot of time monitoring where the industry's going. After doing it for many, many years we see trends, and we also at Oakman, spend a lot of time on the science and technology side, so doing the first offs, prototypes, things like that. What we see happening is the systems are going to be more interoperable, more open system architecture, but more importantly I think, as the machine learning and the artificial intelligence starts coming in, to be able to monitor the system and the system of systems. These very, very complex multi-unit constellations, or very high performance mission payloads, are going to require a faster response times with less people in the loop. So again, I think those things, and then in the production side of the house, being able to put in a capability for these systems to do built in test in emulation, so rather than having a whole set of test equipment that's wrapped around your system, have that built into your system from the start, so that it cannot only sell test itself but then emulate what it's doing as it's going through the production line.

I think those are some of the constructs that we'll see. Eventually, and I didn't coin this term, Dr. Jim Lyke did down at Air Force Research Lab, but eventually there is going to be what's called push button tool flow. Being able to actually get online, be able to select what your mission is, what your parts and pieces are, have them composed, run design reference missions to meet the functional performance requirements of those systems, and then go and either additive manufacturing print those, or compose those, to be able to very quickly get those systems on orbit and have them inter-operate.

John Gilroy: I'm taking careful notes as you're speaking Stan. Emulate versus simulate? Any difference there or is this a big difference in your world?

Stan Kennedy: A little bit. From a simulation perspective, so we do a lot of modeling and simulation. If you can not only do the simulation, but do it in a very realistic physics-based model, you can actually emulate fault, fault detection and recovery. I think being able to have that capability to not only test. Everybody

knows how their system is supposed to work on a good day. How do you know when it's either degrading, either gracefully or catastrophically, and how do you predict that in the future? If you can emulate how those things manifest themselves, and be able to put checks and balances in the system to be able to guard against that, or at least know that those things are happening, that allows you to do planning and execution of your follow on missions.

John Gilroy: Another word you sort of tossed out easily was the word additive manufacturing. When I wrote it down, I wrote down additive, then A, Atlanta, and then 3D printing. I think of 3D printing when I think of additive manufacturing. Maybe that's part of the puzzle here too.

Stan Kennedy: It is. Again, 3D printing is a small piece of additive manufacturing. Things like embedding electronics into the structure, being able to build up electronic components while you're building the structure.

John Gilroy: Really?

Stan Kennedy: Those are the types. There are a lot of folks that are out there doing things like embedding copper polyamide into their structure, or electronic boards into their structure, and using structure as the printed wiring boards. Those types of things are what is fundamentally going to change how we operate in space.

John Gilroy: Wow. And I thought concepts like carbon nanotubes applied to the other parts of the aerospace industry, but all kinds of advances in this part of the aerospace industry too, aren't there?

Stan Kennedy: Oh, most definitely.

John Gilroy: I'm just, it's just, I don't know how to keep ... Maybe you to go to conferences like this, where's there's thousands of people running around here.

Stan Kennedy: This is a very good one to go to.

John Gilroy: Yeah. Tomorrow I'm going to sit down with Carolyn Bell. I read an article this morning that she wrote, and she talked about Asia, and new concepts and small sats in Asian countries like Vietnam. I mean, small countries throwing into this thing. It looks like this is very international. Maybe SmallSat will be in Japan in two years or five years from now. I mean, what an area of expansion.

Stan Kennedy: Again, I think we spend a lot of time at Oakman working with small medium enterprises around the world. We have active teaming agreements with New Space Systems South Africa.

John Gilroy: Wow.

Stan Kennedy: Thales in Switzerland, Unibap and others in Sweden. The list is very long. You mentioned Asia specifically. Asia has, and the Asia Pacific Rim, has really come into their own in terms of starting to not only work in the small satellite world, but seeing the benefits of how those technologies feed back into the everyday life. They're really taking a lesson back from what the US did back in the 60's and 70's, by spurring the space race and working those technologies. The spinoffs of that into everyday life are what raises up the economy, what raises up the working living class, and everything else. I think many, many nations see the new space and small sats as a way to invigorate those economies.

John Gilroy: Early in the interview, you used these classic phrase, graceful degradation. That's what I used when I looked in the mirror this morning and said, "Well. My goal is graceful degradation." How does that apply to the world of small sats? Replacement for existing sats?

Stan Kennedy: There's a bunch of different business models. If you talked to Chris over at Planet, they do replenishment. They've actually extended their mission life. Some of their early missions, they would set them up, they were low altitude, and they'd basically, three, six months burn out, and they'd put new ones up. They now are extending those mission lives through very unique ways of maneuvering while still getting their mission data take. That's one way to do it. Another way to do it, and what we're seeing now, is many companies are putting in either redundant systems or disparate systems, such that if they do have a life limiting issue, wheels or something else, they have a backup to torquers, or other parts and components that will extend those mission lives. The mission operators are extremely good at eking out every ounce of performance in every day of operation to continue to generate revenue.

John Gilroy: Last week I sat down with Brigadier General Greg Touhill, and boy, what a guy. Just a really fascinating guy. We bounced some type of public private partnerships, and we talked about NIST and the federal government, Washington, DC. What about partnerships? Do you think that partnership will bring this innovation to the next level?

Stan Kennedy: I'm a strong proponent of partnerships. Being a small company, we don't have the ability to put five or six people into Harwell out in the UK, or into ESTEC up in Noordwijk. What we do is we team with the local small medium enterprises, and I think that the industry to industry small medium enterprise partnerships are very important, but we also spend a lot of time, and we're headquartered in Colorado, we spend a lot of time with Colorado Space Coalition on trying to develop out the small medium enterprises, not only in the state, but then also with our partners across the pond or across the world. I think there's a benefit of not only industry to industry partnerships, but then tying back in the public

side of it through either academia. We have a master service agreement with the University of Colorado up at Boulder, and those types of partnerships really bring the really smart innovation from some of those universities, or some of the public side of the house, with some of the private funding that can then extend those out into saleable products.

John Gilroy: If you walk around the show here, you see some concepts that are just unimaginable. I went to the front of the show and I saw the people from NASA. Saw the people from NASA, saw the people from Utah State. We have independent folks like you from Colorado. This is a tremendous mix that's taken advantage of this public private partnership, academia, the federal government, smart startups, and maybe large organizations as well. It's a hot mix.

Stan Kennedy: It is, and I think it's, over the years, we're in our 32nd year here, over the years it has grown from full disruptors and the academic side to industry government. You mentioned NASA row. I think they have 14 booths, and only 12 centers. So, that shows you how big this conference is.

John Gilroy: The booths are swarmed by the way. You've got to elbow your way in there.

Stan Kennedy: It's all good, because I think NASA is doing some really outstanding things in the small set world. You've got NASA Ames doing a bunch of outreach with the Small Sat Virtual Institute. They're actually tying in all of the different centers through a virtual institute, and you know, folks like Bruce Yost, and Charles Norton, and a lot of those thought leaders at NASA are really turning the civil side into what NASA was back in the 60's, which was: take a little bit more risk, be able to use some of those small sats and really balance them out.

We're focusing on small sats today, but I wrote a paper at this conference a long, long time ago. I think it was over a decade ago on the balance between capital assets, medium assets, and then the new startup small sats, and you need each one of those. James Webb has been under the microscope lately. It's over budget but it is going to do some exquisite things. But more importantly, how do you take risk on maybe an earth ventures mission, or on small sats, or now starting to get into planetary missions with things like Marco, and those types of systems that are going to Mars? That balances, I think, what we need to recapture in terms of continuing to balance innovation with some of the hard decadal survey type questions that are trying to be answered.

John Gilroy: Tomorrow we'll sit down with Dan Hart on this podcast. He talks about being at Virgin and needing competition. It's like, "Yes." It validates the business almost. It's an important part of this world. I normally like to quote people in my interviews. I'm going to quote this real smart guy by the name of Stanley

Kennedy. He once wrote that, "Small satellites are no longer a novelty but the norm." So, what do you see as the next stage in development of small sats?

Stan Kennedy: Over the years, I think what's happening is we're seeing the larger systems come down in size. So what used to be a 1,000 kilo, or a 500 kilo system, coming down into the 150 to 250 range. I also see the novelty CubeSats going from 1Us to 6Us to 12Us. We had a couple of folks talking about 27U. Those are now actually in the 75 kilo to 150 kilo range. I think those, coupled with the launch opportunities, are what's going to continue to spur the constellations and the innovation in this business case. I've postulated these two bifurcated size of spacecraft, and they're not going to be monolithic, but you know, 200 kilo for very high performance systems, and 75-ish, 50 to 75 kilos systems for a lot of the new technology and the innovation in those constellations to keep the price point where it's at. That's where I see the business going.

John Gilroy: I keep thinking of boxing, and heavyweight, and middleweight, and welt, and then bantam weight, a little bit in sizes of satellites in those categories.

Stan Kennedy: Yeah. Monitor the launch vehicle capabilities because as those new launch vehicles, like Electron or Vulcan or excuse me, Vector, and others. Vulcan's another one that's coming online, but it's a large system. As those systems come online, those price points are where people are going to build their satellites to be able to fit within.

John Gilroy: Let's go back to Colorado. A small growing company, but one of the biggest challenges, I think, for our company, I think for every company on the floor here, is finding smart folks. Kids in classrooms, you know? How do you get that stem going, and no, no, no. Not Silicon Valley. You ought to come look at us. Come work for us. How do you find your talent?

Stan Kennedy: We do a lot of internships. We start with them when they're in ... We've done as early as high school, but we've also done college students. We're very successful at getting them in. As a small business, the environment is very, very important for this new generation coming up. I've spent time at the big companies, at the medium companies, now we're running our own company. I think having the open environment that they can come in, make a quick impact, and be part of a team for the long-term is very important. Is it hard to find people? Most definitely. We compete daily with the large contractors in Colorado.

We've done very good. Last year when we were here at Small Sat, we were 11 people. We're up to 22 now, so we doubled in size over the last year. And as part of that though, the new folks that are coming in are just amazing. I mean, they have skillsets that are just fantastic. They're coming out of school well

trained. They understand what they're trying to do. So, as many hits as the millennials get, they do pretty good work.

John Gilroy: I have three kids that are millennials. They don't want to wear suits and ties, but they're going to be more creative than I can ever dream of, you know? You've got to have that balance. Suits and ties and creativity, and usually guys in suits and ties are the guys with the money. And now, we got to our final question which is going to be investments. The guys with the suits and ties, the guys with the money, you see more and more money come in to this whole world. What lessons learned would you share with us as someone who's been beat up and knocked around a few times, and has got some battle scars?

Stan Kennedy: I think a lot of the new entrants think that if you hang your shingle out, wheelbarrows full of money are going to immediately show up. It typically devolves into a four letter word called work. You get up every morning and you know, you work hard at it, and over time you establish your street cred. My advice to a lot of the new folks is, the money's there, but you've got to answer the VC or the investors, why. Why are you doing it and how are you doing it? So those two things, and then last piece of advice would be stick to your knitting, you know? Know what you know. Know what you don't know. Be able to understand the differences between those, and really become the best you can be at what you're good at.

John Gilroy: Start with the why. That's easy said, but a little three letter word can make or break a pitch to an investor candidate.

Stan Kennedy: Yep. Most definitely. The why is so important. As we put our business plans together, we had a couple of really good mentors that came back and said, "You're not answering this question. You're not working this part of the business equation, so go back." We took our lumps many times, and that makes you a better person. Last bit of advice is, the only difference between success and failure is getting up one more time than you're knocked down, so keep your chin up and get back in the game every day.

John Gilroy: That applies to our bantamweight people, or the heavyweight people.

Stan Kennedy: We're back to boxing.

John Gilroy: Back to weight categories.

Stan Kennedy: I feel kind of like we're ringside here.

John Gilroy: Yeah, with all these people walking by. Well Stan, unfortunately we are running out of time. I'd like to thank our guest Stan Kennedy, President at Oakman Aerospace.