Constellations Podcast

Episode 62 – Precision Attitude Control, Innovation in Small Companies and DARPA

Guest: Dan Hegel, Director of Advanced Development, Blue Canyon Technologies – 21 minutes

John Gilroy: Welcome to Constellations, the podcast from Kratos. My name is John Gilroy, I'll be your moderator. We are recording this podcast from the floor of the Small Sat Conference here in lovely downtown Logan, Utah, metropolis of the world. Much bigger than London, much bigger than Tokyo.

Our guest today is Dan Hegel. He is the director of advanced development at Blue Canyon Technologies. He is going to talk about the business of small satellite companies, and the military and commercial space companies' interest in small satellite development, making it most hotly competitive part of aerospace. And in spite of it being this hotly competitive, his company is really killing it. In fact, Blue Canyon has been doubling the size of their company every year. The growth is explosive. Your company has been very successful. Dan, do you think this kind of growth will continue for small satellite companies in general?

Dan Hegel: Well, I don't know about all areas of the space market, but I think with small spacecraft, yes. There were a lot of peripheral companies, generally products, propulsion, payloads, data analytics, various component manufacturers, etc., which keep popping up daily seems like. I mean, you walk around the field house; it's just amazing how many companies. But they tend to water down the market. So yes, the demand is growing rapidly, explosive, but so do the number of companies. They're filling that demand. So as that demand increases, so do the number of companies, and kind of waters down the growth potential for a given company.

But I think BCT, Blue Canyon, is unique in that there really aren't that many players producing the high end small satellites in our price class. So for us, we see the continued explosive growth.

John Gilroy: And it really is. I mean, even last year the parking was easier than this year. Next year, we may have to park way far from here. It's really so exciting. So many people here, early in the morning here. All kinds of people running around at the small sat show.

What else we'll see is that, okay, we see a lot of successful companies out there, and I see small satellite manufacturers are being acquired or maybe forming partnerships with big primes. Do you think that trend will continue, and do you think we'll go full circle and back where we started?

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Dan Hegel: Yeah, that's a good question and very hard to predict. It really depends on the culture and vision of each company, what their goals are going in. You know, a lot of people spun these small companies because they don't want anything to do with the big guys, and it's just not in their DNA, and no goals to do that. Each company is very different. I can't speak for Blue Canyon as to where we'll be one, five, or ten years from now. That's above my pay grade.

But speaking more broadly to include other spacecraft products as I was talking about earlier, payloads and propulsion and radios, I don't see any shrinkage in the number of companies. I mean we're talking about the size here. For example, this conference just a few years ago, everything was housed, all the booths, in this one building, Taggart Student Center, and now it's overflowed into the field house, where it seems like there are probably twice as many booths. Over there it's jam packed. If anything this is going the other way. I don't see consolidation, I just see a proliferation of new ideas, new innovation.

So yeah. What is their long-term vision? I'm sure that there are many who would love to get swallowed up by a big prime. You know, that's their goal. They go in, let's make a flash, get noticed, and get bought up. Others want nothing to do with it.

John Gilroy: Yeah. Some people just want to live in Colorado, do exciting things, and ski on the weekends and have fun, and be innovative and creative. And if you look around here, I think that's the key. I've done dozens of interviews here on Constellations, and there's so many people, so many good ideas. And I think the small companies give that flexibility to try things against this ability to fail a whole lot. Let's try this. Well, Dan's going to get mad. No, try this, try that. And so the flexibility and looseness allows for that creative process to take place, where the larger companies may not have that wiggle room.

Dan Hegel: Right, yeah. I remember, for example, one of our younger engineers hired, it was probably less than a year out of out of college, and we have this little interface device to talk to our hardware and then do some protocol conversion. A little thing that was, oh gosh, half the size of a deck of cards and we wanted to put on an air bearing, but we needed a wireless, because on an air bearing you can't have wires and stuff, it'll get in the way. And he said, oh, how about you just put some Bluetooth on this and just set up to be wireless? It was like, you can do that? And just over the weekend he did it on his own, just took his time, no real approval process. In a big company that would've required IRAD funds and months of approval process, and it was done over a weekend, worked exquisitely.

John Gilroy: And that guy could have quit in frustration. You know? That's the thing.

Dan Hegel: Yes, exactly.

John Gilroy: Yeah. So I think small satellite companies bring innovation to the table. But if you're a large prime or an organization looking to put something in space, why would they choose a small satellite company over a big proven prime? Why would they choose you guys? And they are, by the way, aren't they?

Dan Hegel: Yes, yes, absolutely. A lot of it is the flexibility, less process. You go to a big prime, they've got their standard way of doing things that's been done for decades, and that's all that their employees know. And so you try and get something done fast, it's just not in their DNA. Yeah, just paperwork, paperwork. Just a contracts nightmare.

And also the cost. So because of the way they've done it for decades, they've got their parts, their way of doing it, level two parts, rad hard, S class, whatever. So right away you are talking bigger form factor, more expensive parts, and longer lead times to get those parts. So they just really don't know. Their engineers haven't been trained how to use those cheaper parts, where to go, what is usable, what's not.

And innovation. A lot of them are kind of doing the same old thing and not looking out to see what's being done differently. Whereas the small companies are just naturally looking for the newest, latest technology. And also you get a lot of this, well, it's just the way we do it at company X, Y, Z. So don't look to be innovative, this is just the way we do it. It's a tried and true process. It works. Don't rock the boat. Don't take risks.

But also, another thing that you have at the primes, very specialized, very deep. Which is great. I mean, the primes will come up with some amazing missions and amazing mission analysis. Phenomenology, they'll have a staff of hundreds of PhDs who have knowledge of their little sliver of the electromagnetic spectrum so they can figure out exactly how to do something. But to get something done, then, because everyone's so specialized, it requires many more people to cover all the bases to get something done. And that adds a lot of costs and time with all the interfaces and communication.

Whereas with a smaller company, you're forced to be more interdisciplinary. You take on many roles.

John Gilroy: You don't have a choice.

Dan Hegel: Yeah, you don't have a choice. I mean for example, so I was chief architect over attitude control system, this is [Gene Sealy 00:07:32], the early days of the company. And we would do power analysis where I would work with the

systems engineers, and would they say, well, if we fly this direction, what will the solar AC, how much power will they get? And then they would feed it into an Excel spreadsheet to do power calculations. And I got tired of doing all that. So I put together a simulation that models the power system and the attitude control to do this unified analysis. And I knew nothing about power, so I just became a junior power engineer interviewing, talking to our power guys. How does a battery charge? What do the equations look like? And just learned it enough where I could program all that. And we now have this really slick tool that within matter of hours you've completely analyzed the spacecraft.

John Gilroy: Great, great, great.

Dan Hegel: But out of necessity, because we just didn't have the people.

John Gilroy: Let's jump around and talk about NASA here. Recently your company, BCT, was selected by NASA to collaborate with two universities to provide multiple spacecraft for NASA's lasercom infrared crosslink, called CLICK, small sat flight demonstration. So tell us about CLICK, if you can.

Dan Hegel: Yeah, sure. Well, I'll just repeat a lot of what was in a wonderful paper yesterday during one of the talks by one of the MIT students. But yeah, we're building three spacecraft. Three of our 3-U CubeSats. CLICK has two phases. There's CLICK A, which is to demonstrate lasercom to the ground, and then there's CLICK B and C, they'll launch sometime later, and those are for inter-satellite communications and time transfer.

So there'll be able to communicate with each other, but also equally importantly be able to transfer time and their position and velocity. Which is important when you're trying to do synchronized measurement collection.

John Gilroy: Innovations in satellite communications have been standard for years and years. Something new is coming in and improving it with speed and reliability. This is crazy, isn't it?

Dan Hegel: Yeah, we're working with MIT on the TROPICS Program as well as some other programs. So we have a really good relationship with MIT, and looking forward to this program.

John Gilroy: Speaking of programs, there are many programs that need precision pointing capability, and they've been driven to acquire rides on large spacecraft or purchase large spacecraft bus. The engineers at your company, Blue Canyon, found a way to fit that capability into a miniaturized package. Can you talk about how this might be an example of small satellites becoming mission ready for government and commercial applications?

Dan Hegel: So our company, the flagship product is our XACT product. X-A-C-T. And that was started by an SBIR with the Air Force. And at the time it was to provide precision attitude control for CubeSats. Now at the time, they were just tumbling around and maybe they get 10 degree pointing, and they thought precision would be two tenths of a degree. At the time people thought, well that's going to be really hard. But we beat that by almost two orders of magnitude. So we're down around 0.002 degrees.

John Gilroy: Wow.

Dan Hegel: But we designed it for overkill because we had kind of a "If you build it they will come" mentality from the start, knowing that if you can really do something exquisite that it's going to enable the market, grow the industry. Which it has. So we're supporting a number of different government programs that people only dreamed about years ago. They just never thought possible.

And then there's some NASA programs that we've supported. For example, MarCO, that was talked about yesterday as well. That was with JPL. Two interplanetary CubeSats. They flew from Earth to Mars, a 300 million mile journey, and they rode along in formation with the InSight lander, and were used as data relays to carry all the entry, descent, and landing information back to Earth during that process. So 7 million people around the world were listening in a YouTube and various podcast tracking what was going on, listening to the results. And that was all carried by two CubeSats, partly enabled by our attitude control and other small sat technologies as well.

John Gilroy: It sounds more clever than anything else. Who thought of doing that? But you put two and three together and you have something very original.

Dan Hegel: And there's another mission we do with JPL as well called ASTERIA. It's a mini Kepler mission where it's looking for a planet crossings in front of stars. They measured our line of sight stability at 1.6 arcseconds RMS, which is equivalent to something like the width of the Empire State Building as viewed from Los Angeles.

John Gilroy: Incredible.

Dan Hegel: The system points better than 98 to 99% of any spacecraft that has ever flown.

John Gilroy: Wow.

Dan Hegel: So it's really enabling a lot of technology now, a lot of missions.

John Gilroy: You know, Dan, thousands of people from all over the world are listening to this podcast. If you are listening and like to get email alerts when new episodes are available, go to Google, type in Constellations podcast, click on Kratos, give us your email, and we'll keep you updated with all these exciting developments, especially from the folks out at Blue Canyon here. Wow.

Let me go back to our friends at MIT. A professor from MIT said that Blue Canyon's CubeSat platform will enable new capabilities for coordinated and distributed sensing missions. So we just mentioned these capabilities. So who will benefit from some of these capabilities?

Dan Hegel: Well, everybody in the world actually. I mean it sounds grandiose, sounds kind of presumptuous, but it really is true.

One of the areas will be in the way of weather. We're working with multiple companies, programs, for weather monitoring. One of them is an MIT mission called TROPICS, a series of microwave scanners. We're building seven CubeSats that we'll fly distributed around the Earth to provide a higher revisit times.

We're also working with Colorado State University on Tempest-D. That one's already flying. It's a millimeter wave detector that's able to peer through the clouds and look at moisture content of hurricanes and storms. And the plan there is have a string of pearls where every five minutes a satellite goes over to see how the storm has progressed in three dimensions.

John Gilroy: Oh wow.

Dan Hegel: So you'll be able to do a much better job of predicting where storms are going, where hurricanes are going, and weather forecasting. So the price of one exquisite weather satellite that may have a revisit time of three days over your neck of the woods, you could potentially have a satellite that comes by every 15 minutes. So that will dramatically improve weather forecasting.

John Gilroy: This is almost like a recruiting podcast for MIT and Colorado. I mean, this is going to get kids excited and want to go there and study and contribute. And this is really what you want to get. You want to get the bright young minds to look at new concepts like this. I mean whoever thought of doing some of those things, you know?

Dan Hegel: Right. And anyway, just saving costs. I had heard that just having one or two days better forecasting for weather helps shipping industries. They go through so much gas and it just saves cost. Because if they don't know exactly where a storm's going to be, they have to go out of their way and expend extra fuel to make sure they go around the storm because of the uncertainty. If they know

better where it is, they can take a more direct path and save hundreds of millions of dollars per year of fuel costs.

John Gilroy: Well, you pick up your phone, you go to the Google News, see what's going on, and you folks, your company, Blue Canyon, have been all the news because DARPA awarded you a contract to define bus and payload requirements for a program. A DARPA representative, and this is from the article, said that the future will be about expendable assets networked together in real time. This exquisite to expendable transition is changing how technology is built, how it's bought, even how decisions are made.

I mean, this is like discovering America or something. This is a big, big shift. I mean, it's like, oh yeah, expendable, but it still works.

Dan Hegel: Yeah, it's very exciting to be on that cutting edge. So yes, Blue Canyon was one of three bus developers. So we just had our PDR last week, it was for the Blackjack program, where DARPA wants to demonstrate up to 20 satellites interacting, formation flying, inter-satellite links and such, to do just a whole new realm of mission capability.

And we're very excited. Our bus, we think it's an exquisite system. I talked about how good the pointing capability is. It's not a huge platform, but in terms of, again, the pointing, what you can do on a small platform, it is exquisite. But yet, because of low cost, people will consider it expendable. They're willing to take chances. If they want to do over it after three years and put something up with better capability, fine. As opposed to having some billion dollar asset that took 15 years to build, and say, well, there's no way we're going to take that down.

John Gilroy: You know, a few minutes back I talked about picking up my phone and reading Google News, and you can argue that we're all living in the world that DARPA created. I'm getting the news over an internet connection; I've got desktop computers and everything else, notebook computers.

So what's next? I mean, what direction is DARPA heading? And there must be some initiatives working with companies like yours and MIT and Stanford on different and emerging technologies. So what are two or three of them that might be exciting for the next few years?

Dan Hegel: Oh, let's see. Mesh networks, I think, in space, they're utilizing the up and coming mega constellations to route data around to war fighters in the field, and people doing analytics, getting more rapid data to players that need it in a hurry. Laser cross links. A variety of different small payloads. So just as they are funding small buses, development for Blackjack, they're funding many payloads

that can be co-manifested together in ways that couldn't be done before. Low cost. The autonomy.

One of the really interesting aspects, I would say the DARPA hard aspect, of Blackjack in addition to the cost is the autonomy through the Pit Boss, where it will be sharing information between through the cross links from one satellite to the next, tipping and queuing. Say, hey, I saw this phenomenology, queue another satellite, what do you see from yours? But you're a different detector, different wave length. And then be able to share information and process that real time. And then send the results to a user in the field saying something was detected of interest, take action, rather than having to download all the data and have it processed somewhere else and take hours or days to have this done real time.

So very exciting,

John Gilroy: I'm taking down notes as we're speaking, talking about Blackjack and Pit Boss. I think know what their hobbies are with these folks.

Okay, let's lighten up the conversation a little bit. Go from poker to Colorado University. I think your company is participating with them on a part of a competition sponsored by NASA called NASA Cube Quest Deep Space Derby. It sounds like a lot of fun, doesn't it? And so from the way I understand it, you folks are putting together a small CubeSat that is going to go beyond Earth orbit. Talk about precision with communication, this is where it seated. So do you think we'll be able to communicate with Earth at that kind of distance, or maybe with your technology it can, huh? How far is it going to be away, by the way?

Dan Hegel: Well, the competition, as I understand, kicks off actually around 4 million miles away. But on that first launch, it's space launch system, SLS, there's something like 13 CubeSats that are being deployed, and we have hardware on at least, I think, 10. 10 or 11 of those.

John Gilroy: Wow.

Dan Hegel: Yes. CubeSats. And so for this particular one, we have a substantial part that we're playing. We have a great relationship with University of Colorado. A long history of collaboration. Worked closely with them in the beginning of the company, actually. We occupied some space on the university campus as part of the eSpace Incubator at the time. And we've hired quite a few students from there and shared resources and such and worked back and forth.

But yeah, so they will be using a C-band spacecraft working with Atlas Ground System. And I guess something like after four months it will be about 4 million

kilometers away from the Earth when the competition begins, and they'll demonstrate communication with their system. And it's a matter of just how much data you get and the max data rates. So I have real confidence that they're going to do it. I mean Scott Palo is running the group there, excellent RF engineering professor. He's done wonderful things with the program there in satellites and space classes.

John Gilroy: NASA is encouraging this in order to proof of concept, or why are they doing this? And what do you think they'll find?

Dan Hegel: Well, everybody loves a good competition. I mean, this type of competition goes back to Lindbergh flying across the Atlantic. It was $25,000, which nowadays it'd be like multiple millions potentially. But, yeah, everyone loves a context. Who's the first to do this, or who can be the best? You know, the Olympics. Everyone wants to see a good race.

So this inspires students and other companies to get out there. And even though they may not make a whole lot of money, it gives them a lot of notoriety, which on the back end they can certainly make money, get investments. Say, look what we did with a limited resource. So invest. And then it's a really safe bet for NASA because they don't have to pay anything out until awards are actually completed. And over all, the cost they're demonstrating to see can we get some new propulsion or some new communication demonstrated far less than if they were to fund a program from start to finish with guaranteed results.

John Gilroy: It's classic agile software development of iteration testing, fail testing. These are 10 tests going at the same time. Someone's going to win, and that technology would be improved upon.

Well, Dan, unfortunately we are running out of time here. I'd like to thank our guest, Dan Hegel, director of advanced development, Blue Canyon Technologies.