Constellations Podcast

Episode 36 – Sputnik, Constellations and the Evolution of the Small Sat Industry

Speaker: Dr. Pat Patterson, Director of Advanced Concepts at Utah State University Space Dynamics Laboratory and Chairman of the Small Sat Conference – 24 minutes

John Gilroy: Hello again from the Small Sat Conference in lovely downtown Logan, Utah. You know, the growth of small satellites has been fueled by the promise of shorter development cycles, lower cost, new technology, and more frequent launches. Our distinguished guest on the podcast today is Dr. Pat Patterson, director of advanced concepts at Utah State University Space Dynamics Laboratory. He has over 30 years of experience in the space industry. He has a broad background in space system engineering, small satellites, and mission operations. Dr. Patterson is here to discuss new technologies, design methods, and operational constructs for small satellites. Let's not forget Dr. Patterson is the chairman of the annual AIAA/USU Conference, or the Small Sat Conference, and that's what we're sitting in the middle of.

How are you, Pat?

Pat Patterson: I'm great. How are you? Glad you could have me, and it's always great to see you guys here. By the way, I saw John Monahan kicking around here. It's always great to have him here. So John and I used to work together back in the '90s flying small satellites, so it always brings back good memories.

John Gilroy: Good, good, good. I went to YouTube and looked up your name. I saw a couple of videos and you talked about the growth of this conference. I took notes on it, but this is like a baby that's now 20 feet tall. This thing is growing and growing and growing. You're busting out at the seams, aren't you?

Pat Patterson: Well, it has. And I'll tell you what. You guys are in a great position here and a great location. You're right in the middle of the student center. We've got people all around us here. So this year, we have 3000 attendees for the first time ever. We've got 22 different technical sessions. Each of those technical sessions will have six or seven or eight different papers being presented in each one. We're going to have over 700 different organizations represented this year from over 40 countries, so it's pretty amazing. We've got 215 different exhibits, of which you have a very nice one here. We've got poster sessions and flash talks. For Logan, at least this week, this is the place to be.

John Gilroy: Wow. Really amazing. And so the theme I wrote down is Delivering Mission Success. That pretty much sums it up in three words?

Pat Patterson: That's it. That's it. Yeah. And the conference really mirrors what's happening in the industry, right? So wherever the industry wants us to go, that's where we go. We talk about a lot more than just the satellites themselves, right? Because you can get into this spot where you talk about the satellites and the sensors, but there's a whole lot more to the industry that makes these things happen. And we do talk about satellites. We talk about primarily systems that are less than about 500 kg. So if you take a nice big refrigerator, and you load it with some electronics, and put some solar rays on board to harness the energy from the sun, maybe put some batteries on board to store that energy for later, communication system, cable harnesses, a payload, you get something that comes up to about 500 kg. Anything from that size on down to about the size of something that you could hold in the palm of your hand like say a Rubik's Cube or a baseball, those are the kinds of systems that we're talking about here today.

Now it's interesting to think about where we came from, because we like to think that small satellites are kind of a new thing. But really, we came from small satellites originally. Back in 1957 when Sputnik was launched, that was a sphere about 2 feet across in diameter. It had some antennas and things dangling off of it. But it had a mass of about 84 kg. So by today's standards, we would certainly consider that a small satellite. In 1958, the United States launched three satellites of our own. One was Vanguard, which was a kilogram and a half. So that's pretty small. Then you've got Explorer, which was, I believe, just shy of 15 kg and Pioneer was just shy of 40 kg. So certainly we started in the small satellite age.

Then came the '60s though, and the '60s were an incredible time for the space age. There were a lot of things happening. You got to think, we went from flying our world's first satellite in 1957, and had got to the point by 1969 where we placed a man on the moon. So there were a lot of technologies being advanced, and the scientists and engineers were beginning to apply a lot of those capabilities to satellites because they wanted to perform more capable missions. There were just a lot of things happening. As those satellites became bigger, they became much more complex. They became much more costly, took a lot longer to build, and so things changed a bit.

Now there had always been a handful of small satellites being launched each year. But for the most part, the approach was the bigger the better. Now in the 1980s, things began to change a bit. Of course, the microelectronics boom was well underway. And what was happening was we were able to put more and more capability into smaller packages. Solar cell technologies and their efficiencies were steadily on the increase, so that meant that you could have smaller solar rays and harness just as much of the energy from the sun as you could with larger ones. Same things were happening with battery technologies.

Battery chemistry technologies were changing quite dramatically so you got smaller batteries.

So all of the building blocks of the satellites we fly today, whether they be large or small satellites, were really starting to take shape. Now this conference started in 1987. We had, by the way, about 50 attendees here.

John Gilroy: Sounds like you and your closest friends.

Pat Patterson: Yep, yep. 50 attendees. So at the time, I was actually a student. And I went to the conference. I didn't know anything about small satellites. I sat in the back, because that's where the doughnuts and the juice was, so I kind of hung out back there. But it was pretty cool to see that. But as the industry started to expand, we expanded right along with it. And our approach has always been very simple. All we wanted to be was a forum for the world's experts to come, and get together, and to share ideas. And wherever they wanted to go, we went. If they had a topic that was hot on their minds that they wanted to talk about, we put it in our theme, and we addressed it.

And now you're seeing the industry go to the point now to where we have each and every year, we're seeing more and more small satellites being launched. Dedicated launch vehicles are coming online. We're seeing ground stations and data analysis centers being stood up. It's just an incredible time to be a part of this industry.

Now, there has been, what some have talked about, a transformation in the industry. And the transformation, I think, really goes back to two very key and important aspects. One is the affordability, and the other is responsive timelines and shorter development cycles. So in terms of affordability, I think they all had a positive impact on different parts of the industry. In terms of the students, our future workforce, right? First off, because the systems were small, that meant they could actually build them up in their university labs. Because they were affordable, that meant that some universities could procure some hardware, and students could actually get their hands dirty. And third because of the shorter development cycles, that meant that students could enter a program as, say, a sophomore, and by the time they had graduated as a senior, they were able to go through the entire design-build-test process.

John Gilroy: Rather than waiting for their retirement to see the satellite go in the air.

Pat Patterson: Exactly. So they get this whole comfortability working with these systems. Now another part of the industry that was affected in a positive way was the supplier side and the small company side. Because the barrier to entry was simply lower for small satellites, that meant that more and more small companies were

beginning to come online. That brought a lot more competition, which brought a lot more good ideas to a table. And then of course affordability from a customer side means that probably there are a few more customers who are able to actually afford to fly these missions. And because they had, some of them at least, wanted to fly things quicker, the shorter timelines meant that they could do that.

So now you team all three of those things together. The students who are gaining a better education, and they're comfortable with small satellites. You got the supplier side bringing more and more good ideas to the table. And you have the customer side, who wants to get things flowing more quickly. And because they have a little bit of money, you start to get growth. And that's kind of what I believe are the building blocks of the transformation of the industry today.

Now more recently, we have seen investments from the private investors who are actually looking to invest in private corporations to build these constellations to turn a profit. That would probably be the fourth part. But I think everything goes back to the affordability and responsive timelines.

John Gilroy: Let's talk a little bit about constellations. You just brought it up. So what do you make of the mega small sat constellations that are due to launch in the very near future? Will they change this industry drastically?

Pat Patterson: Well, they could. My belief is I think they will. But I would also say that maybe they're already starting too. From some of these small satellites that are being launched, we're seeing changes every day in the way we view the planet from some of these systems. And the resolutions of these systems are pretty good. One to five meter resolution? That's pretty good stuff. I'm a little more on the side of the science, but from a science side, the way we make scientific measurements could certainly be changed. When you think of a constellation, you can now make multi-point simultaneous measurements multiple times per day. Now that is just a different dataset than can be collected from a single, or one or two or three satellites, no matter how capable those systems are.

And these systems aren't just being built for…when I started in the industry it was government funding. It was all about science or for military purposes. These are now being funded by private investors, and they're working with private corporations to develop systems because they want to turn a profit. And it's just a very different approach because the data that they deliver, or the answers, maybe I should say the answers that they deliver or the communications bandwidth that they will provide, is just something that could impact our typical user. Because Joe User can actually access that data and get access to it, right?

John Gilroy: Yeah.

Pat Patterson: So the fundamental change in the industry that I really see is the way we view space, the way we use space, and the way we incorporate whatever it is that they're providing into our daily lives.

John Gilroy: On the Constellations podcast, we've sat down with some rather large companies. And I wonder what the relationship is with the small sat and smaller companies. It is complementary? Do you think they are competitive? Do you think they work together? What's the relationship there?

Pat Patterson: Well, look. In our industry, there's always ... well, probably in every industry ... there's some form of competition. There's no doubt about that. I like to think of them, though, as more complementary. Look, small satellites need to do what they're good it. And it really is about the mission that matters. It's all about the mission. The satellites can be big. They can be the size of school buses. The satellites can be small. They can be the size of loafs of bread. It really is the requirement and the way you formulate the mission that drives how big the satellites need to be, how many of those satellites you need to have on orbit, and the capability that they need to have.

So let's assume that you have an earth-imaging mission, for instance. If you want to take very high-resolution images of the earth, you're probably going to need a big camera. You need a big camera, and you need a big satellite. There's just no two ways around it. If you can get away with a more moderate imaging resolution, that probably means you can have a smaller camera, which results in a smaller satellite. But because the per-unit cost of each is so much lower, it also probably means that you can afford to buy more of them, which allows you to have a higher revisit rate. So now you team the two of those things together, and they become very complementary with the big satellites doing what they're good at, taking the high-resolution imagery, the small sats doing what they're good at, providing the higher revisit rate. And I think that if our designers think of it that way, and they design systems that are the right size, capability, and number for the mission at hand, it basically just gives them another tool in the toolbox that they can choose from no matter what the next mission is that's coming down the line.

John Gilroy: All working together, it sounds like, from your perspective.

Pat Patterson: It is. It is. It is. Yeah.

John Gilroy: Well, good. So a lot of satellites up there. They're going to be producing a lot of data. And in my world of software development, there's this phrase that's

tossed about called big data. And I have to admit, driving over here, I saw a billboard. On the billboard, it said, "Bigger is not better. Better is better."

Pat Patterson: Yeah. Better is better.

John Gilroy: So what about big data? Better data?

Pat Patterson: Better is better. There's no question about it. But there's going to be a lot more data than we see today. But if you remember back to last year, our theme last year was Small Satellites, Big Data. And the reason we developed that theme was because the folks in this industry had been asking us to talk about that for quite some time. So that has been important on the minds of many for a long time now.

But I think there's an important point in there that it's not just about the satellites, it's not just about the sensors. It's about a whole lot more. There's a whole lot more behind the scenes that you don't see. And one of the things is certainly how you deal with the data. How do you deal with the data and get it to the ground? Or how do you get it to wherever you're going to process that data? Because what you really want to do is provide answers. Your users don't want a whole pile of data. What they really want is answers. They want it in a timely way so that they can make use of it, whether that be for the agriculture industry, energy, oil and gas-

John Gilroy: Maybe they need big answers.

Pat Patterson: It's big answers really. Now it takes a lot of data to develop those answers. But I believe the constellations that are going to be successful today are the ones who are putting just as much energy and effort into solving the data side of the equation as they are solving the satellite and the sensor side of the equation. Each of those are just pieces of the puzzle, and you have to solve each one of those independently but put them together and integrate them together so that the entire system works very well together.

John Gilroy: I want to bounce back to this conference here. I went to your website, and I don't know who did your website, but nice three-word summaries: Renew recent successes, explore new directions, and introduce emerging technologies. Very simple but very profound too.

Pat Patterson: Well, yeah. There really are a whole lot of technologies that are changing the way the industry's going. We talked about data. There are a whole lot of things happening. You got to get the data into the hands of the users in a timely way. There are things like propulsion. We've talked about propulsion before.

Dedicated affordable launch vehicles are very important. And I would say so are, at least on my list, is the way we fly these constellations of satellites.

Now as far as propulsion goes, propulsion is not a new thing. It's been used very, very well and for a very long time by large satellites all over the world. Whether that be for divert maneuvers, meaning to change velocity to move the satellite from one location to another or one orbit to another, or even for attitude control, changing the pointing direction of the satellite. Now typically we will use wheels to actually take care of the rotation of the spacecraft. But we'll use propulsion to dump the energy that is stored up in those wheels. So in either case, propulsion can be a very, very important part of an attitude-control system.

Now even though those systems have existed and worked very, very well for a long time, they were seen by small satellite providers as large and expensive. They just did not fit within the size of a small satellite. So you think about now a satellite that is the size of a loaf of bread, there's just not a significant amount of volume in there where you can put a propulsion system to get a significant amount of delta-v. And with constellations, this propulsion is very, very important if you want to maintain a proper spacing within a specific orbital plane between your satellites to make sure that you have a proper revisit rate. Or, if you have multiple planes and you want to make sure that each of those planes maintain proper spacing with respect to one another, that's a very, very important thing.

But today ... and when I say today, I really probably mean the last few years. There's been a lot of energy being put into developing propulsion systems that are the right size for small satellites. These systems are about the right size. They're about the right cost. And they just make it so much easier for our systems to get flown.

Now, electric propulsion will certainly help. But I think I just see them, again, as another tool in the toolbox that providers can use to apply to whatever the mission is at hand. Dedicated launch is critically important. And what I'm getting out of here is that the launch capacity today that we have just simply is not enough to place the number of satellites that we want to have into orbit. And launch capacity, or lack thereof, has been something that's been on the minds of many in our industry for a long time. Since the '80s, our approach has basically been ride share, where you hitch a ride with another larger primary system, probably one that's already paid for the entire launch vehicle or most of it. The problem there is that because they're the primary, they call the shots. They go where they want to go. They go when they want to go. If that happens to match up with your mission requirements, that's great. Typically it doesn't, but beggars can't be choosers.

But more recently, launch vehicles have started to come online. These are about the right size. They're about the right cost. And the more important thing is, because they essentially make you the primary, that means you do get to select where you want to go and when you want to go. So these dedicated launch vehicles are very, very important to us. We hope they come online soon. And we also hope they make a profit, because we need these folks to stay in the industry for the rest of the industry to be successful.

John Gilroy: And I can't wait till tomorrow. We have Dan Hart sitting in that chair answering those specific questions.

Pat Patterson: Yeah, yeah, yeah. That's a big deal. There's been a lot of skepticism as to whether these dedicated launch vehicles could turn a profit, and I am rooting for them, I'll tell you. We really need them.

Now the last thing I would say in the capability area that would be high on my list is probably how we fly these constellations of satellites. We've gotten really good at flying one or two or a handful of 30 satellites. But when you started talking about flying hundreds or thousands of satellites in a constellation, that's a totally different ballgame than we've ever been accustomed to. There's going to have to be some forms of autonomy. It's a totally different approach. And just like on the data side, I think the folks who are truly going to be successful in developing and flying and operating these constellations are the folks who are putting just as much energy and money and effort into figuring out the whole how to fly constellations side as they are into the satellite and the payload side.

John Gilroy: And that word autonomy and autonomous, it applies directly to the world of data centers-

Pat Patterson: Absolutely.

John Gilroy: And managing big data is that humans can't keep up with the changes. How can humans keep up with the number of satellites out there? It has to have some kind of an autonomous situation, an autonomous solution. I don't know what else you can do.

Pat Patterson: Yeah. This whole thing about machine to machine, right? So I work in this industry every day, and I can't even keep up with what's going on here at the conference. There are just new ideas I see every day that I don't know about. So being able to flow data one place to another and having satellites communicate with one another and act as a system. Back in the early days, we talked about a satellite as being a satellite, and a sensor, and a ground station. That's what we did. We flew the satellite. We collected the data. We passed it to the ground, and we were successful. Now it's how do you fly the whole system? How do you

fly 5000 satellites, have them do their job together? So it's a very, very different approach.

John Gilroy: Yeah. It's almost a mathematical approach or maybe a social approach, where group dynamics are more important than individual dynamics. And managing the number of satellites that are out there, the amount of information coming back and forth. That's a project for new students here at the university.

Pat Patterson: Well, I know there are a lot of people working on it, a lot of folks from different universities. There was a cool thing I saw. It was at the Olympics, when they had the Olympics on TV. And they had all those drones flying during the opening ceremony, and they were all flying together, and they made this picture like a snowboard or something. I thought, "That's what the small satellite industry needs right there."

John Gilroy: The swarm of solutions.

Pat Patterson: The swarm of solutions, yeah.

John Gilroy: Swarm of solutions.

Pat Patterson: Yeah, yeah.

John Gilroy: So coming to the end of the interview here, take a look at the show, looking at the future down the road, I look at all this success in Asia. Is this show going to take place eight years from now somewhat in Asia? Where's this whole world coming?

Pat Patterson: Well, I hope not. If it does, I probably won't be there. I'm pretty happy to have it right here. It makes it a lot easier for me. But our scope has changed quite a bit. Since 1987 when we started with students and education. We still talk about students and education today. We still talk about satellites and the sensors today. But we're also talking about other things, data, launching them. We're talking about rendezvous and proximity operations. We talk about space traffic management and policy and regulations. It's just grown a whole lot more than what we used to in this industry. And the types of people that you see here today are very, very different. You will see from the science organizations, NASA, NOAA, NSF, the European Space Agency is here in force, the Japanese Space Agency. A lot of different agencies here supporting this whole small satellite area.

You got the same thing happening with the DOD. Of course you got the Army, Navy, and Air Force. There will be other militaries here. And more recently now,

you have private investors and private corporations who are building out these sets of constellations.

John Gilroy: So Dr. Patterson, last year, it was Small Sat, Big Data. This year, it's Delivering Mission Success. So what's going to be the theme for next year? You want to give us a hint?

Pat Patterson: So we don't know.

John Gilroy: Oh. You know.

Pat Patterson: No, the honest answer is I don't know, and here's the reason why. We are just a forum for this community. We take the feedback from our attendees very, very seriously. We will gather all of that feedback. We will go through it over the next month. And we will allow them to help guide us as to where we're going to go in the future. Once we make that decision, we'll pick a theme. We will pick a keynote speaker, and we'll start laying out the show for next year. It's all about where the industry wants to go. We are here for them.

John Gilroy: And unfortunately we're running out of time. I'd like to thank our guest, Dr. Pat Patterson, director advanced concepts, space Dynamics Laboratory, Utah State University.