Pierre de Vries: Well, everybody, welcome to Silicon Flatiron's annual spectrum conference. This year, we're looking at 3D wireless, which is the promises and challenges of next generation, airborne and space wireless technologies. My name is Pierre de Vries. I'm co-director with Dale Hatfield of the Spectrum Policy Initiative here at Silicon Flatirons, and it's a real pleasure to welcome you here today.

I'd like to just start by briefly setting the scene for this conference. Why are we doing this? Spectrum policy used to be simple. And anybody in the audience who's ever done Spectrum policy, at this point, rolls their eyes and says, "Spectrum policy has never been simple." At least the geometry has been simple. Because, in the good old days, it used to be that licenses were points. There was an antenna, there was a transmitter at the point. Transmitter, for example, for TV. Or you had a geostationary satellite that was in orbital slot, that was a point. Then you got fixed point-to-point microwaves. So, you had points and lines. Then, there was the big innovation in the 80s, of cellular area licenses. So, then we went points, to lines, to areas.

What we're seeing now is a move to volumes. So, the geometry gets much more interesting. And so, to give you just a sense of what we're talking about, I have to use a prop. And so, this football, soccer ball, imagine this is the Earth, right? Diameter about 12,000 kilometers. So, to scale, a geostationary satellite is in orbit about two feet away from this ball. And, in fact, if I close this eye, this is the view that the geostationary satellite has of the Earth. You can see, it's about most of the Earth. And that orbit [00:02:00] is chosen, such that the satellite goes around the Earth in 24 hours.

And if it's on the equator, going the same direction as the Earth, seen from a fixed point on the Earth, it never moves, so it's stationary. That used to be it for satellites, mostly. Now, we're filling in a whole bunch of things. So, people talk about medium-Earth orbit satellites, they cover a range of altitudes. But, typically the kinds of things we'll be talking about today for broadband, it's about 8,000 kilometers up, so that's about six inches. Five-and-a-half, six inches.

And these things go around the Earth, two hours, ten hours, something like that. Then you get low-Earth orbit satellites. So, these, again, variety of altitudes, but typically, for the stuff we're talking about today, it's about 1,000 kilometers. That's three quarters of an inch. And these things go around the Earth, depending on altitude, about 100 minutes, to complete an orbit, which means, if you're on a particular spot on the Earth, you'll see one of these rising and setting in order of ten minutes.

So, these are the satellites that are now filling in the space between geostationary orbit, and low-Earth orbit. But, of course, that's not all. Oh, by the way, for scale, the moon is at the other end of the table, and this is the Earth. So, that's the scale.

One of the things you'll hear us talking about is high-altitude platforms stations. Things like, Lockheed Martin's high-altitude airship, Facebook's ocular drone, and so on. These things are at about 60,000 feet, and, to scale, that's about one one-hundredth of an inch above the soccer ball. But, to give you a sense of what 60,000 feet means, commercial aviation typically is 30,000 - 35,000, ceiling is about 42,000. So, these things are twice as high as most commercial planes get, and higher. Then, in commercial [00:04:00] airspace, we're seeing more and more, particularly in combat areas, unmanned aerial vehicles, drones.

Which can be quite big, flying at all these altitudes. And then, the big innovation over the last few years has been low-altitude drones. Mass deployment of drones, the new rules of the FAA, Federal Aviation Agency, they can fly no higher than 400 feet. So, that is the Washington Monument. That's 555. Or, for those who take a football rather than a soccer view of the world, it's half the height of the Eiffel Tower.

So, we're seeing things at all these altitudes, all of them use radios. They all use radios for command and control, and many of them use radios for payload. Payload meaning, for example, providing broadband internet service, or doing streaming video if you're doing surveillance.

And that takes us to this notion of 3D wireless. So, this is…this slide is, actually, up on the website, and let me just do a quick footnote, the primer that we had in the previous hour, this slide, Julie Knapp's keynote, and the conference brief are on the conference website. If you search for Silicon Flatiron 3D wireless, look in the right-hand margin, scroll down, all these things are there. So, this is just a small sliver of the broadcast allocation. You can't see it from the back of the room, but this is 18 to 32 gigahertz, the upper microwave. And you can see that we have a mixture of terrestrial services. Satellite services are different altitudes, and of course, satellite services typically have things on the ground as well. So, this is why we talk about 3D wireless. And the goal of the conversation today, is to look at the intersection between all these things. Aviation, new space, [00:06:00] and Spectrum.

And one of the things that struck me as I started to thinking about these things were collisions. And so, you'll be hearing about different kinds of collisions today, three kinds. For example, the first is the physical kind, where one piece of satellite's material bumps into another, perhaps creates a cascade, creates space debris. For most of us, a more worrying one would be if something bumps into a plane we're flying. So, those are physical collisions.

There are collisions of radio signals inside receivers, known as interference. And, because you have more and more of these systems, systems change dynamically, that interference becomes more challenging.

And, last, but not least, there are collisions between different institutions. There are, at the national level, different agencies with overlapping interests in all these areas. There are national and international agencies. And, on the other hand, you have collision between companies. There's a lot more competition. There are new companies entering the business.

And, to help think through, at least to a first approximation, what this area is about, we'll have three panels for you. One to look at innovation, one to look at some of the challenges, another to look at solutions. And then we'll wrap it up. We'll bring the moderators together for a short panel at the end to try and draw some conclusions.

To kick it off, I would like to introduce Professor Bobby Braun. He's the Dean of the College of Engineering in Applied Science. It's a great honor for us to have him here. He's a former chief technologist at NASA. He's used to placing bold bets. He's an entrepreneur, founded a company called Terminal Velocity Aerospace, that makes hypersonic flight products. University of Colorado, Boulder, is the national leader in aerospace research, aerospace teaching. [00:08:00]

And, Professor Braun is a new, energetic, leader here who's transforming engineering at CU. Ladies and gentlemen, Bobby Braun.

[Applause]

Bobby Braun: Thank you, Pierre. Good afternoon, and thank you all for allowing me to come here and speak to you. I'm genuinely excited to be here with you, and just thrilled about the topic of this conference, and of this session, which really is both cutting edge, and at the intersection of so many important topics.

So, just as a little bit of background, I'm an aerospace engineer. I have been in the aerospace field for, I don't like to admit it, but, for 30 years. Right? For 30 years now. And, I've seen a lot of things come and go in that time. And, what I believe, and what I can say, honestly, is I've never seen a more exciting time in the aerospace sector than right now. Not only do we have government programs that are going full bore, in both the civilian and the military sides of the house, but we have a very strong, and up and coming, continually growing industry presence in commercial space and aeronautics.

Frankly, like we used to talk about 20 years ago that we wanted, we've actually got that going on right now. And you can see that in the plethora of companies that are out creating an aerospace future for our society. Whether we're talking about SpaceX or Blue Origin and their rockets that they're generating, or OneWeb, or Planet, there's just a whole host of these companies springing up.

In fact, I read the trade press, space news, and the most interesting thing to me [00:10:00] was that the top news last week were about talks given by Lockheed Martin and SpaceX at a conference all the way over in Australia, talking about one day having humans on Mars. The headlines weren't about NASA administrator describes humans to Mars, it was about Lockheed Martin officials, by the way, from the state of Colorado, and SpaceX officials laying out their visions of the future.

Also in that meeting, you had officials from Planet talking about their constellation of small sats, that are going to provide continuous global coverage imagery of our world, and the rapidly changing effects of our world.

OneWeb was there talking about telecommunications. SpaceX gave other talks, talking about their telecommunications, visions of the future. And, so, it's just a remarkable time in the aerospace sector. And, by the way, it really is remarkable both in space, and also in aeronautics, where there are major undertakings happening, and major advances still occurring. In fact, the advances in space and the advances in aeronautics are somewhat synergistic because they all have to do with things getting small, and things being autonomous, right?

Those two advances, small and autonomous, lead to unmanned aerial systems, drones, or what have you. They lead to small sats, hundreds, thousands of them, doing what a big satellite used to do. So, I'm very bullish on the future of our space sector. And one of the reasons that I'm here today, is because I placed a bet and I moved to Colorado, right. And one of the reasons that I moved to Colorado was because of the strength of the aerospace industry in this state.

So, you probably know Colorado has the second highest number of jobs [00:12:00] in the aerospace sector in the United States. Per capita, it's the most. All the major space companies that I had been doing business with from the East Coast were here, so, why shouldn't I move, right? Why shouldn't I move to work more closely with Lockheed Martin, and Ball, and Sierra Nevada, and the hundreds of small businesses throughout the state of Colorado that are making a future for themselves in aeronautics and in space every day.

And so, what's at the epicenter of this Colorado aerospace ecosystem? It's the Department of Aerospace Engineering Sciences, right here at this University, at the University of Colorado, Boulder. This is the department that, frankly, I used to be envious of, and that I'm honored to be a member of today. This is a department that is leading the way in small spacecraft, in unmanned aerial systems, in autonomy, working with folks in computer science, moving into cyber security, this is a department you can be proud of.

It's a top 10 department nationally. It is the department that gets the largest number of applicants every year when we're filling out the freshman class, for our aerospace program. And it's a department that, I'm very happy to say, was recently approved by the Board of Regents to get a new building here on campus.

So, one of the things I wanted to mention, is that new building. Towards the end of this month, on October 26th, we're going to have a ground-breaking for the new aerospace engineering sciences building. It's going to be over on East campus. And that building will be up and fully operational, occupied, students, laboratories, faculty, industry, coming in and out of that building, by the fall of 2019. And, we're very excited about it, first of all, because of the potential [00:14:00] that that building offers the campus, but also because it's located on East campus, very close to LASP, the Laboratory for Atmospheric and Space Physics.

This is a laboratory that has built instruments, space-flight instruments, that have visited all the planets, whether Pluto's on your list of planets or not, they've got an instrument that's been there, right. And the synergies, I believe, between LASP and Aerospace Engineering Sciences, in fact, the whole college of engineering, including computer science, and electrical engineering, mechanical engineering, those synergies were just beginning to grow.

So, I'm very proud of that department, but I'm also equally proud of the college for what it offers the campus and the state of Colorado. We have the first, and still going strong, interdisciplinary telecom program, and you'll hear a little bit more about that from David Reed, during a session today. That interdisciplinary program is, kind of, is representative of the kind of interdisciplinary thinking that is happening across this campus now.

As another example of interdisciplinary thinking, between engineering and business, we're rapidly growing our entrepreneurship programs. And, we're doing that in connection with the greater, bolder entrepreneurial community. So, you're going to see a huge increase over, if you were to look five years ahead, you're going to see a very large increase in the number of student-led and student-active startup companies coming out of this campus, and going off in domains like we're discussing today. Not just in this domain, but certainly in this domain as well.

One of the other points I want to make about our college, is its strength and its ability to grow. So, this is a college that's growing very rapidly on campus. [00:16:00] It's growing both in size, in quality, and, actually, in diversity and access to students and people across the state and across the nation. In our freshman class, our freshman class that's here on campus today, we have 850 students in engineering. That includes computer science, by the way, for those of you not on campus. It's called Engineering and Applied Science.

In that class, 850 students, we have 38 percent female engineers. The average is 20 percent. Our freshman class is at 38 percent. 21 percent underrepresented minorities, 17 percent first-generation students in that same class. This is not only the strongest academic class we've ever had in the College of Engineering and Applied Science, but it's clearly the most diverse. And, it's really just a sign of where we're heading. Our college has announced the goal to be the first public engineering, educational organization at gender equity in our student population. Within five years, we hope to be 50 percent female, 50 percent male, like the world, right.

I mean, we're trying to prepare students to go into the world, right, so it kind of makes sense that while they're here practicing being in the world, they ought to be in an environment that is a good simulation of the world. So, this is something that we're also, that I and the college, are very proud of.

Turning my attention back to a little bit closer to the topic of this session, let me just say as a practicing aerospace engineer who has worked on flight systems that have traveled to Mars, and some come back, these systems are critically dependent on telecom. They're critically dependent on data, bandwidth, all of the topics, spectrum, all of the topics that you're going to be covering today. [00:18:00]

In fact, how would I know that the spacecraft that I built with my own hands, and helped launch to Mars, how would I know that that mission was actually successful, if it weren't for the data, the telecom that sends that back? The imagery, the science data, the health status information, all of that. And if you think about where we're headed with a more commercial space world, more and more activities in space, more and more activities monitored either from space, or from unmanned aerial systems, not just from the ground, from our ground assets.

Think about how all those things are going to play together. Not just in 3D, actually, but in 4D, if you include time. Time, I think, is a very important variable in this. I actually don't think there's going to be enough spectrum for all of the activities that we want to accomplish. And so, I imagine there'll be some sort of allocation sharing scheme in time across assets and across companies, governments, what have you.

So, I'm thrilled to have a number of representatives of the College of Engineering here in this session today. I think engineering can play a critical role in the discussions of this event, and in the activities going forward, but, this is an interdisciplinary topic that Silicon Flatirons is known for creating and having a space where people come around together. And this is a topic that, clearly, is bigger than engineering, right? There are all kinds of policy issues here. There are all kinds of communication issues here. There are issues that cross the government/industry divide, and so this is a really meaty topic. [00:20:00]

And I want to commend Pierre and his team for bringing you all together around this topic so we can put together, perhaps, a roadmap to move forward with. Not just as a college, or as a nation, but, frankly, a roadmap that's needed for our new world that we find ourselves in.

I also want to just give a brief thank you to my good friend, Phil Weiser, the Hatfield Professor of Law, who is also the founder of Silicon Flatirons. And I want to thank Phil because Phil, he may not know it, but Phil was actually instrumental in convincing me to come here. I moved out here about a year ago, it was just a little over a year ago, actually, and looking back on what I've been involved in this past year, and what we have planned ahead of us for the coming years, I'll tell you, I'm extremely happy with the decision to move here. Phil didn't have to twist my arm too hard once I saw the mountains, by the way. But, I am indebted to him for coaxing me out of my former, kind of, safe, existence, convincing me to take a risk. That risk has certainly been worth it as far as I'm concerned.

Anyway, I'm thrilled to be here with you as part of the discussion. I'm really looking forward to the conversation that we have around policy, technology, and all aspects of this discussion here today, and I want to thank you very much for allowing me to make some remarks. Thank you.

[Applause]