Constellations

Episode 206 – Massive NGSO Deployments, New AI Capabilities and Enhanced Space Domain Awareness

Speaker: Audrey Schaffer, VP of Strategy and Policy, Slingshot Aerospace – 19 minutes

John Gilroy: Welcome to Constellations, the podcast from Kratos. My name is John Gilroy and I will be your moderator today. Our guest is Audrey Schaffer, Slingshot Aerospace's Vice President of Strategy and Policy. The number of satellites in low Earth orbit is poised to explode over the coming years as more mega constellations come online. This has the potential to bring rise to new threats in space. The massive scale of deployments is driving the need to leverage artificial intelligence to make better sense of the exponentially growing space domain.

Here to discuss the role of AI for space domain awareness is Slingshot Aerospace's VP of Strategy and Policy, Audrey Schaffer. She's going to share some insights on the new capabilities AI enables and how it is addressing some of the key challenges in Space. Boy, Audrey, you're talking about artificial intelligence in space. Sounds like Star Wars or something, doesn't it?

Audrey Schaffer: Absolutely. I mean, final frontier in so many ways.

John Gilroy: Yeah, this is great. I bet when you were at MIT, this is like a dream for you too, "Oh boy, one of these days I could talk about this topic."

Audrey Schaffer: Absolutely.

John Gilroy: Great. Well, my first question is going to be just kind of like intro question. As the space environment becomes more crowded and complex, what role is AI playing to support space domain awareness?

Audrey Schaffer: John, you mentioned the number of satellites is growing really exponentially, but it's not the only thing that's growing exponentially. The data that we have to track and monitor those same satellites in space is also growing exponentially, certainly because the number of satellites we're trying to watch is growing, but also because the number of sensors that are watching those satellites is growing as well. And so when you think about the amount of data that is now being created for space domain awareness, you need tools like machine learning and artificial intelligence in order to make sense of it. It's just really too much for a human or even a team of humans to do on their own. And so what we're seeing is both better exploitation of the data sources that we have also the use of AI tools to fuse different sources of data together to really get actionable information on operationally relevant timelines.

John Gilroy: Yeah, I read all the things about exploiting the number of satellites in space, but it corresponds with the amount of data as well. I'm sure it gets more and more complex.

Audrey Schaffer: Absolutely. We just have oceans of data available right now. People talk about data lakes. I like to talk about data oceans, because of the amount of data that we have available. And you really need these AI and ML tools to be able to sift through all that data and really to identify anomalies or outliers, and also to be able to make predictions on what's going to happen next.

John Gilroy: Yeah. So I think everyone knows that AI isn't just ChatGPT and getting a summary of something. So AI really is a tool, it's a practical tool that's gaining traction in many industries. So do the challenges of working from space make it more difficult to gain the full benefit of AI?

Audrey Schaffer: I don't think so, John. Data is data, whether that data lives on the ground or in space, and it's really more about whether you have the compute power to be able to take advantage of those tools. Now, what we're doing at Slingshot Aerospace is ground-based sensing of objects in space. So all of our processing and data exploitation happens here, and so really there are no limitations in terms of how we can use AI for space domain awareness missions. When you start to talk about using AI on board satellites, it's really just a matter of what kind of bandwidth they have available to them, what kind of compute they have to be able to do their missions. But with the power of processing and just chips becoming smaller and smaller, I really don't think there's going to be a meaningful distinction between what you can do in space and what you can do on the ground.

John Gilroy: Well, Audrey, I know lots and lots of smart people, and they can do a lot of complex things. So what are the tasks and insights that AI can perform that are not possible by only using us mere humans for space domain awareness?

Audrey Schaffer: Yeah, I think one of the best examples is outlier identification and explanation. We have a tool called Agatha, which is intended to look at these mega constellations that you described, these 1,000, 5,000, 10,000 satellite constellations that are all working in concert and that are largely intended to be the same satellites performing the same mission going around the globe simultaneously. Now, Agatha is designed to look at those large constellations and bring in multiple different data sources, whether that's data on where the object is, how it's behaving, what are its communications patterns, and really identify just minute differences in how one particular satellite out of thousands might be behaving to give clues as to why that satellite may be different than the other satellites operating in the same constellation. That's a task that would be incredibly difficult for a human to perform, not just because of the amount of data that they would have to sift through, but because some of these

differences are so small a human wouldn't necessarily recognize them, or may not recognize the patterns across the multiple different data sources.

John Gilroy: Well, Audrey, I think this tool is going to change the way people work in many different areas of professional capabilities, we know that. So how does the impact of AI change the role of human analysts from a space domain awareness perspective?

Audrey Schaffer: Well, if you think about this example of monitoring a large constellation, without a tool like Agatha or any AI system, a human would have to be identifying the outliers before they could even start the process of analyzing, explaining them and investigating them. With the AI tools integrated into your workflows, the human doesn't have to do that initial flagging and identification. The AI can do that just as well, if not better, than the human analyst. Where the human analyst then can pick up is really on the investigative reporting, I would call it. Our system offers an explanation of why it believes the particular satellite is different from the others, and then the human analyst can start with that and really use what humans do best, the additional reasoning, the additional knowledge to run it down, what is actually at issue here, what's the underlying cause. So it just really changes the role of the human from frankly, one of just routine flagging of issues to really deeper investigation.

John Gilroy: Now, we talk about thousands and thousands of satellites being up there, but each satellite in and of itself provides unique information, and if you get that much unique information, it could be called silos of information or unique aspects of information. So what makes AI tools so instrumental in transforming disparate space data into a common operating picture?

Audrey Schaffer: Yeah, it's interesting. It's AI and a whole bunch of other data fusion and exploitation tools. So when you think about space domain awareness, which is the position of where the objects are, but also how they're behaving and contextual information about what they are, it's really putting all those pieces of data together and then making projections about what's going to happen in the future. So in addition to AI, some of the key technologies that we use, certainly data fusion is one of them, and we're able to take different types of data and bring them together to make a more accurate picture of where an object is and what it's doing than you might get from just one piece of data on its own. We're also bringing in the physics of space of how does an object move through space. What does an orbit look like to take information on where an object is today and extrapolate that into where the object is going to be tomorrow. And finally, putting all of that into a visual environment with modeling and simulation tools allows you to visualize and see what's happening in the space domain beyond just the math, the data of where objects actually are.

And one of the analogies I like to use when I think about this mission is Google Maps and how you use that when you navigate in your everyday life. If you look at Google Maps, you've got so many disparate sources of information in one single platform, everything from where you are as an individual to what kind of traffic conditions are on the road, where you might have a speed camera waiting for you. You could even look at restaurant recommendations or how busy it is in the moment. And it's really all of those tools being brought together and putting information on a single pane of glass as we say, that makes the integration of the data so powerful.

John Gilroy: How is AI being applied today from a space domain awareness perspective? Can you provide some examples of the problems being solved?

Audrey Schaffer: Absolutely. We've talked about the outlier identification with tools like Agatha, which look at those large constellations and provide insights into where they may be different. Ways that we can apply techniques like that to other space domain awareness challenges, I'll give you a couple of examples. One, is looking at jamming of GPS. So the GPS that we all use on our phones and in our cars to navigate is sometimes subject to interference or jamming. So we're able to detect those sources of interference, and then we're actually able to layer AI on top of it to not only be more robust and automated in our ability to detect and flag those jamming threats, but also to differentiate between unintentional interference and actually intentional jamming or a nefarious act. So that's one example.

Another example I'll use, which is more about understanding changes to where space objects are over time, is if you think about an object in space, most of the time they follow fairly predictable orbits. They're going in more or less circles or ellipses around the earth. So you can have a sense if you know where an object is today, you can have a sense for where you think it's going to be tomorrow. But from time to time, objects do maneuver. They change their position in space, and it can be a challenge to keep track of them if you don't necessarily know where to look anymore. And so another application of AI that we're using for this mission for space domain awareness is a tool called Raptor, where we essentially are building a database of unique identifier signatures for each satellite. We call them satellite fingerprints. So that this type of satellite has this fingerprint and that type of satellite has another fingerprint.

What that allows you to do is if you lose what's called custody, if you lose an object, if suddenly it's not where you expect it to be, but you pick up another object which has the same fingerprint, you can rapidly make an assessment of whether that new object that you saw is the same as the one that you lost just a few hours ago. So that's another example of using AI to compare across different data sources and make conclusions about what a given object is in space.

John Gilroy: You got to love Raptor. What a good name.

Audrey Schaffer: I think we're pretty good at those names here.

John Gilroy: Yeah, yeah. If you look at AI, that's just one thing. It has all kinds of applications. AI can create pictures, it can create text, it also has some predictive capabilities. So, I think that artificial intelligence is now capable of predicting future events, activities and threats, but can they predict them from a space perspective?

Audrey Schaffer: Absolutely, and I'll give you an example of that. So about a year and a half ago, there was a Russian satellite called Luch, which was purported to be a spy satellite. And it drifted around from satellite to satellite spying on with satellites that were nearby. About a year and a half ago, we picked up that the Luch had initiated a maneuver basically to change its position from where it had been loitering, which was near one cluster of satellites, to essentially being on the move. And one of our machine learning tools not only could predict where the satellite was going to move to just on the basis of physics and the orbital dynamics, but also was able to make a prediction of where the satellite might stop its drift, what its next target might be for spying.

And that was based not only on the physics of where it could actually get to given its orbit, but also its previous pattern of life, what kinds of satellites did this Luch purported spy satellite, what kinds of satellites did it like to hang out next to? What might its mission be? And when you look at that previous history, the AI can then make essentially predictions about where it might stop in the future and what satellites it might be interested in.

John Gilroy: Well, we're both in Washington, DC, I got to ask this question. So how is the commercial and government sector working together to maximize the full capabilities of AI to enable space domain awareness?

Audrey Schaffer: Yeah, it's a great question. AI isn't entirely new to the world of space. If you look on NASA's website and you think about some of the history of NASA vehicles operating autonomously very far from home, NASA has used AI for a very long time in its missions. But as you mentioned, we're both in Washington, DC, and it's funny, I was actually thinking about this question earlier today when I was on the Metro. And one of the things I found really interesting over the 20 plus years that I've now lived in DC, is you can always tell what's on people's minds by looking at the advertisements that are in the metro, because it's sort of like this very bespoke community here that you're advertising to.

And I'll tell you a trend that I've been seeing over the last, I don't know, six months or so, is a focus on the use of AI for military and national security applications using AI to support mission planning and decision making for war fighting. And so I think that's kind of the next frontier in terms of where I think

the commercial and government sector are going to work together on AI for government missions.

John Gilroy: Well, it hasn't stopped in the Pentagon, there's probably a practical application for that advertising, huh? Well, you talk about AI and then you start learning more and more about it, and it's pretty complicated, it's pretty tricky. Setting up LLMs, there's all kinds of best practices and things you can do and can't do. There's challenges and everything. So what are the key challenges of working with AI for space domain awareness?

Audrey Schaffer: One of the interesting challenges is when you have an AI, it needs to be trained, it needs to be trained on data. And while there's certainly a lot of data on how space objects have behaved over time, the beginning of the space age was more than 60 years ago, 70 years ago, we have data, but what we don't have are robust data sets on the newer behaviors that we're seeing in space. The mega constellations certainly being one of them, but also one of the newer behaviors that we're seeing is more dynamic space operations, where satellites aren't just in their same orbits over and over and over again, they're actually moving and changing more frequently than they would before.

So when you don't have that real world historical data that you need in order to train your AI, what you need is simulated data. And in fact, that's what we've done, is we've used algorithms that we have that essentially help us to predict where satellites are going to be to use those algorithms to generate 50, 60 years of synthetic data on how these newer types of space applications work so that we can use that synthetic data in order to train our AI. And in fact, we found that to be a very successful approach. When we use the synthetic data to train our AI, we then, of course, always go back and validate by testing it against current real world applications. So you may train it on 50 years of simulated data, but then you validated that training was successful by confirming your suspicions about what the AI has predicted. And let me give you an example to make it a little more concrete.

So with the Agatha anomaly detection algorithm, we trained it on over 50 years of simulated data for large constellations. And then what we did is we tested Agatha by looking at current large constellations, systems that are already operating in space. And sure enough, Agatha identified within those large constellations, a few potential outliers. And we contacted the commercial company that operated that constellation and said, "Hey, we see some anomalies in this satellite, that satellite, can you confirm?" And in fact, they could. So that's how we were able to validate even with the training of the AI with the synthetic data.

John Gilroy: I think of the big challenge for you is going to be, okay [inaudible] you get a whole team together and you got some synthetic data that works. Well, guess

what? It's going to be two X, three X down the road. So down the road, six, eight months in a year, it's going to be scaling like crazy. That's another problem you have to concern with.

Audrey Schaffer: Absolutely. But Slingshot has the largest corpus of commercially available space domain awareness data. And so we think that even with all those challenges, we're very well positioned in order to continue to train our models and really stay ahead of those evolving changes to the space environment.

John Gilroy: Okay, Audrey, I'm actually looking to the future here. When you look into the future, how do you see AI expanding and enhancing its capabilities to support space domain awareness missions?

Audrey Schaffer: Yeah, John, so when I look into the future, I actually take what we're doing with space domain awareness of really understanding what's happening in space, and the next thing is knowing what to do about it. If you're operating a commercial communication satellite and an AI tool warns you that you're on a collision course with another satellite, or maybe there's a nefarious satellite coming your way, it's one thing to just have the awareness that that's happening, but it's another thing to be able to make recommendations about what to do. And that's, I think, where some of the generative AI tools start to come into play of evaluating different courses of action against different objectives and being able to make operational recommendations. Now, you need, of course, as the foundation that space domain awareness data, to inform those recommendations, but it's really a step beyond where we are today.

John Gilroy: Audrey, I think you've given our listeners a real good perspective on artificial intelligence and space domain awareness, and also a couple of words to talk about, like Raptor and Luch.

Audrey Schaffer: Happy to do so, John.

John Gilroy: I'd like to thank our guest, Audrey Schaffer, Slingshot Aerospace's Vice President of Strategy and Policy.

Audrey Schaffer: Thank you, John.