

Combatting the hidden enemy of the cosmos

Dr Sarah Lipsy: [00:00:00] Good afternoon, everyone. Thank you very much for coming to listen to me talk today about combatting the hidden enemy of the universe. I'm going to talk about space weather today. So my name is Sarah Lipsy and I work in the US division of BAE Systems called SMS, Space and Mission Systems. And if you've heard of Ball Aerospace, that's who we were a year and a half ago. Now we're BAE Systems - very proud to be. We have a history of nearly 70 years of spaceflight heritage. Next year we'll celebrate 70 years. So a long history, very successful. And I'm going to talk about some of that with you today. My role at the company is I'm the director of business development for our civil space organisation. So it's my privilege to share with you today some of our work in civil space that promotes global security and protects civilian and military infrastructure and personnel by increasing our understanding of space weather and improving our ability to predict natural events like solar storms, we can better protect ourselves from negative consequences. By way of introduction to our space and mission systems sector, which is in the US, here's a graphic that shows some of our capabilities. We provide full range of and complement of ground, air and space capabilities as you can see here. Our satellites and sensors include everything from classified military missions to civil space missions that support missions for NASA, NOAA, other government customers and commercial customers.

Dr Sarah Lipsy: [00:01:48] So BAE Systems SMS is divided into five sectors: tactical solutions, ground systems and services, national space, military space and civil space. The image shown here for military space is our defence weather system in the microwave and I won't talk a lot about this. I would encourage you to come to a talk tomorrow at the same time by one of my colleagues, Dave Whalen, who will be talking about this mission. The image for Civil Space is a mission that we launched earlier this year for NASA called SphereX and I'm going to read my card because this is a very complex acronym. It stands for the spectrophotometer for the history of the universe, Epoch of Reionization, and Ices explorer, SphereX. BAE Systems built the spacecraft down here, as well as the cryogenic telescope that sits down inside the payload. It sits down inside those three photon rings that help us do cryogenic temperatures from low Earth orbit totally passively. For this mission that we launched earlier in March, we built the spacecraft, like I said, the telescope and then integrated the full observatory at our

facilities in Colorado and did full integration and test so that when she launched, she's been working fantastically. So I mentioned we have a very long history, here's kind of what we call the family photo. This is some of our civil space portfolio recent with large contributions. So for example, in our astrophysics portfolio up here, I talked about SphereX.

Dr Sarah Lipsky: [00:03:39] If you've heard of the Hubble Space Telescope. All of the instruments aboard Hubble today were built at our facilities in Colorado. XP and Webb are operating on orbit today and in the future. In about a year, we'll launch the Roman Space Telescope. These missions contribute to the broadening of our knowledge of the universe and our place in it, and they set the stage for future human exploration. So, for example, on IXPE, which is an x-ray polarimetry mission for NASA astrophysics, we designed the spacecraft, designed and procured the boom. That's about a six meter boom that holds the x-ray telescopes separate from the instrumentation, and then performs observatory in our facilities. For the James Webb Space Telescope we built the optical system. So those shiny gold mirrors, those are ours. There's 18 segments on the James Webb Telescope. They are made of beryllium, and they are coated with a fine layer of gold. More importantly than the mirrors themselves, on the back of each mirror is a cryogenic hexapod actuator system that allows us to push and pull each of the segments independently, so that we can align all 18 segments to act as one giant 6.5m telescope. For the upcoming Roman space telescope, which is also shown here. We designed and built the primary instrument, which is called the Wide Field Imager, in partnership with our NASA friends at the Goddard Space Flight Centre.

Dr Sarah Lipsky: [00:05:19] We also have a long history of doing Earth remote sensing instrumentation. For example, the tempo instrument shown here is a NASA mission that does air quality measurements from geostationary orbit. It has a sister instrument called Gems that we built for the South Korean government. Same measurements over Asia as we have over the US. And for NOAA's current low Earth orbiting satellite system, the Joint Polar Satellite system. We've built spacecraft and also instrumentation for the five mission series. Turning our attention to space weather now, because I told you, that's what I'm going to talk about, are our space weather portfolio is very recent and in fact, in two weeks we will be launching the Carruthers and the SWFO L1 missions. SWFOL1 and Carruthers. I will talk more about in a few moments, but just to say here that SWFO L1 is the first in a series that NOAA is flying called the Solar Series, now of buoys at the

L1 point. Our Civil Space mission supports scientific progress and advances our understanding of the Earth, the sun, the solar system, and the universe as shown here by our full portfolio and the more we understand about the causes and effects of the natural world, the better we can prepare and protect our critical national assets and infrastructure. Civil space missions also play a critical role in supporting defence goals. For example, a space weather impact can affect civilian and military assets alike.

Dr Sarah Lipsy: [00:07:06] And so things like the GPS satellites, military satellites, the ground based power grid can all be impacted by geo-effective space weather missions. Space weather storms. So these assets that we build are critical to not just civilian science missions, but also to the warfighter. And in addition to space weather monitoring and forecast, this also leads to better attribution when something bad does happen. And better situational awareness. So as we improve our space weather forecast efforts with missions like SWFO L1, which I will talk about and also thinking about planning for space weather Monitoring at the Moon and Mars. As we head out there, we'll be able to improve our space domain awareness and things like cislunar space also. Ok, so let's talk about space weather. Space weather comes from the sun, which is really a big ball of magnetic plasma. And things start on the sun as prominences. There can be flares, magnetic reconnection and helmet streamers out into the corona. The image here shows a coronal mass ejection. That's this thing with a prominence in its core. These are all magnetic structures. And when the sun releases these this energy out into the solar system, it impacts our magnetic field. We get beautiful things like aurora. But we can also have satellites that are in low Earth orbit or medium Earth orbit impacted by these kinds of storms, things like radiation from various kinds of particles traveling through the solar system. And so it's really important to be able to identify when these kind of events happen quickly. The photons of course, from these events happen. They travel to the Earth at the speed of light. So in a couple of minutes we'll see these on Earth. But the particles from these events do not travel at the speed of light. So it can take days for the high energy particles from coronal mass ejections, prominences, flares to reach our magnetic field and impact things like the satellites and the power grid. So what NOAA does, which is the US weather service, is they've decided to deploy buoys, space weather buoys, at the Earth sun Lagrange point, a gravitational sort of saddle point between the sun and the Earth. And it's a nice place because you don't need a lot of energy to keep your satellite there. You can just run in a Lissajous orbit once the charged particles interact. As I said, you can get

aurora. You can also get power surges, either in satellites or ground based power grid data corruption and other various hardware issues that we can protect against. But they're very challenging. So even if satellite operators have enough warning to enable, for example, safe mode on their satellites prior to a space weather event, the unplanned downtime in those satellites can affect the mission and functionality. And if you're an astronaut aboard the space station, you better believe you want some warning so that you can limit your radiation as you're on the space station.

Dr Sarah Lipsy: [00:10:28] For example, in 2024, just last year, there was a storm called the Gannon Storm. It was on Mother's Day in the US Mother's Day, at least, last year in May, and it was the largest geo-storm in the past three solar cycles. It caused GPS signals to be off by hundreds of feet. So tractors, farmers in the US were impacted during the height of planting season. Some recent papers estimated that this was about half a billion dollars in economic impact just from that one solar storm, and that one sector in only the US. So for reasons like this, it's expected that the first trillion dollar natural event will be a space weather event. Lots of sectors impacted, lots of countries impacted, and very, very broad. Another example to talk about spacecraft is that in 2022, the density of the atmosphere, the outer atmosphere increased due to solar activity. And that geomagnetic storm caused enough drag on low altitude satellites that Starlink satellites were lost. 38 of them were lost because they had enough drag. They were just brought down into the atmosphere. So we're we're working on these heliophysics missions to help us deepen our understanding of space weather so that leaders in our world can take action to mitigate the risks to both civilian and military personnel, equipment and infrastructure.

Dr Sarah Lipsy: [00:12:04] So how do we accurately measure coronal mass ejections, prominences, flares and their impacts on people and equipment? How do coronal mass ejections evolve as they move through our solar system? This is a video created by NASA that shows some of the assets that we have in space that have been used to measure space weather as a coronal mass ejection. A solar storm passes through our solar system. So we need data like these to continue the observation and analysis that is so important to making these models correct. So these space based assets include you saw Soho, which is at the Sun-Earth L1 point. Soho sits at L1 at BAE systems. We built one of the instruments. Curiosity is a rover that's on Mars. It carries instruments that are intended to measure the opportunity for life on Mars to exist, but it also has

instrumentation that can measure things like particle changes, particle density. Maven is called the Mars Atmosphere and Volatile Evolution mission, and it orbits Mars. Same deal. It has instrumentation that measures the upper atmosphere of Mars and can tell us about changes. Rosetta is an ESA mission that is hunting for comets. It's a comet chaser mission. Once it found its comet, it rendezvoused and it followed that comet around the sun and then landed onto a comet surface again, had instrumentation that was able to.

Dr Sarah Lipsy: [00:13:44] So here's Soho. Now we're out at Mars and we're getting Curiosity and Maven, and then we're going to go on out here as Rosetta. This is the one that crashed into a comet. Then we're going to go out to Saturn and look at Cassini, which Cassini-Huygens studied Saturn's rings and moons before crashing into the planet. And then further out, there's New Horizons, which was a mission that studied Pluto. And in fact, BAE Systems also had an imager on this mission. So we've been to Pluto. And then even further out, Voyager two is a mission that NASA produced, Voyager one and Voyager two, the only satellite, Voyager two, to visit both Neptune and Uranus as it slowly makes its way out through the solar system. We also had hardware on Voyager one and Voyager two. So the point here is we need all of these assets and we need to continue sending them into the solar system to really start to understand how space weather evolves through the solar system and improve our models and simulations. So I promised I would talk about some of the missions that we're launching in two weeks. These will be launched on a mission with a mission called iMap, which is also a NASA mission. And these two, these two missions, Carruthers and SWFO, are rideshares on that. And they'll launch out of Kennedy in Florida.

Dr Sarah Lipsy: [00:15:05] So I'll start here with SWFO L1. Like I said, at BAE, we built the bus, which is the the primary structure here. The solar panels go on this side. This is the Magnetograph, Magnetogram I'll talk about in a little while. And the coronagraph is on the underside and the particle detectors are into the page. So SWFO L1 is designed to orbit the sun at the Sun-Earth L1 point. And it can constantly make measurements. Then it's never on the dark side of the Earth. There's no eclipse time. It's going to make real time measurements of thermoplasma, the magnetic field and the solar wind characteristics. So for instruments, the first one that will get used when there's a solar event is the coronagraph that's tucked on the sunny side over here. It sees in white light the corona of the sun. And so when there's an event, you'll see that

helmet streamer come off the sun. If it's a halo event, that means you see it all the way around. It's either coming straight towards you or straight away from you. And so we'll we'll watch it and see which direction it's coming and determine if it's going to be geo effective. There's two in-situ particle instruments. One is called the solar wind plasma sensor or sweeps. And it's going to measure the temperature, the density and the solar wind as it passes by the spacecraft. The other particle sensor is called STIS.

Dr Sarah Lipsy: [00:16:32] That's the suprathermal ion sensor. And it's going to measure the ions and electrons. Again density temperature as they pass by the spacecraft. And then there's the magnetometer which I said sits down here. This structure here is a boom that on orbit will pop and extend out about six meters to keep the magnetometer far away from the spacecraft. And the magnetometer measures the magnetic field of that magnetic material as it passes by. We see that change as well as the strength of the magnetic field. So this combination of advanced sensors, along with the highly capable spacecraft that we built at BAE Systems, allows for advanced warning of impending space weather events. And as I've indicated before, these data will have applications for both civilian and military contexts. At BAE Systems SMS, we partnered with NOAA, our weather service in the US, to develop the high performing spacecraft, one of the most challenging requirements for this spacecraft is called the magnetic cleanliness. And the deal here is, if you want that magnetometer to be able to measure small changes in the magnetic field from that passing solar material, you have to have your your spacecraft not be producing magnetic fields. So our engineers in Colorado selected the subsystems and the components very carefully, and then did a ton of testing to make sure that they were not going to produce magnetic fields themselves. And we came up with special processes in developing the spacecraft and then integrating the observatory so that we did not develop a magnetic field on the spacecraft itself.

Dr Sarah Lipsy: [00:18:12] Magnetic cleanliness. Also is equipped with our company, BAE systems Rad750 single board computer. This is the core of the command and data handling subsystem that's used to control the spacecraft, as well as transmit data to the ground. Rad750 single board computers have powered more than 100 satellites that carry out a variety of space missions, and are trusted to perform critical criteria while enduring the harsh environments of deep space. We have also been selected by NOAA to develop the next two spacecraft for the Solar Series, so SWFO will be the first in this

series, and we just learned that we have a contract now for the next two, which is very exciting. So launching with SWFO is also the Carruthers Geocorona Observatory. This is a NASA science mission that's designed to provide more insight into how the sun's influence on the Earth's exosphere during times of solar activity. So from its future location at L1, Carruthers also will sit out there at the Earth-sun L1 point. And it has a UV camera that we integrated. It's up here under the words that was developed specifically for this science mission and as I said, it's going to provide this deeper understanding of the physics that happens in the upper atmosphere when their solar activity.

Dr Sarah Lipsy: [00:19:59] And this is really critical in terms of understanding the impact on the Earth of these solar storms. For Carruthers, we built the spacecraft, integrated the instrument, and then performed observatory testing. So we're going to gain this excellent understanding of space weather. It's going to have civilian applications, military applications. And we need we need better and better models. Also, as we learn about the causes and consequences of solar storms terms and their effects on the Earth's magnetic field are predictions will improve so that we can protect our infrastructure and our people. So studying space weather improves our space domain awareness as we enter into other parts of the solar system, heading toward the moon and towards Mars. We really need this deeper understanding of how to keep our people safe, so that when they travel to the outer parts of the solar system, they don't have huge impacts from radiation. It's also important to understand the impacts of space weather so that we can do attribution properly. When something happens to a satellite, is it human activity or is it natural activity? And we can attribute those things. The human activity could be either unintentional or targeted. This knowledge just gives our decision makers better information so they can make quick decisions to protect our personnel and property, which of course increases global security. So I will stop there and happily take any questions that you have. Thank you very much.