Below is the text version of the April 8, 2021, Wildfire Mitigation Webinar Series: Sensing & Detection | Fire Testing Capabilities.

MEREDITH BRASELMAN: Ladies and gentlemen, good afternoon, and welcome to the U.S. Department of Energy's Office of Electricity Wildfire Mitigation webinar series. We are so pleased to have all of you here with us today. I'm Meredith Braselman with ICF Next, and our team will guide you through the webinar today and the webinars throughout the rest of the month. Before we get started, we have a few housekeeping items.

Please note that this WebEx is being recorded and will be put on the Department of Energy's website. It may also be used internally. If you do not wish to have your voice recorded, please do not speak during the call. If you do not wish to have your image recorded, please turn off your camera or participate by phone. And if you speak during the call or use a video connection, you are presumed to consent to recording and use of your voice or image. If you have any technical issues today or questions, you may type them in the chat box and select "Send to Host." We have muted your lines upon entry, and they will remain muted for the duration of the webinar.

We are taking questions today. You may submit your questions throughout the presentations, but we're going to hold them until the end. So, when you submit your questions in the chat, select "Host" from the drop-down menu, and please also reference either the speaker's name or the topic when you submit them so we can ask the right panelist at the end. Finally, if you need to view live captioning, please refer to the link that will appear in the chat panel. So, to get us started today, please join me in welcoming Pat Hoffman, acting assistant secretary for the Office of Electricity.

PATRICIA HOFFMAN: Thank you very much for the introduction. As Secretary Granholm said during some of her very first remarks as secretary, there is no greater challenge facing our nation and our planet than the climate crisis. Climate change is intensifying and ravaging our community, and it's costing us billions and billions of dollars. We must tap the solutions at the Department of Energy's national laboratories in partnership with industry to tackle our climate emergency, and create healthy, safe, and thriving communities with consistent and resilient access to our electricity grid. The Office of Electricity's mission is just that, to ensure that the nation's energy delivery system is reliable, clean, and resilient.

During the recent events in Texas, Secretary Granholm commented, one thing is certain. America's electricity grid is simply not able to handle extreme weather events, whether it's the wildfires in California or the polar vortex in Texas. We need to upgrade our grid infrastructure as soon as possible. According to the California Department of Forestry and Fire Protection, approximately 10% of wildfire ignitions are sparked by faults on electrical infrastructure or electrical equipment failure. The growing dangers of wildfires pose increasing threats to our country's electric infrastructure, a vital piece of our nation's safety, prosperity, and well-being. To help diminish the threat of power grid-triggered wildfires, we must be able to inspect and monitor electric utility equipment to identify points of failure that can spark a fire.

During the next four weeks, we will hear from the department's national laboratories about their technologies and solutions for wildfire prevention, mitigation, and response. In preparation for this series, the national labs provided information about more than 30 technologies with the potential to be used now or adopted within the next 6 to 10 months. The technologies we identified fall into five separate categories: sensing and detection, fire testing capabilities, situational awareness, modeling and analytical tools, and post-fire analysis. The webinars, running through April, will delve into these important topics. Today's webinar will focus on sensing and detection technologies and fire testing capabilities. We are pleased to have experts from Oak Ridge and Sandia National Laboratories present today. While we are highlighting the national labs' capabilities, we understand that many utilities and other government agencies are working on their own solutions to mitigate wildfires. We are interested in hearing about what you are working on as well.

So, please reach out to Mr. Stuart Cedres, who is the lead on this topic in the Office of Electricity. His contact information will be on the final slide of this webinar. In closing, I hope these sessions will offer you the opportunity to connect with the national laboratories and leverage their world-class capabilities to help mitigate wildfires, as we all work to combat the effects of climate change. Thank you for your time, and I truly hope you enjoy this webinar.

MEREDITH BRASELMAN: Thank you, Pat. So now it's time to hear from our colleagues at the national labs. As a reminder, please submit your questions as we go. Because we're holding them until the end, submit your questions with either the name of the speaker or the topic referenced in your question. So, let's dive deeper into the sensing and detection capabilities provided by Oak Ridge National Laboratory. We are pleased to welcome Aaron Wilson from Oak Ridge to discuss its distribution arcing fault signature library. Aaron?

AARON WILSON: Thank you, Meredith, and thank you all for attending this webinar. My name is Aaron Wilson. I've been with Oak Ridge National Laboratory for about two years now. And what I wanted to talk about today is kind of a high-level overview of two different projects that we are currently working on in this area, both including distribution arcing fault detection and the construction of a signature library. Next slide?

OK, sorry. OK. The novelty of--sorry, having some technical issues here. The novelty of this work lies in the fact that we are using optical sensing technology. And this sensor that we have deployed is high fidelity, in the sense that it contains very high sampling rates and also very large bit depths, which can help us detect events that may not have been found using other sensing technologies. Oak Ridge, Lawrence Livermore are working with Pacific Gas & Electric utility company on the installation of this optical sensor cluster on a distribution feeder for the purpose of detecting early indicators of arcing faults and potential mitigation strategies for those. Additional capabilities of this particular sensor that we have installed include microphones and vibration sensors that may help us to correlate readings that we obtain from electrical readings to help kind of learn more about the events that are detected.

So, a little more on the sensing technology discussed being worked on right now. At the core of the technology is a passive optical sensing mechanism capable of monitoring AC voltage current, acoustics, temperature, and vibration. The frequency range of this optical sensor can be tuned to cover over 30 kilohertz worth of bandwidth. And as I mentioned earlier, this sensor is also capable of measuring things such as temperature, vibration, and acoustics, which again, may help us learn more about events that may not show up in the standard electrical waveforms. This device can sample upwards of 2 megahertz, and the nominal sampling rate is around 20 kilohertz.

So, what we are planning to do at Oak Ridge involves the following for arcing fault detection. In our work with Lawrence Livermore National Laboratory, we are comparing two different types of sensing technologies installed on the same feeder leaving a substation out in California. Lawrence Livermore has installed a micro-PMU device that measures magnitude and phase angle of voltage and current readings. And to complement their readings, we have installed this sensor, which, of course, reads point on wave readings, or oscillographic waveforms. The combination of these two might be helpful for kind of gleaning more about the events that we're looking to help detect and then therefore mitigate down the road. Once we have detected an event using the optical sensor, then we can ingest that event into the signature library, which I will talk about on the next two slides.

Arcing events are relatively rare. Building a data set for analytics training and testing will require exploiting knowledge about arcing faults from existing public data repositories, in addition to events captured by our sensors installed out at the substation. So, this poses a research question. What features can the optical sensor detect in an arcing fault that traditional sensing mechanisms cannot? And this is kind of the core of the research that we are beginning to embark upon here.

So, I mentioned on the previous slide the usage of a signature library. The objective of this signature library is to maintain a collection of labeled events or anomalies. The other primary function of the signature library is that it will enable machine learning and traditional analytics research to predict and monitor power grid health. And I will briefly talk about how that will work on the next slide or two.

And a signature in this case is set of measurements, whether they're voltage, current, frequency, acoustic, vibration, et cetera, that characterize an event which could be an anomaly. The framework of this signature library will help us to ingest, store, and access event signatures from disparate sources.

So, on this slide, this is just kind of a brief overview of the existing framework that we have for our signature library. First, we are accepting all kinds of different data formats, such as COMTRADE files, CSV files, and TXT files, that would then be ingested into this database through some sort of normalization process, such that it fits within the database schema. The signature library also includes a web application for visualization and uploading signatures.

Let me move on to the next slide and talk a little bit more about that. So, these are some of the core functionalities that the signature library presents. So, the user is able to log in to the web interface. They are able to collect their signatures that they have, whether they're labeled or not. And they can upload them, or download existing signatures, as well as visualization.

They are also able to upload unlabeled event data. And from there, we are working on a signature-matching tool that will accept this unknown labeled data, pass it through this matching tool, and return the top end--whatever number that may be--matched signatures that might help the user kind of learn what type of event they possess.

So that is the core framework of the signature library, and how we plan to move forward with it. So that was a very high overview of the projects we are working on here at OR now. These five are a list of contacts that you may reach out to--myself included on this list--if you have any questions that are not addressed in the webinar today. And with that, that's the end of my presentation.

MEREDITH BRASELMAN: Thank you so much, Aaron. We appreciate that. Now we're going to turn it over to Hong Wang, also of Oak Ridge, to talk about monitoring structural health of high voltage transmission lines. So, Hong, you have control.

HONG WANG: Thank you very much for the opportunity. [INAUDIBLE] is a part of work funded by [INAUDIBLE] mining program. I would like to acknowledge [INAUDIBLE] of Oak Ridge for providing [INAUDIBLE] for [INAUDIBLE] help and the support. He was [INAUDIBLE] project.

Here is a highlight of relevant capabilities, and the research of the outdoor facility dedicated to the power line conductor accelerated testing. [INAUDIBLE] 2,400 feet of conductor. The system can inject as high as [INAUDIBLE] of current, and the [INAUDIBLE] to extremely elevated temperatures. Also working with the conductor on [INAUDIBLE] system for more than two years of the projects [INAUDIBLE].

[INAUDIBLE] the transmission line is related to the wildfire in many incidents, the main triggering mechanism [INAUDIBLE] are downed lines, vegetation contact, [INAUDIBLE] power line [INAUDIBLE] have been in service for more than 25 years. Those conductors are subjected to continuous [INAUDIBLE] condensation, oxidation, and corrosion [INAUDIBLE]. As a result, [INAUDIBLE] and of course, [INAUDIBLE] lines. On the other hand, the structural degradation is generally progressive, so I improvised [INAUDIBLE].

These are also [INAUDIBLE] mitigation strategy [INAUDIBLE] consider [INAUDIBLE] complexity of the issue is a project that focuses on the [INAUDIBLE] what is regarded as the weakest link in the system. [INAUDIBLE] a single-stage [INAUDIBLE].

[INAUDIBLE] several [INAUDIBLE] validation method for [INAUDIBLE]. There are [INAUDIBLE] surface and the infrared camera, as [INAUDIBLE] on the right side, [INAUDIBLE] more the [INAUDIBLE] properties like electrical and thermal [INAUDIBLE] transducer is a very bulky and costly, unsuitable for large scale deployment. Moreover, only provided data in the [INAUDIBLE] more labor intense.

So [INAUDIBLE] is smart patch-based electromechanical impedance [INAUDIBLE] as EMI technology [INAUDIBLE]. And on the other side, is a diagram for the servicing of our two-stage [INAUDIBLE] industry [INAUDIBLE] analyze. The [INAUDIBLE] that EMI is sensitive [INAUDIBLE] condition [INAUDIBLE] components are a [INAUDIBLE] you saw as EMI, and for the strange condition to be monitored by the EMI signals.

The [INAUDIBLE] EMI [INAUDIBLE] is called the Damage Index, which included the [INAUDIBLE], so I noticed [INAUDIBLE] kind of making the relation between the EMI-based damage index, and that is the lower mean squared [INAUDIBLE] mechanical qualities.

The specimen we used is a segment of strength of the steel core, and it weighs [INAUDIBLE] the steel joints from [INAUDIBLE] on the surface as a [INAUDIBLE] and that shows how the disbursement was set up [INAUDIBLE] machine [INAUDIBLE] of course the steel core. So [INAUDIBLE] occurs between the two parties, including and is established very well. So therefore [INAUDIBLE] the mechanical strength could be estimated.

So [INAUDIBLE] steel [INAUDIBLE] of a concept stage. [INAUDIBLE] basic structural monitoring system and a transmission line comprising [INAUDIBLE] in the current technology [INAUDIBLE].

So right now, we have a one-year patent issues, and I'm [INAUDIBLE] license with a digital [INAUDIBLE] of technology maturation. When [INAUDIBLE] comments or suggestions [INAUDIBLE]. Thank you very much for your attention.

MEREDITH BRASELMAN: Thank you so much, Hong. We appreciate all of the information. Next up, we have Peter Fuhr from Oak Ridge to talk about real-time aerial sensors for extreme environments. So, Peter, when you are ready.

PETER FUHR: Hey, Meredith, that's so kind of you. So, hello to everyone. Good afternoon, good morning, good evening, I don't know where you are. But hopefully, everybody is doing just fine. So indeed, there are some nice presentations you just heard from colleagues at Oak Ridge National Lab, and there's some wonderful [INAUDIBLE] from Sandia and others, and as Pat was saying, throughout the entire month of these webinars.

So here, as you can see, there's that picture. We got a fire, we got a transmission line, we got some stuff going on. We're going to talk about a few activities that we have for extreme environments. And I think you'll see what's going to happen here. Just a few slides. Yes, they'll be made available. We can answer all sorts of questions through the chat or later et cetera, et cetera. Let's get right to it.

So on this slide, it's dense. There's a lot of stuff. But what we like to focus on is probably where your eye already--maybe your eyes, both of them--gravitated to. On the right-hand side, you see a drone. And that is a commercial off-the shelf DJI Phantom 3 that's flying around. And it's actually at the training site for the electric power board in Chattanooga.

These are de-energized lines, and then there's another area that has some energized lines. But the main thing is that we're going to talk about some unmanned aerial systems that are flying some sensors around. Much more than just a camera. It's not just a flying camera. We're using it as a transport vehicle to bring some sensors into proximity of stuff that we're interested in.

So, on the left hand-side at about 10 o'clock on this chart, you see all these little graphics, these little pictures? These are some of the parameters that are being measured that have their measurement equipment. And there's some telemetry and some communication gear that are inside that red box that the drone is carrying. It's going to go right next to the transformer right inside.

So what we're measuring are radio frequencies. And we're looking for specific impulses and some other stuff. Because you may think, when you're driving down the road and you're listening to AM radio--because it still exists, it does. And all of a sudden, you hear all this static; it's not white noise. There's structure inside that, and some of it is indicative of what the heck is going on with the transmission line itself. Many of the experts on this particular meeting already know this.

So, the device itself has software-defined radios, and certain things that are tuned to special frequencies that were of interest. We have acoustic detectors. What's that? We got microphones, with some filters on top of that that are sitting inside this particular red chassis, or the one in the middle--the stationary thing. What are we looking for? We're looking for impulses. It is acoustic detection in its classic sense, coupled with match filtering and some other signal processing that's going on, tailored to the acoustic spectrum. E&H? Oh, that's where your electrical engineers and even physicists, who are measuring magnetic fields, we're also measuring electric fields. So, there are things inside here. And yes, there's interference caused because it's in close proximity to the mothership, the drone itself. But we know where their signatures are; we can filter it out.

On the lower left-hand side, again, about 9 o'clock, you see ambient. There are ambient condition sensors, temperature, humidity, some chemicals, et cetera. And then there's a timestamp, hence the occurrence. So, all of these measurement capabilities are inside that box that you see in the middle that's colored white, 3D printed. It's got a touch screen on top. It's got some cameras here for a second.

So, lower left at about 7 o'clock, we're measuring pieces of the electromagnetic spectrum that are indicative of activity that's happening on the transmission lines--distribution transmission on the power lines. Certainly, we just talked about RF. So, we have RF measurements. We have ultraviolet cameras, or camera singular. And we have an infrared camera.

And we're not talking FLIR. We're not going that expensive. But it's relatively easy to tear apart a Nikon DSLR and get filters out of it and have that as an ultraviolet sensor--it works; we can talk about that--and infrared.

Right in the middle at 6 o'clock, there's a thermal image of--right there, look at that transformer. So, what we're trying to show here is that we have the capability demonstrated of measuring multiple parameters in either stationary or mobile platforms. We have some videos. We have some other stuff that could show this is what it is in action. If you'd be so kind as to zip to the next slide?

Thank you. This thing is rather interesting, and it's the beauty of the software that's layered inside this. And we're not talking really sophisticated things. We don't need a freaking high-performance computer. Heavens, no. But we are having some reasonable computational horsepower doing things. What the graphic is showing is the following.

The ultraviolet can pick up arcing, and it looks like that. That's an actual image in UV, looking at some arcing that's happening in that particular substation. What you're seeing it overlaid with is that matrix, at 8 by 8. So, it's a 64-element matrix that is generated because of radio frequency sensing-- --so we have good spatial acuity in looking in the [INAUDIBLE] and measurements of what are you measuring at the right radio frequencies at this location, at that location, at the next location.

So now we call this augmented reality. It's an overlay of what the RF sensors and the associated software is synthesizing an image. Here it is, a bunch of squares. The squares change their color based on the intensity. There's some other things based on the wavelength we can do. Color shifting, we're going to have some stuff. And it's overlaid onto an ultraviolet picture of arcing.

So that is all wrapped inside the software that's inside that flying little system on top of the drone. Again, now you'd say it's AR. It's an augmented reality, where the image here is not visible. We're sitting here in the UV, and we've synthesized this RF array on top of that thing. Next slide?

So there's some reports that have been written. We have a YouTube video from a couple of years ago about how we were flying drones at EPB in the training site and using their fiber optic communication network layered on top of--well, we have wireless on top of that--and relaying live imagery from that sensor system into the control center at the utility. Again, there's a video, there's some other materials that--if you're interested--we're happy, happy, happy to actually provide. Next slide, please?

So, what about the hazardous material stuff? There's that other part of the title. It's like, oh, we're going to do stuff in a hazardous environment, absolutely. And this is where these things come into play. I think you're going to see it. So, we have a sensing capability, a platform that can measure a bunch of things.

On the left-hand side, you see the picture of the U.S. Hey, there's the map. And there's the green dot way in the upper left-hand corner of Montana. It's Libby, Montana. And Libby, Montana is highly, highly polluted. If you're an outdoors person, it's spectacular Montana near-glacier scenery. It's just lovely.

And if you zip over to the right-hand side of the slide, you'll see this map. And what the map is showing--it's areas where asbestos that's coming from the vermiculite mine--hence the picture at 6 o'clock in the

thing. And basically, they have been mining for a long time, vermiculite. In fact, the place is called Vermiculite Mountain. Shaved it off, cut it off, made some asbestos, processed it in town, and unfortunately, they polluted the heck out of it. It is an EPA Superfund site.
And I want you to think about this for a moment. On the right-hand side of the map, you see--oh, what's that? It's a reservoir. It stretches up to Canada. And there's a dam there. And then it comes to this lovely, lovely river. So, the river's fine. If you're inside the red area, it is so contaminated [INAUDIBLE] you are supposed to be in a blue hazmat suit on SCUBA. And if you step out of it right into the river, you're in shorts and sandals and having a fine time.
So, we have this project underway with the U.S. Fire Service, through the U.S. Forest Service, through the USDA, that's trying to look at bringing the multivariate sensing system into this environment, and can we measure things that are happening specifically if there's a wildfire? The next slide, please?
Thank you so much. So, what does this have to do with how we started? That first graphic--the universal graphic you're seeing in all these presentations--about transmission lines, with a big fire in the background? Well, BPA has transmission lines that run right through this area. And over the summer--so I've been told by the fire service--BPA is going to be doing some reconstruction and rehabilitation of some of those transmission lines.
And the question is, can we provide sensing during that phase and afterwards that will be indicative of--ooh, there's something going on the line. Is it going to result in--dare I say it--a wildfire, or at least an ignition or some sort of spark. So again, what we're talking about here and presenting on these very few slides is a capability that the lab has developed as augmented reality, as multiple sensor systems. The applications are sitting right here in northwest Montana at this specific location. But it could be used other places. Next slide?
We're out. That's it. If you have any questions, contact me, contact our colleagues, or just follow Meredith and company through DOE. And you get the slides, et cetera. Thank you very much.

MEREDITH BRASELMAN: Thank you so much, Peter. We will be making the slides available on the webinar website. Should be available on Monday for you all to get the slides, and the recording will be available later next week. So, thank you so much. I'm going to hand it over to Andrew Duncan now from Oak Ridge to close out the sensing and detection capabilities, discussing multi-modal autonomous vehicle networks. Andrew? Andrew, I think you are still muted.

ANDREW DUNCAN: Thank you, Meredith, sorry about that. I couldn't find the mute button there for a second. Can you confirm that you can see my slides, Meredith?

MEREDITH BRASELMAN: We can.

ANDREW DUNCAN: Awesome, thank you. Good afternoon to all the participants in today's webinar. My name is Andrew Duncan, and I am the lead pilot and UAS technical specialist with the Oak Ridge National Laboratory's unmanned vehicle development lab. I'd like to take the next few minutes to speak with you about the development of networked small UASes and their potential applications for wildfire mitigation.

So, networked UASes are becoming a hot topic in the industry due to advances in low size, weight, and power and cost technologies, which are making networking UASes affordably priced, appropriately sized, and accessible to users. Advances in radio technologies, such as mesh networks and digital data links, from companies such as [INAUDIBLE] Labs, Silvas, Persistent Systems, or [INAUDIBLE] Tactical, are providing users with high-bandwidth connections to entire fleets of UASes. Companies such as Autherion, Verizon, Skydrone, and Flybase are commercializing cellular technologies in both 4G LTE and 5G. Open-source projects strive to bring low-cost satellite communication options to users, in addition to commercial providers, such as Cobham and Honeywell.

Why are these companies investing in network UAS technologies? Well, because it has many advantages. Data can be easily shared between users, other vehicles, and ground assets. This becomes powerful when, for example, network drones can autonomously query nearby weather stations to obtain information about weather conditions that might affect flight, or possibly even have impacts on a wildfire. Users can also access and operate fleets of vehicles and reduce cost in both time and money.

Response times to disaster events can also be reduced. For example, a single pilot can conduct a flight in Washington state, and then immediately conduct a follow-up flight in Alabama without incurring the costs or time associated with traveling to these locations. Cloud processing architectures allow for more powerful computing solutions. And I'll provide an example of this capability shortly. Importantly, users are able to gain an entire or whole-picture view of situational awareness for their fleets to enhance both safety and improve efficiency.

Here at Oak Ridge, our team has been researching the applications for network UAS, and have developed our own solution, known as MAVNet, or the Multi-Modal Autonomous Vehicle Network. MAVNet was developed at ORNL in 2018, and commercially licensed in 2020. It's expected to become commercially available within the next year.

It allows for multi-network UAS command control and compute in a small size, weight, power, and cost configuration appropriate for most small UASes. This technology allows for multiple connections over line of sight, cellular, and satellite communication technology simultaneously. As you can see in the video playing on the slide, an example of this would be an operator who chooses to use a local digital data link or local line-of-sight network.

In the event that that operator actually needs to move beyond the range of that digital data link, the system will automatically choose either a cellular network connection, or, if cellular is unavailable in that location, it will automatically switch to a satellite communication. Using multiple networks allows for use in a variety of situations. Line-of-sight works best in situations where the drone is being flown locally.

But as I mentioned, if there's a need to extend the range and cellular is available, the system automatically switches to cellular. If cellular's unavailable, which are scenarios such as post-disaster scenarios in which infrastructure may have been damaged, but yet there's still a need to operate remotely from those areas, the system known as MAVNet automatically uses the iridium satellite network to maintain the telemetry connection and continue to operate the UAS.

MAVNet allows for global operations, regardless of the infrastructure in the area. In 2019, our team demonstrated this with a long-distance flight with the operator located in Vienna, Austria, and an aircraft being flown in Oak Ridge, Tennessee. While the scale is a little difficult to see on this slide, the hardware shown in the lower right corner of the screen is approximately the size of a credit card and weighs less than 100 grams. The small size and weight of this hardware makes the technology appropriate for most small drones.

The web-based ground control system that's associated with MAVNet is very powerful and allows for global operations without need for specialized software. It runs within Google Chrome and allows for an entire picture view of situational awareness, and provides solutions for personal tracking, weather monitoring, and data processing, all from a single screen. In addition, APIs have also been developed to enable additional custom applications.

I'll provide a quick example of some ongoing work that we are currently conducting using MAVNet that you'll see in this very short video here. So, as a background to the work that we're currently doing, we are looking to do post-disaster inspections of electrical distribution infrastructure. So, what you're seeing here in this image is a video of our web-based ground control system uploading a mission to an autonomous vehicle, that aircraft then taking imagery as it's flying along, the aircraft actually detecting damaged infrastructure. In this case, it's actually a downed light pole.

And then actually, the aircraft communicating that back to the operator autonomously. So, in this case, the operator is not sitting there looking at images. The system is completely autonomously detecting damage, notating that damage, and sending that information to the appropriate individual. This is also going to be powerful when conducting large area surveying for both mitigation as well as response technologies. And with that, I'll hand it back to you, Meredith. Thank you.

MEREDITH BRASELMAN: Thank you so much, Andrew. We appreciate that. As a reminder--you guys are doing a great job, but please continue to submit those questions in the chat box. We've got a long list going, this is fantastic. So, now we are going to begin discussing fire testing capability at Sandia National Laboratories. And to kick off this portion, please join me in welcoming Dr. Randy Shurtz, who's going to discuss the thermal test complex. Randy?

RANDY SHURTZ: Thank you very much. I'll just be turning my camera off here, so you can focus on the presentation.

MEREDITH BRASELMAN: All right.

RANDY SHURTZ: Let's see. OK, so I'm--oh. We seem to have jumped to a--

MEREDITH BRASELMAN: Hang on one second, Randy. Let me get that back over to you. Andrew, if we can--

ANDREW DUNCAN: I think I just found it.

MEREDITH BRASELMAN: You got it?

ANDREW DUNCAN: Yeah.

MEREDITH BRASELMAN: There we go.

RANDY SHURTZ: Thank you, OK. So, I'm in the fire science and technology department, and we'll be talking--this is basically an introduction to what we do and how it relates to wildfires. So, in terms of fires, forests, and electrical sources, a lot of these wildfire scenarios that we're discussing, you have intersections of a large-scale fire, high-power electrical sources, and forest materials. There's been a good historical safety record for power transmission through forests. But increased wildland fires in recent years are causing concern, as has been mentioned in previous presentations, and in the introduction. One likely cause is that there may be excess dry forest materials that contribute. And it was mentioned--I think about 10% of these at least have been attributed to transmission equipment that may ignite fires, or act as a compounding hazard for fires already taking place. So, the fire science and technology department at Sandia has capabilities that can improve the understanding of current and future wildfire risks.

Basically, what we do is we routinely take a look at risks that intersect like these do--and this is well within our wheelbase--to design a test that will accomplish a specific objective. And we'll talk a bit about what some of those might be. We're going to emphasize the fact that we've got experience in these intersecting hazards, and we have very unique test facilities.

So, this is a picture of a fire whirl test that was done in one of our facilities. We design and execute fire tests. We do measurements on these fires. We do analysis of these fires. We do simulations of fire scenarios. Our experience includes customizing a fire and a test scenario to a wide variety of materials, sizes, shapes, and so forth.

We strongly emphasize making sure that we can safely execute tests with intersecting hazards. As we mentioned, high-power electrical sources--one thing that will happen in a fire is you'll get soot-laden gases that become conductive, so you may get arcing when power equipment is nearby. We can handle solid, liquid, or gaseous fuels. We can safely handle toxic gases, and elevated pressures, and a variety of other things.

So, our primary facility is the Thermal Test Complex, which is shown here on the right. We're located in Albuquerque, New Mexico, at Sandia National Laboratories. This facility was designed for our department's use and built about 15 years ago. The intent of the facility is to evaluate weapons safety in abnormal thermal environments, which includes fires. But these same capabilities are often used in discovery and model validation testing for other agencies, such as NASA, Department of Transportation, Coast Guard, and of course, DOE.

So, I'm going to emphasize these two facilities, FLAME, which is Fire Laboratory for Accreditation of Modeling by Experiment, and the Crosswinds Test Facility. We also have the radiant heat test cell and the abnormal thermal environments. Anyone interested in learning more about these facilities than I can cover in this presentation is more than welcome to take a look at our online self-guided tour. I'll touch briefly on that. We have additional fire testing facilities that are available at Laurence Canyon Burn Site.

OK, so at Thermal Test Complex, it's designed to study large outdoor fire scenarios under laboratory control, and this makes it very unique. We developed it to provide validation data for fire simulations, which we also do. And some of these facilities--especially these two--FLAME and XTF, have access to a 5-megawatt electrical source. We have our own substation, which means that if we were in studies of wildfires, we could characterize interactions between large electrical sources and fires in both FLAME and

XTF. FLAME is representative of low-wind outdoor fires, and XTF is representative of outdoor fires driven by strong crosswinds. I'll get into a bit more detail on each of these.

So, here's FLAME. We can do fires with up to 20 megawatts of thermal heat load. We have a 10-foot diameter pan here in the middle. The dimensions of this test cell are 50 feet high, 60 feet in diameter. And we have a very unique controlled convective radiative test environment.

So, what happens here is these walls are water-cooled. And that's why this simulates an outdoor fire, because the fire--like one of these--radiates out to the walls, and none of that radiation comes back, which means it's acting like it's outside, and it's radiating out to infinite distance. This grate, which you can see a little bit in this illustration here, we can have airflow up past the fire through here, which can add up to 150,000 cubic feet per minute. So, this stimulates the air that the fire draws in as it burns in an outdoor environment.

So, we will set the airflow to match that, and that's the other part of how we match the convective environment of an outdoor fire. We can vary that, depending on the size of the fire we're doing. Here it's shown that we have access ports in the walls for advanced optical diagnostics. We can actually move the pan up and down, so that you can sample from different heights in the fire.

And we also use conventional measurements of temperature, heat fluxes, flow of the air and soot, [INAUDIBLE] the air flow of fuel, if it's a gas or liquid soot production. We can do visible or infrared video and more. As I mentioned, we have a 5-megawatt electrical power source, and we can combine that with a very uniquely controlled fire environment, which makes it well-suited for studies of wildland ignition from power lines, or the influence of existing fires on power equipment.

The Crosswinds Test Facility was developed to simulate wind-driven outdoor fires. We can do fires of the same size, 20 megawatts thermal, but with winds up to 20 miles per hour. We do that with airflow that can go from 8,500 to 170,000 cubic feet per minute.

This test cell is a big, long rectangle. It's a 25 by 25-foot cross-section 83 feet long. We have refractory concrete walls in here, which actually allows us to do tests that have the equivalent of up to about 100 pounds of TNT. Another thing that the refractory concrete allows us to do is we're able to do X-ray measurement techniques on request, as well as all the other measurement techniques that I mentioned for the FLAME facility.

We really expect wind-driven fires to behave quite a bit differently. I mentioned we also do simulations, and we can see strong evidence of that in simulations we've done in the past of forest fires. So, we could move some wildland materials into either one of these facilities, along with powered equipment if desired, to take a look at what those interactions would be. We could look at things like effects of high crosswinds on wildland ignition from electrical power sources, effects of wind-driven fires on powered electrical equipment--so depending on whether you have the fire first or the electrical source first--and also, the rate of flame spread in wildland material is driven by high crosswinds.

Now we have other fire-testing facilities. I've done quite a bit of work myself in this radiant heat test cell. We call this dial-a-fire capability, because sometimes, we want very repeatable abnormal thermal conditions. We want to be able to have a fire environment that we know what it is, and we can repeat it and do it many times.

So, we use these electrical quartz lamps. And we can use those to heat up to 1,000 degrees in about 45 seconds for a test unit. This has the same power supply as FLAME and XTF. It's supplied at 480 volts and 1,000 amps. If sometimes we want to go to higher temperatures, but not quite as fast, then we'll use silicon carbide rods.

This is an image of a simulation of that kind of environment. We also have a lab where we investigate smaller scale bench scale-type heat sources, ovens, small pools and burners, and things of that nature, if we need to understand the mechanism of something on a more fundamental level. So, that allows us to go smaller, but we can also go much bigger, which is what we do up at the Laurence Canyon Burn Site, which is where most of our original tests were done before we built the TTC. So, that's where we do our largest-scale tests still in the future.

OK, so just to summarize, Sandia Fire Sciences is ready and has the capability to help out with wildland ignition studies. We have the expertise to design and safely execute fire tests with complex intersecting hazards. One advantage of being in New Mexico is that we can measure all these things in fires, temperature, heat fluxes, airflow, soot production, and so forth.

But in many of these scenarios, the question of concern is, what happens now that sections of the forest contain more dry fuels than they might have done when the power supplies were put in place? And the fact that we have a dry climate in New Mexico means that we can very easily test wildland fuels with different levels of moisture. At the TTC, we've got thermal sources ranging from bench scale up to tens of megawatts thermal. And we have a dedicated 5-megawatt electrical substation that we normally use for simulated fires, but we can also use it to consider interactions between fires and large electrical sources. I believe that's it. Thank you very much.

MEREDITH BRASELMAN: Thank you, Randy, appreciate it. Next up, we have Alex Brown from Sandia as well, who's going to talk about testing of wildland ignitions from high-flux sources. So, Alex, you have the ball.

ALEXANDER BROWN: Thank you, Meredith. Please confirm that you can hear me?

MEREDITH BRASELMAN: I can, and I can see your screen as well.

ALEXANDER BROWN: OK, perfect. So, the previous presentation by Dr. Shurtz is representative of one of the facilities that the fire group uses to study fires. The work that I'll be presenting may have some relevancy to this problem, in the sense that we've been doing some recent work on very high-heat flux ignitions, and those are the types of things you may get out of arc faults and electrical equipment failures. We've been doing it under other auspices, but there's an alternate facility at Sandia, Margaret Gordon and Francisco Alvarez being the point of contacts that I have at that user facility.

So, the National Solar Thermal Test Facility at Sandia is a user facility, and they use it to concentrate solar energy, principally for power applications, but they also have a fairly robust business model looking at materials testing. The NSTTF has a number of facilities, and I'm going to highlight two of the facilities that we've been using recently for testing.

In particular, starting in about 2016, we have been working on a campaign to understand the effects of nuclear weapons, specifically, fire ignition from very high heat flux sources. And these are also relevant to the wildland fire electrical problem that we're discussing today. There is a current project that is aimed at looking at the nuclear winter problem, which has just recently been funded. We'll be continuing some tests at this facility. This was funded out of NA-24 at DOE.

So, the large-scale tests that we performed were at the Solar Tower Facility. It can access as much as 5-megawatt concentrated solar power. We typically have been running with about a meter-sized spot. And they also have electrical power at the top of the tower, 480 volts/100 amps. So, we could potentially expose electrical equipment at Solar Tower to very high fluxes as well.

For smaller scale testing, we have a facility called the Solar Furnace. And we can access up to about 3 megawatts per meter squared, with a spot size of about 5 centimeters in diameter. And that's pictured on the far right.

Now these facilities are also used to test in other environments, such as reentry ablators, electrical cable response to metal fire environments, and the nuclear weapons' effects on infrastructure. And these have been ongoing over the last five years.

So, what I want to do is explain why it's important to study high-flux ignition problems in their appropriate environment. And I illustrate this by going back to some tests that have been done in the 1950s and 1960s. Stan Martin and company published in 1965 the plot shown on the left, which highlights a number of ignition regimes, based on a normalized radiant exposure--think of that is the fluence, how much energy you're putting into the material--and then a normalized irradiance, the heat flux--how fast are you putting the energy into the material?

And what they were able to demonstrate through tens of thousands of experimental tests with blackened cellulose is that the ignition tends to fall along some curves, and you can highlight regimes. Normal fires typically being in the upper left quadrant of this plot. But as we get up into higher flux ignitions, you can see that we have a no-ignition regime down there below, and an ignition regime. You can achieve ignition with a lot lower energy input compared to when you have a very high flux.

And so, they were able to map this out for cellulose. And in the testing that we've been doing recently, we've been able to show that this curve generally holds true for most materials. So, as you get out into this higher flux regime, less total energy input is actually required to achieve ignition, as you can increase the heat flux exposure.

So, this is an image of their facility. They used an arc lamp and some parabolic reflectors. These are images of the facilities that we've been using for some testing that we've been doing. The image on the left is the Solar Furnace. A single heliostat mirror tracks the sun and directs the rays into the Solar Furnace Facility. A 7-meter diameter solar concentrator focuses down to a spot, and the shutters control whether or not the rays are allowed into the system.

The Solar Tower is exhibited on the right, and it has a field of heliostat mirrors with a control tower. And we're able to access much larger scale ignitions at this facility. And I'll get into why that's important here in a minute. So, I have a video here. And what you're going to see is close to real-time exposure of 16 different materials. And probably, we're more interested here in the green needles and the dry needles. As we expose these to a nuclear weapon-relevant environment, the dry needles ignite. In fact, almost all of the materials that you're seeing here achieved ignition. The exception to that was, I believed, well, obviously, the aluminum. But the PMMA and the green needles did not ignite. And these were all exposed to a relatively comparable high-flux condition. And so, not having been able to ignite these green needles is an illustration of how a green versus dry biomass makes a difference in terms of ignition.

So, somewhat provocatively, we took very similar materials up to the top of the Solar Tower. And in this case, we exposed a tree--a green tree, relatively recently cut within minutes. We exposed that to a comparable heat flux and fluence exposure. And whereas we did not get ignition at the smaller scale, we did readily achieve ignition, and we had active burning for nearly a minute from this small-scale tree exposed to very high heat flux.

And so, this is illustrative of scale effects that we think exist in terms of the ignition parameters. And these were not explored particularly well by Stan Martin in the historical data sets. And so, this represents not a total gap, but a partial gap in our knowledge basis of how high heat fluxes can result in ignitions of wildland material. And that video is available on YouTube.

So, what I did is in this view graph--this is kind of my summary view graph. I want to kind of explain where we see certain frontiers in the research. The work that we've done for DTRA did not focus in particular on wildland ignitions. But one thing that we know is that there's a lot of parameters that are important to the ignition, such as the moisture content, the wind, the geometry, the scale, et cetera.

And while we've done a number of tests at these various facilities, we haven't yet collapsed anything. We don't have a wide enough range of data to really fully understand the response space of materials under these types of environments. So, the work that is kicking off right now is actually focused on particle emissions. The nuclear winter problem is concerned with large-scale fires, how much smoke gets into the upper atmosphere, and how it may result in a cooling of the Earth's environment due to the particles that are up in the atmosphere and hard to remove.

And so, the tests that we'll be conducting, we're still kind of in the design phase on these experiments. But we're really looking at the yields of organic and soot particulates. And so, we expect to have some data sets of this nature coming out of the Solar Furnace on shorthand.

The last main bullet point--I wanted to talk to a few points of interest that I think might be relevant to this community. The way we see this problem, arc-faults can be caused by fires through multiple mechanisms--one in particular, smoke deposits on electrical equipment. And that can create unintended conduction paths for electrical power. Smoke can also increase the conductive of the atmosphere, and this will cause arcs through the atmosphere. And smoke is a very important and key aspect of these fires, as they relate to ignitions from high-powered equipment or the behavior around high-powered equipment. And then, of course, some of the other programs that we've been working--heat can cause melt or burn of insulators and expose conductors, and that can result in arcs as well.

So, the movies and the work that I've done is just kind of the tip of the iceberg of what we've done. My last view graph just highlights the fact that we have a relatively large number of relevant publications in this area, maybe not specifically on wildland fire, but especially on high-flux ignitions. And so, I show this in case there's interest in further follow up on these topics. Thank you for your attention.

MEREDITH BRASELMAN: Thank you so much, Alex. And thank you to all of our panelists. This has been such great information. And it's so good to hear all of the things that you all are doing. We're going to open for questions now. Again, you guys have been using the chat, which has been fantastic. What we want to do is go through the questions. I will call them out for each one of our presenters and give them some time to answer. We're going to try to get to as many questions as we can in the time that we have left here.

So, the first question is going to be for Aaron, so I'll let you unmute yourself here. Two related questions for you. Who is the intended user, and will the signature library be open-source?

AARON WILSON: So, the first question, as far as who the intended user is, I believe that's in reference to the signature library. And so, I would say the intended user for this includes utilities, operators, universities, researchers, national labs, et cetera, et cetera. As to the open-source question, as of now, no, I don't think we are planning for it to be open-source. It will be credentialed access. For specifics on that, I would refer you to some of the other contacts listed on my penultimate slide.

MEREDITH BRASELMAN: Very good, thank you. Hong, the next question is for you. Will other types of HB connectors be evaluated like fired wedge connectors?

HONG WANG: Yeah, I would like to see them [INAUDIBLE] to the one we have done through here, compression collimeters. And the reason is that you are using a single digit targeted [INAUDIBLE], so you are [INAUDIBLE].

MEREDITH BRASELMAN: All right, thank you very much. Peter, the next question is for you. Is the camera and program accessible to utilities to do trials? Is this something that is deployable to others?

PETER FUHR: Super question, super. So, thank you so much for that. Is it available at this moment as a test [INAUDIBLE]. The system is sort of inside the lab, but we could talk about the possibility of using it or demonstrating it at specific utility sites. Probably, the lab does things--like we have at national labs--about licensing, et cetera. And that is for further discussion. I could bring other people in on that.

MEREDITH BRASELMAN: OK, very good, and I've got one more for you, Peter. Was the arcing in the substation photo the disconnect being opened?

PETER FUHR: Yeah, I saw that in the chat room coming in from Mike Dyer. Mike, I love this question. Because basically, what was happening is--see the pattern, and it was absolutely a disconnect when that was happening. In the environment, the ambient conditions at the time were relatively low humidity. I think it was 18%. And not too hot, it was in the mid-60s. So, we had that data.
And it's interesting to see--[INAUDIBLE] says--I'm going to call it the arc--should take a minimum path, right? A minimum pathway. And you can see how it found its way through that fractal pattern to get from point A to point B. [INAUDIBLE] pretty interesting a little thing. We did somewhat similar ideas. I was talking to Drew at Epry about that, using their particular facility to see if we could replicate it. To come back to the simple answer--was it the disconnect? Yes.

MEREDITH BRASELMAN: Thank you. Andrew, the next question is for you. Are these UAS applications based on line of sight, or do they also assume non-line-of-sight operations? And are you working with the FAA to determine how to improve the non-line-of-sight or remote operations?

ANDREW DUNCAN: All right, thank you, Meredith. This is a popular question. Obviously, beyond visual line of sight operations is exciting. It's pretty new. And as many people on this webinar already know, beyond visual line-of-sight approvals from the FAA are becoming more common. And a lot of entities are searching for technologies to improve reliability of communications [INAUDIBLE] line-of-sight operations. But to the question--in reality, the beauty of MAVNet is it really allows for flexibility for a variety of operations and environments. In some of these applications, we would be operating in line of sight, so the drone would be close to the operator in those applications. In that type of scenario, the MAVNet system autonomously configures itself to maintain that line-of-sight connection.

But in the event that the operator needs to continue--has all the approvals in place, and needs to continue into a beyond visual line-of-sight operation--then the system automatically configures for that as well, like I said, using multiple different networks, using either a cellular network or satellite communication network. So, kind of the beauty of the system is that it really allows for flexibility for both line of sight and beyond visual line of sight. So, a lot of these applications can be used in either, depending on the operating permissions for the specific operation.

But my team--to the second part of the question about the FAA--so my team is not actually currently working with the FAA directly. Most of our work has been through other agencies, such as DTRA. But our commercial licensing partner is actually working to build that capability and build that relationship to begin working with the FAA, in order to help strengthen those beyond visual line-of-sight capabilities. Thank you.

MEREDITH BRASELMAN: Thank you, Andrew. Aaron, the next question is for you. You made the comment that arcing is rare. Are you able to generate signatures analytically and/or experimentally, and can you speak to machine learning versus model-based approaches?

AARON WILSON: This is a great question, and it is definitely one of the core tenets of what we're going to do with this project. I'm certainly an advocate for transient modeling and simulation. However, arcing events are caused by a wide variety of different physical phenomena. And they may be manifested in ways that are just completely different from each other.

For that reason, modeling and simulation does become a bit difficult without narrowing your problem space down to a few different types of event patterns to look at. However, that doesn't mean that modeling and simulation should not be performed. I think a balance of both simulation and machine learning techniques is probably the best course of action.

MEREDITH BRASELMAN: All right, thank you. Randy, this question is for you. How can groups work with Sandia for modeling fires, and can any utility work with Sandia, or is that something that's closed?

RANDY SHURTZ: We do take outside work. Obviously, stuff that comes down from the Department of Energy is the main portion of what we do, but we certainly do take outside work. So, if someone like me could be contacted, and then we discuss what's the nature of the problem, and what you'd like to learn, and what is a test or a modeling study that we could appropriately do to answer the question that the customer has. And then that goes up to through management, and they decide whether we'll take on the work, based on our current workload and so forth.

MEREDITH BRASELMAN: OK, very good. And another question for you, Randy. Have Sandia National Labs or any others developed models to quantify the risk of forest wildfires from transmission line fault ignition under prescribed wind or dryness of wood or moisture?

RANDY SHURTZ: We don't have models that are quite that specific in nature. But we have a number of staff who have some knowledge in this area, and this is a topic where we could have a positive impact.

MEREDITH BRASELMAN: OK, very good. Hong, this next question is for you. Are the compression connectors the weakest link in [INAUDIBLE] that trip off and get cut?

HONG WANG: Yeah, that's a good question. [INAUDIBLE] compression [INAUDIBLE] is to consider the weakest link in the power line system. The major reason is [INAUDIBLE]. And you have so many interfaces involved. So [INAUDIBLE]. One is [INAUDIBLE]. Another one is mechanical. [INAUDIBLE] some percentage that can be estimated. [INAUDIBLE] because of observation. Also, at the same time, you get accretion. [INAUDIBLE].

MEREDITH BRASELMAN: OK, thank you. Aaron, this next question is for you. Is the signature collection only applicable for high-frequency measurements from optical CTs? Is there anything utilizing conventional CTs?

AARON WILSON: No, it is not intended for only optical measurements. The intent of the signature library is to capture signatures from a wide variety of different sources. As to your point of conventional CTs, we actually do have existing data in the signature library that was recorded by potential and current transformers.

MEREDITH BRASELMAN: OK, thank you. Randy, this next question is for you. Through your wind-driven fire studies, have you found any correlations among wind speeds and wind-driven electrical fires? Also, during your simulation, did you simulate the impacts from wind gusts?

RANDY SHURTZ: Apparently, the one little picture I showed of the simulation is getting a lot of attention. But we haven't previously combined the response of high-powered equipment with fire, but the facility enables this type of study. We do have some understanding of the effect of wind on fire intensity than what we had time to present here. One thing to note is that Alex's presentation gives some good illustrations on the current state of ignition knowledge, in terms of model capabilities. So, some of his stuff ties together with the facility stuff I showed, and it's also tied together with some of the models we do.

MEREDITH BRASELMAN: OK, thank you. Aaron, this next question is for you. What are the signatures being captured, and how good is the current model in capturing those?

AARON WILSON: So right now, we're still in the beginning phases of the project. We have just recently got the sensor installed. And so, after that, we are going to start data collection. And then from there, we are partnering with PG&E, who will have access to their event logs. From there, we can go back and comb through the data obtained by the sensor to help us retrieve these events.

MEREDITH BRASELMAN: Very good, thank you. Randy, this question is for you. Has the Sandia Fire Science Group tested probability of ignition of fuel due to electrical arcing?

RANDY SHURTZ: As I mentioned before, we haven't specifically looked at that, but it's certainly within our capabilities to design some tests that would.

MEREDITH BRASELMAN: OK, very good. Let's see, I have two questions here. I'm not sure who they are directed at, so I'm just going to read the question out and let you guys decide who wants to answer. With regard to direction technology, has there been any consideration given to whether or how the corresponding notification will be delivered to first responders or emergency planners, and will it include location information?
Anyone want to answer that one? You might be on mute. Nope? All right, we'll come back to that one. This one--again, I'm not sure who it was directed at. Can you elaborate more on how electrical transmission equipment can compound existing wildfire scenarios? And are you referring to faults or cascading failures in the electric grid?

RANDY SHURTZ: This is Randy. I think that was referring to a comment I made. And I was mostly thinking about in terms of--there's two problems. One is that you've got a large fire that could have been caused by some electrical equipment. And the other piece of it is once you have that large fire, we could also look at how does that interfere with operating electrical equipment, such as power transmission. All the smoke that's present could cause some arcing in ways that are difficult to anticipate without a certain amount of testing. So, those are the kind of scenarios I had in mind.

MEREDITH BRASELMAN: OK, one more question for you, Randy. Is your testing capability better able to help rank and understand different types of fire risk, so utilities can better risk-adjust wildfire mitigation efforts?

RANDY SHURTZ: That's the general idea. We could help with that. We'd have to pose the question a little bit more specifically and design a test that--a test series, from what this looks like--that would appropriately help us derive some understanding of the probabilities. So yeah, we could help with something like that.

MEREDITH BRASELMAN: OK, very good. And the final question we have today--I'm going to ask Stuart Cedres from OE to answer this question. I understand the long-term ramifications of dealing with infrastructure issues and climate change. But in the immediate need situation, what is being done to mitigate ignitions so you don't have fires? So, Stuart, I'll let you unmute yourself and answer that one.

STUART CEDRES: OK, I'm going to answer in three forms. Number one, one thing that I want to make people aware is that the topic for today was sensing and detection and fire testing capabilities. However, we're going to have other types of topics as it relates to capabilities and wildfires in other webinars. Now when it comes to the ignition part--trying to stop ignition--that's a good question, by the way.

The issue we have is that, as stated by the acting assistant secretary, Patricia Hoffman, in her remarks, about 10% of the wildfires are created by equipment failure. But we still have that other 90% of wildfires that might be created by either arson, or somebody camping, and you have a fire accident. You could have lightning that hit a tree [INAUDIBLE] equipment getting on fire. So, we still have to consider capabilities that can mitigate against that other 90% in order to avoid cascading effects. If you lose transmission lines because a forest catching fire, we have to have the ability to detect that so we can--we meaning at the utilities and industry--so they can detect that and make the appropriate mitigation move to respond to the wildfire.

And finally, at the moment, we're only sharing the capabilities provided by the national labs. But this is an effort that's actually being worked by the utilities, and they are doing great work, and they're working on prevention. They're working on other things. Some of them have contacted me. I encourage them to continue contacting me to share what they're doing. Academia is doing their part too. So [INAUDIBLE] representing only what the DOE labs are doing, we also recognize that the utilities are doing great work, and they're addressing this issue from the prevention, detection, and response perspective. Thank you.

MEREDITH BRASELMAN: Thank you, Stuart. There was one final question to all the [INAUDIBLE] that there's been a push for DOE to make data projects generated more broadly available to help advance complementary research initiatives. And there was a question speaking to the availability of that data. And so, what we are recommending is that you follow up directly with the individuals who presented today. We will have their contact information available to you. But they can speak to individually their different projects.

So, we thank you all so much for your questions today. We had a lot in here. This has been really great. And again, thank you so much to all of our speakers for your time and your energy this afternoon. We do appreciate it.

We are going to post a PDF of today's presentation on the wildfire webinar series website on Monday. And I should advance the slide here so we can see it. And a recording of the presentation will be available next week, as I said earlier. If you have not already done so--and I know many of you have--please do register for the upcoming webinars to hear more about the national labs capabilities.

Please do share with your networks about this great series. We have over 1,600 people already registered. Our next webinar will focus on situational awareness capabilities, and will feature speakers from Argonne, Oak Ridge, Pacific Northwest, and Sandia National Labs. And the link to register--we're going to put that in the chat for you if you need that.

So again, thank you so much for your participation today. We look forward to having you join us next week, next Thursday, starting at 2:00 p.m. Eastern time. The dates for the next webinar are on the screen. We will be sending notes and a thank you, and have a wonderful day.