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Nuclear Waste Technical Review Board (NWTRB)

Transcript

Winter 2022 Board Meeting

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VIRTUAL PUBLIC MEETING - DAY TWO

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BAHR: Hello, and welcome back to the U.S. Nuclear Waste Technical Review Board's Winter Meeting. I'm Jean Bahr, Chair of the Board. Yesterday, I described the Board's mission and introduced the other Board members. So, to save time today, I will just direct you to our website, www.nwtrb.gov, where you can find information on our mission, our members, as well as our Board correspondence, reports, testimony, meeting materials including webcasts of the public meetings. We experienced some technical difficulties at the start of yesterday's meeting, but the meeting was recorded, and I understand that the recording has already been posted to the website. So, if you missed some of the introduction yesterday and some of the first presentation and want to go back and refer to that, I encourage you to go to our website. If we could go to the next slide.

Yes, this show's yesterday agenda. We heard an update on DOE's dual-purpose canister disposal research and development activities. Then we heard from national laboratory researchers who were conducting research and development efforts for DOE's repository-scale performance assessment that includes nuclear criticality after repository closure and spent nuclear fuel cladding degradation modeling development efforts. Ned Larson from the DOE Office of

Nuclear Energy summarized DOE's storage and transportation research and development activities and provided a status update. We heard from national laboratory researchers about spent nuclear fuel interim storage canister corrosion and surface environment investigations.

Today, we'll start with a presentation on DOE's storage and transportation research and development effort and hear from a national laboratory researcher on investigations of aerosol transmission through simulated cracks in dry storage canisters. Then we'll hear about the Hanford Lead Canister Project that is supporting efforts at the Hanford, Washington site and DOE's integrated waste management program.

After a 15-minute break starting at 1:45 p.m. Eastern Time, we'll hear about two software tools developed as part of DOE's integrated waste management research and development efforts. A presentation from a national laboratory researcher will describe updated requirements for, and enhancements to, the Next Generation Systems Analysis Model. Then Erica Bickford from the DOE Office of Nuclear Energy will update us on DOE's stakeholder tools for assessing radioactive waste management transportation. The last presentation of the meeting by Alisa Trunzo from the DOE Office of Nuclear Energy will update the Board on DOE's consent-based siting efforts.

We'll have a public comment period at the end of the day, and we'll be including in that comment period the comments from yesterday as well since we experienced some technical difficulties at the very end of the meeting. As a reminder, we can only accommodate written comments because of the virtual format of the meeting. When you joined this meeting, you will have seen a link for submitting a comment for the record. Comments we receive during the meeting will be read online in the order received by Board staff member Bret Leslie. Time for each comment may be limited depending on the number of comments we receive, but the entirety of the submitted comments will be included as part of the meeting record. I'll just note that we appreciate and welcome these comments. We are happy to include them as part of the meeting record, but we'll not be attempting to respond to them during the meeting. The meeting will end at approximately 5:00 p.m. Eastern Time.

So, without further ado, let's start today's first presentation with Sam Durbin and we'll bring Sam up and then I will go away. So, I will see if we see Sam spotlighted. I see his slides. Is Sam in the spotlight? Yes. Now he is in the spotlight, so I can go away. Thank you. Okay, take it away Sam.

DURBIN: Thank you, Dr. Bahr. Today I will be presenting,

as mentioned, the Aerosol Transmission through Stress Corrosion Crack-Like Geometries. I just wanted to pause and acknowledge my young researchers, coauthors, Phil Jones, Jesse Phillips, Ramon Pulido and Hector Mendoza here at Sandia and over at Pacific Northwest National Laboratory, we have Andy Casella and Mark Lanza.

Okay. Standard disclaimer. Again, I won't go through this if you want to read the legal text to this, basically it says that anything I say is superseded by the standard contract with DOE.

The objective of this research is to mimic the aerosol transport through a stress corrosion crack in a simulated spent nuclear fuel canister. To do this, we have pressure-driven flow at prototypic pressures and near prototypic canister volume. We're measuring the flow rate and aerosol retention directly of an engineered microchannel which is a stand in for a stress corrosion crack. I'll describe that in more detail later in the presentation. The characteristic dimensions that we've chosen for this microchannel are similar to stress corrosion cracks observed. The big difference being this is a slot orifice with rectangular cross section. The crack that we're looking at for this particular study is a divergent nozzle and it has a linear transition from inner to outer characteristic crack

dimensions which I'll show in more detail later. And, again, we're directly measuring the mass flow rate through this simulated crack as well as the aerosol concentration both upstream and downstream of the crack. So, we have a simplified geometry which is ideal for validation of modeling with well controlled boundary conditions as well.

Here's Andy Casella, also Mark Lanza over at Pacific Northwest National Laboratory. You can see here on this figure; we have two regions of interest that are highlighted. The dashed blue line shows interior of the canister. And for those efforts we're using GOTHIC and MELCOR to model the aerosol depletion in the canister. So those are the bullets that are highlighted here in blue to match the blue boundary. We also have some efforts to look at the transmission through the stress corrosion crack. That is the zoomed in area here showing pictographically high concentration of aerosol on the inside, transmitting through a stress corrosion crack, and then exiting to the environment. Those efforts as shown by the red boundary are highlighted here by the red bullets. So, we do have some flow work going on at PNNL. The main thrust is here at Sandia, and we're looking at this experimentally. It's the focus of this presentation. I will show a few results from the GOTHIC and MELCOR modeling which are coupled with this effort. And then I also wanted to highlight the

work of Yadu Sasikumar at Oak Ridge National Laboratory where they're using first principles to look at this region of interest.

Okay, so, just a quick primer on some aerosol science. We have aerodynamic equivalent diameter, that's referenced throughout this presentation and commonly abbreviated as AED. So, aerosols, they tend not to be spherical in the real world. And so, if we have an irregular particle, we equate to a spherical particle using a shape factor, and basically, it gives us the same terminal settling velocity by using this. And then we further simplify that by equating it aerodynamically to a particle of water and so there's a density correction for things heavier or lighter than water and it basically works out to square root of the density. The reference density being ρ_0 for water, 1 gram per cc. So, commonly for spent fuel, if you just round and assumed 10 grams per cc, the conversion factor for geometric to aerodynamic equivalent diameter is a factor of 3.2 for spent fuel.

One other definition I wanted to go over is respirable particles. So, these are the fraction – this is the fraction of particles as a function of size given by aerodynamic equivalent diameter that can penetrate into the human airway. And so, we have three different cuts of the

particles. One is called inhalable and basically, that's the particles that can make it into your head but basically stop before they reach your throat. Then you have the thoracic which is the blue, those can make it down into the trachea and down into the lung but, generally stop about there. And the body has mechanisms for expelling particles that make it this far down into the lung. They're coated by mucus and over time the body rejects that mucus back up into the mouth and they're swallowed. They tend to be expelled relatively quick. The third fraction is respirable. These are the relatively small particles, and they can penetrate all the way down into the lung into the alveoli and can then deposit into the air sacks where the gas transmission into the bloodstream and out of the bloodstream occurs. These tend to have a relatively long residence time and they dominate the dose for particles that are released. You can see here that the respirable particles tend to be relatively small, and the cut is generally defined at 15 microns AED, so this is the line at which we're really concerned about particles entering into the environment.

So, I wanted to get right to the bottom line. These are the aerosol transmission results we have from last year. Now, let me start by going back to the geometry that we're measuring. So, this is a microchannel and we're presenting aerosols on the upstream side. On the upstream side, we have

a 13-micron opening and on the downstream side, it opens up linearly to 25 microns and this occurs over a length of 8.9 millimeters or just under 3/8th of an inch. This wall thickness is a little bit thinner than what you would experience for a standard dry storage canister.

On the plot here, we have aerosol transmission fraction that is unitless. This is a mass aerosol transmission fraction. And that is a function here as of initial mass median diameter. This is a measure of the size of the aerosol that's being presented to the crack. We have results for both air and helium. Air in the blue squares and helium in the red diamonds. You can see that we have a strong dependence on the initial size of the aerosols that are being presented to the crack where we're varying from about .61 all the way down to just over a 10 percent transmission. Oh, so the crack is effectively acting as a filter. The aerosol is being knocked down, restricted and accumulating on the crack itself. So, it's restricting the mass flow of aerosol or the particulate in the aerosol into the downstream.

So, what initial aerosol densities are we considering? Well, we have taken from the literature the respirable release fraction that can be derived from the work by Brady Hanson at Pacific Northwest National Laboratory from the Fuel-in-Air FY07 report. If we limit ourselves to

respirable particles, which again are AED less than 10 microns, we can derive this respirable release fraction which is about $9x10^{-6}$. If we assume this respirable release fraction, a dry storage canister that's holding 37PWRs with 520 kilograms of UO_2 per assembly, make some further assumptions, 1 percent fuel rod failure, no deposition and initial pressure of 800 kPa which is the high side for industry. Average gas temperature of about 187 degrees Celsius and 6 cubic meters of free gas inside the canister. And reference conditions of 101 kPa and 298 Kelvin. So, you put all of that into the pot, stir it and you end up with a reference density of about 54 mg of aerosol particular per cubic meter at standard temperature and pressure conditions.

So, just recall this number when I'm showing some of the results later. We use this as kind of our benchmark for the tests we're conducting and try to stay in this ballpark to represent a 1 percent fuel rod failure.

So, for our testing, management doesn't like for us to use radioactive spent fuel. So, we have conceded and we're using cerium oxide as a surrogate. The density of cerium oxide is 7.2 g/cm^3 as compared to 10 g/cm^3 for spent fuel and so this works out to be a pretty good surrogate based on aerodynamic diameter and some other considerations like the shape factor of the geometric particles. But we're also

focusing, again, on respirable particles, so the surrogate material that we have has a mass median diameter of 2.4 microns with a geometric standard deviation of 1.9. So, most of our particles are respirable. In fact, 75% by mass are respirable so this is stock material that we're using for our experiments.

Here's some more detail on the engineered microchannel which is, again, the stand in right now for the stress corrosion crack. We have a crack width of half an inch, 12.7 millimeters. We have an initial crack opening of 13 microns and an exit of 25 microns. So, again, that's the linearly diverging opening for the crack. These are made by taking two different gauge blocks. One has been EDMed to have the 13x25 micron opening and then those get mated together and assembled into a test section and that is how we introduce the crack into the flow system. Here's a picture of the flow system. We have 240-gallon storage tank on the right here. This is where we pressurize and introduce the cerium oxide surrogate. We have an upstream test section and a downstream test section. Both of them have an aerosol spectrometer that's measuring both mass and size information of the aerosol. We have that on the upstream side and the downstream side. The microchannel is mounted right here in the middle of the test section. These spectrometers then go up to a photo

multiplier and digitization equipment that is recording all of the aerosol measurements.

I apologize for my slides. Apparently, it's on some automatic timer and so it's advancing faster than I would like. On the downstream side of the test section, we do have a mass flow meter that is measuring the total flow rate exiting the test section and we also have mass flow controllers on the spectrometers, so we have good mass flow balance into the crack and out of the test sections.

This is a flow visualization that we were able to capture. We took the downstream test section out and flipped the cracks. This is actually exhausting through the crack, and there was a laser or a green light sheet here that was intersecting the flow and we were able to visualize some of this flow coming off of the microchannel. And so, we did witness an upward vector jet at the mid-plane and the microchannel was mounted on the bottom half for this visualization. We think that possibly there was sensitivity to the mounting orientation but when the downstream section is mounted in here, there's a confinement and so this is probably much more mixed for the test set up.

Here we have a table that summarizes the air testing, and I don't want to go through the entire table. I just want to summarize by saying we had 17 tests with air.

Most of these were in a blow down configuration. The blow down configuration is when the tank was pressurized and seeded with aerosol open to the test section and then allowed to naturally come to ambient pressure. We have another mode of tests which is a constant pressure test where we're actively controlling the tank pressure to keep it constant. And so, we also have three different starting initial pressures for delta pressures across the crack of about 120 kPa, about 416 and then just over 700 kPa. So, these represent the fleet at various lives and different designs of spent fuel canisters. I mentioned earlier that the mass concentration we were referencing was about 54 milligrams per cubic meter. You can see we have tests that exceed that as well as go below that. But that was our reference mark and what we were aiming for. We feel like we captured a one percent fuel rod failure based on the fuel release fraction that was available in the fuel air report.

The plot I showed earlier was shown as a function of mass median diameter and here you can see that recorded and geometric standard deviation. And then, these are the integrated transmissions that you saw on the dependent axis. For air, we had an average mass transmission of about .41 and it ranged from 0.26 to 0.61.

We also had testing at helium. Last year we were

conducting mostly blow down tests and we did have some constant pressure tests. We did not do any 2-bar tests with helium, but we had 5-bar tests which is a delta pressure of 420ish kPa and then for the 8-bar test, the delta and the pressure across the crack is about 720 kPa.

Mass median diameter ranged from 1.7 to 3.5 microns with an average aerosol mass transmission of 0.26. Now, moving forward, we do feel like we'll probably be conducting more testing using the constant pressure mode. We feel that the blow down is probably creating too much of a transient for the instrumentation to handle and so, we feel that by minimizing or eliminating this variable and turning it into a constant that we will have more confidence in the transmission results that we will record.

Here are some pictures of the blocks when they're disassembled. Recall that these are two different gauge blocks. One has been etched and the other is unmodified. This is an older set of blocks but it's typical of the results that we see. And so, when these blocks are assembled, the plus sign mates up to the plus sign and the minus sign to the minus sign. And so, you can see an accumulation on the leading edge of the crack here, and also on the topside, and the flow direction is shown by the white arrows, so this is the leading edge. Over on the right-hand side, you see the same crack.

Again, with flow coming via the arrows and then we have these aerosol deposits that are better defined in these images and when we zoom in quite a bit, you can see that these accumulations are actually made up of individual particles that have glommed on to each other.

So, the next steps in the testing, we want to introduce more and more features that are prototypic of stress corrosion cracks. One idea we have is to introduce controlled tortuosity, kind of a step in the crack. We've also received examples from Jon Tatman at EPRI where he has provided us lab grown cracks. And we look forward to testing these with clean air and then, ultimately to present aerosol laden flow to these cracks and measure the transmission efficiency through these cracks.

I mentioned earlier in the presentation the modeling efforts that are synchronized with this testing effort. So, these models are being conducted with GOTHIC and MELCOR. These were codes that were created originally for severe accident analyses of nuclear power plants. They've been modified in order to simulate dry storage conditions. So they have been independently developed. GOTHIC is more of an industry code and MELCOR is maintained here at Sandia, and it's owned by the Nuclear Regulatory Commission.

So, one of the important things that I'm asking the

modeling team to develop is aerosol depletion models for spent nuclear fuel canisters. So, what you see here is normalized depletion. And so, we have for each model, MELCOR is shown by the solid lines and solid symbols. It's this curve here. And for GOTHIC we have the open symbols and dashed lines. So, it's these curves here. So, this is the aerosol mass concentration normalized by the initial mass concentration taken at just a little bit in time. So, we have a starting value of 1. And then these are unit values of those mass concentrations, so 200 mg/m^3, but this is at storage conditions. So, at standard temperature and pressure it works out to be about 50 mg/m^3 and so then we're stepping down the aerosol mass concentration in the models. But, over a range of 50 – a factor of 50, we don't see much change in the models. This is for a log normal particle size distribution. So, we have a mass median diameter and geometric standard deviation that are based – again, on the Fuel-in-Air Report at PNNL. And so, taking these as the baseline for the particle sizes, putting them into the codes and then changing the aerosol mass concentrations, these are the normalized depletions that we get.

And so, a couple of features, the GOTHIC code has plateauing because of an imposition of minimum count density so these plateaus that you see are kind of artificial. We

would expect in the physical world that these would continue to drop. Both codes show nearly six orders of magnitude of depletion in less than two hours. The source term inside of the canister available for release is dropping down very quickly according to the codes.

So, in summary, we have explored flow rates and aerosol retention in a diverging microchannel. These are characterized by using hypothetical aerosol laden flow through a simplified stress corrosion crack and we're directly measuring that aerosol concentration and characterizing the size distributions of the particulate. The dimensions of the microchannel that are the stand ins are characteristic of stress corrosion cracks but do not represent the tortuosity and other features that are endemic to a stress corrosion crack. We have a large parameter space we're exploring and we're using prototypic pressures. We can conduct tests with air and helium. The preliminary results that we have right now show that aerosol mass transmission is ranging from about 12 to 61 percent. This is a reduction factor that has to be accounted for when doing a consequence analysis. We show a strong dependence on initial particle size distribution as characterized by the mass median diameter. Preliminary modeling shows significant depletion in less than two hours. We have identified differences in the codes. We're working

right now, this FY, to get those codes in better agreement on the initial conditions and get the treatment of the different physical parameters in line.

For future work we're continuing to test on the diverging microchannel and we're isolating the effects of the carrier gas and particle size. We are preparing for the testing of lab grown cracks, clean testing first, no aerosols, and then finally with aerosols to measure the transmission. Modeling will focus on unification of the two codes so we can have more meaningful comparisons and then we intend to identify parameters of highest impact and rank the mechanisms of depletion. With that, I'll stop and accept any questions. Thank you.

BAHR: Thank you, Sam. I can, yes, I'm in the spotlight. I have a couple of questions and I see Paul Turinsky's hand up. Your initial particle size distribution was relatively narrow and all within the respirable range, is that correct?

DURBIN: 75 percent respirable.

BAHR: Do you think there might have been differences in the percentage of those respirable particles that are transmitted if you had started with a larger range of particles? Are there some particle-particle interactions that might occur if you have a larger range of particle sizes?

DURBIN: That is possible, and it is one of the

parameters that we would like to explore. Thus far we've only been using one batch of cerium oxide, so we have been locked into this distribution. Running thing that is are bigger is very much of interest and having those types of interactions would probably change some of these results. I would say most of those interactions are probably going to occur in the tank and not in the test section. So, we need to look at that a little bit further. That's a good question.

BAHR: Did you measure the particle size distribution of what was transmitted and compare that to the initial particles, the zero before transmission?

DURBIN: So, we tend to roll things up into mass that is the most or that's the best measure for the consequence analysis that would occur after we define the source term. We do have that information and we have looked at it in the past, but we tend to roll it up into mass.

BAHR: I was just wondering if there was some difference between what actually got transmitted versus what you started with which also might inform some of those.

DURBIN: Right, we do see that smaller particles are the ones that tend to make it into the downstream. So, we do see a selective filtration by size.

BAHR: Then, your simulated cracks, they're relatively smooth, is that correct?

DURBIN: They are. They are electro-discharged machined. So, if you blow them up far enough on a scanning electron microscope, you can see the pits that are caused from the electro-discharge machining process, but comparatively, that is a relatively smooth surface. So, yes, they do have very smooth surfaces.

BAHR: And I guess the laboratory grown cracks will be rougher. Do you anticipate differences in transmission as a function of crack roughness?

DURBIN: Yes, both the crack roughness and the tortuosity are likely to increase deposition in the crack.

BAHR: Okay, thanks. I will turn it over to Paul Turinsky now.

TURINSKY: Thanks Jean. Sam, I have several questions. First, can you make clear what you mean by depletion, are we just talking about settling of the aerosol?

DURBIN: Not settling. Basically, when I referenced depletion, it could be any of a number of mechanisms. Settling is one. Impaction would be another. Browning diffusion, another. I'm rolling depletion into saying that the aerosol has no longer, or the particulate in the aerosol has gone away out of the gas.

TURINSKY: Okay, so it's not available to leak through the crack anymore.

DURBIN: Right.

TURINSKY: Have you looked for sort of an expected crack size? How long depressurization would take place for a real canister?

DURBIN: Right, so the – the characteristic dimensions that we chose seem to be represented by literature review as well as stress corrosion cracks that have been witnessed in industry. So, this dimension, I would say is pretty well defined and that was the reason for us choosing it. The crack width, you might argue is in play. We could do something smaller or larger. The flow rates that we're seeing would probably lead to depressurization pretty quickly. So, the flow rates we're measuring are pretty high compared to what I've seen in the literature.

TURINSKY: Okay. So is this a one-time event when you depressurize or is just breathing through the temperature changes of weather and all.

DURBIN: The flow system would be a depressurization. If you're at, even at two bar, it's going to be venting from the inside of the canister to the outside. Once you've hit an initial equilibrium, you will have breathing and it will pull gas into the canister and then sweep via the diurnal heating patterns.

TURINSKY: But it seems a key thing that you need, and I

couldn’t get from our data because so many variables were changing is basically the fractional release that is a function of pressure, or you can translate that to really velocity is what we’re talking about here.

DURBIN: Yeah, we – yeah, it’s a good question. The study that we’re doing is very much dominated by the initial pressure release. So, it’s when the canister still has a significant amount of gas inside and it’s venting to the outside. We’re not covering the diurnal or the breathing patterns that might occur afterward. But we do feel that that initial depressurization is when you would have the maximum potential for pushing contents from the inside to the outside.

TURINSKY: Okay. And it seems like, because the depletion occurs in a very short period of time, it’s pretty unlikely you would have fuel failing at the point of the crack opening up and depressurization unless there was a cause/effect there and that it is not clear in my mind what the cause/effect would be.

DURBIN: That’s right. And so, you have to make some suppositions to kind of create it in engineering worst case where the crack is just about to fail through wall and then, say there’s a seismic event that simultaneously causes fuel to fail as well as opening the crack up all the way. And so now you have synchronization between fuel to canister release and

then pathway to environment.

TURINSKY: Okay. Did you see any clogging at all through the crack? I guess this is, I guess you said, a pretty smooth surface.

DURBIN: We do see accumulation in our images, and we have measured some blockage, decrease in flow rate. But it hasn't been enough to completely stop it. And again, the point is well taken that our crack is very smooth. Based on these streaks and some of the downstream measurements that we've encountered, we do think we have some breakthrough. These accumulations can push through and that may just be a function of us having a very smooth crack.

TURINSKY: Okay. Thank you.

BAHR: I see Tissa's hand up next.

ILLANGASEKARE: Yes, actually, you sort of answered some of the questions I had in mind. This is really interesting modeling work. I'm trying to understand – I have experience with the fractures, tortuosity fractures and surface roughness of different applications. I just want to understand the similarities and differences to understand the complexity of what you're trying to do. The first question is related to what Paul asked. We need to look at the fractures, the asperities we call asperity, the hills and valleys in the fracture has an effect on we call transmissivity on the way

things move. In your case, let's assume that you factor those in, when you factored those in, then you get that accumulation, and you may create a heterogeneity of the surface basically because the way the buildup produces heterogeneity. So, then what happens is when the buildup happens, and the flow goes through it’s going to take different, sort of preferential pathways. So, is that correct conceptualization is correct as you see many go from the smooth fracture to a rough fracture?

DURBIN: I don’t have a good answer for you right now. We’re hoping that when we move to the more prototypic cracks, we’ll be able to explore some of those things independently. But right now, because we – our geometry is so simple, I can’t speculate.

ILLANGASEKARE: Yeah, I understand what you’re doing. I’m just trying to ask questions for me to see the similarities. The next question is that I assume that you’re modeling the flow. You’re solving an area equation for the flow, is that correct.

DURBIN: I’d have to defer to some of my coauthors on these results. I can offer up these descriptions and I can speak more to MELCOR which I’m more familiar with, but it uses the control volume approach and solving both mass and energy.

ILLANGASEKARE: So, my question is, again, for the detail

you may find useful for future work. When you go to that scale, then if you model the asperities, the roughness, we use what I call effective parameters. We basically assume – we cannot measure everything, but we say on a small grid size we can get effective roughness type of concept. So, my question is, in these models you must be going to very, very high-resolution grid simulations. Is that correct?

DURBIN: For these models, they actually go the other way.

ILLANGASEKARE: Oh, I see.

DURBIN: They use – grid is not the right term for these codes because they're control volumes. Everything is handled by a sub model. So, it's kind of – if you want to think of it as having sub grid resolution, that's probably more appropriate.

ILLANGASEKARE: The next question is when you, one of the figures on your slide, I don't know which slide, but the slide which shows the flow coming and basically creating this pattern when it gets out, it's a cloud. That green slide. So, when you're modeling your boundary conditions are not defined for the fracture. Your boundary conditions are also defined for the container. Because I'll tell you what happens is that, because you're not modeling – to model that cloud, then you need to have some sort of other domain which is a crack

domain and the container that exit domain. So, you're defining boundary condition for that whatever container at the end. Is that correct?

DURBIN: It's a very good point. But right now, we intend to treat the problem in this fashion. So, the modeling is doing the internal of the storage canister and then empirically, through the testing is what we're looking at the crack as well as the work by Yadu at Oak Ridge. So, this, we have the first principles modeling through-wall and then the experimental results. We're relying on the MELCOR and GOTHIC code to give us the internal source term.

ILLANGASEKARE: I see. I see. I see. So, how about that little cloud which is coming out? So, that's not modelled because that's the --.

DURBIN: We do have the ongoing work at Oak Ridge which is looking at that. And we have the empirical results that I presented today.

ILLANGASEKARE: Okay. Thank you very much. Very interesting.

BAHR: Next up is Lee Peddicord.

PEDDICORD: Yes, thank you. I just wanted to understand a bit more of your discussion with Paul Turinsky in terms of, you mentioned about the clogging and so on. If I remember correctly, the size of the crack on the inside is 13 microns

and then expands to 25. Do I have that correct?

DURBIN: Yes, sir, you do.

PEDDICORD: And, but then you showed the modeling of the particles, of course you were noting you were using a spherical model, but the particles are irregularly shaped and so on, you know, and some dimensions, some fraction of them could be bigger in one-dimension than 13, uh, yeah, 13 microns. You had mentioned about the clogging, a question comes to mind is to what extent would be the clogging due to this, the actual irregular shape of the particles? But then, secondly, you're also talking about the crack itself is going to be, I guess the inside wall is fairly jagged and so on. Any chance to sort out what might be two different effects here? And what fraction of clogging is due to piling up at the entrance as opposed to some getting hung up as they're passing through in the crack. Maybe that's a pretty torturous thing to try to understand. But it's really interesting when you get to these real aerosols.

DURBIN: It very much is and the biological pathway for the human airways is also incredibly complicated. But the accumulation that we see, if I were to be able to show you a closer in picture of these. At least with the cerium we're measuring, the shape factor doesn't seem to be all that distorted. It's actually pretty close to 1. If I go back to

the aerodynamic equivalent diameter slide here, you can see this particle is kind of exaggerated with a shape factor of about 1.4. What we see is, you know, they're granular. They're ceramic but for they, for the most part they have a shape factor of about 1. I have seen some SEMs of spent fuel and one could argue that they have shape factors that is vary from 1. The codes tend to ignore this all together and assume a shape factor of 1 for most analyses and modeling.

PEDDICORD: Well, looking at your numbers there, your shape factor, 1.4x10 so it's 1.4 -- well, no that's the density, I'm sorry, but 10 microns, you get to 14 which is bigger than the opening size of the crack. So, yeah.

DURBIN: Right.

PEDDICORD: Thank you. Nice stuff. Good work here. Interesting stuff.

DURBIN: And to your point about the measuring on the leading edge versus internal to the crack with a more torturous path, these are things that we're looking to potentially characterize but they're probably going to have to be destructive and so we need to put more thought into how to look at the crack after the testing.

PEDDICORD: Also, you made the point, you know, the biological pathways. What are in – what are the commonalities and the distinctions between, say the crack pathways and the

biological pathways?

DURBIN: For the crack, you have to get down into the alveoli to get dimensions similar to what the crack has. So that's where your flow rates, your settling velocities, you know, things like that, the browning motion that you would have relative to the link scales. That's where it would be most similar to the crack.

PEDDICORD: But you're still going to have a big biological impact even before you get down to those levels too.

DURBIN: With the exception that if the particles settle in the upper part of the air way the body has evolved defenses to expel those types of particles.

PEDDICORD: Okay. Thank you.

BAHR: Okay, do we have other questions? I see a couple of staff members Andy Jung, first.

JUNG: Hello, thank you so much for your very informative presentation. I have two questions. On slide 16 for next steps in testing. I think it's a good idea to have some tortuosity with the stepped channel. And the lab grown cracks, as you may know, the most case – many of the cases we dealt the stress corrosion cracks could be a branch or multiple cracks. It's a mixed type. So, when you prepare the lab grown cracks, you may consider how can you make a mixed

type with a branched one, if possible. And the second one – also, when you are modeling for transmission, and depletion also, it may be possible to go more than one crack? Maybe more than one crack could be possible considering large surface area of the weld. And maybe in the case, you may have a different – gas depressurization rate and can also affect the deposition and transmission too. The second question is related to on slide 18 your depletion modeling result. I can see the significant depletion. So, you already clarified what is a mechanism for the areas of depletion so, in the future, maybe you have clarified what portion of this percentage could be related to the gravitational settling or the, as you've said, the browning motion of impaction, whatever you have the mechanism and, also maybe you may consider resuspension in case, if needed. And maybe that will be very helpful for others. Or so if you have the validation verification plan for these models, it would be very helpful.

DURBIN: So, I will attempt to go back and answer some of these. Your point on the snowflake nature of these cracks is very well taken. We feel that we'll have to probably investigate a statistically significant number of cracks in order to get an understanding of what they're actually providing as far as the data because they are so unique. So, that is our plan to characterize them as extensively as we can

with nondestructive examination up front and also flow rate versus pressure without any aerosol before we actually conduct an irreversible test with aerosol and foul the crack. That is a good point. On the depletion, we do have ongoing efforts right now to independently characterize the different depletion mechanisms, so settling, impaction, diffusion. We think that is readily available in MELCOR and it's being explored by the GOTHIC team as well. So that's also a very good point. And then finally, the resuspension. That is something that is of interest to us and we're looking to include that in future modeling.

JUNG: Thank you.

BAHR: I see Dave Sassani has his hand up. He maybe wanted to clarify something as well.

SASSANI: Thank you, Jean. I was just going to add to, Sam covered it very well. Andy, there's also a recent nuclear energy university program call for universities to submit proposals regarding all of those mechanisms and do testing specifically to separate those different mechanisms for use in validating the modeling work at PNNL. As Sam presented, there's a lot of variables involved here. So, there's always places where more testing is going to help. And so that will address some of that as well.

JUNG: Thank you.

SASSANI: Thanks.

BAHR: I see Bret Leslie with his hand up.

LESLIE: Yeah, thank you Jean. Sam, could you provide a little bit more input or insights in terms of how much information is actually known about the particle size distribution from failed fuel and is any of the ongoing testing at Oak Ridge with the high burn up going to help you better constrain or better understand?

DURBIN: That's a great question, Bret. The answer is, yes, there are ongoing efforts at both PNNL and Oak Ridge with the sister pins to provide more information, more data on particle size from failed fuel and so, we look forward taking that into account with available information from the literature such as the Fuel-in-Air Report from 2008. There's also work going on over in Europe where they're impacting fuel and then looking at the size distribution. So, there's a host of information, a lot of it's what I might characterize as outside of the energy spectrum that we might expect for storage conditions, just a fuel rod failing because of a seismic event or some light energy input. But we do try to keep our eye out and we're very much clued into the Oak Ridge and PNNL efforts.

LESLIE: Thank you.

BAHR: Okay. I think that brings us about the right time

to end this. Thanks again Sam for an interesting presentation.

And we're now going to go to Nick Klymyshyn and Gary Cannell who are going to be talking about a project that's called the Hanford Lead Canister project. If we can get, I believe Nick is the first presenter if you can get him in the spotlight, we can get started.

KLYMYSHYN: Let's see.

BAHR: I hear you, but don't see you. Let's get you in the spotlight. Okay. Very good. And we need to get your slides into presentation mode, I think.

KLYMYSHYN: Okay. Is that showing the right way? Or do I need to reverse the video?

SPEAKER: You need to swap the video.

KLYMYSHYN: I do? Okay. Great. Thank you. So, I'm Nick Klymyshyn from Pacific Northwest National Laboratory. I am here to talk about the Hanford Lead Canister Project. I also have Gary Cannell with me. He'll speak to a few slides. He's from the Fluor or the Central Plateau Cleanup Company or CPCco. That's the Hanford contractor that is working on cesium and strontium dry storage project.

This is the standard disclaimer. I don't have anything to add about it.

In a nutshell, the Hanford site is putting cesium

and strontium capsules in dry storage using dry storage systems that are very similar and that evolve from spent nuclear fuel storage systems. The lead canister will be an extra canister off on one corner of the pad that is observed very carefully over the years, and it has electric heaters inside instead of nuclear material to provide the representative decay heat and temperatures within the system to represent the most limiting canister load out on the pad. The canister system is shown in the right with a cut out view. The red are the heaters stacked in where the cesium/strontium capsules would go.

A key feature of this project is the collaboration. There are a lot of people involved, a lot of organizations. This work is funded from NE-82 and we're carefully watching what is happening in NE-81. In industry, NAC International are the vendors of the casks and canister systems. They're in close contact with us. EPRI is in close contact and has a specific project I'll mention later in the presentation. A lot of us are involved in ASME Boiler and Pressure Vessel Code code case for mitigation repair of steel canisters. What we talk about and learn in the code case, we bring into the Lead Canister project. On the EM side, Gary, Gary Cannell will talk more about this. But we're talking about putting a – developing a Lead Canister for real site for a real

application.

So, the timeline is interesting because it's very long. So, we're in 2022 where we are doing testing and confirmation of the Lead Canister system. And between 2022 and 2026 when the canister will be deployed there's an opportunity for R&D to be done pre-deployment as the Hanford canister is just being used for training purposes and is otherwise sitting idle. Now, we mention at least one project we're doing there. Once this is deployed on the site the plan is to do long term data collection and conduct R&D after the fact. Because it doesn't have nuclear material inside it the Lead Canister will be very accessible to come in and do some research or development activities. One late breaking piece of news is that the deployment year is now 2027. There's been a delay and now 2027 is the best estimate of when the Lead Canister will go live.

Here is an outline of the presentation. Next up Gary will talk about the background of the lead canister and then I will come back and talk about connections to important technical topics and then give an update of project status and tell you where we're currently and then have some closing remarks. So, Gary, you're up.

CANNELL: Great. Can you hear me?

KLYMYSHYN: Yes.

CANNELL: Okay. Thank you. Sorry for the optics, I'm in a hotel room. Apologize for that. I do appreciate the opportunity to take just a few minutes to describe what we're doing at the Hanford site with regard to the Hanford Lead Canister. As Nick mentioned, we are preparing to transfer our cesium/strontium capsules these from wet pool to dry storage. And, as noted, they'll be packaged into pretty standard dry cask storage systems, very similar to those used by spent fuel with differences with regard to internal basket configuration and maybe shielding from some radiation and thermal differences between capsules and spent fuel materials.

However, from an aging management standpoint, the canister associated with these is very similar in terms of exposure to the environment, exposure to the environmental degradation mechanisms, effects and so on. So, it's very representative then of the spent fuel systems. Probably the biggest difference between our systems and those of spent fuel is that ours are designed for a storage term of up to 300 years. Next slide, please.

So, with regard to that storage term, there are some things that are somewhat unique with our systems. First off, our systems were designed and fabricated specifically with aging management in mind. Some of the design features include an expanded annulus which will provide or facilitate in-

service inspection and mitigation and repair activities. From a fabrication standpoint, probably that which is most notable is that we'll be isolating the vulnerable weldments from the environment by depositing a metallic coating via cold spray. Then maybe a key to our overall program management, we'll have a lead canister that will be used to lead the inventory. Next slide, please.

So, with regard to the Hanford Lead Canister, it's a full production, quality system and we've identified multiple functions associated with the lead canister and the primary function obviously is that to performing leading indicator function for corrosion performance ahead of the cask inventory. Secondary functions include and maybe just as important, it will be a non-radioactive mockup that will be used for training, procedure development, practice, associated with in-service inspection and mitigation repair activities. Another function will be available and used as a mockup to develop the mitigation repair technologies needed for those activities. There are a lot of potential technologies that have been identified within the dry storage community and I'm sure you're familiar with those. None of which yet have been demonstrated in actual field condition. That is one of the primary advantages of the lead canister. It provides that real life laboratory and field research mockup for those types

of activities. And then as Nick mentioned, another function is collecting field service data over the long term. Next slide, please.

I'm sure you're all aware there's significant interest within the dry storage community surrounding mitigation and repair. We're going to start looking for and inspecting these systems and we want to be prepared to address things associated with the need to mitigate and repair. And certainly, as you know, there are multiple programs within the DOE, EPRI and industry that are looking at these technologies. And as Nick mentioned, the ASME is currently developing the code case to establish rules for mitigation and repair. DOE, at the Hanford site is making the lead canister available to the community for these activities and primarily for technology development and demonstration. So, with regard to leadership for the lead canister, basically we have three entities, Hanford obviously will be responsible for facility operations, maintenance, infrastructure, service and taking care of the lead canister. PNNL has been identified as a technical interface between the dry storage community and the Hanford site operations to help coordinate the activities from or within the community and how the lead canister will be used to help with those activities. PNNL also is very involved in preparing the lead canister and Nick will discuss more on this

but preparing it so it can perform these functions identified. As well as overall strategy on how best to manage the lead canister. And finally, EPRI, our third leadership partner, very involved in technology, mitigation and repair technology development and demonstration. In fact, I've already prepared some panels that will slip down into the anulus so that these activities research and development can be for mitigation and development technology can be performed.

So, in conclusion, I would just like to say that we as a project, are very pleased with the response, you know, the interest, and the collaboration with dry storage community regarding the Hanford Lead Canister especially Jon Tatman and his team at EPRI and then certainly Nick and his team at PNNL. And we're very hopeful, and grateful that we think we have the opportunity to use an otherwise excess DOE asset to add additional value to the dry storage community to help develop and demonstrate some of these technologies. With that, I will turn the time back over to Nick.

KLYMYSHYN: Great. Thanks Gary. So now I will talk about connections to important technical topics. This first one, the stress corrosion cracking in the canisters, this was talked about a lot yesterday. You know, the issue is that we know we have a tensile stress state in the canister. We know we have susceptible materials, but how corrosive is the

environment within the overpacks? On the right, this points to the SFWST program R&D priorities, and the welded canister's atmospheric corrosion is a level one priority right now.

So, the Hanford site is an inland site. I like this map because it shows the Cascade mountains are kind of separating the Hanford area from the coast. The canister will offer easy access to do canister surface, for dust sampling. We're hoping that it can be used for validating deposition models. PNNL has some – a bunch of particle deposition modeling efforts going on. This should offer insight into what an inland dry storage environment would look like.

Another big connection is the mitigation and repair of stainless-steel canisters. Gary mentioned that these are the first canisters that at production will have cold spray applied and we'll observe how those behave over time. And then there's a couple other specific projects related to mitigation and repair that I will talk about.

First one is the EPRI Coupon Panel Project, and the point of contact is Jon Tatman. The idea is to put the coupons. Let's see. I have a laser pointer here. The coupons are up here. They're steel plates basically that are bent to fit against the side of the canister flush. And, during the pre-deployment phase, the lead canister will be sitting in this mockup truck port that they have at the Hanford site.

This is for training the personnel that will be doing the loading operations. But there will be periods of time where this is sitting empty and unused and available. And that's when EPRI will come in and do this, put their coupon panels in and demonstrate in-situ mitigation and repair. The heaters will be turned on so they have an accurate heated environment, and they will remotely apply these repair and mitigation technologies to the panels to demonstrate they can be done in-situ.

The PNNL coupon concept is different. This is a long-term coupon panel that will stay with the lead canister throughout its lifespan. The idea is to cut out a window of material on say the back side of the canister and weld in a specially prepared coupon panel material that will have the same shape but will have mitigation and repair technologies applied to it. The challenges here are, we have to make sure nothing that we do to the lead canister is going to harm its ability to predict corrosion in the weld areas. That early warning detection is the purpose of the canister, and we can come in and do basically anything we want to from an R&D standpoint as long as it doesn't compromise that function. Right now, we’re doing analysis to determine how big of a coupon panel we can put in there without effecting the residual stress state throughout the canister. If it turns

out we can't do this as a cut out, we have a couple other alternatives in mind. I can talk about those if you're interested.

Here's a look at the -- what the coupon panel would look like. There's kind of a lot to talk about here but Ken Ross is the task lead. He's come up with a priority list of the technologies to put onto the coupon panel. If you would like, I can come back to this slide and talk to more of the details.

Thermal modeling is always a big deal with spent nuclear fuel canister systems. In this case, we have another scenario for direct validation with thermal models. On the left side of the screen, this temperature plot shows the temperature predictions for the loaded Hanford system and in here, these are the cesium and strontium capsules rendered in detail in the model. For the Hanford heated system, this has the heaters put in, attempting to match the heat load and contours it shows a pretty good agreement in temperature distribution is achieved with these heaters.

On the right over here, this plot is a comparison in thermal results between the MAGNASTOR spent nuclear fuel system compared to the Hanford canisters and the interesting point about this analysis is that the exact same heat load is assumed in both cases. So, you can see these numbers. They

don’t -- these trends, these lines don't line up on each other. That's because the Hanford canister is smaller so it’s naturally going to have higher temperature for the same heat load. What we like about this slide, or this graph, is it shows the trend lines are the same. And if you could reduce the decay heat in the Hanford canister, you could get them to line up right on top of each other. Sarah Suffield with PNNL is the lead for the thermal model.

Another interesting connection is the concept of the consolidated interim storage site. The Hanford sketch is on the left and that has approximately 20 units on it. And on the right, this hypothetical interim storage pad, that has 200 units. But a real facility you’d need to add another factor of 10 on there so we’re talking about a lot of canisters. What we learn from the Lead Canister project might inform us to implement a lead canister at a consolidated interim storage site. One reason that might be very desirable is if new canister systems have to be developed for the consolidated interim storage site.

Now, I’ll talk about the project accomplishments and status, sort of where we’re today. The heater design is a big accomplishment. Getting them fabricated this year has been a bit of a challenge with supply chain delays and issues. But we have the heaters designed. They are -- each heater

assembly has the same kind of geometry as the universal capsule sleeve which holds up to six cesium and strontium capsules. It's designed to be directly replaced in the canister. The heaters can swap in for the UCSs. The heaters, they're – they have an inner carrier tube with heater wires wrapped around them, heater wraps with an outer sleeve to complete the outer geometry.

Down here, here's a sketch showing the two separate heater wraps, the green and blue. There's two of them for redundancy. If one of them burns out, we want to heater control system to kick in and make sure the right amount of power is being sent to the heaters.

We're preparing now to do a fairly large bench test of all the heaters when they arrive at the Hanford site. They're arranged in a grid situation that kind of mimics how they would be in the canister. In the canister, there's a circle of holes where these heaters would go into. The point of this testing is really to plug all the heaters in, make sure the control system is working, make sure all the temperature cut offs are working and that we understand how the system is going to work when we put it into the canister. We're planning about two weeks of data collection before we move on to the next thing.

Some analysis was made to -- going into the bench

test using the thermal models and the Dakota software from Sandia National Laboratories which is used for parametric variation, uncertainty quantification, and it implemented statistical methods, Latin hypercube sampling method to estimate what kind of uncertainty bands do we have when we run this test? For example, emissivity is an unknown that we were wondering how it would affect the test.

Here's the results of the test or of the analysis, of the uncertainty analysis. On the left is the bench test run at 3.5 kilowatts. This is the heat load that we're expecting the Lead Canister to be run at when it's put into surface. It's relatively low in heat and the temperature is relatively low, below 150 C on the heaters.

This higher heat load case creates higher temperatures. We need it to go this high to support the next test which is putting them all into the Lead Canister when it's in a truck port and confirming that the heated canister has enough tolerances where the insertion of the UCSs is not hampered by thermal expansion. So, this higher heat load case, we do get heater temperatures getting up above 1000 F which is where the heater manufacture is recommending, we keep the heaters below. During the test, we'll need to make sure the temperature cut offs are working and the control system is working as intended.

Another thing we're working on this year is the long-term test plan. This is defining what we want to collect over time when the canister is deployed. We're sure it's going to include temperature collection at the inlet and outlet and each of the heaters has a RTD inside. So, we'll have temperature data at several locations. We're also expecting periodic visual inspections of the canister to look for signs of stress corrosion cracking or corrosion or discoloration, kind of warning signs. We don't know what that period is going to be yet. And then, we're expecting to have a long-term observation and mitigation and repair technologies. That's the PNNL coupon panel or whatever else we do that is slightly different from that. We're hoping to include inlet and outlet air velocity data for the lead canister and do periodic dust sampling and just work with people on the community to figure out what information they would like collected.

And so, I want to give a shout out to my team at PNNL. There's a lot of good people and support. One thing I want to point out is that we -- we're hosting interns under the DOE Office of Science SULI program. Alec Bovee is currently on the team in the spring semester and then in the summer, we have another SULI student lined up. So, this is -- it's fun to bring in undergraduate interns in the SULI

program and have them help out.

I would also like to thank Jay Wellwood of NAC for his review and assistance with this presentation. And I'd also thank you the support of the DOE sponsors.

So, with that, I'm happy to take some questions. Thank you.

BAHR: Thank you very much, Nick. Do we have questions from Board members? I see Lee Peddicord's hand up.

PEDDICORD: Yes, thank you very much. Nice presentation. Good project. It's good to see the investment over the length of time to really yield some good results, multi years and so on. I just wanted to drop back to your most recent point and the involvement of a SULI student. Is that something new for you all to have a student through SULI coming to be part of your effort?

KLYMYSHYN: Not for me. I've been a SULI mentor for at least five years, bringing them in and I wanted to highlight in this venue that we're actively doing that.

PEDDICORD: So, of course, SULI is, as I recall, funded out of the Office of Science and not NE or EM or anything like that so it's excellent that you're able to connect with SULI and have students coming in. Do you see that as being an ongoing opportunity? I mean, we on the Board really highlight the idea of getting the next generation involved in this

mission of addressing waste and so on. And I've got to say, I'm very pleased to see the steps you're making to do that. I hope that is something you can sustain and continue. Is Alec with you on site or is he doing something virtual? Or how's this all working out?

KLYMYSHYN: It's remote. We're still at PNNL in a mostly remote posture. Even the summer interns, currently we have to assume they will be remote. But that's – I mean I've had great results with the SULI students. I love the SULI program. I'm going to -- I was doing it every summer for a while and now, I've -- also getting into the -- during the normal school year.

PEDDICORD: Yeah, okay.

KLYMYSHYN: So, it's good.

PEDDICORD: So, finally, I tend to write quite a few letters of support and recommendations for students applying to SULI. So, I think I 'm going to encourage them to think about you all as maybe their SULI opportunity. Thank you very much, appreciate it.

KLYMYSHYN: Appreciate it, thanks.

BAHR: I see Rob Howard's hand up. Maybe he wanted to add to that discussion.

HOWARD: Yeah, Lee, I wanted to emphasize that, you know, we're constantly looking for interns and students through SULI

and through the NEUP program. In fact, Kim Petry and I have emphasized to all of our Federal and lab staff during our annual planning processes that we need to be looking for projects for students to bring them on. We fully support it, and I would also encourage you to talk to Dr. Sassani on his side of the program that they've set up a special work scope between Sandia and Berkley to develop a pilot program to encourage students to join.

PEDDICORD: Thank you, Rob. This is off task from the Board, but, yeah, we have a number of students interested back end of the fuel cycle opportunities and career direction. So, that's great to hear, Rob. Thank you.

BAHR: Yes, I endorse all of that. I see Dan Ogg's hand up. Dan.

OGG: Thank you. Thanks Nick and Gary for the presentation. I see as far as the coupon panels and the testing work goes; you don't have a lot of -- whoops.

BAHR: Get your ...

OGG: I was on and then it went away. Sorry. I see you have the – the ideas about the coupon panels but my question is do you have any more specifics especially with the DOE NE-8 program for investigating CISCC? Do you have a point of contact for the research effort, and do you have at least some concepts of what exactly you want to test in support of NE-8?

KLYMYSHYN: Well, I've talked with Charles Bryan and Rebecca Schaller about what they would like to see. Currently, we're really focused on the heater bench testing and things. And so, the long-term test plan that's kind of the next thing. It's on my radar for this year. And I want to really pick their brains on how much dust sampling they would want and how they would do it.

We talked once about having -- putting on some kind of like small scab panels or something that could be removed with a robot, like a small, thin sheet of something on the side of the canister to make it -- just pull out a credit card sized coupon or something that has all the material on it. But now, they're doing, I'm seeing they're looking at robots, crawlers going in and doing the dust sampling. So, I think what they've learned over there can help guide us for the canister and come up with something that effective that gets the information they need.

OGG: Remind us again when you think the Lead Canister will be up and running and ready for testing.

KLYMYSHYN: 2027.

OGG: Okay. So, you have time to plan the details still.

KLYMYSHYN: Yep, yep.

OGG: Okay. Okay. Thank you.

KLYMYSHYN: Yep.

BAHR: Just a follow up on that, what kind of plans do you have for background, environmental monitoring of dust or what do you know about potential aerosol composition in the Hanford area. You mentioned it's an inland site and your chart of necessary conditions for corrosion only had potentially in terms of the environmental conditions.

KLYMYSHYN: Yeah, I know there's a lot of work that has been done to characterize the environment of the Hanford site. But we're not there yet in terms of the project. So, I'm expecting that we'll have a piece that monitors like a small weather station or something locally to -- yeah, to understand what is floating around and compare it to what actually attaches to the canister side. So, there's a piece there that needs to be ironed out still.

BAHR: Okay, thank you. Are there other questions from Board members or staff at this point? I see Paul Turinsky's hand up. Paul.

TURINSKY: Nick, Nick has gone away but I hope he can hear me still. What do you see the major challenges technically of this project? Is it the heater reliability, is that what we're talking about?

KLYMYSHYN: Uh, no. I think the challenges are more about – so the heaters are designed. I have good faith in the heaters. We haven't tested them yet. We don't have them in

hand yet. They're arriving soon, within the next couple of months, maybe in May. But whenever they arrive, we'll test them and make sure they're working as intended. And, if we spot any problems in their function there's time to fix them before we need them.

I think the biggest technical challenge is going to be getting -- being sure we get the right information for the researchers in the field. What do they want? What can help? You know, what, what can we get out of here that is bigger than just the early warning system for Hanford? How do we get good information that is useful to people? One of them, one thing, for example, the EPRI coupon panel where they're going to come in and do a demonstration, I mean, that's good. There's not really a, you know, that helps. Even before the lead canister is deployed, it's going to help the industry. And then, thinking about what will happen? What can we get information wise out of the lead canister when it's long-term operation? I think that's where the challenges are.

TURINSKY: Okay. And you have some nuclear plants out there. Do they have dry storage out there at any of those and if so has EPRI done sampling of that plant?

KLYMYSHYN: That I don't know. I don't know.

TURINSKY: It's something you might want to think about.

KLYMYSHYN: Yeah, I appreciate that, thank you.

BAHR: I see Dan Ogg has, maybe you have something.

OGG: I have a quick answer to one of those questions and that is the Columbia Nuclear Generating Station does have an ISFSI site with canisters and casks on the pad. I do not know if they have done EPRI type inspections yet. They may have done it under the NRC aging management program, but I don't know for sure.

TURINSKY: Okay. It may give you some insight on what to expect from their environmental conditions.

KLYMYSHYN: Thank you.

BAHR: Thank you. Other questions or comments from the Board or staff? Okay. Well, seeing none, we're next scheduled for a break that will last until noon Eastern -- sorry 2:00 p.m. Eastern Time, noon my time in the Mountain Time Zone. So, I suggest we go ahead and take our break and we'll resume at 2:00 p.m. Eastern Time. Thank you.

BAHR: Okay, welcome back from the break. And our next speaker is going to be Robby Joseph from Idaho National Laboratory who's going to give us an update the Waste Management System Analysis Tool Requirements and Enhancements. And I see Robby there and I see his slides so I will turn it over to him.

JOSEPH: Okay, thank you Dr. Bahr. As Dr. Bahr said, I'm – my name is Robby Joseph, and I am the Control Account

Manager for System Integration Analysis and Support. And today I'll talk about Updated Waste Management System Analysis Tool Requirements and Enhancements.

So, the standard contract disclaimer has been covered before, but I'll leave it up a few seconds and main thing to note is everything I'll talk about is, are potential options and the standard contract still prevails.

So, kind of a preview of my presentation today. NGSAM provides for flexible analysis of an integrated waste management system. So NGSAM is the Next Generation System Analysis Model and it's an agent-based discrete event simulation tool that was developed at Argonne National Laboratory. It was designed from the beginning to model spent nuclear fuel from origin site, when it comes out of the reactor, to when it's disposed.

NGSAM allows analysts to add, remove or modify the model logic. We can generate custom reports and we can analyze a wide range of integrated waste management system configurations, approaches, scenarios and different assumptions and different options. NGSAM uses reference data from UNF-ST&DARDS and the DOE's spent fuel database, and UNF-ST&DARDS is the Used Nuclear Fuel – Storage, Transport and Disposal Analysis Resource and Data System. And within UNF-ST&DARDS, there's a unified data base that we use data from.

NGSAM has been discussed in prior NWTRB meetings and today's presentation provides an update to where we are now.

On the right is the splash screen when an analyst uses the NGSAM model and below that just kind of shows the detail of steps that you might see in an agent-based tool. It can go very detailed in our modeling of the waste management system. And I'll just mentioned that sometimes the terms spent nuclear fuel and used nuclear fuel are used synonymously.

So, an outline of what I'll cover today. I'll look at the NGSAM background, then development, execution, and capabilities. We'll look at outputs for system analysis that are produced by NGSAM. We'll look at some future plan capabilities and go over the conclusions. Before I started, I want to mention I'm the Control Account Manager that manages this work, but we have multiple national laboratories, both NGSAM developers and system analysis contributors to this work. At Argonne National Laboratory there are developers, Brian Craig, Chuck Olsen, Lucas Vander Wal, and Evan VanderZee. And at the rest of the national labs, there are system analysts, myself and Gordon Petersen at Idaho National Lab. And, at Oak Ridge National Laboratory, Abi Adeniyi and Riley Cumberland. And then at Pacific Northwest National Laboratory, Mark Nutt. Mark Nutt used to run the Calvin Model

which you may be familiar with, but that was the model before NGSAM and was developed. And he still helps us as a senior adviser on NGSAM.

So how does NGSAM help analysts? Well, it helps us model potential waste management system strategies. As I previously mentioned, it models the backend of the fuel cycle for both spent nuclear fuel and high-level radioactive waste. It allows multiple detailed customization options including, you can look at dry and wet storage facilities, different packaging options, you can look at -- you can estimate rough order of magnitude costs. You can look at various throughputs. And you can estimate the number of transportation assets needed. And along with that, it can help answer questions related to, what are the implications of having scenarios involving multiple facilities, what are the shared resources required, like transportation assets? You can estimate site inventories, both reactor sites or an ISF or a repository as a function of time. And you can look at different potential options for consolidated interim storage facilities.

This figure on the top right just kind of shows from reactor sites to storage and disposal and transportation in between it. NGSAM can model all of that.

This figure on the bottom right looks at packages

and dry storage on the Y axis over time at an example reactor site for an example scenario. And you can see in this scenario the storage at the reactor site increases over time. There's a little bit of pickups of fuel while the reactor is operating. Then the reactor empties its pool, and this is all the fuel being picked up in the hypothetical simulation.

So, this figure kind of looks at, from a high level, how NGSAM can be used to compare numerous alternatives to answer what/if questions. Starting at the left on this figure, it looks at a reactor, interim storage, packaging and repackaging and the repository. These are different phases that NGSAM looks at. From top to bottom here, there's different ways that spent nuclear fuel can be stored. At the top, there's storage in existing dry storage systems in this brown here and there's storage in a wet storage pool in the blue. And the gray is storage in a waste package compatible-sized container that could go into a repository. This is just a high-level illustration of the potential alternatives in a future waste management system. And all these arrows mostly represent potential transportation between these different phases. So that was kind of a high-level look at the waste management system.

The next slide presents two different ways NGSAM can be executed. It can be executed standalone where all setup

and simulations are performed on the analyst's machine. But this is mostly useful for testing small changes to the logic before you run larger simulations. Because NGSAM runs require a lot of data and computing resources. But if you don't have internet connection for some reason, you can run it standalone. Most analysts use NGSAM in the client server mode where you can setup the scenario on your machine, but the simulation is actually executed on the NGSAM cluster at Argonne National Laboratory. The scenarios usually take about 35 to 45 minutes to run and after that's over, the analyst can retrieve the results from the server after it's executed and there's a website to help us retrieve the results. So, as I mentioned, there's a lot of data and computing resources to run these scenarios so this is useful for that to have a cluster. The cluster can currently run 12 simulations simultaneously which is more than adequate for the number of scenarios that we run.

I wanted to go into how NGSAM has been developed and how it continues to be developed. And that is with a spiral methodology. NGSAM is typically released two to three times per year. In this requirements phase, analysts are typically involved. We give requirements to the NGSAM team of how we want NGSAM to behave to simulate a certain part of the waste management system. Then the NGSAM team develops that into the

tool. They test it and then they do a release that includes, usually, multiple changes. So, even in this development and test phases, the analysts still have a close relationship with the NGSAM developers. They often ask us questions while they're developing it to make sure they're adequately addressing the requirements that we requested. I think that's resulted in a very good product to have the analysts and the NGSAM developers collaborate so closely. And the Board asked about the status of NGSAM, and it can now model the whole system from generation to disposal. So, it's ready for use. But we still add enhancements as needed when we realize there might be some specific question and we can't necessarily answer. Those are the, what I would term as minor enhancements that we are still adding. I would say that NGSAM is definitely ready to use.

Since this is somewhat of an update, I want to go through some of the recent NGSAM enhancements that have either expanded capabilities or improved user experience. This isn't all of them but is major ones we picked out. On the following slides, I'll go into more detail about some of those changes. But this is just kind of a list of a few things to give you a flavor for some of the new things. We've added additional output reports. We've modified existing ones.

This second bullet here, we've added a logic for a

hypothetical scenario that looks at allocation, kind of the order that spent nuclear fuel is picked up from sites. And instead of allocating to specific reactor sites, it'll just allocate it to the utilities and custodians of those reactor sites and then they would use that allocation for their specific sites and we kind of assume in this hypothetical logic that they would -- they might go one side of the time once they get those allocations. But that's just a hypothetical option we can study. We're not commenting on how that might work.

Another thing we're looked at is hypothetical allocation method that seeks to reduce the number of packages loaded into the dry storage at reactor sites. It does this by kind of looking ahead and projecting on when sites might load from the pool and that's when the model will come and pick up fuel from those sites and it be loaded from the pool directly to transportation. That prevents some dry storage at reactor sites.

We've also added support for multiple loading map options as well as the ability to have packages with multiple compatible transportation over packs so that our model is more realistic.

We also have the ability to model hypothetical scenarios where repackaging might need to occur at reactor

sites. We've added some capabilities for loading at the ISF from, if the ISF had pool storage, to loading into dry storage at the ISF.

One of the main improvements for analysts from a usability prospective is, we can now generate and implement user edits via the NGSAM website. This is one example here on the right here in this figure of what you might see if you were trying to either add a hypothetical canister or a new canister that was developed or if you were trying to modify an existing canister that's already in the system. As I mentioned, this is just a flavor of some of the changes. Now, I will go into more in depth about certain change that are new to NGSAM.

So, this slide talks about recent transportation related NGSAM enhancements. They have both expanded capabilities and improved the user experience. We can now track railroad escort car and buffer car acquisition. We've added heavy haul truck and barge routes for some sites as well as support for user-defined intermodal route. So, the user can actually go in and generate their own routes and then they can use those in their simulation. And the example transportation routes are incorporated from START, that's the Stakeholder Tool for Assessing Radioactive Transportation. Dr. Erica Bickford will talk more about START in the

presentation after mine. On the right here, this is just some examples of START routes and I'll note that the example routes are for illustrative purposes only and do not reflect the selected destination site. You can kind of see, START can give a route from a starting point to a destination. You can do minimum travel time, minimum population, or minimum travel time with restrictions. Here, there's just a box here, so this blue route is avoiding that area. You can kind of see, START is a very flexible. We've also added updates to logic that check the transportation cask thermal limit maps prior to transport. And we now have the ability to model transloading which is moving spent nuclear fuel casks from one transportation mode to another, like from barge to rail or heavy haul to rail.

So, like transportation, we also have a slide just summarizing some of the updates we've done to the modeling capabilities and database structures for DOE-managed SNF. Some of the initial improvements include, we've changed the level of the modeling from the canister to the individual fuel element. Additionally, we've added additional packaging logic for DOE-managed spent nuclear fuel because of the variety of geometries that may be -- the DOE managed spent nuclear fuel is in. They're in a variety of geometries. Now in the model, multiple, different DOE-managed fuel types can be packaged in

the same type of canister.

On the right here, you'll see this 18-inch by 15-foot DOE standard canister. It may contain 30 Advanced Test Reactor elements or 5 Fort St. Vrain elements.

We also added additional disposal over pack paging logic so packages containing DOE-managed spent nuclear fuel could be co-loaded with high level waste in disposal over packs. And on the bottom right here, you can see an example. You have high level waste around this 18-inch by 15-foot DOE standard canister and this is the over pack how it might be stored, transported, or disposed of.

Improving this modeling capabilities for DOE-managed spent nuclear fuel enables analysts to more accurately estimate the number of canisters required to package DOE-managed spent nuclear fuel and in turn the number of over packs and transportation resources that may be required. When we start estimating things for DOE-managed spent nuclear fuel, these model improvements will help with that.

Now, switching gears back to commercial sites. Over the past few years, there's been some research done about reactor-site-family operational limits. Those are just estimates to restrict the number of spent nuclear fuel loads taken from the pool and from dry storage at a reactor each year. So, what we did was, we categorized all the reactor

sites into 14 families based on the number of operating reactors on site. Were they a PWR or BWR? The length of their refueling cycle, the number of spent fuel pools they had and how their spent pools were configured.

So, kind of an example of this, if you look on the right, if a site had one unit and one pool with a conservative estimate or more aggressive estimate, there still would be plenty of time, we believe, to load from that pool. However, the more units there are, say there are three units with three dedicated pools, with a conservative estimate, it's looking like it could be difficult to load from the pool because there are lots of outages. So, with an aggressive estimate there would be some windows. But this – we did this because this information is useful for estimating in NGSAM how many casks may be shipped or loaded per year from each site. It just helps with our estimates.

So, kind of switching gears, so, why do we develop NGSAM and why do we do system analysis? Well, as you know, the existing light water reactor fleet has and continues to generate spent nuclear fuel that must be managed. On this figure at the right, the left axis that goes with this blue, red, green and purple figure is metric tons of heavy metal spent nuclear. So, this blue is the historical, generated spent nuclear fuel and the red is our projection. And then

down here in green is spent nuclear fuel in dry storage and the purple is our projection. So, using this particular reference scenario there would be potential growth to about 138,000 metric tons. As you know, there's already around 3,000 dry storage canisters and about 200 added per year. So, this fuel must be managed and that's why we developed NGSAM and why we do system analysis.

So, I have three slides following this, and the following examples are just hypothetical examples, but they show how system analysis results can be used to both support DOE's consolidated interim storage effort as well as inform stakeholders and decision makers.

Switching to those illustrated system analysis, this analysis showed that SNF receipt rate can affect how quickly sites are cleared, as you might expect. Independent of destination, if you're picking up approximately 500 casks per year which is probably more than 6,000 metric tons a year. You can see that this percentage of sites cleared. Sites are cleared much faster than if you said had a 200-250 casks per year which is approximately acceptance rate of around 3,000 metric tons of heavy metal. So, on this axis right here, the percentage of sites cleared, you can see, we can kind of show, given your choice of acceptance rate, these are the implications on the system and how fast that you can clear

sites. Now, another thing we look at in system analysis is, well there's a tradeoff there. If you have more acceptance rate, additional infrastructure capabilities at both receiving facilities and within the transportation system would be required. So, there's tradeoffs there and that is the type of thing we look at in system analysis using NGSAM.

Another illustrative system analysis that we looked at is the higher the ISF capacity can enable more reactor sites to be cleared of SNF before an NGR opens. So, we looked at a few different scenarios, but just looking at these top two, the difference between having an ISF capacity of approximately 125,000 metric tons and 74,000 metric tons could be the difference between if you only have an ISF and the repository is still in progress. It could be the difference between clearing 43 sites versus 13. Now this is just a hypothetical scenario. We assumed oldest fuel first, acceptance cue here. This just gives kind of a flavor of some of the system analysis results that we've investigated.

And the final system analysis we have investigated. This scenario was looking at what if you had two interim storage facilities and one accepted dual-purpose canisters, which may require repackaging prior to disposal, and one accepted standardized canister which are designed to be compatible with transportation, aging or storage, and

disposal. On this figure at the right, this is the fuel and how much metric tons of fuel versus time. So blue is storage in the spent fuel pools and then these green bars with different shades are standardized canisters stored at different locations. And these more orange and red shades are storage in existing-sized canisters or DPCs. So, we can kind of, with NGSAM, the results from NGSAM create figures that kind of show, well, here's how the system would look over time and it would show when fuel is stored in STAD canisters over time and where it is stored as well as when fuel is stored in DPC's over time and where it's stored as well. So that kind of gives you a flavor for some of the system analysis results we've generated. This is just three examples. We've done a lot of system analysis over the last 10 years.

One of the questions that the Board asked was about multi-objective optimization. So, kind of, the integrated waste management program has actually done multi-objective evaluation framework analysis in the past. MOEF considers multiple objectives and stakeholder perspectives. So, we plan, and we've done it before as well, but MOEF analysis is planned to be performed outside of NGSAM using data produced my NGSAM runs. But I did want to note some outputs in NGSAM were originally selected to feed in the MOEF analysis. We did that before and if there's data needed for the MOEF analysis,

we can configure NGSAM to produce those results in a way that it's easy for the MOEF analysis to take those results in and then perform their analysis. And MOEF research may be restarted, depending on funding and future program direction.

So, I talked about kind of our current and future work about adding minor enhancements to NGSAM but another area we have been thinking about are preliminary requirements for advanced reactor fuel cycles. We have some – we've worked on some preliminary requirements for advanced reactor fuels reprocessing and treatment and conditioning. Those are not implemented in NGSAM yet. We just have the requirements. There are other nuclear fuel cycles system analysis tools that are sponsored by DOE-NE that might be better suited for initial high-level analysis. But we believe that NGSAM can add value by modeling in greater detail the transport, storage, and disposal of spent fuel and waste from advanced reactors at the fuel element and waste container levels. It is also envisioned that NGSAM could be able to estimate reprocessing and/or treatment conditioning facility capability needs.

And why do we care? We think that integrated waste management system analysis can help better understand possible various options, approaches, and strategies to inform all stakeholders and future decisions about advanced reactor fuel

cycle. We just want to make sure that waste is considered from the beginning as advanced reactor fuel cycles are considered. We think we can help with that in NGSAM.

So, kind of summing up. NGSAM provides for flexible analysis using data from UNF-ST&DARDS or the spent fuel data base. It's been designed from the beginning for origin site to disposition site modeling of spent nuclear fuel. It is now fully functional and additional enhancements are implemented as necessary. NGSAM allows analysts to flexibly analyze a wide range of scenarios, configurations, approaches, and potential waste management systems. We've developed preliminary requirements for advanced reactor fuel cycles and hope to implement some of that soon. And I showed some of the system analysis results generated by NGSAM. And we believe they can be used to inform decision makers and stakeholders on DOE's consolidated interim storage program. And that concludes my presentation and I'll be happy to answer any questions.

BAHR: Thank you very much, Robby. I see a hand up from Steve Becker of the Board.

BECKER: Thanks Robby for a very interesting presentation. You gave us a good sense of what NGSAM, the system, can do in terms of transport, storage, and disposal analyses. What would you say are NGSAM's main limitations?

And then a little bit of a follow up to that, in the example you gave in slide 10 you had routing information from START, the Stakeholder Tool for Assessing Radioactive Transportation, to what extent are NGSAM and START packages compatible and able to be used together.

JOSEPH: So, your first question is kind of the main limitations for NGSAM. I would say just to point out, it's not necessarily an operational planning tool. It's a tool developed to compare options. So, I guess its limitation is I don't expect, and it wasn't developed to be an operational planning tool. Other limitations are it's not -- it's not capable of optimizing anything so the analyst has to think about what options they want to compare because it's not really an optimization tool. Those are two limitations, I think.

And then, so START and NGSAM aren't necessarily connected. However, START output can go directly into NGSAM. We designed NGSAM such that the output START gives can easily be put into, you just put it into a folder and NGSAM can use it. And that's been useful because it allows users to change their routes as they can generate additional START outputs.

BECKER: In a sense, you're saying you can use it serially, that you would effectively do a run on START, get some sort of output, and then incorporate that into what you

do with NGSAM.

JOSEPH: Yes.

BECKER: Okay. Thanks very much.

JOSEPH: Thank you.

BAHR: Next up is Paul Turinsky.

TURINSKY: Robby, I'm still trying to understand a little bit more about how this works on it. A simple question first. Have you put in basically the dual-purpose canisters yet, the capability to analyze direct disposal?

JOSEPH: So, on the disposal part, the main thing we have at NGSAM is it has the capability to check the heat limit. The user or analyst would put in a heat limit. So as a canister would arrive it would -- you also -- the analyst is also able to declare which canisters are directly disposable. But also, you -- it has to meet the heat limit. Yes, we can analyze that on those two parameters.

TURINSKY: What I'm thinking is, in contrast to a DOE provided disposal package, these all have different sizes and number of assemblies inside each of the canisters. And that adds a degree of complexity, somewhat degree of complexity to the analysis.

JOSEPH: Oh, absolutely. And we haven't focused on that type of analysis in NGSAM. But, if there are requirements in the future or if there's a potential option someone would want

to model, with the agent-based model, we have the capability to check the canisters in the model and provide an answer as to how that might work.

TURINSKY: Okay. And then my more detailed question is again trying to get a better understanding of this. What, NGSAM actually -- can it tell you quantitative information? I'll give you an example, let's say I input basically as a function of time the capability of a geological repository to receive packages. Okay? And let's say, I also have an algorithm of which fuel gets shipped first. Will NGSAM then be able to tell me, okay. This year, these sites we're going to ship this much fuel from this site, from this site, from this site. I need this many rail cars to basically deliver those products. I need this many overpacks of different designs to dispose of the fuel. I'm thinking, again, dual purpose canisters here. But, you know, in general. Will it fit basically, given the end desirement of loading so much fuel in the geological repository as a function of time. Will it tell me everything else I need to know? Or is that a trial and error by the analyst?

JOSEPH: No. No. NGSAM has algorithms like that. If you set an acceptance rate or a disposal rate, it can handle going and picking it from the sites, but the analyst does have to define what the allocation queue at the sites is. But NGSAM

does checks on what is ready to be disposed and you can model an aging facility at the repository. So, yes, we would have to be given the requirements of the algorithm is different than what's in there right now. But NGSAM and agent-based models are capable of doing that and estimating how many rail cars you need. And I'll note too. You can run it where it buys the rail cars if it needs them or you can tell it, I have this many rail cars and then the acceptance rate may be just lower than what you asked for. You can constrain rail cars, or you can tell it to buy it when it needs it. You can run it either way.

TURINSKY: And, if it's determining the rail cars, it's recognizing the travel time from the site to the repository, back to another site. The time for loading the rail car. It does all that analysis?

JOSEPH: Yeah, great question. Yes, so that in the agent-based model, it has the START routes and it uses the START routes and the times we've assumed for each of those processes, yes, it'll go to the site, and it'll take it to the next site, and it'll also simulate it going back empty and it'll also simulate it going to a cask or facility maintenance facility, if needed.

TURINSKY: How does it know, let's say it's just made to the delivery to the geological repository. How does it, is it

just, I'm available now? I will go to the next site or is there a cleverer algorithm that – no, no, there's another shipment coming in two days. There's something more -- it will minimize travel time in other words. Those sort of things.

JOSEPH: Yeah, it has an algorithm that looks at making sure that it's using resources effectively in the transportation system.

TURINSKY: Okay, so it sounds like you may not have full optimization capability, but you have a number of algorithms that optimize the various pieces of decision making.

JOSEPH: Yeah, and Ingrid Busch at Oak Ridge National Laboratories, she developed TOM and then what we have is basically a module called the JAVA-based TOM which is JAVA based transportation operation model. She actually developed TOM for a different program and then just modified it for us. But, and I'm not the expert on this, but there is actually – to figure out what rail cars you send places. She actually has a strict packing problem algorithm where she kind of optimizes the transportation system that way. And yeah. There's – there is, good point, there's optimization in certain parts of NGSAM. For example, we can't optimize on cost or something like that.

TURINSKY: Will the public ever have an opportunity to

run a version of this?

JOSEPH: Right now, it's limited to NE-8 analysts and the amount of training required to run it may make that difficult. But, in our consent-based siting for interim storage program there are plans to make some of the results of some of these scenarios public.

TURINSKY: Okay. I would think that universities might be interested in it. Lee Peddicord teaches a fuel cycle course. This might be interesting tool for his students to become familiar with the back end of the fuel cycle.

JOSEPH: Okay, yeah, I will have to get back to both of you on that.

TURINSKY: Yeah, there's Lee. I'll sign off.

BAHR: Sort of a related question is, are there plans, not to have stakeholders run this, but solicit stakeholders on what kind of scenarios they would like to see run to get their questions to inform what the analysts actually look at.

JOSEPH: Yes, I would expect -- so a lot of the scenarios we've run, well at least some of the scenarios we're run have been due to stakeholders asking questions of different people in the Department of Energy. So, yes, I suspect that's one of the ways this tool would support the interim storage program is to run hypothetical scenarios and that might be affected by their input. We can run scenarios based on different

questions.

BAHR: Rob Howard might be able to shed some light on this.

HOWARD: Yes, Jean. That's a great question. It’s actually one of ongoing research. Part of the trick for some of our stakeholders is going to be understanding what it is that they want to understand about the system, which could be very different from what it is that we’ve historically been interested in. So, as we start to engage with stakeholders, that's one of the things that our team is really going to be looking hard at is getting that kind of input from them so we can go back to our systems analysts and make these tools more flexible and usable to answer the questions that other people are interested in. Not just systems managers and systems analyst. It’s a great question, and part of our look forward in this area.

BAHR: Okay. Thank you. I see Tissa's hand up.

ILLANGASEKARE: Yes, I may have asked this question in the past, but I’ll ask it again. In the processes happening in these systems, seems like you get the answer to Paul’s question, but the processes are not simulated during the system operation. You are basically -- the analyst has to put these -- let's say the question is, you put a certain type of container in a certain geology, this is going to happen. But

that process information is not part of the simulation because that analyst had to put -- do a simulation separately and put that information into the system. Is that correct? Where did the processes come, what happens to the system?

JOSEPH: Well, so the analyst has to kind of set the assumptions you're using. For example, the repository or the ISF, but yeah, the processes, it's all assumption driven on how long those processes take and what canister might be used. Those are either assumptions or we have historical data on the assemblies or the cask.

ILLANGASEKARE: So, the analyst in theory can run a process model to ask the questions you need to ask from the system, is that correct? Because the reason some systems model, I'm familiar with, you ask a question or are looking at scenario. The scenario may require you to do process simulations and that information goes back to the systems tool and the output goes into the systems analysis. But in your case, those things have to be put in parameters or some variables come from a completely different simulation model.

JOSEPH: Yes, it's -- in an agent-based tool, you have to kind of define, you have to define the times and the assumptions about the path that you take. So, yes. It's, so it's agent based so it's very assumption driven and how you describe the scenario in the model.

ILLANGASEKARE: Okay. Thank you very much.

BAHR: Lee Peddicord. Yep, Geoff Freeze had a hand up maybe he needed to clarify something.

FREEZE: Thank you Jean. Yeah, I wanted to elaborate. Some of the questions had sort of touched on, how does this interface with disposal and sort of the design of the disposal system. Yes, even if the current generic models, are depending on the geology and thermal conductivity of the engineered barriers in the host rock are designed to some sort of waste package and drift spacing that satisfies the thermal management constraints. Knowing what sort of thermal loads would be needed for, you know, specific waste packages, that would be a parameter that NGSAM would take into account if it were delivering waste packages to the repositories. NGSAM doesn't calculate it but the information from the GDSA models on what sort of waste package thermal load is necessary would help to inform, I think, the delivery schedules.

BAHR: Thanks Jeff. Lee Peddicord.

PEDDICORD: Yeah, first of all I wanted to follow up on Dr. Turinsky’s segue -- that, yeah, this would be a capability in whatever form that I think would be very helpful to engage with our students and get them up to speed on what you’re doing.

I had one specific question. I think it was

answered on the slide that was just being shown. But do these capabilities inform questions like acquisition of rolling stock to make these things, the various components, cars, buffer cars, escort cars, stuff like that. You showed from 500 shipments a year at one end to 200-250 the other year. So, does this tell you when you need to make investments in the system, so you have capabilities to meet these scenarios?

JOSEPH: Yeah, it can estimate using the assumptions about turnaround times and other sorts of things, how many rail cars you need, how many escort cars, how many buffer cars. Or, you can also run the scenario where you say, this is how many cask cars I have, how many railroad cars I have, how many buffer cars I have, and then if you put in that acceptance rate and set the level of all your transportation assets, it will tell you what acceptance rate you'll actually be able – it will estimate the acceptance rate you'll actually be able to move with that amount of rolling stock.

PEDDICORD: And do you know what are the lead times to acquire these? Let's say I want to go buy a buffer car this afternoon and I went to Amazon or eBay, how long is it going to be before it's going to be rolling up here?

JOSEPH: That's probably a better question for Dr. Erica Bickford. But there is an element in our model where we're kind of – we're assuming that -- it's kind of we're analyzing

and assuming, well when do we need it. In terms of the lead time, that is probably a better question for Dr. Bickford.

PEDDICORD: Well, it was hypothetical but, thank you.

BAHR: I guess the question is, are the lead times built into NGSAM. So, if you run it with a scenario that says, well how many escort cars do we need? Does it tell you; you're going to need 20 by 2030, and that means you need to order them in 2025?

JOSEPH: It does tell you when they're needed. We don't have anything in there right now on when they need to be ordered. However, if we have -- I'm sure we have that type of estimate. If we have that estimate, we could add that capability to the model. That is not -- right now it says this is when we would probably need it.

BAHR: Okay. Thanks. Bret Leslie.

TURINSKY: Let me just comment it's more complicated than that. It says I need 25 rail cars on this day. They have a production capability to produce so many per year. The time to produce those 25 would be -- would depend on how many are in production at a given – you know, their production capacity, basically. You may have to start early.

JOSEPH: Yeah, absolutely. Hopefully NGSAM can give estimates for how many we need by a date so that the production can be planned early.

TURINSKY: Some other program will take over figuring out when they've to start placing orders.

JOSEPH: Yes.

BAHR: Okay. Thanks, Paul. Bret Leslie.

LESLIE: A question. Robby, nice talk. You indicated that NGSAM is now limited to NE-8 analysts. And you've outlined how DOE spent fuel canisters can impact NE's responsibilities, which is transportation. But I can envision that this tool could be quite helpful for EM in terms of their own packaging decisions because they're responsible for packaging, not NE. So, are you involved with DOE EM in like Idaho?

JOSEPH: My colleague Gordon Petersen is actually -- he works with EM as well, and he's the person that works with the ANL NGSAM developers on how we're modeling DOE-managed spent nuclear fuel. So, yes, I would expect we have some of the people in my group work at INL working with EM, so yes. I don't -- that's not necessarily laid out how that would work. But these models definitely could benefit EM.

LESLIE: But has EM basically said we're going to use this to help our packaging strategy?

JOSEPH: I don't think they've said that explicitly, no.

LESLIE: Okay. Thank you.

BAHR: I see Rob Howard's hand still up. I don't know if

that is just a remnant from his last participation.

HOWARD: Sorry, that's a remnant.

BAHR: Okay. Well, I think it’s time to move on to our next speaker. Thanks Robby. And, next up is Erica Bickford who’s going to be talking about the transportation software package, START. So, if we can get Erica and her slides up, we can get started. Hi Erica.

BICKFORD: All right. Can you see my slides?

BAHR: Yes. Go ahead.

BICKFORD: Great. Thank you. Thank you for the invitation to present to the Nuclear Waste Technical Review Board on our START tool. I’m going to be talking today about the current functions and capabilities of the Stakeholder Tool for Assessing Radioactive Transportation, also known as, START.

Here’s the same disclaimer text that I think you all have seen several times now.

So, in this presentation I’ve actually presented to the Board on START before but it’s been quite a few years so I figured it couldn’t hurt to do a refresh as I’m sure we also have some new folks. I was going to cover just some background on what START is, some of its development history and how the program has been using START and future plans. As well as talk about some related activities or supporting

activities in terms of validation of the tools, some recent improvements we have made, some of the challenges we have encountered, as well as our plans for future work.

What is START? In a nutshell, START is a geospatial analysis tool built using geographical information systems, also known as GIS, to enable data visualization and analysis in support of planning for future DOE spent nuclear fuel transport. It's a web-GIS based application. It's built on ESRI's ArcServer, ESRI being one of the major software providers in GIS space. It also uses ESRI's network analysts' extension to support the routing capability of the tool.

So, going back to the history of START, the first version of START was developed around fall of 2013. And then it was first published in, about a year later. We selected Idaho National Lab to host that early version of START and the rationale for that was, when we started investigating different options for hosting, we talked to folks at DOE headquarters and we said, this is our GIS tool. It uses this type of software and his type of computational requirements. And the response we got was, what is GIS? So that didn't give us a ton of confidence. And we had been looking at other options and when we went talked to Idaho National Laboratory, the response we got from them was, we know exactly what this is. We have other applications using the same software. We

already have the software licenses, which the licenses can be very expensive, and so if you host it here, you'll contribute a portion to those licenses versus having to pay for the full freight.

That ended up being a great option for us and it was a great option for a number of years. However, as time went on, that hosting environment, which START was hosted on a physical server became more limiting which was a physical server which other applications were also hosted on. So, if those applications crashed the server, then START went offline, or if those applications were using a lot of the server band width, then it would slow down the functionality of START. At first that was not much of an issue but with physical computing equipment, as you move through time, it becomes more problematic.

So, in the summer of 2018 we started exploring options to move START onto a cloud-based server, wanting to explore more functionality and flexibility that a cloud server environment provides, which was also around the time that a lot of the federal software capability was being encouraged to move on to cloud servers as well. So, we found at that time that DOE headquarters was in the process of setting up a cloud server using Amazon Web Services. From our research and investigation, we had learned that had Amazon Web Services was

a very compatible hosting environment for START. It's compatible with running Linux servers which are cost effective and that the ESRI software that START runs on very well in that environment. So, we decided to pursue that path because we had also talked to Idaho, and they did not have plans at the time to implement a cloud server. They since have. They did not -- they went with a different server environment and not Amazon Web Services.

So, we made an agreement with OCIO to pursue that path. At that time, they gave us a 6-to-9-month timeframe for being up and ready to go, so we said, alright, let's do it. We went down the path of procuring the GIS software licenses which federal procurement can take a while so that took until about the middle of next summer. However, the timeline that OCIO had given us originally was pretty optimistic. One of the confounding elements at the time was also the 10-year big OCIO support contract changed providers during that period of time, which contributed to some pretty significant delays on their side as well.

They came back to us in the spring of 2020 and said they were ready to host START on Amazon Web Services and let's get going. We talked to them for a couple of months but then other tasks, they were tasked with focusing their efforts and resources on getting enterprises systems, so those are the

software that are used agency wide up onto the cloud server first, so we kind of took a back seat to that.

In parallel with that we continued hosting START at INL. However, in the fall of 2020, INL implemented some major security changes to their server systems, which compounded the challenges we were having hosting START at INL.

How START is developed is we have our great developer who developed START in a development environment on his system which is also an Amazon Web Services hosted environment, develops it, tests it, packages up, sends it to Idaho, schedules time with staff in Idaho to get it populated on to their production environment and then troubleshoot any conflicts or issues that arise. And then it used to work pretty well but when the security changes were implemented what happened was the INL staff were no longer able to have direct control on some things, it required putting in a ticket for another security team to address that. It became very cumbersome and much more of our resources and labor were being spent on just getting our developed version of START to function properly on the INL’s server so that continued to motivate our interest in pursuing the path to move START to a cloud-based system at headquarters. The idea being we could have control over the production environment at headquarters and have it mirror the development environment. And make the

process of updating START and pushing new versions much more automated and cut out a lot of that labor intensity that we were having with the current hosting system.

So then, last spring, luckily the Office of the Chief Information Officer, OCIO, came back to us and said, okay we're really ready for you this time and so we continued discussions with them, negotiated sort of what the hosting relationship would look like. Some of the challenges here were really first mover issues. As I mentioned before, they were focusing on the enterprise software systems that were used agency-wide whereas, comparatively, START is just this little, small software application and so kind of had to figure how that was going to fit into their hosting model and security requirements and all those things. So those are what those discussions were about. Those cloud accounts were finally procured for us last fall and we also had to begin a security review process. Any software that you host on the DOE website, you have to meet certain security requirements, and so starting in December, January timeframe our START developer has been working on migrating our START tool into that cloud server environment. So, that's actively in process and we expect to have a production version, and so that's like what is posted on the website as what a production version means, up and running at DOE headquarters later this spring.

I will say that, when that first version of START that was published in fall of 2014, we had to go through a classification review for that. The classification review came back and designated START as for "official use only." And so, this whole time, START has been accessible to federal, state, tribal, government representatives that have a justifiable need to use START. We have had requests from folks at universities, researchers, students and others who have been interested in using START but have not met that official use only threshold. With the migration of START to a new cloud service and new security review, I'm hopeful we'll be able to remove that official use only designation because we have learned subsequent to 2014 that the wrong classification guide had been used for that tool and there were just some misunderstandings about its fundamental capabilities. And so, removal of the official use only designation should allow us to provide access to START to those other groups. So, I'm hopeful we'll be able to do that.

I don't know since the Board asked about making it publicly available, we don't have plans at this time to make it widely public available just because of the resources that would require having sort of full-time customer service support available and things like that. But we certainly want at least to start by trying to grow our user base

incrementally and certainly make it available to folks at universities and places that have -- that could have a real beneficial use for it for their own work as well as to the broader waste program. So that's the background of the history.

Going into how the program has been utilizing START, sort of the impetus for developing start was originally to replace a routing tool capability that was lost. The program had previously used TRAGIS provided by Oak Ridge National Lab that became unavailable around 2012-2013 time period. And so this was an effort to replace that capacity and so it focused on routing from A to B using rail, highway, waterway as well as intermodal options. And then as time has gone on, and as we've presented the tool to our stakeholders, primarily state and tribal partners as well as sometimes federal and other DOE folks, we've added capabilities and functions based on the feedback that we have gotten.

Some of the things that are now in the tool is we have a capability to support what is known as needs assessments or sort of training preparations. So, say DOE was going to do shipments and you identify a route. The states, tribes, and local communities along the route might want to do a needs assessment looking at where the route is going, where their fire and police stations are, hospitals relative to the

route and where they would want to prioritize training -- emergency response training.

Things like DOE's Transportation Emergency Preparedness Program, the TEPP program, which is the training DOE provides along corridors that we transport radioactive materials. We have the TEPP trained personnel data loaded into the START tool, geospatially, so you can see where there are TEPP trained personnel. We've been in talks with the Office of Environmental Management as well as the Carlsbad Field Office staff about using that geospatial display of the data to make sure that our training investments are efficient. We might very well have overlapping regions of transports and we want to make sure we're not duplicating training efforts in some locations while leaving other areas uncovered. We also currently have layers that you can put on in the tool that show where all the current WIPP routes are. When we have future spent fuel routes, we can similarly add a layer where those are, where the overlaps are, where the gaps are, things like that.

One of the other capabilities that's really has been valuable with START that was maybe not initially conceived of is its use as a communications tool. You, yourselves, probably fall into this category. Most folks don't have immediate mental map of where all the nuclear power plants and

DOE facilities are relative to the railway networks, highway networks, and waterway networks. I more or less have that now, but I realize I'm not most people. So, when you talk to people in the public or tribal and state stakeholders and they say, how is this going to work and where is this going to go, and if you're moving fuel through this location, we want it to go south, we don't want it to go north. START's been very helpful in just being able to display the relevant information and talk through some of these questions and concerns. When you can open the tool and say, well here's where the nuclear power plant, here's where the rail goes. South goes to Mexico and we're not doing that. So, the only option is that it has to go north. That's just really helpful to the discussion because it's more convincing when people can see the information for themselves rather than just rely on what you're telling them.

The other capabilities, Robby's presentation talked about how START output is used to support the NGSAM work. It integrates with the broader systems analysis tool and we're also adding capabilities in START to support environmental analysis. In thinking about future federal interim storage facilities and/or repositories and the kind of environmental analysis that you need to do for the transportation to those facilities. We are actively working on building the

capability within START to support that kind of analysis focused on, right now, on things like building in dose estimates for the spent fuel transportation.

So, I mentioned START's original purpose was to look at different routing options. This just shows an example of its capabilities of looking at different route considerations. When you go out and talk to the public or other lay people and you talk to them about transporting spent nuclear fuel, the first reaction many people have is, well, do we have to do, but just don't move it near people. You don't want it near any people. In the START tool, we have the capability of running routes. In this example you see a green route that’s run, they’re all at the same origin and destination. You have one route in green that is minimum travel time. You have the route run in red that’s minimum travel time but requiring the shipment to go through Tulsa. These are all just hypothetical routes for analysis purposes. And then you have this blue route which minimizes population. In addition to the visual of the routes, what START also does is produce summary attributes for each route. So, this provides us with the capability to kind of talk through some of these considerations.

You have three different route options for the same origin and destination pair. Let's look at their attributes

and weigh the pros and cons. For the minimum population route, you, of course, have a lower population but what do you also have? You also have a longer transport distance and longer travel time. You have a higher accident likelihood because what you will find is, especially with rail infrastructure, the rail network was designed to connect cities, to move goods where the people are. And that's where you have your most robust infrastructure. Outside of that, you have generally lower quality infrastructure and so that increases your accident likelihood where you have lower quality track. Similarly, where people are is also where your emergency response capabilities are. In the less populated area, you also have a lower emergency response capability. So being able to kind of break down the data and talk about it with people this way has been very helpful in understanding that it’s not just people or no people. There’s other factors, safety and security factors that come into play. And START’s been very valuable for supporting these discussions.

Alright, so I mentioned that we have intentions of using START in support of future activities related to the integrated waste management system which could include licensing actions related to federal interim storage facilities and/or eventual repositories and supporting the transportation analysis for those. And so, we want to make

sure that START is a very robust and defensible tool to be used for those purposes. So, we have begun, a couple years ago, looking at some ways to validate the results that START produces, both to support or both to ensure it's a high-quality tool for our own internal analysis and communications work, but also to support future analysis that may be used in a licensing action.

We've done this through both informal and formal means. So, this slide shows an example of some of the informal validation we've done. We did a rail routing workshop and this focused in the rail routing functionality in START. We embarked on this at a request of our state and tribal stakeholders. Many of them have a lot of comfort with highway transport of radioactive materials just based on familiarity of the WIPP program and much less familiarity with rail transport. So, through DOE's National Transportation Stakeholders Forum, or the NTSF, a Rail Routing Ad Hoc Working Group was set up to explore some of these questions. One of the things they wanted to do was better understand how rail routes are identified. So, we solicited volunteers from among the Ad Hoc Working Group to choose origins in their jurisdictions or near their jurisdictions and use START to look at routes from those facilities to a geographically neutral destination.

On the graphic on the left, you'll see some of the examples from the participants. We had the Prairie Island Indian community participate, the State of Illinois, the State of Vermont, and the State of Arizona. And so, what happened was, the state and tribal volunteers picked origins and destinations and used START to run rail routes. We also then reached out to rail carriers from UP, the Union Pacific to BNSF, CSXT and Kansas City Southern and asked them to run same routes on their networks with the same origins and destinations. We all got together and had a full day meeting and talked about the results that each came up with and compared and contrasted them. The outcome of that was that the routes generated using START compared very well with the rail carrier routes. And the rail industry uses what is called the Rail Corridor Risk Management System, or RCRMS. This is a proprietary tool that is not publicly available. We've tried to get access to it to do some validation for START and have not been successful. But this provided us a good indication that there was a good comparison between START's rail routes and what rail carriers would generate themselves.

We also found that there were some differences in the tools, for example, START produces population along routes but uses an 800-foot buffer versus RCRMS which uses a 322-

meter buffer. There were some operational differences in how some of the rail carriers operate certain segments track only northbound or only southbound. That's something that START doesn't capture, obviously. One of the things we talked about was that the rail carrier is based on a 2008 routing rule and are required to evaluate the safety and security risk of routes transporting certain hazardous material, including spent nuclear fuel. And their tool, the RCRMS tool, gives equal weight to safety and security risks, which the group discussed is of questionable validity given that historically all rail incidents have been caused by safety issues and not security issues. So that was a very useful experience all around, gave everyone confidence in understanding how rail routes are identified, and how rail carriers do it versus how START produces rail routes. So that was an informal example.

And then more recently we've moved on to a formal validation effort. We call it a verification & validation or V&V. We've engaged Pacific Northwest National Laboratory to take kind of a deeper, more technical dive into the functions of the tool. They've done that by comparing the outputs that START produces against independent GIS applications.

They used ArcMap which is also and ESRI product and QGIS which is an open-source GIS product. They started with looking at the population values that are produced associated

with the route as well as the distance calculations. And the outcomes of that so far are generally good agreement with some differences, all within plus or minus 5 percent with most within one percent. We've gotten some good feedback and found some issues that we've been able to correct through that process. And the intent of this is to continue conducting this verification and validation. PNNL has set it up so they have codes they run so every new version of START that we put into production they can then run this verification and validation each time. So, that's great and we look to continue that and expand that to help ensure that START as good as we can make it.

So, some of the recent improvements with START that I wanted to talk about. As I mentioned before, START is built on ESRI's ArcServer software. And so ESRI started off as most of this software did, primarily in a desk top environment, has really in the last decade been moving into the web environment, and has been porting more and more functions from their desk top software into the web-based software. And so, as those features become available and as they're applicable or useful to what we want START to be able to do, we've been implementing those. Anything from just like an address search widget, to being able to measure distance from A to B or doing, you know, localized travel time estimates and things

like that we've been incorporating.

Another thing we've added is a batch routing capability. Initially START was developed, you have one user, and you'd pick your origin, and you'd pick your destination, and you'd pick your mode and you run your route. For systems activities, like what Robby just talked about with NGSAM, you really need all the routes to evaluate the whole system. So we have made do in the past by employing an army of summer interns to just run routes all summer and they did a great job and that was wonderful, but we certainly recognize that we could really do this more efficiently. And so, based on that feedback, we've since added a batch routing capability which allows a user to queue up origins, destinations, mode for many, many routes and then just click, go, and have them run in the background. So that's now in there to support current and future analysis.

I mentioned before that we're building out START to support environmental analysis type work and that we're starting with dose rates that is, so far, incident-free dose rates from a crew traveling with a shipment, the public that are not on the transportation infrastructure, public that are traveling on the transportation infrastructure, so in a vehicle on a highway near the shipment and things like that. We've had some of this capability for a long time but really

debated how best to portray it in START given the users of START as DOE and national laboratory technical experts, but a lot of state, tribal, and hopefully, in the future, some members of the public or students and things like that who are not health physicists and may not have a lot of expertise or understanding of what dose values mean. And we certainly encountered among the public this concern or this misunderstanding that any nonzero radiation dose value is concerning or hazardous or what have you. That was kind of our struggle with, we want to provide as much information as we can, but we also want to do it thoughtfully. And, so, we've recently determined that we're going to display the dose values as a percentage of background, that's U.S. average background, to try to give it some context for folks who may not be as familiar with radiation dose values or units. So that's in progress and then planning to add incident free and other things as well.

We make continuous improvements to the routing logic as we encounter them, as our users encounter them. We release new versions of START on the order of quarterly, give or take. It's not a strict schedule but basically, as we make a list of things we need to improve, once we get a good chunk of things done, and feel like it's robust enough for a version, you know, 3.2 or 3.3, then we'll go ahead and put it out there.

We have capabilities to extract route information based on jurisdictional boundaries. If you have a cross country transport, but you're just one tribal jurisdiction or a state or a county and you just want to extract the attributes of the route for your jurisdiction, you can do that.

We regularly update the data that's in START. Most of the GIS data that's in START comes from Department of Homeland Security. HIFLD data, that's the Homeland Infrastructure Foundation Level data. That's the most comprehensive U.S. nationwide source of geospatial data. They release at least once a year, some layers more frequently than that so we update it. Layers like the TEPP training layer we update on the order of every six months. We have the TEPP trainer send that to us directly. Another improvement we've made is creating a hybrid highway network layer. We had a less detailed highway network layer and found that was not suiting our needs. We got a much more detailed highway network layer and that was great in some respects, but it was computationally more expensive, so we decided to go with a hybrid of the two. We recently rolled that out and are going to test that out. I mention the ongoing verification and validation work as well.

We of course have challenges. Data quality and

coverage is an ongoing challenge. As I said, most of our GIS data comes from this external data source produced by the Department of Homeland Security. It's only as good as it is. One of the things that is disappointing in the data is the quality of fire station data. So, there are meta layers in the data whether they're paid firefighters or whether they're volunteer, whether they have paramedics, what other hazmat training or other things that they've had. Most of the data is unpopulated. The DHS partnered with the National Fire Protection Association a couple of years to do a big data call to try to improve the quality of that data. And only about 8 states responded. Unfortunately, that is not something that I or DOE can really address. We just kind of hope that the broader geospatial community kind of brings things up to our standard. Similarly with the rail network, the way the Federal Railroad Administration is the authoritative source for the railroad network and how that gets updated is rail carriers add or remove a rail network from their system and they submit that on paper to the Federal Railroad Administration then somebody has to digitize that from the paper and implement it into the network. There's long delays, unfortunately, in that process.

Challenges the rail routing system is very challenging. In general, if you have highways or waterways

and you have motor vehicles or a boat, and it’s a navigable waterway, you can more or less, just go. Rail is very different because it’s privately owned infrastructure and to make it further complicated, if you have a rail carrier, they can operate on their own track, but it’s not just their own track, they can have haulage rights or trackage rights with other rail carriers. There can be wholly or partially owned subsidiary short line carriers that aren't considered an interchange. And so that just -- this isn't widely known or publicly available information. A lot of this we just kind of encounter as we run into unusual results or things in START, users in START find things and aren't sure why that is happening, and we have to investigate that. We’re trying to build START to be as real-world representative as we can but it’s on-going challenge and there’s also many data layers we add manually. We’ve made great use of summer interns that have been very helpful in updating or improving those data layers and we appreciate that.

So, for future work, continue to maintain data currency. Our tribal and state partners have asked us to do virtual trainings on START which we are very eager to provide them with once we get that production version of START going in a virtual environment. Again, one of the advantages of a cloud-based servicer is we can artificially increase the

server capacity to support a scheduled training and bring it back down to its usual capacity and that's one of the great attributes that we are looking forward to taking advantage of with a cloud-based server, continuing the verification and validation, making use of whatever diagnostics are available in the cloud platform. I've already mentioned continuing to develop NEPA-related analysis functions, you know, more conditions for dose estimates, accident case, things like that. Make sure that we're working well to support the system tools like NGSAM and any others. Maybe consider a suite of use cases for DOE activities or applications for other analysis for possibly other DOE based forums and things like that. So that is, I think my time and I happen happy to take any questions.

BAHR: Thank you Erica. Do we have questions from any Board members? I see Steve Becker's hand up.

BECKER: Hi Erica, very nice presentation. Obviously, a lot has gone on since the last time you spoke with us. Sounds like you've faced some trials and tribulations and had some successes as well. So, I'm struck by the fact that START has a lot of information that could be useful in training emergency response personnel for different sorts of nuclear waste transport scenarios and situations, everything from where the TEPP trained personnel are located to where fire

Departments are located, critical infrastructure and so on. Has any thought been given to using START in tabletop exercises and things along those lines aimed at exploring various situations in order to prepare response personnel?

BICKFORD: Yeah, sure. Thanks for the question. That's certainly something we have discussed with our state and tribal partners. I will say some of the state and tribal partners do have their own state GIS capabilities. Some of them are very robust for their own internal use, others much less so. So, we have certainly, you know, made START available for that use and are open and eager and willing to add other capabilities to support that need. It's just a matter of whether there's a preference among states in particular, to some degrees tribes, to use their own in-house resources versus make use of this. But that's certainly, being able to support what I mentioned before in terms of needs assessment, training needs assessments and things like that, the idea of using it in a tabletop, that's a good one. It certainly could be used for that for sure, at least if not provide visuals or things like that. That is absolutely something it could be used for.

BECKER: Okay. Thank you.

BAHR: Paul Turinsky?

TURINSKY: Yeah, Erica, I was wondering, do you work with

other parts of the government that are also transporting hazardous materials. I mean, the defense folks' part of DOE do a lot of transporting of nuclear but there's a lot of other hazardous materials, ammunition, conventional ammunition and all. They must have – I would say, I wouldn't go as strong as similar, maybe related is the word needs where you folks can learn from each other. Your databases are probably pretty common of what your needs are.

BICKFORD: Sure, thank you for the question. We've certainly done coordination within DOE, the Office of Environmental Management and I think we presented START to NNSA a number of years ago. In answer to your question, I will say so we haven't reach out to private sector shipments or anything like that, but we certainly have made use of their data. I was talking here to Mark Abkowitz who's our lead contractor for the START tool and he asked me to obtain from the Surface Transportation Board what's called waybill data which gives you origins and destinations as well as for rail shipments as well as the type of shipments, whether different types of hazards. And so, he really dove into that data to look at specifically what's called poisonous inhalation hazards and toxic inhalation hazards because we don't have a lot of rail transport of spent nuclear fuel so that wasn't its own category, but the TIH and PIH categories is sort of a

corollary in terms of routing considerations. It's a large enough category of high hazard material that we could use that to look at how those shipments are routed and to use to tune the START rail routing logic to try to map to that. That is where we certainly pulled in routing data from other hazardous shipping sectors for sure.

TURINSKY: Yeah, I would think DOD, you know, shipping ammunitions, et cetera, around the country with similar issues that you folks face.

BICKFORD: Yeah, possibly. I'll say that that -- they don't like to talk to other people too much. We certainly would be willing to talk to them but it's a question of whether they would want to talk to us.

TURINSKY: It might be interesting to use them in some sort of review fashion of your work rather than asking them, what do you do, have them look at what you've done and maybe extract something that way.

BICKFORD: Sure, though, I will say things like munitions may not – so in terms of like the routing regulations for rail, there are certain categories of materials. So possibly, I guess certain explosives possibly, but we focused on those TIH and PIH hazardous because that was more similar to the grouping that high level nuclear waste or spent nuclear fuel would have.

TURINSKY: Have you had outside experts look at the software and critique it?

BICKFORD: I just, so what I talked about the verification and validation we have had going on at PNNL as well as just sort of an origin/destination routing comparison that we've done with the -- a couple of the rail carriers.

TURINSKY: Okay. Thank you.

BAHR: Mark Abkowitz's hand is up. Do you have something to add to the answers.

ABKOWITZ: Just a quick comment since Erica made reference to my involvement and what we've been working on. It's been a real challenge to try to find the kind of data that is relevant to radioactive transportation and, actually, for hazardous materials transportation in general. So, we have kind of scoured pretty much all the different data sources that are out there and feel pretty comfortable that of what is at least available through the Department of Homeland Security and some of the other agencies, we're pretty aware of what's going on. But I do think Paul raises a very interesting question which is sort of improving our interactions with other parts of the Federal Government that are dealing with moving either radioactive shipments or other shipments that fall into a similar category of risk. I think our reluctance to do that up until now has just been we've

really tried to get the tool to a point where we feel pretty comfortable and, particularly, in the AWS environment that it’s stable in that respect. But I do think there’s an interesting opportunity both to see how others are doing and do sort of a check against our results. But there may even be an opportunity beyond that because I suspect there may be several agencies who have responsibilities somewhat related to this who may not have tools that are as sophisticated as this one.

BAHR: Thanks Mark. Erica, to what extent does your tool incorporate understanding of hazards like earthquakes on the West Coast or flooding or seasonal sorts of hazards to transportation?

BICKFORD: Actually, I might kick that one to Mark Abkowitz as well because independent from the START work, I know in his work as a university professor, he’s been looking at climate change hazards and things like that. I think the short answer is that START doesn't currently account for those except where the underlying infrastructure may already account for those. Whether there is or isn't a road there or is or isn’t rail infrastructure there. Beyond that, I will kick that one to Mark.

ABKOWITZ: Excellent question, Jean. We have not tried to get into the specifics of what the earthquake risk is on a

particular segment of the system. But we do have a number of different background maps that the user can switch in and out of just by clicking. I will have to check; I don't know if whether we have the USGS earthquake prediction maps, but we can certainly easily add that and that would give you an opportunity to see what portion of a trip may be going into the red zone or yellow zone which are defined by the probability of an earthquake occurrence of a certain magnitude within a certain period of time. As far as climate is concerned, we haven't really talked about that although it's an interesting question since the campaigns will be going on for decades. We could look at some of the midcentury information that's coming out of the climate models and look at differences in things like precipitation and extreme heat and I presume we could come up with some type of index to show to what extent we would be seeing changes of those kinds in different parts of the country. So, I guess we could add that to the list of things to explore in the future.

BAHR: Thanks, Mark.

BICKFORD: Thanks Mark. The only thing I'd add to that is, I don't think we have the earthquake map, but we do have a base map that shows the FEMA flood zones. I will also say that spent fuel, we're using the national transportation infrastructure. We not using our own special infrastructure

or anything like that, so impacts of earthquakes or other disasters or climate change that effects the national freight infrastructure will affect us and vice versa. So that's certainly something we'll have to maintain situational awareness for sure.

BAHR: Thanks. Steve Becker has his hand up again and then Dan Ogg. Steve first.

BECKER: Just to follow up on some of the earlier questions. We know, of course, a number of countries in Europe, for example, are a little bit further ahead in the process of dealing with nuclear waste than we are. I'm wondering, are there examples from Europe, let's say. From countries that are a little bit further down the road than we're of using systems like START and if so, are there any lessons to be learned or improvements that could be gleaned from that experience?

BICKFORD: Thank you for the question. Certainly, in many respects, we certainly look to the European programs and Canadian programs as well on their successes in waste management and ways that we can get the benefit of their experiences or lessons learned or best practices. I would say, transportation routing is one of the areas that's least applicable, in part, due to the U.S. geography and scope and scale is so much larger. When we've tried to talk to, say,

Switzerland, and say, how did you select this route versus alternatives. They're like, this was the only road, the only road between point A and B. There's those kinds of differences. Also, when we talk about freight rail routing, it's very different in Europe. In the U.S., the freight rail infrastructure system is privately owned. In most of Europe, if not all of Europe, it's nationally owned and in general, passenger transport is prioritized over freight rail transport. So, in terms of the routing considerations and logistics in Europe as I mentioned before how rail routing in the U.S. is tricky because it's private infrastructure but there's shared routing rights and stuff like that. In Europe, to the extent that I understand, it operates much more like highway or waterway routing where if it's a nationally owned infrastructure, if you're train and there's rail, you can operate on it give or take any prioritization for passenger transport. But I'd say on the waterway is maybe one of the ones where we'd really like -- especially the Swedish program. They do all of their spent fuel transports by water. We've looked at them just in terms of their operations and communications and trainings and stuff like that. It's probably going to be different because they use a marine vessel and when we've looked at waterway transport of spent nuclear fuel in the U.S., it's probably more of a costal

barge, inland waterway type vessel. Certainly, it’s helpful to point to those examples because some of the state stakeholders we have talked to are very comfortable with barge transport, you know, it varies by geography. Some regions are like, oh yeah, we transport stuff by waterway all the time, that's great. Others, it’s much concerning to them. Oh my God what if the boat sinks? What if the cask falls off the boat? What are we going to do? How do you make it secure? So, it’s very helpful to have international examples that have much – you know, decades of experience to point to.

BAHR: Dan Ogg.

OGG: Thanks, and thanks Erica. I wanted to go back to discussion about natural events and weather events. Erica, you briefly mentioned flood maps. I know that the USGS has detailed flood risk maps that show flood levels that may happen once every 10 years or flood levels once every 50 years. Do you have those kinds of detailed map overlays available in START? So that if you know it’s the wet season, you can put the map in and avoid a section that might be susceptible to flooding during the flood season.

BICKFORD: Sure, so in START, it’s called a base map in START. If you’re familiar with Google maps you can have the graphical background or you can switch to the satellite background in Google maps. It’s the same in START where we

have a wide variety of different base maps just for different map aesthetics, also a population background base map, topographical base map, and then as you mentioned, we have that flood map that shows, you know 10-year floods, 100-year floods and things like that.

OGG: Okay. Thank you.

BAHR: Mark.

ABKOWITZ: Just wanted to add there's a feature in START we don't really advertise but it's relevant to this conversation. We have what we call an elevation widget so wherever you are in the country, you can press on that, and we'll tell you the elevation there. So as a – from a seasonal perspective, that could be useful in terms of looking at what type of form of extreme weather you might encounter depending on where you happen to be.

BAHR: Thanks, Mark. Any other questions for Erica? Okay. Well, seeing none. I think we're ready to move on to our final presentation of the day and that's going to be Alisa with an update on DOE's efforts on developing a process for consent-based siting of interim storage facilities. I see Alisa. And do you have your slides?

TRUNZO: Yeah, just give me a second to share my screen. All right. Can you see my slides, and can you hear me?

BAHR: Looks good. Thank you.

TRUNZO: All right. Well, hello everyone. I'm Alisa Trunzo. I'm the Strategic Communication Specialist for the Office of Nuclear Energy. Thank you all so much for the opportunity to speak with you today. We spoke previously at the fall meeting, so I'd like to use the time today to dig in a little bit deeper on our consent-based siting effort and provide an update as we're rapidly approaching the end of our Request for Information or RFI comment period.

With that, let's begin. Nuclear energy is absolutely essential to tackling climate change. We need nuclear technologies to achieve 100 percent clean electricity sector and net zero emissions by 2050. The flurry of activity in the Office of Nuclear Energy reflects that understanding. I'm sure many of you on the Board have seen our office's notice of intent and request for information on the Civil Nuclear Credit Program which represents a $6 billion strategic investment through the Bipartisan Infrastructure Law to help preserve the existing U.S. reactor fleet. We continue our efforts to bring advanced nuclear energy technologies closer to deployment. This includes our work on the Advanced Reactor Demonstration Program, plans to develop High-Assay Low-Enriched Uranium availability program, and the exploration of other nuclear industry partnerships such as clean hydrogen production. But as we continue to deploy nuclear energy as a

solution to meet increasing energy demand and improve access our energy, decarbonize our economy and tackle climate change, we need to make progress on the back end of the fuel cycle. Our focus on developing a consent-based siting program reflects the Department's efforts to ensure that nuclear energy helps our nation transition toward a clean energy economy. There are, of course, other really important reasons to make progress as well. Inaction on this issue has cost the taxpayers nearly 9 billion in settlements and judgements. And, while spent nuclear fuel is stored safely all over the country, the communities that currently have our nation's spent nuclear fuel never agreed to host the material long term.

As you all know, management of the nation's spent nuclear fuel and high-level radioactive waste is the Department of Energy's responsibility and that includes the responsibility to develop a comprehensive, integrated waste management program. An integrated waste management system will include consolidated interim storage capacity, a permanent disposal pathway, and the transportation infrastructure needed to move to the spent nuclear fuel and high-level radioactive waste in a way that protects people and the environment. And in order to sustainably and responsibly manage spent nuclear fuel, we’re going need to site interim

storage and permanent disposal facilities. And, importantly, we'll need to identify willing and informed host communities to be our partners in that mission.

Right now, we're focused specifically on interim storage. In the Consolidated Appropriations Act of 2021, Congress provided the funds for the Department to move forward on establishing a Federal interim storage capability and with the final appropriations, we're able to begin pursuing activities related to the process for identifying an interim storage site. While new legislation would be required to actually build an interim storage facility, there are a while a range of activities DOE can pursue now. That includes collaborating with the public and potentially interested communities on the consent-based siting process, as well as moving forward under existing authority to identify an interim storage site.

So, here's some fun legalese. DOE believe that current law, including Subtitle C of Title 1 of the Nuclear Waste Policy Act, allows us to proceed with the consent-based siting process, negotiate an agreement with the host community, and design and seek the license for an interim storage facility. But further development and operations of an interim storage facility would be subject to the specific constraints in the law that would need to be addressed.

But once established, we expect that a consolidated interim storage capability would provide several really important advantages to an integrated waste management system. Those include the potential for earlier acceptance of spent nuclear fuel by the government, valuable research opportunities, added system flexibility and beginning to address those taxpayer liabilities. Importantly, we also hope to build trust and confidence with the public by demonstrating a new approach to siting which could be applied to other facilities needed as part of the integrated waste management system as well. We expect that any work that we do to develop the consent-based siting process for interim storage facilities would certainly apply to permanent disposal facilities in the future.

Speaking of demonstrating a new approach to siting, the Department is committed to a consent-based approach that enables broad participation and centers equity and environmental justice. Consent-based siting, as we see it, makes the needs of people and communities central to the siting process itself. Communities can elect to participate and work collaboratively through a series of steps and phases with the Department as the implementing organization. Each step and each phase helps a community determine whether or how hosting facilities is actually aligned to the community's

goals. And by its nature, a consent-based siting process must be flexible, adaptive and responsive to any community concerns. The phases and the steps in the consent-based siting process are intended really to serve as a guide, not a prescriptive set of instructions and we fully expect that the consent-based siting process will look really different in each community. But by working through the consent-based siting process collaboratively, we hope to build trust and a beneficial working relationship between DOE and any potential host communities. Potential outcomes from the siting process could include a negotiated consent agreement that would be defined be the community in collaboration with DOE, or a determination that after exploring the option, the community simply is not interested. We would really consider both to be successful outcomes based on the process. And we understand this is like a very daunting challenge, but we think that a consent-based approach is both the right thing to do and our best chance for success.

In December, as you know, we issued a request for information on using a consent-based siting process specifically to identify sites to store the nation's spent nuclear fuel. And, just as a brief reminder, we asked for feedback on a range of topics that included the consent-based siting process itself, removing barriers to meaningful

participation, especially for groups and communities who have not historically been well represented in these conversations and interim storage as a component of the nation's waste management system.

The last time I checked, which was yesterday, we had received about 125 responses. I did see a number more come in today so, I think it’s a little bit higher, but I haven’t verified sort of the -- we occasionally getting a phishing attempt here and there, so I haven’t validated whether they’re are true responses to the RFI or not. But we’re expecting more responses to come in over the next couple of days, and as a reminder, the RFI comment period closes on Friday. So, really soon.

At the end of the comment period, we’ll be shifting to analyzing the feedback. But already we have identified a few themes. And I should emphasize that the comment period is not over, so this is a very high level and very incomplete preview of what we have seen so far. But, just to share, we have heard some concerns about how long interim storage will last as well as the legality of interim storage under the Nuclear Waste Policy Act in the absence of a repository. We’ve also received comments related to developing a fair process including the need to build trust and have participation from a diverse set of stakeholders. We’ve heard

comments about determining who will be authorized to consent and the key relationship between local, state, and federal governments. We've also heard some suggestions regarding what resources communities will need for informed consent, including funding for citizen input panels and hiring trusted experts to conduct in-depth evaluations. And we have heard concerns about transportation and safety. And, further, we've received comments regarding social equity and the fair distribution of outcomes.

We plan to use the feedback we receive from the request for information to develop a federal interim storage program that uses a consent-based siting process to work with willing host communities. And while this RFI was specifically focused on interim storage facilities for spent nuclear fuel, we certainly expect that what we learn from the RFI, as I mentioned, as well as the next steps with consent-based siting, will apply to siting permanent disposal facilities in the future, and potentially to siting efforts for other technologies or place-based initiatives outside of the nuclear space.

I want to emphasize that we're not starting from scratch. In 2015, the Department began developing a consent-based process for siting storage or disposal facilities collaboratively with members of the public, communities,

stakeholders, and governments at the tribal, state, and local levels. As part of this initiative, we issued an invitation for public comment and conducted a series of public meetings across the country to seek feedback and inform future efforts. Based on that feedback, as well as the findings of several expert groups, we published, we developed and published the *Draft Consent-Based Siting Process for Consolidated Storage and Disposal Facilities for Spent Nuclear Fuel and High-Level Radioactive Waste*. In January of 2017, since that title doesn't exactly roll off the tongue, we mostly refer to it as the draft consent-based siting process. As I mentioned, the draft process also incorporated the recommendations of key expert groups. That included, of course, the recommendations of the Board as well as those of the Blue Ribbon Commission on America’s Nuclear Future and the National Academy of Sciences, among others. Further, the draft consent-based siting process was heavily influenced by practices from international experiences as well as other complex siting efforts. Throughout the draft consent-based siting process, I'm sorry, the development of the draft consent-based siting process, we had national lab experts who were analyzing experiences in other countries, we engaged really closely with the Nuclear Waste Management Organization in Canada. We employed program consultants with key experience in international and domestic

programs. We engaged experts in the siting of nuclear technologies and other controversial facilities including inviting them as speakers and panelists at our public engagement events. And we conducted extensive literature reviews and incorporated the lessons learned from other organizations.

All that is to say that there was a great deal of engagement, both domestically and internationally as we developed the consent-based siting process and we're expanding on that work now by continuing our engagement with the Nuclear Waste Management Organization, expand our team of experts, specifically to include social scientists who've had experiences in siting international and domestic facilities and expanding on those literature reviews.

We expect to continue to incorporate lessons learned from domestic and international experiences. That's going to include reviewing siting-relating documents from Sweden, Finland, Canada, Spain, and other nation's siting programs to analyze the key elements, best-practices and lessons learned from those efforts. We also really hope to increase our participation in the various multilateral international organizations and working groups related to those that are focused on spent nuclear fuel management but, also those focused on public participation and stakeholder engagement on

nuclear energy. In my opinion, those organizations provide really important opportunities to share information and best practices and we expect that to be really beneficial to our efforts.

But, pulling us back to the drafting consent-based siting process which you see up there on the screen, after incorporating public feedback and the recommendations of expert groups domestically and internationally, the Department issued its draft consent-based siting process for public comment. Perhaps due to the timing of the publication or the shift in program priorities right after we released the document, which meant we weren't really able to do much outreach on the document itself. We didn't receive as many comments as we'd hoped, which is why you see in our RFI some questions specifically about the consent-based siting process -- or the draft consent-based siting process to give people another opportunity to weigh in. At the time, when we released the draft document for public comment, we received 45 pieces of correspondence, 10 of which were duplicates and five of which contained no comments on the process.

Our team at the time processed the 30 remaining pieces of correspondence and identified several themes. At a very high level, we heard comments on the need for a national strategy, new legislation, or organizational changes. We also

heard about the importance of public engagement, including early on the consent-based siting process, as well as the importance of early, frequent, and ongoing communications. We heard about the lack of trust and confidence in DOE based on past engagements. We heard concerns about transportation safety, on the role of consent with transportation, and many commenters provided feedback or requested further information on the nature of consent and who could or should provide consent for siting a facility. Some commenters also discussed issues specific to the unique status of tribes and they provided really helpful feedback on elements of the consent-based siting process that could be updated to reflect tribal concerns. Some commented on environmental justice and suggested that environmental justice should be expanded upon in the siting criteria. Some commenters expressed concerns about access to financing and funds throughout the lifecycle of a facility and some communities requested additional information early in the process in order to assess consent-based siting and potential benefits. I should note that a longer summary of these comments, as well as the comments in their entirety, can be found at our website, that's energy.gov/consentbasedsiting.

And, as we begin to process and analyze the feedback, we received through the RFI, which again closes on

Friday, we're simultaneously performing analysis on the comments to the 2017 draft consent-based siting process. So, we expect to analyze those kind of in tandem. Some stakeholders have responded either, you know, amending slightly or reaffirming the comments that they provided earlier which is helpful to us to know if there has been a change in sentiment, but we are analyzing them together so we should be able to factor both of them into our future planning.

We're taking the feedback that we receive through the RFI and public comments on the draft consent-based siting process really seriously. And we're using that feedback to inform some of our next steps. In the near term, we're going to be hard at work analyzing the responses to the RFI, updating the draft consent-based siting process from 2017, clarifying our broader strategy for an integrative waste management system, and preparing a funding opportunity for interested groups later this year.

We're also developing public participation and engagement plans to support each of those activities. And part of our public participation and engagement planning includes thinking about the best ways to share information. That takes a lot of forms but something I want to highlight today, given the presentations you have just seen from Robby

Joseph and Erica and also given, Dr. Bahr your very poignant question, and Rob Howard's helpful answer, but as we develop these technical tools, we're also thinking about ways to use them to enable effective participation and informed decision making. Our systems and transportation analysis tools can provide quantitative information to stakeholders that could help them explore the potential implications associated with hosting a spent nuclear fuel management facility, either an interim storage facility or later a permanent disposal facility. And as we begin to work with different groups and communities and once, we're little bit further down in the consent-based siting process, tools like NGSAM and START can be used to explore a range of questions as we're talking to different groups and communities.

For some examples, it could be helpful to explore how many shipments could take place in any given period, what effect would a shipment, a specific shipment rate have on a facility size, continued construction or direct employment at that facility. Or how could a facility size construction and direct employment, in turn, influence the local economy, housing demand, local traffic and other factors that a community determines to be important to community wellbeing. And as Rob mentioned, it's really important that we engage with stakeholders and different groups to tell us what would

be useful in using those tools because we don't pretend to know what every community is going to find useful, relevant or helpful to the decision-making process.

And, we do have some work to make those tools a little bit accessible and digestible for them to be of the most value as we work through that process. We do hope to work with stakeholders to improve those tools and explore those questions that are most meaningful to different groups and communities. And make sure we're developing resources in way that actually helps us to share the information effectively.

As I mentioned, we're committed to building public participation into our decision making and that means we are gonna need to be thoughtful and open in the ways we share information. With that in mind, I just want to emphasize that while the RFI comment period closes on Friday, this is just a first step in our public engagement. There are going to be many more opportunities to weigh in our plans as well as the consent-based siting process itself. Again, our goal is to be adaptive in our approach and open and transparent in our planning, decision-making, and our communications.

As we pursue these next steps that you see up there on the screen, we're also doing some organizational planning to support interim storage consent-based siting and a

comprehensive waste management program. This includes thinking about how to align the technical and social elements of our program. As you have no doubt noticed over the past two days, I have some really smart technical colleagues and the work that they do to advance R&D on disposal, storage, transportation and the integrated waste management system is incredibly important to our efforts to develop a solution for managing the nation's spent nuclear fuel and high-level radioactive waste. As we move forward, we are going to need to identify willing and informed host communities to be our partners in this mission and, as I mentioned before, we'll need to build public participation into the siting process and programmatic decision making. Further, we need to do some work to center issues of equity and environmental justice in the consent-based siting process itself, as well as the way we implement the waste management system as a whole. Our goal is to foster a sustainable partnership both with potential host communities as we move further in the consent-based siting process, but also from the public and, in general -- the public in general and groups of stakeholders who have followed the government's previous attempts at siting waste management facilities. That history and the stalemate on the nation's spent nuclear fuel means that we're starting from a position of a trust deficit with the public. It's our job, and it's a

really tough one, to carefully and thoughtfully build that trust back. That takes time. It requires slow, deliberate planning. It requires openness and transparency, and it requires us to think differently than we're used to as an organization.

We see that hinging on three skill sets within our program. First, communications expertise to tell our story effectively and openly and engage meaningfully with the public. Second, social science and behavioral psychology expertise to shape our public participation planning. And third, technical creditability which starts with those smart colleagues I mentioned, as well as the years of R&D work that they've already done to inform our planning and the recommendations of expert groups such as yourselves.

But, as we work towards progress on this issue, we hope you will continue to engage with us and allows us to benefit from your expertise. By prioritizing communities and people, we really think we can find a solution to the decades long stalemate on managing the nations spent nuclear fuel and keep driving toward the clean energy future we all need. So, with that, I really want to thank you for the opportunity to speak with you again and I'll attempt to answer any questions or maybe toss them to my colleagues.

BAHR: Okay. Thank you, Alisa. As you know, consent-based

siting has been something that the Board has been keenly interested in for a long time and I see Steve Becker's hand up, so I will recognize him to start the questioning.

BECKER: Thanks Jean. And thank you, Alisa for an interesting and informative update. As we said in our January 2022 letter, the Board commends DOE for starting this new effort on consent-based siting and for recognizing the crucial importance of effective risk communication, full public engagement, and inclusiveness in the siting process. And we certainly appreciate the commitment to transparency, openness and effectively engaging all stakeholders including historically underrepresented communities in any consent-based siting process.

For the current RFI information gathering exercise where responses are due by the end of this week, if I heard you correctly, I believe you said that so far about 125 responses have been received, and I recall that the last time around in the 2016-2017 exercise, DOE received about 450 unique pieces of correspondence. Why do you think the level of response has been so much lower this time around?

TRUNZO: That’s a great question. I mean, we had 450 unique pieces of correspondence, that sounds right to me although I’d have to confirm what the number actually was. We had that in mind to set expectations for ourselves internally.

I do think that – I think we needed to ask questions again through the RFI because time had passed and, you know, our focus has shifted back and forth over time. I think it was right to ask the public to submit input again. But I also recognize that asking people to respond on the same topic again which, you know, people have weighed in over the years many times and that's a burden. There are resources required to respond to things like RFIs and, you know, where it's labor resources, it takes time, it takes focus. So, I think part of it is, people have weighed in before and they don't necessarily want to weigh in again.

So, I think that's a real concern, but we're factoring in the input we received through the 2017 or the invitation for public comment on the 2017 draft process as well as the public feedback that we received through the various outreach that we did prior to developing the draft process. Hopefully that will give us a bigger lens and comprehensive view of the different points. But I also mentioned this is just one step in building public participation into our process. The nature of issuing an RFI limits your audience because not everybody combs the Federal Register, that's fair. So, we need to think about ways to continue the conversation and to parcel out pieces of the conversation so that we're reaching more people.

BECKER: That leads to, if I may, a follow up question about reaching out and engaging people even early on in information gathering processes. So, it's good that DOE has identified environmental justice as one of the general principles guiding a consent-based process. I'm wondering how DOE has worked to tap perspectives from diverse populations and from organizations representing minority communities and underserved populations in the current information gathering processes that are underway. To what extent do you think you've succeeded in getting input from diverse populations.

TRUNZO: We've tried to expand the audience on this issue. And we've leveraged some of the, in our roll out for the RFI, we leveraged some of the sort of contact lists and suggestions of other people in DOE that are working in this space including the Office of Diversity and Economic Impact, I think I'm getting their acronym wrong, but they've been extremely helpful. So, we've tried to expand the conversation, but I don't think we have done a good enough job. And 90 days truly is not enough time although that's extremely long for the government RFI process. It's very long. It's not enough time to do work like that. That's something we have to do more of in the future and we need to get more of a perspective into our planning. We're balancing the urgency to get to some of the next steps with providing

enough time to do outreach to new people and new audiences. Partly, the funding opportunity I mentioned we plan to issue next year, we want to use that as a way to provide resources for people to engage on this issue because as I mentioned, there is a barrier to participation if you don't have the labor and time, don't have the resources. If you don't have sort of a business development team that's looking through the Federal Register and maybe responding to RFIs and things like that, it's really hard to engage in this conversation. I think the Federal Government, that DOE needs to offset some of that and provide resources for people to actually begin the process of engaging in the conversation and participating.

BECKER: I don't want to hog the questions. There are lots and lots of resources currently out there in the public health sciences and other fields on ways of doing focused outreach. But I'll hold off for now on asking further questions so that I can give me colleagues an opportunity to contribute to discussion. But thank you.

TRUNZO: Just to touch on that for just a moment. That's part of what we do want to know through the RFI is, where should we be looking? What's a good example? Where can we do better and who can you point us to tell us, look they did a better job than you so follow their example.

BAHR: Okay, thanks Alisa.

BECKER: Fair enough. Maybe another follow-up question and discussion later on, but I don't want to hog the questions so, turn it over to Jean again. Thank you

BAHR: Okay. Thanks Steve. I see Tissa's hand up.

ILLANGASEKARE: Thank you for your talk. I'm also interested in the issue of environmental justice you mentioned and the international. So, the question is, this environment justice issue, of course we are quite aware of this issue in here, but you also mentioned the international lessons. So, are there any examples, international you can learn, or you can, this issue exists in other places based on your interaction with international partners.

TRUNZO: That's a really good question. The primary thing that comes to mind for me is the work of the Nuclear Waste Management Organization with their First Nation communities and outreach that they've done, I think could be helpful in guiding our thinking. That's what jumps to mind but I'm sure there's more to be learned in those areas and part of our emphasis on bringing social scientists into our team is because we think we need other people to be looking at that. We need social scientists with that understanding that have that lens, and that know sort of where we should look and be pointing to get that expertise would be really helpful. And then also, further down the road, social scientists have more

of a lens of doing field work to say, if we're working with a particular community to sort of get a richer understanding of what those things mean to a particular community, especially with environmental justice. I mean the way we talk about benefits and sharing of benefits or sharing of risks, I mean from DOE's perspective, we might not even understand what a benefit or a risk is to a particular community. It's very complicated – it's a tough question and that's why we're sort of bringing this expertise into our team to help us do a good job of this.

ILLANGASEKARE: At least in the climate change, which I'm familiar with, environmental justice, may not be correct word, but there are a lot of countries which are affected by poverty that are a lot of cultural issues where the social scientists are studying the effect of climate change on the unique cultures like island nations, for example. I was thinking in terms of that -- even though the U.S.A. environmental justice issue may have a different dimension, maybe a lot of the social scientist, this must be knowing about helping the country deal with these types of issues. The main problem in my experience coming from that part of the world originally, is that the people have to have the education to make this type of decision. You may not know -- you may not be informed enough to make that type of decision whether it's good for you

or not. So, this is a communication issue also in this country, at least in some of the developing countries I'm familiar with. The issue of communicating to people who are affected that this is something -- this is not something you should look at, this is something you should be looking at when you are considering the long-term impact of things, you're going to control your lives.

TRUNZO: Yeah, that's absolutely right. I try to remember always that everyone, all of us as individuals, no one can be an expert on everything. We don't have time. A lot of the responsibility for how we share information and how we do that communication, that's on us. We need to do a good job because if we can't demonstrate the value and if we can't engage in those conversations meaningfully with different communities, then, first of all, we won't be able to succeed and second of all, we haven't done our job.

ILLANGASEKARE: Thank you very much.

BAHR: Thanks, Tissa. Alisa, where are you getting your social science expertise? Are these consultants that you're hiring? Are these people from academia? Are you adding new DOE staff? Are they coming from national labs?

TRUNZO: Yes, to all. We're hungry for advice. We're hungry for expertise. We've brought some social scientist expertise into the national lab team we're working with very,

very closely. We hope to be able to hire additional positions in the future at the federal level. And we – I can't talk too much about it because the funding opportunity is closed, but the solicitation is open, but I think as I mentioned to Board last time, we did have an opportunity on consent-based siting, an integrated research project on consent-based siting.

BAHR: Thanks. I had another question, you mentioned that some of the concerns that have been raised in the past include, who is it that gets to offer consent and thinking about interim storage facilities and even repositories, there's sort of a broad geographic expanse that people who could be concerned that includes the communities right around the sites themselves but also the communities, there may be some places where you have limited number of transportation corridors, for example, and so the communities along those transportation corridors also have stakes in that. Have you thought about what's the -- what's the scope of who gets to -- geographic scope of who gets to offer consent?

TRUNZO: We'll, we've certainly thought about it. I think we've thought about it a lot. It's a very, very difficult question to answer. Some – I know the feedback through this RFI and previous engagements, many people have felt very strongly that we should define that early on. The thinking on our team is really that we can't pretend to know what that

will look like. So, as I mentioned, the consent-based siting process is going to look different in each community. So, we don't want to define it because we think that a community should define that in collaboration with the Department through the consent-based siting process. If sort of everybody in a community says, heck no we don't want this, that makes it easy. That makes it clear. The Department then knows there's not consent there. But what we're more likely to see is that some people think it's a good idea and some people don't think it's a good idea. And then, what does that mean? We have to define that through the consent-based siting process with the community and we think it should be a community's ultimate decision to say whether it's sufficient for a particular official to vote on that issue, for there to be a referendum. We have ideas of what there could be and, again, that's just at the very local level.

So then, where do you tie in the state? Obviously at some point the state is going to have to agree or not oppose. But we want to leave those definitions to the community. I think we'll have to think carefully about it because we have seen feedback from stakeholders that they want more of a definition around what it means to consent. But we're balancing that with the knowledge that we don't know what that means to a particular community until we talk to

them.

BAHR: Okay. Thanks. Steve Becker has his hand up again.

BECKER: Just to follow up briefly on the question from Tissa. So again, I think it's great that you will be looking to social science expertise to augment the effort. But I again want to suggest that you go more broadly than the social sciences that there's a lot of knowledge and expertise on risk communication, public engagement and inclusiveness found certainly in behavioral science and public health sciences. On the behavioral science side of the house, there is a great deal to be learned that is relevant and related to people's different perceptions of risk and what different populations think of as constituting the environment, which is very relevant to any kind of siting process. And then in the public health sciences there's very extensive experience with engaging harder to reach groups because ultimately the success or failure of any health program depends on being able to identify and effectively reach and effectively engage people. There is a direct link between all of those practice-based experiences and then a very large body of literature and research based on that, that I would suggest could be of significant benefit. There is much more than that I could say but I leave it there so as to not monopolize the conversation.

TRUNZO: Yeah, I think I mentioned -- I hope I mentioned

it as I ran through my remarks, but I failed emphasize it when you asked your questions before, we are also bringing behavioral scientists and experts, behavioral expertise, into our team. I think your point is a really good one that, you know, in the health world this is super relevant in at least expanding the conversation and making sure that your message is getting to different groups. That's a helpful suggestion.

BECKER: That is definitely the place you will find the largest body of relevant research on engaging hard to reach populations, diverse populations, underserved communities, including by the way, strategies for focused risk communication that are much more culturally sensitive and appropriate if you will. So, it is very important to take a broad-brush approach in looking at the science and looking at the research.

BAHR: Okay. Thanks Steve. Dan Ogg has had his hand up for a little while.

OGG: Thanks, Alisa, for your presentation. My question is quite a bit different. It’s more of a nuts-and-bolts kind of question. You’re doing a lot of work – it looks like you have a quite a bit of work ahead of you going through all the comments, working on the funding opportunity and all that kind of stuff. So, I just wanted to know what kind of support you’re getting, how integrated you are within the DOE office.

Are you in the integrated waste management group and how many feds and contractors do you have working with you on this effort?

TRUNZO: That's a tough question to answer. So, I'm actually, I work for the front office I work for NE-1 directly as a Strategic Communications Specialist, but I've been like -- I want to say 100 percent dedicated but what I really mean is maybe 125 percent dedicated to consent-based siting because we have been busy. And as far as the team, it's a team of federal employees as well as the national lab system, we're working really really closely together. And, obviously, integrating really closely and leaning super heavily on my colleagues in NE-8 and the integrated waste management program in particular. But, as far as the number of people, I don't even know how to answer that. Rob, can you give an estimate of how many of us -- I feel like I basically weekly beg you for somebody else's time on something.

HOWARD: Yeah, I would say directly in the consent-based siting program area, it's -- we have got over 40 folks working on it, not all full time, but on that order. It's a significant part of the overall NE-8 and NE-82 budget. We've got a -- it's a separate control account, just the same as transportation. The other thing I would say is that we really work hard on making sure that the entire team is in tune with

this approach, consent-based siting approach. So, Alisa may beg to differ, but I tell everybody this is our top priority. And typically, when she asks for a resource, she gets it, or I hear about it.

OGG: And Alisa, do you have any other full time federal employees working with you on this?

TRUNZO: Yeah, so, obviously we pull a lot from different places. We beg Erica's time quite frequently or Jack’s time quite frequently. We also have another employee that we brought in sort of recently that’s focused entirely on consent-based siting, and we have -- we may or may not have stolen a very important person from PNNL to come on detail to work on consent-based siting fulltime. So, Rob’s probably mad at me. What else is new?

OGG: Okay, I just want to get an idea of the team that you’re building and the efforts that is being spent.

TRUNZO: I’m sensitive to the fact I probably can't talk too much about hiring plans, but we do intend to be hire more people to work in this space.

HOWARD: And I’ll just add that DOE’s emphasized to the lab staff we have to beef up our areas -- in fact at PNNL, we’ve created, just this year, an entire new team related to environmental justice and stakeholder engagement, where we picked up some of the social scientists and behavioral

scientists to support Trunzo. So, it's important. We're behind the curve on staff support in this area. As you know, it's hard to hire folks right now in this country for anything. So, but we're trying.

OGG: Okay. Thank you.

HOWARD: If you get resumes, send them my way.

BAHR: Okay. Thanks Dan. Paul Turinsky has his hand up.

TURINSKY: I'm not sure if you can answer these questions, but that never stops me from asking them. The RFI, the public has an opportunity to engage with you folks in writing in this case. They will have an opportunity to engage after you go out and formally enter into a process of identifying communities with an interest in hosting a consolidated spent fuel site. How does the public engage with you in that interim period?

TRUNZO: That's a really good question because we don't -- what we don't want to do is sort of go radio silent. We're going to have to balance, I think – there is a perfect follow-on question to the previous question we have to balance our labor resources as we move towards those all of those next steps I had laid out. We do want to make sure at the very least, we don't remain silent. So, a lot of what we're doing right now is planning for what, you know information we need to put out in the meantime. We're working really carefully to

develop a communications plan and prioritize the particular types of information we need to put out first. We're developing a visual brand and tone that we want to go forward with. We'll be sharing a bunch of information in the meantime, in between now and the funding opportunity, as well as after that time because once the funding opportunity goes out, we want to get the word out and tell people that this is available and start that conversation. We don't want crickets once we've put that out there. We have to tell people that it's there, that this is a conversation that we're having, and this is a narrative that everyone in the country really has a stake in, and that, yeah, we need to continue that work.

TURINSKY: When do you think the funding opportunity would go out?

TRUNZO: Later this year? I think that's all I can say.

TURINSKY: Okay. But it's going to be in this fiscal year? Or calendar year?

TRUNZO: I'm not 100 percent sure. It's honestly, it will be based on the review process. We've done a ton of work and we are shaping what we think that will look like and we are hoping to get it out as quickly as we can, but it is going to go through a lengthy, lengthy review process within the department, I'm sure.

TURINSKY: As you well know, two-way communication is a

lot better than one way.

TRUNZO: Absolutely.

TURINSKY: You have one way communication so far.

TRUNZO: Absolutely. Well, the RFI is one small way of getting input back into us. But certainly, we always need to be thinking about the actual sharing both ways of information.

TURINSKY: Yeah, because people have to feel that you're hearing them and acting on what you're hearing. Okay. Thank you.

BAHR: I see Lee Peddicord's hand up.

PEDDICORD: Thank you, Jean. Thank you, Alisa, always fascinating to hear you're doing. It's so important. It occurs to me that if we look at the four models or the four places where things are kind of moving forward on waste things, that there's two quite different paradigms at work in these places and unfortunately you don't get to pick which paradigm you might explore.

TRUNZO: Yeah, that would be nice.

PEDDICORD: In consent-based siting. So, the ones I'm thinking of in Scandinavian countries of Sweden and Finland. They've made the choice on both interim storage and final repositories to go to communities where they have nuclear power already and a fairly high level of acceptance.

As we know, in Sweden, they did the competition

between two communities and that brought to a successful conclusion. Finland kind of just picked one but it worked. But then you have France and Switzerland where they're going to more, I call green field sites or locations where there's not anything nuclear in those communities particularly for the repository. Any rate, it seems to me the stakeholder engagement would be quite different for these two different paradigms. And, as I say, we don't yet know in the U.S. which direction we're going to go although it kind of looks like towards option B. So, as you are kind of building your thought processes, it would seem to me to be interesting, at least, to look at these and glean the lessons learned. You've talked about that and so on, and the like, you mentioned what is going on in Canada, all good stuff. But it would seem to be useful to try to peel back the onion in the different ways and particularly the two paradigms and, probably, which one we're going to have to follow in the U.S. So, a thought is all.

TRUNZO: That's a really interesting idea. And yeah, I mean as you mentioned, we don't have any particular sites in mind. We're looking for communities to drive the process, but we're thinking a little bit about what -- how to handle communities that might raise their hand in the future that are, you know, sort of at different -- I don't know. Not at

different phases in the process but at different readiness or, you know, willingness to engage at different levels in a conversation with us. We are trying to factor that into our planning, especially with the funding opportunity that it can support a range of different levels of interest, levels of background or history on this issue. You're right, it's different for everyone.

PEDDICORD: Yeah, and can you do some of these in that process of "what ifs," with these communities as opposed to your stepping forward, holding up your hand. We're going to have some time to get this done and so, going through an exercise with a community and see what the dynamics are probably understand them a lot, pretty well and having the community engagement in this might be interesting. I'm not sure.

TRUNZO: Yeah, so even when we issue the funding opportunity, we're not asking someone to volunteer as a host. It's an interest in learning more and working through those things and we really, one of the primary goals we have behind that is anybody that participates in our funding opportunity gets something out it whether they decide to continue talking with us or not. I think that is long the lines of what you're thinking. There's community engagement and work that can be done that looks different for every community but ultimately

is just about a conversation with the Department.

PEDDICORD: That's great. Good luck. This was great.

TRUNZO: Thank you.

PEDDICORD: All the best to you.

BAHR: I see Bret Leslie's hand up. Bret?

LESLIE: Thank you Jean. And thank you Alissa, Alisa, sorry. So, you had mentioned something early on in the presentation that you have the statutory authority under the Nuclear Waste Policy Act to move forward on consent-based siting. So, in a way, if that’s true, consent-based siting is defined the Nuclear Waste Policy Act by certain stipulations. In other words, how affected units of local government, how regulation occurs. So, these are things that were addressed differently in different countries, and I will give you an example of Canada. While you’ve talked about looking at how the programs were implemented, and that’s fair because you’re the implementer, probably more importantly is to ask how the federal government got to the point where the implementer was implementing a consent-based siting program. The reason I say that is because in this consent, it is federal, state, tribal, local, but DOE is not federal. It is a part of it. But it’s about trust in the government itself and how the government defines what that process could be. I guess – I don’t know if

there is an answer, but have you looked at the factors that other countries used in consent-based siting and do those capabilities exist under the Nuclear Waste Policy Act because it might be that people are going to ask for things that you can't deliver.

TRUNZO: Yeah, I think that's a fair assumption. And, the Nuclear Waste Policy Act, while it does define some elements of it. I don't think -- well I don't want to get in trouble with any lawyers, but I don't think it means you can't do anything beyond that, necessarily. And, because we're – we are only able to go like under existing law to go through the consent-based siting process itself, identify a site and maybe negotiate an agreement and we expect that legislative changes would need to happen after at that point. I think the – our goal is to work something out, and to work out a process that will work that we think is the right approach, that we think is the right guess. And then, see what needs to be done at that point.

LESLIE: Okay. Thank you. That is helpful. Another question is, we have examples in the U.S. where attempts to find a facility have been thwarted by non-consent or incomplete consent across the federal government, for instance, a private fuel storage facility was licensed by NRC, but the federal government was not aligned. In other words,

parts of it wanted it to move forward. Other parts seemed to cause problems. And so, I think that's an example, again where we have to look at what the existing framework is and ask ourselves, seriously, you know, is this the right framework that allows consent of all the parties to be possible?

TRUNZO: Uh-huh. Yeah. I think that's right and that's a good way to think of it. I'm not sure I can add anything else.

LESLIE: No. That's fair. Thank you.

BAHR: I still see Paul and Lee's hands up. I don't know if those are additional questions or if those are legacy issues. Paul, did you want to ask another question? No. I see Andy has his hand up, so we'll go to him.

JUNG: Yes, I think this may be silly questions. I mean because you indicate that you have 125 responses and, Steve mentioned that relatively is a very small number responses compared to previous one. In the meantime, during the process and your analysis, is there any potential second round of RFI possibly?

TRUNZO: We haven't talked internally, really about issuing another RFI. I expect at some point in the future we might issue an RFI on a different topic. But, if you're asking if we're going to reissue this particular RFI, we don't

plan to at this point, although we may look at ways to parcel out some of the things, we were hoping to receive feedback on from this RFI that we did not necessarily get like the breadth of response that we wanted to. We might look at ways to just pull a piece of it out and see if we can find ways to get more input on a particular -- maybe not particular questions, but particular areas that we were hoping to get feedback on. We're still working that out and I also -- I think we don't want to presume, you know, I mean there's only two days left in the comment period. But we do usually get quite a few at the very tail end of the comment period. We haven't really had a chance to really to dive into that and see which areas we need more input on yet.

JUNG: Okay. That's very helpful. So, you still have some potential for another RFI for the specific or any additional topics.

TRUNZO: Yeah, absolutely.

JUNG: Thank you.

TRUNZO: I do just want – maybe I'll humble brag a little bit. Someone told me that the average response to RFIs from the government is 20 responses to 125 is still looking pretty good.

JUNG: Okay.

BAHR: Alisa, my recollection is the last time around you

– prior to issuing your draft guidance, you had a series of public meetings as well. And were those held prior to an RFI request? I guess where I'm going is, did those public meetings actually generate additional responses to the RFI beyond what you would get from simply a Federal Register posting?

TRUNZO: Yeah, it's possible. We issued -- so we issued an invitation for public comment first. And then we held public meetings. So, it's possible that we generated more responses because of that process and the work that we did with those public meetings. Of course, you know, it was not -- there wasn't a global pandemic at that time. Travel and hosting meetings in person was possible. But I think also, you know, so we did that and then we used that input to inform the draft consent-based siting process or to develop the draft consent-based siting process which we then issued for public comment which I mentioned earlier. But I really do think there is a point where the public feels a burden in responding to the same subject area again and again. So, I think we need to be sensitive to that and just respectful that people don't have time to weigh in again and again through the RFI process. As important as it's in the government, it's only one tool. I think we need to do some thinking about how to have other ways to have effective conversations with

people.

BAHR: When you did have those public meetings the last time around, how did you choose what communities to target and how did you publicize the public meetings to get people to come to them?

TRUNZO: I hate to answer this question because I feel like no one believes to me when I say it was kind of random. People think the communities were targeted we just were trying to do geographic dispersion, sort of like a nice dispersion across the United States and ultimately, the leadership told us with where to go, so we went. Hopefully, I mean, we certainly were able to talk to a lot of people, which was fantastic. I know that we publicized them with press releases and targeted media outreach. We put them on our website. We sent notifications to stakeholders that we knew would be interested or who had weighed in, in the past. We did – what else did we do? I think we did radio spots a couple of places. You're making me think back to a long time ago when I was lowly communications consultant to the program. Rob, any ideas.

HOWARD: Yeah, we did all of those things. We did social media, press releases of course, newspaper ads, word of mouth. We contacted universities to let them know that we were going to be in the areas. And I would say to the question of, how

did we target the areas. Yeah, we were told, but if you look at the places we went, there was some care given that we went to places like Boston, right? And downtown Boston and downtown Chicago. Places where we weren't physically intending to site any kind of facility. We didn't want to create the air of this notion of targeting. The balance is, do you get the right mix of people when go to cities and you don't go to rural areas. It's tough. There's no right or good answer for how to divide up those areas. Thanks for your help.

BAHR: Okay, thanks. Are there any more questions? We have time for about one more question Steve has his hand up again.

BECKER: You'll be happy, in fact this is not a question. It's a comment. I think, Alisa, you used the word daunting to describe this process. It's obviously very important work. I don't know how many people appreciate just how complex and how challenging it's. You are doing some things that involve a lot of heavy lifting and we certainly appreciate the importance of that work. It is very challenging and very important work, so thank you.

TRUNZO: Oh man. Now I have the warm fuzzies.

BAHR: Thank you, Alisa. We very much look forward to seeing what you come up with when you have sifted through the

comments that you have received, and this will clearly be an ongoing process and something that the Board is keenly interested in. So, thanks for coming to us today with this preliminary version and we'll look forward to hear more about it as it develops.

TRUNZO: Thank you so much.

BAHR: Yeah. The final part of our meeting today are the public comments and Bret Leslie will be reading both comments coming in today during the meeting as well as ones coming in from yesterday since we weren't able to get to them. Just as a reminder we welcome these comments. They will be part of the public record of the meeting on our website. We won't be attempting to provide any responses to them.

LESLIE: Thank you, Jean. And, hopefully, today you can hear me. And we have about 20 comments spread over the two days. I'll start with the comments from yesterday first. Let me scroll back up. In giving these comments, I will be identifying the name and any affiliation and just reading the comments

Our first comment came in early in the day from Kalene Walker. She said, "regarding the High Burnup Demo Cask Project - when will a hot cell be ready to receive the high burnup fuel for analysis, and where will it be located?"

The next comment came in right at the end of Tim

Gunter’s presentation from Andrew Kadak who said, “why don't you design an overpack that handles DPCs of all types?”

Next, we had a comment that came in just as Laura Price started her presentation on criticality. That comment was from Donna Gilmore from SanOnofreSafety.org and her comment is, “is the DOE and NWTRB aware the boron metal in the canisters is not credited by the NRC to prevent criticality in storage nor in transport? I have technical references if needed at SanOnofreSafety.org.”

Also, during Laura Price's presentation, Andrew Kadak had another comment. His comment is, “how different are your models from those used in the Yucca Mountain analysis?”

Another comment came in from Donna Gilmore, SanOnofreSafety.org. “What is the thickness of proposed 316SS canisters? Any references for crack initiation and crack growth rate of canisters?”

Also, during Laura's presentation yesterday. Diane D’Arrigo from NIRS or NIRS, “could someone please describe for a layperson what happens when there is a criticality in the repository and how neighboring containers might be affected? Thank you.”

Later in Brady Hanson and Laura Price's presentation, we got another comment from Andrew Kadak, “amazed at the precision of the analysis!”

Sven Bader from Orano Federal Services comment is, “for Laura Price’s cladding degradation modeling, unclear if the fuel failure models include slumping of the fuel due to phenomena such spring pressure (short term), gravity (long term), cladding strength due to radiation damage (or is it radiation hardening), et cetera.”

Sven Bader from Orano Federal Services had the following comment, “for Brady Hanson, in the cladding degradation modeling presentation, unclear if there’s an implicit assumption that the cladding is more susceptible to failure than the basket structure of the DPC, and if so, should industry find less robust basket materials for the DPC’s to ensure geometry change over disposal durations (or utilize more robust neutron absorbers)?”

Once we got into the storage and transportation presentations in the afternoon Michael Ford from healthphysics.com had the following comment. “Regarding aerosol releases: is the occurrence of aerosol release only informed by capture following mechanical fracture, or are there other scenarios that are more reflective of the actual environment that might be present where a failed fuel canister is breached due to CISCC and remains undetected in that state for a long period of time? Have any considerations for any pyrophoric reactions to occur over a period of days, weeks, or

months?”

Later during Charles Bryan and Rebecca Schaller’s presentation, Michael Ford from healthphysics.com had the following comment. “Suggestion for canister surface environment testing location: to consider a worst case/bounding environment, suggest siting at or near proposed HOLTEC CISF site which is surrounded by four salt playas and possesses nearby surface outcrops of the 25,000 square mile Salado formation which extends to West Texas and the ISP licensed CISF site.”

Those were the only comments that were submitted on March 1st. Moving on to today's comments.

Sven Bader, Orano Federal Services. “Sam Durbin, does the report you cite from Brady Hanson identify the constituents that make up the measured respirable particulates? For example, is it uranium, plutonium, et cetera?”

I apologize for this next one. I’ll have to pause several times. It’s very long.

Sven Bader, Orano Federal Services. “For Sam Durbin, to be clear if a through-wall crack occurs on a canister then for a radiological release to reach a member of the public, the following, near-simultaneous conditions need to occur: (1) one percent of fuel rods, around 100 rods, fail

(again, near-simultaneously) in a manner such that an airborne and respirable fraction of radioactive material needs to be released from these failed rods (so cracks along fuel meat of cladding); (2) this released material needs to not deplete (e.g. plate out on nearby surfaces when pressurized released from the failed fuel nor drop to gravity settling, which is about two hours maximum per your GOTHIC and MELCOR results); (3) sufficient pressure exists in the canister to sustain the drawing of the respirable particulate towards the breach and entrain other particulates that may have dropped out towards the breach; (4) the breach occurs at a location on the canister wall where the airborne and respirable particulate can probably reach the breach during the depressurization (which could occur rapidly depending on through-wall crack size); (5) the through wall crack does not get clogged by either larger particulate or accumulated particulate prior to the release point (noting there are larger non-respirable particulate release that can be airborne from the near simultaneous fuel rod failures); (6) the tortuosity of the through-wall crack will not result in additional deposition of the respirable particulate; and (7) the release point of the through-wall crack has sufficient environmental conditions to be dispersed to the boundary?”

Sven Bader, Orano Federal Services. “Robby Joseph,

seems like the obvious parameter/objective missing from your examples is the money savings or spent for the examined scenario. Does NGSAM perform economic analyses?"

We had another comment come in around the same time from Phil Klevorick, Clark County Nuclear Waste. "Regarding transportation model and rail specifically, how does the anticipated capacity and projected increase from the companies, impact availability for shipments and ultimately cost and other issues such as time for delivery?"

Now, the following comments all came in during the last presentation. Susan Leifer, Sierra Club. "Interested in knowing more about interim storage."

Dan Shrum. "Consent-based siting sounds good. My questions are: How will you weigh the needs and concerns of local versus regional versus state stakeholders? How long will the agreements be for? The Texas and New Mexico attempts have shown that there is support for a season, but that goes away with an election. If an interim facility is selected, how will the funding work out with DOE and will DOE accept the title? I am supportive of the concept, but skeptical of the implementation simply because, as I was told at a public meeting, "it doesn't matter if it's legal and that everyone else agrees, I don't consent and therefore it can't happen." To many people, consent means a hundred percent. This will

need to be addressed. I hope you're successful."

Andrew Kadak. "What lessons have you learned from past efforts at consent-based siting such as for the nuclear waste negotiator?"

John Buchser, Sierra Club, Rio Grande Chapter. "Good presentations both days and excellent questions from Board and staff."

John Buchser, Sierra Club. "Continue to accept and document consent related comments beyond Friday's deadline."

Michael J. Keegan, Don't Waste Michigan. "DOE has 'a crisis of legitimacy.' Please rename DOE to Department of Nuclear Weapons. That would be a good start. No Street Cred!"

Jean, I need to check the inbox to see if there are any more comments that came in. Jean there are no additional comments, so that is the totality of the public comments.

BAHR: Thank you Bret for reading that. Thanks again for all of the presenters for the last two days and thank you for the Board members and staff members for your questions and thanks to all of you who participated both as part of the presenters and also to those of you who have been watching virtually. And if there's any of this that you missed, it will be posted, the recording of today will be posted online in a few days on the Board's website which is www.nwtrb.gov. So, thank you all, and the meeting is adjourned.