**THE U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL AND PREVENTION**

MINE SAFETY AND HEALTH RESEARCH ADVISORY COMMITTEE (MSHRAC)

COMMITTEE MEETING

May 6-7, 2019

The verbatim transcript of the

Meeting of the Mine Safety and Health Research
Advisory Committee (MSHRAC)

Meeting held on

May 6-7, 2019, 8:30 a.m.

C O N T E N T S

May 6-7, 2019

DISCUSSION
DR. KRAMER LUXBACHER

BREAK

INDUSTRIAL MINERALS MINING SECTOR—STATUS REPORT
MR. ROBERT GLENN

POWERED HAULAGE AND MACHINE SAFETY RESEARCH DISCUSSION AND PRIORITIZATION
MS. JENNICA BELLANCA AND DR. ART MILLER

ADJOURN

Tuesday, May 7, 2019

CURRENT AND FUTURE CONTROL TECHNOLOGIES TO ELIMINATE RESPIRABLE DUST
MR. JAY COLINET

FIELD-BASED RESPIRABLE CRYSTALLINE SILICA (RCS) MONITORING APPROACH
DR. EMANUELE CAUDA

TRANSLATION OF HAND-ARM VIBRATION TO THE HEARING CANAL
MR. WES DUBOSE

GROUND CONTROL CHALLENGES IN NEVADA WEAK ROCK
DR. SEAN WARREN

BREAK

BRIEF PROJECT UPDATES

EXAMINER AND HAZARD RECOGNITION UPDATE
DR. BRIANNA EITER

MITIGATING FIRE AND EXPLOSION HAZARDS OF LITHIUM-ION BATTERIES
MR. THOMAS DUBANIEWICZ

PREVENTING SLIPS, TRIPS, AND FALLS AT SURFACE SSG MINES
DR. MAHIYAR NASARWANJI

UPDATE ON BUILT-IN-PLACE REFUGE ALTERNATIVES
MR. DAVE YANTEK

H&S MANAGEMENT SYSTEMS THROUGH SAFETY CLIMATE
DR. EMILY HAAS

PUBLIC COMMENTS

WRAP-UP AND COMMITTEE DISCUSSION ON FUTURE AGENDA TOPICS AND DATES
DR. PRISCILLA NELSON

ADJOURN

P A R T I C I P A N T S
(alphabetically)

JEFFEREY BURGESS, MD—MEMBER
MELANIE CALHOUN—REPRESENTING WILLIAM FRANCART, MEMBER
DALE T. DRYSDALE—MEMBER
RICHARD FRAGASZY, PhD—MEMBER
KRAMER DAVIS LUXBACHER, PhD—MEMBER
THOMAS HARMAN—MEMBER
ROBERT HORN—MEMBER
JOHN HOWARD, MD—NIOSH DIRECTOR
AUBREY KEITH MILLER, MD—MEMBER
PRISCILLA NELSON, PhD—CHAIRPERSON
JEFFREY H. WELSH—DESIGNATED FEDERAL OFFICIAL
MICHAEL J. WRIGHT—MEMBER
KYLE ZIMMER—MEMBER

MR. KELLY BAILEY
MS. JENNICA BELLANCA
MR. LINK BOWERS
DR. EMANUELE CAUDA
MR. ANDREW CECALA
MS. MARIE CHOVANEC
MR. NICHOLAS CLARK
MR. JAY COLINET
MR. MONTY COOPER
DR. MARYANN D'ALESSANDRO
DR. PATRICK DEMPSEY
MR. THOMAS DUBANIEWICZ
MR. WES DUBOSE
MR. TOM DUFFY
DR. BRIANNA EITER
MR. MARK ELLIS
MR. ROHAN FERNANDO
MS. JOSIE GASKEY
MR. ED GREEN
DR. EMILY HAAS
MS. NOEMI HALL
MR. JOHN HOMER
DR. HONGWEI HSIAO
DR. DOUGLAS JOHNS

DR. JESSICA KOGEL
DR. A. SCOTT LANEY
DR. GEORGE LUXBACHER
DR. RJ MATETIC
DR. ART MILLER
DR. MAHIYAR NASARWANJI
MR. DREW POTTS
MR. MIGUEL REYES
MR. TODD RUFF
MS. CHRISTINA STALNAKER
DR. SEAN WARREN
DR. DAVID WEISSMAN
DR. DANA WILLMER
MR. DAVE YANTEK

MR. WELSH: Can everybody take their seats please? We'd like to get started. Is anyone on the conference line that can acknowledge?

MS. CALHOUN: Hi, this is Melanie Calhoun and I'm with MSHA.

MR. WELSH: Okay, can you hear me, Melanie?

MS. CALHOUN: I can hear you.

MR. WELSH: Very good. Okay, good morning. My name is Jeff Welsh, I'm the Designated Federal Officer for the MSHRAC Federal Advisory Committee. I want to welcome you to our Spring Meeting.

There's a couple of items I want to go over before we get started with our meeting. First, the restrooms are just off the lobby. You can go out any of the three doors in the back of the room, head all the way to my left, and the ladies' room is the closest and then on the other side of the lobby is the men's room.

In case of an emergency, you can go out the lobby door or in the hallway immediately to the right, there's another door that you can go out, and we'll meet in the lower level parking lot out front.

I want to mention our plans for lunch. There will be two food trucks that will be in the parking lot just off the lobby. One is Ash & Kris Kitchen, which is Mediterranean, and the second one is a Vagabond Taco Truck.

I also wanted to mention that we will be audio recording this meeting like we have for the last couple of years, and that is for putting together our transcript of the meeting. Brian up front is our audio man that is taking care of that.

I'd like to welcome two new members to MSHRAC. One of them is here, Tom Harman. I'd like to welcome you to MSHRAC. Welcome. Tom is the Senior Director, Safety and Health, with the National Mining Association, and he replaces Bruce Watzman on MSHRAC.

The other new person, Robert Horn, he is a partner with Husch Blackwell, and he replaces Marifran Mattson. Robert is in the area, and I thought he'd be here by now, but we'll be expecting him shortly.

I also wanted to mention that for this meeting only, Melanie Calhoun will be the MSHA ex officio official rep. Bill Francart could not make this meeting, so we officially made Melanie his replacement, and she will be able to participate and vote, and she is on the telephone.

The other thing I wanted to mention, that the MSHRAC members participating in this meeting must be free from any conflicts of interest. Members must self-declare if there's any conflicts that may arise during the meeting, and recuse themselves from any discussion related to that conflict, and abstain from any voting for that particular matter.

I will now do the roll call, to confirm a quorum, which is eight members. Ron Bowersox is in DC, could not make it. Jeff Burgess?

DR. BURGESS: Here.

MR. WELSH: Melanie Calhoun?

MS. CALHOUN: Here.
MR. WELSH: Dale Drysdale?
MR. DRYSDALE: Here.
MR. WELSH: Richard Fragaszy?
DR. FRAGASZY: Here.
MR. WELSH: Tom Harman?
MR. HARMAN: Here.
MR. WELSH: Robert Horn is not here yet. Stacy Kramer could not make it. Kray Luxbacher?
DR. LUXBACHER: Here.
MR. WELSH: Aubrey Miller?
DR. MILLER: Here.
MR. WELSH: Priscilla Nelson?
DR. NELSON: Here.
MR. WELSH: Mike Wright will be here later this morning, and Kyle Zimmer?
MR. ZIMMER: Here.
MR. WELSH: I declare we do have a quorum, so this is an official MSHRAC FACA meeting. I will now turn it over to Priscilla Nelson, our Chair, to officially conduct the meeting.

INTRODUCTION, ANNOUNCEMENTS, APPROVAL OF MINUTES

DR. NELSON: Thank you very much, Jeffrey, and welcome, everyone. We have a really interesting agenda today and I'm very excited about it, with the National Academy Dust Committee report and the response of NIOSH to that, and then Kray's working group on metal mining, and Jeff, we get an update of the Health Advisory working group. So really proactive kind of activities by the MSHRAC. This is super.

So our first order of business is the minutes from our November meeting that was nicely hosted in Arizona. Did everyone have a chance to look at the minutes? Are there any changes, any corrections or additions to those minutes? Then may I have a motion to approve the minutes?

PARTICIPANT: Motion to approve.
DR. NELSON: Second?
PARTICIPANT: Second.
DR. NELSON: Motion is approved and seconded. All those in favor say aye.
PARTICIPANTS: Aye.
DR. NELSON: Those opposed, nay. Okay, the minutes are approved, and we thank you very much.

So, we are set to embark upon the agenda, and our first presentation is John Howard.

NIOSH DIRECTOR'S OPENING REMARKS

DR. HOWARD: Yes, I am. Can you hear me okay?
DR. NELSON: Yes, we can, John. How are you doing?
DR. NELSON: Well, thank you, very well, and thank you very much for allowing me these few

minutes to update you. First of all, I want to welcome all the new members and hope they enjoy their experience, and to say thanks to all of you for taking time away from your very busy schedules to participate in offering advice to us for our mining programs, so thank you very much.

The Budget is still early for FY20, but we do have House Appropriations subcommittee work that was accomplished last week, and right now, we have an additional $10 million in our budget proposed by the subcommittee, so we'll see how that plays out. I emphasize, it's a long process—and hopefully by the October 1 deadline, they will have a Budget that's for FY20.

I just wanted to update you on two issues that I thought maybe you might be interested in. One issue relates to our work on opioids, and we have about five of us working with NIOSH on that issue. For first responders and opioid and other polypharmaceutical approaches, we have seven HHEs that are posted, in addition to a video which just came out too, aimed at preventing occupational exposure to first responders. That's on our fentanyl page. And we also published a paper in the *American Journal of Industrial Medicine* on some of the HHEs, illustrating the importance of responder exposure.

The second issue I wanted to just give you a teaser about, because the mining program is also involved, where we participated with the International Labour Office on May 1 at the United Nations in New York on their Future of Work Initiative. They published a book which is on their website entitled *Safety and Health at the Heart of the Future of Work*. As some of you know, every organization seems to have future of work type publications, but issues that are not related to safety and health. So ILO decided to fill the gap and deals very nicely with our own NIOSH Future of Work Initiative which we're just getting started in a coordinated way. The reason I'm saying coordinated way is we have lots of threads of work that are going on in NIOSH related to the topic of the future of work, and here I emphasize the more near future of work as opposed to a lot of futurists who talk about, you know, 2050 and beyond. But we have our robotics research center, our direct reading and sensor technology, the Mining Program has done a lot in this area and still, I think, you will be hearing about some of those things in your meeting now.

So we want to pull that together in a singular initiative. One of the challenges, as you know, at NIOSH is coordinating a distributed organization. We're in eight different states, four time zones, and often times it's a challenge. So our Future of Work Initiative, you'll be seeing a new website in which we're going to try to pull it all together, including the ones that the Mining Program is doing.

So with that, I'm just going to stop and ask if anybody has any specific questions that they might be interested in asking for me.

DR. NELSON: Well, thank you very much, John. I wondered if you had any comments, if you had a chance to review the NIOSH response to the National Academy of Science's

Recommendation on Dust Committee report, if you had any thoughts on that.

DR. HOWARD: Well, sure. I don't want to steal anybody's thunder today since it is on the agenda, so I'll just say that a lot of hard work has been going on within the Mining Program and with MSHA, and with stakeholders, to try and fashion an important, shall we say, future of work issue out of the Academy's recommendations. As you know, the Academy offers a lot of recommendations and sometimes it's hard to get them into the implementable stage, and that's something that does take time, and I want to just shout out to Jessica and the entire team that has been working on this, and look forward to hearing your reactions to our thoughts.

DR. NELSON: Well, that's great, thank you. I can share with you that I was just last week down in Washington at a workshop that was dealing with, the concern about the debris after major disasters, what actually happens to that. And one of the major discussion points that came up had to do with first responders and the dust associated with recycling concrete and other materials, and it overlapped directly into these kind of discussions that are being had, particularly with the silica content. Very interesting to see some places where maybe we hadn't thought about there being overlap, but in fact there is overlap and a shared purpose there. That'll be interesting to follow up with.

Any other questions or comments? No, okay.

Well, that's wonderful. Any other comments, John?

DR. HOWARD: No. I wish you a great meeting. It's a crowded schedule, as you said, and I look forward to hearing all of your comments and advice for us. Thank you.

DR. NELSON: Well, good luck with the Budget. We look forward to hearing good news.

DR. HOWARD: Thank you.

DR. NELSON: Thank you very much, John.

All right, so Jessica Kogel has taken the podium and she will give us the report on how the Mining—NIOSH has been doing, and planning, because there's been a lot of plans, haven't there?

DR. KOGEL: Yes, a lot of work.

REPORT FROM THE ASSOCIATE DIRECTOR FOR MINING

DR. KOGEL: Thank you, Priscilla. This morning, I'm going to follow the same structure that I do every time, and I'm going to start off with a brief overview of our agenda. Before I do that, I'm going to tell you what our topics are. Here they are. I won't go through them individually.

Here is our agenda overview, and you have the agenda in front of you—but there is a method to the madness in how we've organized the meeting. We'll start off this morning with reports from the various divisions. I'll kick it off and then we'll go to PMRD and SMRD. We'll hear from RHD and NPPTL. We'll also hear from George, who will give us an update on the activities that have been going on around our extramural research.

Then we're going to have lunch, and Jeff did mention, there are food trucks. So

when we break for lunch, you don't have to go anywhere.
And as Priscilla mentioned, we'll hear from some of our MSHRAC workgroups. Also, Bob Glenn is on the agenda to talk about the Industrial Minerals Sector Report, and for those of you who were at the last meeting, you will recall that he was unable to travel because he's got a family medical situation. That has continued. We put him on the agenda hoping he could come but, in the end, he couldn't, so Kelly Bailey is actually going to be giving a very brief presentation just to give everybody a status update on that work.
And then we will start with our research project overviews, that's what we'll conclude the day with. Tomorrow, we'll start at 8:00 and we'll go to noon, and we'll have nine project overviews during that time.
Here's a slide that you're all very familiar with, and this just basically shows how our projects align with the three strategic goals and the corresponding intermediate goals within each of those strategic goals. And as you can see, we cover the three strategic goals fairly well, but there's a little bit more of a focus around strategic goal #2, which is to reduce mineworkers' risk of traumatic injuries and fatalities.
So I think you'll get a good kind of broad overview of research that has been happening in the program since we last met, and hear about some new things as well.
I will start with just a brief update of the progress that we've made around our restructuring of the program. I spent quite a bit of time talking about this at the last MSHRAC meeting, and just wanted to tell you what progress has been made since we last met in November.
I thought it would be good to start with a brief reminder of why we're going down this path. Going through restructuring is not an easy thing to do, and it's not something to be done casually, and something that has to be done with a lot of deliberation, and it takes time. I showed a slide last time that really talked a little bit about some of the negative impacts of reshaping, and this program in particular has gone through it about every five years, so we're actually on track. And this is not planned. So the reasons we're going through this reshaping is we really need to create a flexible program. If you look at the mining industry and just the world in general, I think things are changing, and so we want to have the flexibility to respond to those changes, particularly those that are important to our stakeholders. So that's a big part of it.
Also, we have to become more efficient. It's really about optimizing our resources, and I think what I showed last time is that our funding has been flat for the last, I think, seven years. And also, our employees are retiring and something like 50% over the next three years are eligible. This is something that's happening across the federal government; we're not unique. But it's difficult to keep pace with hiring to kind of stem the flow of people that are leaving because of retirement. So if you

look at it, with flat funding and not a growing workforce, we have to become as efficient as we can.

So then there are some other things that we think we will achieve as a result of this. One of them is to have more sharing and collaboration across NIOSH, within our program itself, between our divisions, and then also with the bigger NIOSH, as I call it. And so we feel that this is really important, to become more efficient, to leverage our resources.

So we also would like to promote multidisciplinary research, which leads to innovation and creativity. We feel that's very important. And I talked about the major structure that we're going to put in place to help facilitate that.

Also, what's very important is that we build on the core strengths. We're not going to throw the core strengths out. We're going to take the core strengths, build on those, and then we're going to address emerging issues, and we've already started doing that.

And then the last bullet is one that I think is incredibly important, especially in this day and age, and in today's work environment and the work environment in the future, and that is to create an inclusive work environment. And we really want to foster people's professional development and we want to provide them an opportunity to grow as much as they can professionally within our organization so that they can meet their highest potential, and that's good for everybody and it's good for the organization, and that's really what we need to create.

So really what this means is that we have to work together to achieve our shared mission, and when I say "together", I mean a very broad together. We don't want to have silos. We don't want to just work within our small work areas, whether it's our team or branch or division. We do this now, so I don't want to imply that we aren't currently doing this. We're doing it, and we're doing it well, but we have to continue to build that capacity and we have to do more and more of this. A very important part of what we do, and so we're going to continue talking about how we're going to create a culture of collaboration. And again, it's really about optimizing our resources.

So this is what has happened since November when we last met. We continued to gather feedback, and that feedback comes from a number of different resources including employees, leadership both within the Mining Program but also outside of the Mining Program, the NIOSH OD for example, and then our stakeholders. And so as I meet with stakeholders, I share with them our plans, I get their feedback as well.

So we've pretty much finalized what I'm calling the 2B structure, and this will be the future structure, and I showed you an org chart last time, and it is basically that with a few small tweaks. We're very close to completing the reorganization package, and that's the administrative piece of then putting this whole thing in motion.

So the other thing that we've done, and I think this is very important, we've started down the path of creating what I had called our ecosystem for collaboration, and we've done a number of different things in this area. And the reason this is so important is putting a new organization in place is not enough to make change. In order to make change, we also are going to have to underpin that with some changes in the way we work, and again, we're already doing many of these things but now we're going to start really formalizing and emphasizing them, and really bringing them to the next level.

So we've got some focus groups that are scheduled at both of the divisions. This will give us the opportunity to bring our employees together who can then work on shared issues that we have across the organization, to find solutions together. And so it's really an exercise of bringing people together and actually getting some work done that needs to get completed, and it helps at this stage for the new organization once we stand it up.

We've also formalized cross-organizational collaboration at the project level. Again, we're trying to incentivize people to do this, and so we've taken that step. And then we're also establishing communities of practice. We have two that are in their fledgling stages but they're coming along nicely. There's a ground control and then a modeling and simulation community of practice.

DR. NELSON: When you talk about the focus groups and the communities of practice, what stakeholders are engaged in that?

DR. KOGEL: So right now, the communities of practice are very much happening just within our program, so there aren't any stakeholders involved at this point. They're organic. They're—management isn't forming them. These are voluntarily formed by researchers within the program who see an opportunity and a need to come together over particular topics, these two for example. And so at this point, it's just them really establishing those communities within the Mining Program itself.

Our longer-term vision is that it will go outside of the Mining Program, but to start, we've got to start here and kind of get them going, get some kind of momentum behind them, and then they will grow beyond that. That's the vision for them.

DR. NELSON: And I can offer the RMON meeting in 2020 is going to be at CSM, and both of those topics for the communities of practice are extremely pertinent, and that might be an opportunity to…

DR. KOGEL: Opportunity, right.

DR. NELSON: To do some engagement.

DR. KOGEL: Yes, that's fantastic. So that's exactly what we would like to do. The focus groups also are internal. They're going to be looking at issues that have come up through employee feedback. That's something that I have, throughout this whole reorganization process, have been inviting feedback from employees, and I did that when I first came in as the Associate Director. I sat down and had roundtable discussions. So we've been gathering feedback through both of those

mechanisms, through—I have an employee input mailbox where people can share their concerns, their ideas, whatever it may be, about the restructuring, then we've got an employee viewpoint survey which happens every year. So that's a third piece of feedback. And so these focus groups are going to take all of those feedback mechanisms, all that information that we've gotten, and there are going to be five different topics that employees will be working on that are kind of shared things that have come out of those various opportunities for feedback.

DR. NELSON: Thank you.

DR. KOGEL: You're welcome.

So this is a revised timeline and sorry, there's so many question marks on it. I get a little nervous putting dates down. That's just our reality unfortunately. So we expect the package to be submitted this month, and then it will go through a review and approval process and at that point, that's why there are question marks because it's sort of out of our hands, and we don't really have a good idea of what the timing will be. I would like to see this; we'd like to stand this up between now and the end of this calendar year. That's what we're hoping for.

DR. NELSON: No, but you have—you got approval out of, since '19 NIOSH?

DR. KOGEL: Yes, so thank you for mentioning that, Priscilla. I should have mentioned that on this slide. I put it here. So there is a two-phase part of this reshaping that's happening at NIOSH. Phase one has been approved and is in the process of being stood up. So that's happening, and that was one of the things that was kind of driving our timeline. We are phase two. So we wanted to get phase one through the approval stage before we submitted our package. So, yes.

Okay. I just want to give a few slides here on the ten-year program review. I think you will all remember that Dr. Amia Downes came to Tucson and she gave a presentation on this topic, and I just wanted the committee to know that we were about to go into this ten-year program review and what the method was for doing that review. So one of the things that Amia talked about, and I'll just remind you, is that the way we're doing this review is we're using a contribution analysis framework, and she gave you, I think, a pretty in-depth overview of what that's all about. But just as a reminder, the way this works is we start with a logic model, and basically what that logic model does is it describes how the program goes from input to impact. And you can think of it as a hypothesis. And then from there, we gather evidence that will either support the hypothesis or not, and from that evidence—and this has got to be credible, documentable evidence—we create an evidence package. It's all centered around impact. What we're trying to do is we're trying to demonstrate impact of the work that we've done in the program, and that in turn demonstrates overall program relevance.

So that's how the method works, and there is an independent review panel, and this review panel is made up of representatives of all sectors of mining. It also is comprised of our stakeholders and we also have evaluation experts as well as

training experts on that panel.

The next slide shows you a timeline and where we are in the process. This is about a two-year process and we're about a year into it, and so on this slide, the boxes that are in blue have all been completed, and so we started about a year ago, it was June last year, and the first step is selecting topics. So this review, I want to emphasize, is different than the review that was last done by the National Academies. That review was the entire program. This review, and the way we are doing it under this new contribution analysis framework, is not to do a program-wide review but to select topics within the program that meet certain criteria. They have to demonstrate impact. We wanted them to be things that were stakeholder priorities, and then there were other criteria that we used as well. I won't go through the whole list.

But out of that, there were three topics that we selected: disaster prevention and response, ground control, and respirable hazards. And so even though that's not our entire program, it really does span our program. It's a good breadth of the whole scope of the program. So once the topics were selected, we prepared the logic models and then we started gathering the evidence. After that step, we were able to start writing the evidence package and this, there are many, many people involved. I would like to thank everybody, and many of the people from NIOSH that are in the room today were involved in this. This is a huge, huge project and so many people have been working very hard on this. The evidence package went out to the review panel last week I believe, last Friday. So as we were doing all of this, there was a third party contractor selecting and approving that panel. So the panel is in place. They have the evidence package. They will conduct their actual formal review. We'll have a meeting June 5 in Atlanta where we will give them presentations, we will meet with them for a day and then after that, they will go back and they will write their report, and they will provide us with scores. They'll score us on impact and burden and need, and will also make recommendations to NIOSH, much like a National Academies report. We will then prepare our responses to the recommendations and then those will be publicly posted on our website along with the evidence package, which is also a public document.

Any questions about that, yes, Aubrey?

DR. MILLER: Just I was thinking about kind of the push and pull between program level accomplishments versus the transdisciplinary combination, and how do you kind of parse through that? You know, some of the stuff is really transdisciplinary issues but yet you're trying to identify programmatic outputs, or people are probably coming from that perspective. How do you kind of work through that and give credit for transdisciplinary work in a way that benefits everybody at a program level in a way that we struggle with?

DR. KOGEL: Yes, so that's an interesting question and I think within NIOSH, before our program was under review, there were some things that were done with the

Mining Program that were part of the evidence package for construction for example. And so it is included in the evidence package, and for our evidence package, RHD has been very much involved in it, particularly the black lung surveillance. NPPTL also has been involved in the preparation of our evidence package through the breathing air supply work that they've done in collaboration with us. So it's very much part of how we do this and it kind of naturally fits. So it seems to work. That isn't an issue, I guess I could say, so yes.

PARTICIPANT: One—sorry. Could you give a brief summary of what your conflict of interest rules are for the panelists?

DR. KOGEL: So I've seen the document and I would have to look at it, but there are things like if we've funded you in the past ten years, during the review period, for instance. And there are some others, but that's the one that I remember.

DR. NELSON: So let me ask you this. That evidence package and the hypotheses that you have chosen would be very interesting to understand. Eventually, will that be made available?

DR. KOGEL: Yes.

DR. NELSON: Yes.

DR. KOGEL: It will be. It's a public document. It will be made available. It will be posted on our website, yes.

DR. NELSON: Good. If you can notify us when that happens…

DR. KOGEL: Absolutely. Yes.

DR. NELSON: That would be good. Thank you.

DR. KOGEL: Okay, so let me just give you a little bit of an update of the Lake Lynn experimental mine replacement. So the good news is that it's continuing down the path, and that's, I think, a very, very good thing. I don't think we've gotten anywhere as close as we are to actually securing something as we are today. So it's very, very exciting. I'm very, very hopeful, and so this is where we are.

So a draft environmental impact statement has been completed and there was a public meeting that was held near Mace, West Virginia, which is the location of the proposed site. That was in March. We had about 60 people who attended that meeting and they met with representatives from CDC, from GSA, from NIOSH and also the contractor was there as well, the one who prepared the EIS statement.

And so at this public meeting, they were able to share, of course, their concerns and we were there also to explain to them the details of the project and what it was all about. The concerns that were most commonly brought up—were related to water, and that was two aspects of water. It's water quality and also quantity. Many people in the area have wells and they were concerned that something about that facility could possibly impact their wells. So you know, they had people there to discuss this with them, and also they had the opportunity to make public comments. The public comment period has ended. That ended April 5, and the

comments will be addressed in the final environmental impact statements, which will be published some time this summer.
At the same time, GSA is also in the process of awarding a contract to a third party to do an independent appraisal of the property. So Jeff, do you have any additional updates since?

MR. WELSH: That's right. We're waiting for the GSA contract to be awarded and then GSA will look at their appraisal versus what the property owners are asking for it.

MR. HORN: Since I'm new to this process, and I apologize for being late, but what is the purpose of the experimental mine?

DR. KOGEL: So we had an experimental mine, it was called Lake Lynn Experimental Mine. It was located about a 45-minute drive from here. That was the mine where we did our explosion testing; it was the primary reason that we had that mine. Original explosion testing was done here on this site. At this site, it was 1910 when we actually started doing, as the Bureau of Mines, work here and we did a lot of explosion testing. When you came on this property, you saw two mine portals that were used. Well, as you can see, there's lots of neighborhoods in this area now, and so there became a point, I think it was in the early Nineties, when we no longer could do that kind of testing, and so we moved it to the Lake Lynn Experimental Mine. That was a leased property. We lost access to it in 2012. It shut down then. Since then, we've been trying to acquire a new property so we could do that explosion testing. So that's the main purpose of it, and we've done many other kinds of testing there as well.

MR. HORN: And you're talking about almost exclusively coal mining?

DR. KOGEL: So it's a limestone mine, that's what Lake Lynn was, so the new property will be similar. We're trying to basically replicate Lake Lynn so that we can do testing that will be comparable to the testing that was done in Lake Lynn.

MR. HORN: Thank you.

DR. KOGEL: You're welcome.

MR. ZIMMER: Just curious, Jeff, what's the asking price for the mine?

MR. WELSH: I don't know that for sure, It's not been made public yet.

DR. KOGEL: Okay, so this is my last topic. I wanted to talk a little bit about some exciting things that have been happening with DARPA. So that's the Defense Advanced Research Projects Agency. I'm sure many of you are familiar with DARPA. We've had a close relationship with DARPA over the years on many different things, but right now we have two things that are on the horizon that are quite exciting. I think you know about one of these, Priscilla.
So I think it was announced—where's Adam?

DR. SMITH: Last night.

DR. KOGEL: Last night, yay. So if anybody had been reading the DARPA news. So there's this thing called the Subterranean Challenge, SubT Challenge for short, and basically that's a competition where teams will use robots and drones to explore three

different types of subterranean environments. There'll be a tunnel environment, a urban environment and a cave environment. And there'll be two types of competition, there's a systems competition—and that's where teams will actually do the competition in physical underground environments, and there are seven teams that are going to be competing in this competition. And then there's a virtual competition, and that will be in a simulated environment, and there are two teams that will be competing there. And there'll be three what are called circuit events, and then there is going to be a final event. And so as of last night, it was announced that Bruceton will be the site for the tunnel systems competition, and that will be taking place here in August, the 5th through the 23rd.

Priscilla just had DARPA at the Edgar Mine, and I was there last week for the Industry Advisory Committee meeting and heard about how exciting it was at the Edgar Mine, so I got a good preview of what's going to be happening. So Priscilla may have some things she wants to—some advice she might want to share with us.

DR. NELSON: There's a wonderful video.

DR. KOGEL: Yes, and I don't have the video on here but there is a great video of the Edgar event. Maybe we can pull that up.

DR. NELSON: I sent around the link, yes.

DR. KOGEL: So I mentioned there are nine teams. I don't expect you to read about all the nine teams. But really what I wanted to say about this is that the teams are from all over the world, and they include universities, private sector as well as government agencies who are all coming together for this competition, and so you're kind of wondering, so how does this benefit miners because that's really what we're all about. And really, I think the goal of this challenge is very well-aligned with what we do here as far as improving the safety of mines and post-disaster survival. And obviously this is a very similar kind of environment. So these new technologies that are being developed to go in to remotely explore these subterranean environments are environments that are too dangerous for humans to go into. So it's exactly the kind of thing that we do deal with post-disaster. So hopefully there'll be new technologies that come out of this that can be adopted in a mine disaster situation. The environment is very similar. So that's one aspect of it.

Another is that it's going to give everybody here on this site direct access to this state-of-the-art technologies. They'll be here for a whole month. The teams will do the competition here. There are also going to be some upgrades to our mine that will have to happen—Edgar had the same thing—in order to conduct this challenge. And so DARPA is a well-funded agency. They are willing to leave some of that technology behind so we also benefit in that way as well. So I think there are a lot of tremendous benefits for us, and it's going to be very exciting.

So the next thing I wanted to mention is Project Amoeba. So this is a mechanically based antenna. It's going to be tested here at Bruceton and it has

some real potential for through-the-earth communication capabilities, and it works on ultra-low frequency and very low frequency signals, and so it will work in RF-denied environments, underwater for example, as well as in mines. And so this is also an exciting technology for us to be able to have a front row seat of seeing how this works, and so it will be tested here.

And this is just a teaser. I'm not going to talk about the response. My time is up. That will happen this afternoon after lunch, so come back from your food trucks, and at 1 o'clock I think I'm up, and I'll give an overview, but some detail into the response that we've prepared to the National Academies' recommendations. So with that, I will conclude and I can take any additional questions.

DR. NELSON: That's great, thank you very much. DARPA is really excellent to work with. They left quite a bit of stuff up there, including ethernet underground that we've been struggling with anyway. So they're great partners. Wonderful. Good, and I think at yours, I hope we have a mines team that'll at least run the circuit.

DR. KOGEL: Yes.

DR. NELSON: Any other questions? Any questions, comments? No? Okay, well, thank you very much.

DR. KOGEL: All right, thank you.

DR. NELSON: But I think we should congratulate you for a well-deserved honor of being elected to the National Academy of Engineering, Jessica.

DR. KOGEL: Thank you very much.

DR. NELSON: Congratulations for that.

[Applause.]

DR. NELSON: That's great.

MR. WELSH: Robert, I'd like to officially welcome you to MSHRAC.

MR. HORN: Thank you.

MR. WELSH: I'm Jeff Welsh, DFO, and this is our Chair, Priscilla Nelson.

DR. NELSON: Right.

MR. HORN: I appreciate it. I apologize for being late but we got lost.

DR. NELSON: Yes, that's a common thing I think. Okay. Well, our next presentation is RJ, are you ready, RJ, for the Pittsburgh Division?

PITTSBURGH MINING RESEARCH DIVISION UPDATE

DR. MATETIC: Okay. Well, good morning to all of you. Welcome you to sunny Pittsburgh. I have to thank a lot of you in the room for bringing the sunshine here to Pittsburgh. We don't see that that often, so excited to see it today.

I just want to give you a brief update regarding the Pittsburgh Mining Research Division. What you see in the picture is the leadership team in Pittsburgh actually protecting one of our mine portals here on site. We're protecting that because of all of the opportunities we're having coming down the road, and we probably watch Game of Thrones too much, that we've been standing at this portal for a couple of days now, so we're protecting it.

DR. NELSON: Where are the hard hats, RJ?

DR. MATETIC: The hard hats.

DR. NELSON: Yes, where are the hard hats?

DR. MATETIC: We're away from the mine, Priscilla. Okay. What I'd like to talk to you today is about is some of the personnel and staffing updates. I gave a brief overview at the last MSHRAC meeting regarding the challenges we've been having for staffing, and as Dr. Kogel mentioned, provide you with some, where we're at regarding some of our research outputs since the last MSHRAC meeting, quickly go over some new proposed FY 2020 project starts, and then provide you with any recent updates and impacts that have occurred since the last MSHRAC meeting.

If you recall, I showed this slide at the last MSHRAC meeting and I don't know if we have a pointer or not here, we do. You could see over the years, that we have been decreasing in FTE load, and I spoke about this, especially this, at the end of '18, that this is something of concern, and it's of concern for two reasons. One is the implementation of our current portfolio to meet the expectations of our stakeholders. We're getting to that point where the current portfolio is being hard to meet regarding this FTE decrease. And the other thing is sustainability of the program. We have to bring people in to sustain the program and succession plan for that. Dr. Kogel mentioned we have, I think it's over 50% within the next three to five years of people that can retire in the Mining Program. So to sustain our program in a way to meet expectations of stakeholders, we need to figure out unique ways of bringing people into the program. And I got some good news. This just shows you where we're—how many positions we've filled currently. We filled two mining engineers, one in the fires and explosions program area, and one will be located in the respirable dust monitoring and control program area. We hired an industrial hygienist that will serve in our workplace health branch, and that person will be heavily involved in noise control and monitoring aspects of our research program. We've also hired three program operations assistants. These will provide branch and administrative support throughout the program.

Now currently, we're actually on par to schedule nine right now—I'm sorry, to hire nine right now—three geologists, one geologist will serve in our elongate mineral particle program area and two in the ground control program area. We also are hiring six engineering technicians. This was a major concern regarding succession planning because a lot of our technicians can retire within the next one to three years. So we're actually hiring six of those right now. So right now, probably within the next months, nine additional FTEs should be in the program. Moving forward, we are somewhat okay with the next five in the summer, meaning we feel that we will get them on board, and these are three industrial engineers that will serve mainly in our technology integration program moving forward, an administrative officer—that's our administrative officer that actually transferred to CDC about a month ago. We need that position replaced. And also,

we'll hire a general engineer to serve in the ventilation and sensor system program area.

Now wishful thinking, but maybe it isn't wishful thinking, for the fall we're looking at five additional hires, one mechanical engineer in our explosions and battery research program areas, two general engineers in fire prevention and control, and two health communications specialists to actually assist with the exhibits and graphics integration of our NIOSH Mining Program.

So you know, the news is good. We're assuming 15 currently within the month, and hopefully we can get some more on board as we move forward. So it's a positive thing.

I always like to show a slide demonstrating some of the awards from the last MSHRAC meeting that NIOSH Mining Program and its people have received. This is by far not all of them but these are just a few. We were happy to hear that NIOSH Mining Program received the inaugural Robert E. Murray Innovation Award at the SME Conference in Denver in February. The award was established to recognize individuals or organizations who advanced the mining industry through the implementation of technical innovation. The NIOSH Mining Program won this award based upon two technological advancements that we developed and are currently in use in mines as of today, and the two of those are the helmet cam Innovate technology that I think I discussed with you at a previous MSHRAC meeting, and the other is the continuous personal dust monitor that is actually currently being used in underground coal mines.

At SME, also several researchers won the Stefanko Best Paper Award. This award recognizes knowledge movement through the Mining Program and it's presented at a Coal and Energy Division luncheon at SME.

Also, I want to recognize Lt. Michael Shahan. You can see him on the right. Michael was selected as the CDC Engineer of the Year for the National Society of Professional Engineers. Michael was one of 32. Now they move forward to the finals regarding who will be the professional engineer of the year with government. So applause to Michael.

Every MSHRAC meeting I talk about outputs. These are our most recent outputs since the last meeting in November. We break our outputs into science and translational. You could see here that 53% of our outputs are science, 47% are translational. You know, the importance of the translational outputs—and I think we've introduced this several years ago. These are really where we're making our most impact in industry, and when I mean impact, I'm talking at the mineworker level. So what we do is obviously we do good science. We publish our science outputs given those venues that you see, and then we take the science and put that into a translational output that the mineworker and the people at the mine level can understand. For example, like infographics and short things that introduce the technology intervention to the mineworker at the mine level, to

where they then empower themselves and companies to actually use what we do. So they've been very successful.

If we look at how this is distributed across all of the mining sectors, this is what it looks like for the last six-month period. Coal and industrial minerals increased just a little bit from the last MSHRAC meeting, with stone, sand and gravel decreasing just a little bit, and metal and oil and gas remaining the same. So this is just when we have an output, we assign it a code and that code is what sector of mining does it actually affect. So an output can actually affect numerous sectors. So this is just the average of the applicability across all sectors and mines, just to give you a flavor of what we're hitting in a six-month period.

We are proposing to start seven new projects in FY 2020. Disregard the craziness on the slide. I just wanted to give you an idea where these projects would actually fit in a strategic goal/intermediate goal structure. We're proposing two new projects in Strategic Goal 1, which is occupational illness, with the emphasis on respirable crystalline silica monitoring and control technologies in coal and metal/nonmetal mines. We're proposing two projects in Strategic Goal 2, which is reduce mineworkers' risk of traumatic injuries and fatalities. These two involve the identification and mitigation of risk through organizational processes and human-centric lighting to improve mineworker wellbeing. And the remaining three projects are located in Strategic Goal 3, which is improve post-disaster—eliminate mine disasters and improve post-disaster survivability. These involve prevention and suppression of equipment fires in metal/nonmetal mines, utilizing integrated analysis procedures for stability of coal pillars and entries, and using virtual reality to improve mine emergency response and everyday situational awareness around mineworkers. So these are the seven proposed projects for FY20, and I say "proposed". They're going through the phase of research projects currently, so they're not a given or completed.

DR. NELSON: So RJ, can I just ask about this? When you choose these or propose these projects, is that done totally with internal discussions at Pittsburgh or do you work with Spokane for that kind of inter—maybe across location—expertise contributions? Or are these just exclusively internally Pittsburgh?

DR. MATETIC: No, the process, Priscilla, is to obviously send out a call for project concepts. Once the call was made, people, researchers submit two-page project concepts for consideration. From there, there's a determination at the division level on what can be done, what are the highest priorities, and selection is made at that point. But then it goes to—it's shared and it's transparent to SMRD, Jessica, and then we, as a group, determine whether these should move forward, are the specific aims and research objectives, do they make sense, and then we continue like that. If there's other divisions in NIOSH that potentially could be involved in these efforts, they are contacted and included as well.

DR. NELSON: So in that process, you're—these are coming out of Pittsburgh but they have not

been through that subsequent process of looking at it with Spokane, looking at it with the Assistant Director.

DR. MATETIC: Yes, for example, this last call in Pittsburgh, we received 18 to 20 concepts. Obviously funding and our FTE load, we could not address all of those. So we kind of have to put a line in the sand on where do we end this given funding and FTEs, and I'm talking FTEs not only just bodies, bodies of knowledge that can contribute to the portfolio on what we're trying to do. So that's kind of how we do it at the division level, but once that's done, then it's kind of shared with other divisions, Jessica's office, to come up with the best plan.

DR. NELSON: And that will happen during the summer so by October you'll know which ones have been approved?

DR. MATETIC: Yes. Yes.

DR. NELSON: Okay. Thank you.

MR HORN: Let's assume that we're through the process. How do you integrate the outcomes in relation to the MSHA regulations that eventually deal with some of these issues?

DR. MATETIC: Well, if a current research project is involving potentially a new regulation, our plan previously, and we will continue, is to make sure that we collaborate with all of our stakeholders, and all of our stakeholders include MSHA. Everything that we, you know, typically propose to do or are currently working on, MSHA at the headquarters level and MSHA at the technical level knows the research, knows what we're doing, knows what we're trying to accomplish. So it's really pretty transparent. Okay?

Okay, some quick highlights in 2018. The second edition of the popular Dust Control Handbook for Industrial Minerals Mining and Processing was released a month or two ago actually, and this was a major collaboration between the NIOSH Mining Program and the Industrial Minerals Association of North America. The previous version, which was written in 2012, was completely rewritten. A task force of health and safety professionals, specialists got together and rewrote the 2012 document to show proven and effective control technologies to eliminate respirable dust during all stages of mineral processing. The final product is right here. I had some people bring extra copies. They're sitting on the back of the table. So feel free to take a copy. It's pretty thick. If you don't want to carry a copy, let us know and we'll make sure we can actually mail you a copy. But this was a tremendous amount of work. The good news about this is this was a result of major stakeholder involvement, including MSHA, industry, labor, government. So this is the most revised version of that document.

Dr. Brianna Eiter will talk to you about, a little bit more in detail, ten minutes in detail, about EXAMiner. I mentioned this at a previous MSHRAC meeting. It's a hazard recognition tool, and it's PC-based, it's interactive, and it's kind of running crazy now—running crazy in a good way. We've had numerous calls from

stakeholders wanting to expand the program and actually wanting to use the program. You just see a few there. The NMA Core Safety TV actually promoted EXAMiner. It's been published in numerous articles and publications. The NSSGA members have currently used it. We've conducted numerous workshops regarding it. Portland Cement Association is now using it as well to their member companies, and actually MSHA is using it at their district offices to train their own mine inspectors, to improve their awareness of recognizing hazards. And Brianna will talk a little more to you tomorrow, I believe, on EXAMiner and where it's going. We're excited about this new piece on our website too. I don't know if anybody has seen it yet, but to better serve our stakeholders, we've implemented interactive mine and mineworker charts our website. The charts allow the user to select what statistics they want to view for the current time period of 2008 through 2017. Graphs and tables are shown along with the data itself, and the unique feature of this is the user can actually cut and paste pieces, parts of what they actually need for documents, what have you. We also plan to add more years of data. We'd like for this to go back to 1983. And as MSHA post their data, we will actually add to this website.

Let me give you a quick demo if I don't screw this up.

DR. NELSON: Yes.

DR. MATETIC: Okay, this is what you would see from the website itself. So if we wanted to know number of active mines in that ten-year period from 2008 to 2017, this is what the data would look like. So if gives you a graph based on sector and then the numbers below regarding the number of mines. If you didn't want 2008 through 2017 you could, if we wanted to do it from '13 to '17, we could look at it that way as well.

And so if we go back, we can, if we want to know mine operator employees by sector, this is for 2017, this is what the current state of affair looks like. If we wanted to do that over a longer range of time, we can look at it this way.

And then of course, if you go back to the main page, we look at mines, fatalities, employees and injuries. Let's just quickly look at counts and rates by sector, injuries. That's 2014 to 2017. If we wanted a broader view of this, we could go to 2008, submit and then we would have that data, with graphs, charts and the data itself. Okay.

Okay, and last but not least—I'm running out of time here—last fall, we developed the mining section for the NIOSH Spanish language website. This section provides general information about the Mining Program, an introduction to our laboratories, and content on specific mine safety and health topics. There are numerous publications, videos and infographics that stakeholders can download and use this at their leisure. Since it was posted, we've had 1,200 hits to the website, to the page itself, and as we continue moving forward, we will add more Spanish content regarding interventions, technologies, better practices, for our

Spanish-speaking stakeholders. So this is something new and exciting as well.

DR. NELSON: Can you determine whether those hits are from the US or from outside the US?

DR. MATETIC: That's a good question, Priscilla. I would have to look at our—ask our web team. I would assume so. Now, that was 1,200 hits to our—the mining page. So I would assume they probably have that data as a metric but I can't say for sure right now. So that's a good question.

And that's all I have, and this is the portal of our Safety Research Coal Mine looking to the mouth of it. Some of you will be visiting that tomorrow on your tour, and we're very excited to have you here and we're looking forward to sharing our facilities with you all. So thank you.

DR. NELSON: Any final questions before we move on? Okay, Todd, you're up.

SPOKANE MINING RESEARCH DIVISION UPDATE

MR. RUFF: Good morning. I'm Todd Ruff, Division Director in Spokane, and I just wanted to take a few minutes to update you on some of the things that have gone on since our last meeting. I appreciate the opportunity to share what we're doing in Spokane.

So I'll give a quick overview of how SMRD is organized and our research portfolio, mainly to educate new members of the committee and also as a reminder what Spokane is doing.

In Spokane, we have four main program areas that we are addressing. We have underground metals mining ground control, mining-induced seismicity and mine stability, and those two areas are historically our strongest areas in Spokane. That's where we've been working the longest, we've had until recently the most staff and the most senior staff. And that area is looking at both metal mining and coal mining, mostly underground, looking at ground control and mine stability questions and issues in those sectors. But we also have two new areas. Emerging technologies is looking at new technology that can be applied to health and safety problems in mining, also looking at some of the safety applications of new technologies and we are concentrating on some of the momentum we're seeing in automated machinery, especially in metal mining. Miner health and chronic disease is also a new program area for us, and we're building the program, building partnerships in that area to understand long-term health effects and the disease burden on miners.

This is how the division is organized. We have four teams that address each of those program areas that I just talked about—metal ground control, mining-induced seismicity and stability, automation and technology, and health exposure assessment and monitoring team. We also get support from the health communications folks in Pittsburgh. We have two of their staff onsite in Spokane. We have 36 total FTEs right now; that's a little bit lower than the number I had at our last meeting. I think we were around 41 or 42 last time. So we've had some

retirements and some resignations. We were able to hire some support staff, so we're offsetting some of that, but it's been a challenge, as RJ mentioned, the amount of retirements coming up, some of the HR challenges that we have. We're struggling a bit to keep up with the amount of people that are able to go out the door for retirement. We have four student interns right now and three part-time expert consultants that are helping us out. We also have some smaller contracts with contractors that are helping on project-specific issues.

DR. NELSON: Are the student interns undergrads?

MR. RUFF: Some are; some are not. Some are in a four-year program and some are in a master's. Yes. I don't know exactly what the split is, but a little bit of a mix.

So quickly to just kind of go through the list of projects. I won't be able to spend a lot of time on any of these but I'll highlight some things later. But I wanted to give you an idea of what our current portfolio looks like.

For the metal ground control team, we have two current projects, both in their second year. Durable support for western underground metal mines is looking at support technologies, recommendations about installation sequence, what are the best devices, how do you monitor the ground control in underground mines. And alternative mining methods is looking at mining methods and ground stability in some of the more challenging conditions like weak rock in Nevada. We're going to hear more about that from Sean tomorrow. And then also with the deep stress mines, working with the mines in the Silver Valley.

DR. NELSON: Does durable support include corrosion?

MR. RUFF: It does, yes. Monitoring corrosion, understanding the effects of corrosion on ground support technologies. And we will hear an update on the corrosion work. I know that was asked by the committee. Not this round because the person, the researcher wasn't available, but at the next meeting.

DR. NELSON: Thank you.

MR. RUFF: For mining-induced seismicity and stability, two projects there also. Detecting and managing dynamic failure is mainly around underground coal in the west, understanding some of the unique conditions of western underground coal, including geology, the coal make up, and other issues we see that are unique to the west. And then developing a real-time ground stability and informatics system is looking at new ways of collecting ground stability data, analyzing that data, making risk assessment, and presenting that information so that it actually can be taken. So we're looking at machine learning, informatics, and new visualization techniques for ground stability data.

DR. NELSON: So are there—you have two-pagers or something describing these projects in a little bit more detail?

MR. RUFF: Yes, absolutely, we can get you them.

DR. NELSON: Are they on the web?

MR. RUFF: Each project has a project page, on the NIOSH webpage, and you can get more

details there. I can send links.

DR. NELSON: Yes, that would be good, thanks.

MR. RUFF: Automation and technology, three projects. We have, we've talked about at past meetings the development of a field portable diesel monitoring device, in its second year. We have two new projects, emerging technologies to improve conveyor system safety—that project started this year as a mining project. In the past, that was funded under a separate CDC program called iFund. So that was a pilot project and now we've started a full mining project for conveyor safety. And then this last one is a pilot, identification of key factors affecting machine-related injuries. Two goals there. One is to do a deep dive into machine-related accidents around metal/nonmetal, especially stone, sand and gravel. We want to understand the machine-related injuries and fatalities better to focus our efforts. The other goal of that project is to look at new methods in text analytics, where we can pull in MSHA data and other data sources and do some data analytics and some text analytics to determine root cause. It's really difficult to read dozens and dozens of fatality reports and do this by hand, and so we're looking at automated methods of doing that to help us better understand those types of fatalities and root causes.

Finally, for health exposure assessment and monitoring team, we have three projects there, an ongoing project predicting the impact of heat strain on cognitive function. I'll give a few more highlights on that one. It's in its second year. Building an evidence-based framework for improving miner health is really the basis of the miner health program, looking at the data sources that are available for long-term health effects on miners. Can't get all data from MSHA; we have to look at other sources—miner clinics and some of the other sources that are available like insurance claims, workers' comp, that type of thing. Applications of novel interventions for fatigue is a new project. We had a pilot looking at some of the issues and concerns in the mining industry around fatigue, which is a major topic of discussion, and that project is underway. I'll give a little bit more detail on that too.

I won't be able to highlight everything so I picked a couple of things from each team to give you a little bit more idea of what we've done since our last meeting, where we're concentrating our efforts. Dr. Kogel talked about emerging issues, and this is one thing that we're seeing in the metal, especially in the underground metal mining industry where they're moving away from the traditional drill/blast cycle to continuous mining methods in hard rock. So some of the issues around this that our ground control team is looking at is the fact that moving to an automated piece of equipment, moving away from the drill/blast and the traditional ways of installing ground support, there are some new issues that are coming out. With traditional methods, you know, we have the drill/blast cycle where you go in after and install your ground support, which consists of shotcrete, wire mesh and

bolts, using jumbos, jack legs, replacement of wire mesh either by machine or by hand, and then you have people in the stope assessing ground conditions.

So as we move to automated mining, on the right there is an example of the vein hard rock continuous miner that was developed by Atlas Copco and being considered by Hecla, is going to be tested in one of their mines this summer. The issue here is they're going to be mining continuously through hard rock and placing the ground support as they go. The back of that machine that you see there is the ground support installation module. So as that machine moves, it's placing bolts and mesh. One of the challenges here is that they can no longer have these big sheets of wire mesh. It's really cumbersome to handle. Automated machines can't handle a big sheet of wire mesh. They're looking at alternatives to wire mesh as one of the ground support components. So there's some question around, well, if you go to a wire mesh or—if you go to a mesh material that an automated machine can handle, it's got to be able to be either folded, rolled—it has to be something different than what they're currently using. And the question is, is that, is synthetic mesh as strong, is it as effective as mesh.

So that's one of the questions that our team is trying to answer. We worked with a couple of different manufacturers of synthetic mesh. We have a very unique test machine at Spokane called the high-energy high-deformation machine, and that allows us to test different components of the ground support—shotcrete panels, mesh and bolts can all be tested on this machine, and it's basically you put together your components in a panel, and it sits on top of this machine, and a ram presses up against that and we get to our strength load and deformation characteristics of whatever we're testing. And you can see a picture of a tester of some mesh.

And what's happened with that is the manufacturers of synthetic mesh came, tested their materials on our device, and they saw some deficiencies in basically the strength characteristics, how much it can hold and how much it can deform without failing, and they've gone back to the drawing board to redesign their mesh materials.

DR. NELSON: So "synthetic" means a plastic, high molecular weight something?

MR. RUFF: Exactly. There's different, nylon, plastic, there's different materials that they're using.

DR. NELSON: So recently I've been doing some research on basalt mesh. Have you ever heard of basalt mesh?

MR. RUFF: I have not heard of basalt mesh.

DR. NELSON: So you might look at that.

MR. RUFF: Okay.

DR. NELSON: It is melted basalt made into a mesh.

MR. RUFF: Interesting, okay.

DR. NELSON: I'll look into it, about that.

MR. RUFF: I will check into that, thanks. So I mentioned the other issue with automated equipment in a metal mine, in this instance, is that you don't have the eyes and ears in the stope. You've removed people from the stopes. One of the goals of the automation anyway. And so now, how do you assess the ground conditions in the same way? And we're looking at wireless sensor technology where we instrument the bolts that are installed. Those are wireless sensors that are inserted into the bolt itself and they, each sensor in the bolts, you know, there's a whole array of bolts in the stope, those sensors talk to each other and they pass the information to a gateway, and out of the mine eventually on the cloud, where you have data analytics that you can do. You also have methods of presentation of that, the data visualization part of that, for assessing risk and taking action. So some new methods to address the fact that we don't have as much people now assessing those conditions by, in-person.

So as we, as our teams in the ground control and the mine stability areas go forward, they're challenged because the amount of data that's available now for making these assessment is increasing. And part of that is we need to come up with automated methods of processing data to, just to be able to do our research, let alone have the mines take that data and be able to make decisions from it. So both, on both fronts, we're looking at ways to improve data collection and data analytics.

And one of those that, an example here, is in the seismic data area. We have some young researchers just out of school. They insist on using the latest methods of software development and software distribution, and that's, you know, a lot of you are familiar with the open source, and it makes us old guys nervous but we're adapting and we're allowing them some flexibility in the way they develop their software. And one of those ways is through internet communities. So you have our researchers working with a whole community of researchers and developers in the public domain that are contributing to their software development. Very new way of doing things for us, and so the open source and the ability to get this, the development efforts out to the public to get input is something that we're working with quite regularly now, and an example here is the ObsPlus available on GitHub, the Python, developed in the Python environment. And then another thing that they're looking at, like I mentioned, the sheer amount of data that comes in is not, it's not feasible for just a couple of researchers to look at all this data and make decisions about what's going on in the mine, and this example is seismic data. So they, our researchers have developed, they've built on the development of a neural network, a convolutional neural network approach, to locating seismic events. In order to locate—in order to use the seismic data and determine exactly where that event had taken place, you have to pick the arrival time, the time that that waveform hit the seismic sensor, and that's a very tedious operation. But we're working with neural networks, artificial

intelligence technology, to look at doing that for us, to handle large datasets and do that event picking and get more accurate location solutions to seismic data. So Derek is one of our researchers, comparingto some results from the neural network, and they're very comparable.

So we took that neural network approach to a dataset. After, you can train the neural network with smaller datasets to teach it what the arrival time, what the arrival point of a signal looks like, and that refines your location data. And so we started with the data on the left. This is what commercial, just traditional commercial software comes up with for a location. Each of those dots is a seismic event in this coal mining section, and when we passed it through the neural network, it was able to refine that location data. This gives a much better idea of what's going on in the mine when you look at, as the mining progresses, where is the seismic activity, rather than this large scatter. And then it cuts down on time significantly.

Just a quick highlight on what's going on with our health team. One of the projects that they're working on, as I mentioned, is the understanding heat strain and its effects on cognition. As you reach the limits of what we feel are what's in the literature on body core temperature, on what's safe to be working at, we want to understand what the effect of working in those hot temperatures can have on cognitive decline.

We just got an IRB, a Human Subjects Board, approval for a small study of nine people, to determine, in our heat chamber—we have a heat chamber in Spokane where we can simulate hot conditions, high humidity, high temperatures—and we run the test subjects through a set of tasks, mostly on a treadmill, and then we monitor core body temp, skin temp, heart rate. And we've developed a new device that can take the data from those sensors that are on your body and write them to—or record them on a smartphone. The smartphone acts as data collection and also triggers the person when their core body temp is at a certain point to take the cognition test, which I'll talk about here in a minute. But this has been a huge advance and we see applications both for heat strain and for other wearable sensors.

This is an example of the software, or the app, that's running on the smartphone. The test subject, which is one of nine.

DR. NELSON: I just wondered, how are you measuring core body temp with that?

MR. RUFF: It's a pill.

DR. NELSON: Okay.

MR. RUFF: It's a wireless transmitter to…

DR. NELSON: I thought it was maybe part of the harness.

MR. RUFF: Yes, yes, it's a little sensor in a pill. Pretty amazing stuff. But yes, so the test subject, so we have nine, these are mine rescue personnel from an area in the Pacific Northwest, and when they come in for the tests, they fill out some initial

information about their day and about the tasks that they're going to be doing. They get on the treadmill, get their core body temp up. When that's triggered, they get an alarm, take a break and they take the cognitive test, in this case an N-Back test, which is a memory type of test.

We are on test subject number nine this week, so we are going to wrap up this test and have some data. We'll move to a full study with a bigger population for controlled tests in an environmental chamber, then we'll also be moving to field tests in underground mines.

I just wanted to bring this up as an example. RJ had mentioned infographics. We have a fatigue project.

DR. MILLER: Yes. That last project seems to have applications across huge numbers of industries.

MR. RUFF: Absolutely.

DR. MILLER: Is there any collaborations right now with other agencies or?

MR. RUFF: Well, NIOSH has done a lot of research on the heat stress in other industries. So yes, construction, oil and gas—there's a number of different collaborations going on in this, for sure.

RJ had mentioned infographics. Our fatigue project started with a pilot study and then now is into a full project, and we're in the process of taking what we learned from the pilot, and one of the efforts was to look at the other industries. Fatigue is big in transportation, manufacturing, a lot of different industries. We took what we learned and were able to put together a one-page flyer that we can hand to the miners and health and safety professionals in mining, that gives them some information about fatigue, its effects and how it could be mitigated. We're also using this as a way of soliciting partnerships in the industry. So we say hey, have you heard about this study that we're doing in NIOSH, we're looking for partners. So a lot of benefits to doing these different types of translational efforts that maybe we haven't done in the past, but these one-pagers, and the ability to get this information out on social media is really big for us.

We have a project in conveyor safety that I mentioned. I just wanted—we're going to hear more from Dr. Miller on this tomorrow, and I just wanted to mention that we have added some new capability to our facility in Spokane since we last talked. We have built this conveyor test bed in the laboratory. This allows us to test technology before we take them to the field. Part of the system that we're working on is an improved lockout-tagout system, improved situational awareness during maintenance of conveyors. We're looking at Internet of Things technology where sensors, data analytics, cloud-based computing, automated controls for both motors and for the power, electronics that come into the conveyor, and so the ability to do this in-house first and then take those ideas to the field is an added capability for us at the lab.

Quick update, we're going to hear more from Kray on this, but we are talking

about the emerging technologies initiative that we have the lead on, and the first question or the main emphasis right now is on the automation in mining, especially in metal mining right now, both underground and surface. We have several sources that are going to feed into our planning for future research. We need to know what the prevalence is, what's the prediction for automation in the US in metal mining, and what are the priorities for safety research, what are the main concerns around implementing that technology in mines.

If you notice on the picture, there's something very different about this haul truck. I know a lot of you have probably seen it, but this is Komatsu's new truck and there's no cab on it. That's an automated truck, not meant to ever have a driver. So these are the types of things that we want to look at. There's a lot of work going on in other countries. Australia is way ahead of us on this. But they will have some input, so we are seeking input on what they've seen as issues that have come up.

So we've had several different activities for input. We've had the MSHRAC workshop, we've had our internal Mine of the Future Report. I have an initial university partnership meeting and we're going to expand that to include more in the future. I also wanted to highlight that right now, in the Federal Register, we have a Request for Information on automation safety. So here's the link. It's open until May 17 to get input to us on research priorities around automation issues.

And this is my last slide. I just wanted to recap for our miner health program, these are the areas that we're going to be moving into and continuing to grow in Spokane. Working on a strategic plan for miner health—we'll have more from Jeff on that, and the MSHRAC workgroup is going to be conducting an advisory workshop in September. For ground control/stability, I have asked the groups in ground control in Spokane to develop a strategic plan for the next ten years for western mines, and how ground control will be affected by the issues I've talked about around automation and the need for advanced analytics and visualization. Emerging technologies in automation safety, continuing to build the program with new staff, new partnerships, and leveraging new technology—the Internet of Things, wearables, that type of thing we're going to see more of, you know, how can we best apply that to mining. That's it.

DR. NELSON: Okay. Thank you very much, Todd.

MR. RUFF: Sure.

DR. NELSON: Any quick questions? No? Well, thank you very much.

DR. NELSON: And George, you're up and then a break.

MINING RESEARCH PROGRAM UPDATE—MINER ACT EXTRAMURAL RESEARCH

DR. GEORGE LUXBACHER: I'm George Luxbacher. I'm the Deputy Associate Director for Mining, and I'm going to talk today, as I do at each one of these meetings, on a quick update on our MINER ACT extramural research program that includes both contracts and

grants. I always try to pick a graphic to put on my title slide that relates to one of our contracts, and it's interesting. Jessica mentioned Project Amoeba, which is developing a small mechanically based antenna for through-the-earth communications. This little graphic here is the result of a five-year contract—it was a three-year contract that we extended I think four times—to collect noise data on the ground and on the surface related to through-the-earth communications. And this turned out to be a much more difficult effort, simply trying to find mines that were willing to cooperate with us. We originally intended to have 40 mines, the bulk of which were going to be coal mines, and I think we wound up with 28 mines in the final report. But the interesting thing, this is a comparison between data that was taken by the Bureau of Mines in 1980 to '83, and then 35 years later, noise data related to the same thing, using a little bit more advanced technology to measure the background noise. And this data, we did this data here at NIOSH with the idea that we wanted the next generation of through-the-earth communication systems—which have not found widespread acceptance within mining, very few units have actually been sold—but wanted this background noise data to advance that technology. And this has a direct relationship to what DARPA is doing right now, and actually we've transferred all these huge datasets that we've collected over to DARPA for Project Amoeba. But you can see the significant increase in background noise levels, both surface and underground, on this slide over that 35-year period, and this is all manmade noise related to changes in electronics over that period of time.

Very interesting data and the Amoeba, Project Amoeba people are going through this and they've provided this valuable feedback. This was actually our first interaction with DARPA and we met with DARPA and talked to them about the SubT Challenge when we went down to talk to them about Project Amoeba, and we are continuing to develop those relationship. DARPA has significantly more money for research projects, and great to be able to take advantage of some of the technologies and some of the funding efforts that they have.

I'm going to talk about both the contracts and grants. Grants I'm just going to mention that we only have two active grants right now under the U60 grant program, the Western United States Miner Safety and Health Training Programs. We have a couple of other grants that are investigator-initiated grants but they are basically just finalizing final reports. I believe there will be a couple more grants issued this year. But the only thing we have active are these two U60 grants for University of Arizona and Colorado School of Mines. If you remember my update last year, whenever we got together at MSHRAC in Tucson, we were about to go into our first meeting for the U60 grants. Jeff hosted that over at University of Arizona. And we are actually planning for that second meeting that will be held probably in the November/December timeframe and it will be hosted by Colorado School of Mines out in Golden. And our hope this year, last year we tried to tie in

some of our researchers by video conference.

PARTICIPANT: Zoom.

DR. GEORGE LUXBACHER: We tried to use Zoom, and we found out it was more of an impediment to interaction than the type of interaction we really wanted to get. So I think this year, we're looking at bringing some NIOSH SMRD and PMRD research staff actually out to Golden so we get face-to-face interaction, and I think that will contribute a lot to improving that interaction.

We're also in the preparation right now of developing the funding opportunity announcement for the next go-around on this because we're in year two of the three-year cycle, so we're in the process of developing the next funding announcement, which will include significantly enhanced programmatic involvement from NIOSH. We want to make sure we get that in there so that we're an integral part of this. So that will be in the next funding announcement.

In terms of our extramural research contract portfolio right now, as of May, we have 27 existing outstanding technology contracts. We have 13 BAA technology contracts, one RFP and then the 12 BAA capacity builds that are still existing. So I broke those down by year there so you can see, we have still one contract remaining from '16, five from '17 and then the bulk are from 2018 fiscal year. And I added some illustrations of some of the universities and different companies that we're working with on those contracts right now. All those contracts are listed out on the website so you can go to the website and look at anything that we have going on right now in terms of research with a brief summary.

Now, whenever we met in Tucson, I mentioned that we had just come out with a BAA solicitation. Our technology BAA solicitation, which was Enhancing Safety in Mines, that had just come out I think the week before, the pre-solicitation notice that went out in the Federal Register. Since then, the solicitation was actually posted in December. The due date was in January. Just to remind you, we had six focus areas that we asked for specific topic responses on, and then we had the "Other" category which, in response to feedback from MSHRAC, we really enhanced this year. We included this paragraph that noted that we strongly encourage response in topics other than those that we consider focus areas. And so the interesting thing was we did get responses; that did significantly enhance the number of responses we got outside of our focus areas.

But you can see here, our focus areas were non-regulatory, personal measurement of coal dust and silica; next-gen underground communications systems, trying once again to see if we could get something on helmet cam for underground coal; the NAS report which Jessica will talk about, I'm not going to go into any detail on the responses we got on that, but that was one of ours; strata horizon control; and then multi-cell batteries.

To give you an idea of how this cycle works, and this is for this award cycle, and I'll talk about the responses we got in a minute, but I just wanted to show you how

complex this process is, we actually determined these focus areas and completed that determination back in September. So every September, we come up with what our focus areas are going to be for that particular solicitation. We do that by engaging our researchers, our contract officer representatives or our CORs, the divisions directors, Jessica and myself, and our stakeholder input that we gather as the year goes on.

So we come up with our focus areas, we develop that into a solicitation—those six focus areas came out of that type of interaction—we have to put together an acquisition plan, several other pieces of work. We get that submitted in October to CDC, who handles our purchasing, the Office of Administrative Services. Then we get to the pre-solicitation, which is what I talked to you about back in November when we met, then we post the solicitation in December and all the concept papers are due in January. So basically, a solicitation, from the time the pre-solicitation is posted, you have about a month and a half to develop your submittal to us. And you typically submit a concept paper to us, we do an evaluation. Based on that evaluation, we develop questions and input that we would, if we're going to request a full proposal from an organization or a university, we try to tailor it. You have to remember that the idea behind a broad agency announcement is you submit your idea to us. An RFP, we tell you what we want a submittal for. Under BAA, you submit what you propose to do. So our input is very limited in this, and we try to push the limits of that by telling someone exactly what we'd like, what we're interested in in their submittal and what we would like them to focus on. Then we request full proposals. The full proposals come in. We establish a review panel. We have a submittal deadline so that basically we notify you in February, you have a month to develop a full proposal and submit that. We evaluate that and we make a funding decision that we send to the procurement group, and the procurement group negotiates. Once again, we have clarification points, so we try to give as much input as we can on this process. We have very limited ability but we try our best. And the procurement finally happens and the award's issued in September. So you can see, this is a year process. And rejection notifications go out shortly thereafter.

But we're already in the process today of developing those focus areas that we'll use in September for our package for next year, and we haven't even issued this year's contracts yet.

DR. NELSON: So is the funding decision on schedule for Wednesday?

DR. GEORGE LUXBACHER: The funding decision is on schedule. The funding decision has already been made.

DR. NELSON: Have the people been contacted?

DR. GEORGE LUXBACHER: That, we don't do that. That isn't part of the NIOSH Mining Program. That's CDC Procurement. Procurement handles that. We are—and you'll see on my next slide, I have a little note at the bottom that says, "In accordance with the

Federal Acquisition Regulation, no further information can be disclosed at this time." So I'll give you a little bit of an idea of what we're doing but I can't tell a whole lot, because we don't make that contact with those parties. That's done by Procurement, and we're actually barred under the FAR from having that contact. So this gives you an idea what kind of concept papers we got in in response to that solicitation. I sort of abbreviated the topical areas but in your documents that you received, it goes into a little bit more detail and you can always go out and look at the solicitation. But some of these we really received very few concept papers and we elected to move none of those forward to full proposals. Next-generation communications systems was interesting. We received a number of concept papers but nothing that we really were excited about. We moved one forward to a full proposal but I was actually a little bit disappointed on what came out on that, because basically, NIOSH developed the communications systems you're using in mines today. We, under the MINER ACT funding, we pushed that forward, and I had hoped to move that a little bit forward and that just didn't pan out. But you can see here that under the "Other" category, we got 15 submittals and we moved forward with full proposals on 5, and we've recommended, I think I show on the next slide, we've recommended 9 contracts that went up to Procurement, although I can't give you a breakdown in accordance with the FAR. So this just gives you an idea. I went back to our history on this program just to show you, we averaged, this year we got 33 submittals. We actually got 35 submittals. We had one university that submitted two proposals that were received an hour after the cutoff, and Procurement, again it's a CDC division, not a NIOSH decision, anything that's received after the cutoff absolutely cannot be considered, and those were rejected. This is the second year in a row we've rejected a number of these. We also had one rejected on a full proposal because it came in after the time too, and again, we don't control that process. It's very clearly stated in the Federal Register, and those that choose to—don't quite meet it don't get funded.

But anyhow, so we requested 15 full proposals. We actually requested 17. One was received late so it was discounted. One we requested a full proposal from, that organization elected not to submit. They said they basically didn't have the time to put it together. So we had 15, and out of that 15, we funded—we've proposed to fund 9,now, subject to contract negotiations. Right now, Jessica has approved the 9 and the Procurement group is in contract negotiations on those, so I'm going to see where that goes.

Now, this was the year we went out on our next capacity build. I always like to throw this slide in because it does show the benefit of our capacity build program. The intent is to develop faculty, get faculty tenured, develop master's level students and PhD students in areas where we feel at NIOSH that there is a significant need. You can see from this that thus far, we've issued 27 contracts.

We have the 7 ventilation contracts from 2014 are all expiring at the end of this fiscal year. So we've had roughly 100 master's students and 75 PhD students funded under this program.

We went out with the new solicitation—I had mentioned this last year as a draft because it hadn't been posted yet. Since then, we have posted this. It went out on March 8, and the response date was April 22 for our capacity build. And you can see that we've broadened this. Typically we would do a ground control, ventilation—or ventilation, ground control, ventilation, ground control. This would have been our ventilation year. Based on a lot of internal discussion, based on our interaction with the faculty at the annual meetings we make, based on some input from MSHRAC, we broadened this topic to mine system design research for the mining industry. So we broadened the topic out significantly. Our focus continues to be on producing MS and PhD graduates from ABET-accredited mining engineering programs, and to support tenure track faculty as they move forward through the tenure track process.

Now, just to give you an idea what happened on this, when we went out with this solicitation, we actually received 24 proposals from the universities in response to this. You can see that that's significantly above what we've gotten in prior years, because we've broadened the topic. So we've received 62 proposals. We've funded 27 contracts thus far. This 24 is a significant—significant groups of contracts to review, and so this actually takes a little bit more time than I had budgeted to review 27 contracts. We've formed the review panels and we're getting those out to everybody right now to review.

To give you an idea who's submitted under these, we asked for these through the ABET-accredited mining engineering programs. There's 13 programs in the United States that are accredited right now. We received proposals from all but Montana Tech. You have to have a master's and a PhD program associated with your program to receive funding from us. I think Montana Tech, because they do a combined PhD program, I think they have an issue there. But we ask for, we ask at this time for collaboration. We really wanted to emphasize collaborative aspects, and I looked at how I could put that up here, but anything I did probably violated the FAR so I decided I wasn't going to do that. But a number of these proposals, these 24 proposals, probably three-quarters of these proposals included collaborations, internally between departments, for example mining engineering department collaborating with mechanical engineering and electrical engineering, or between schools where we actually have one school is collaborating with two other mining engineering programs. So that's what we're trying to encourage out of this and we're going through those evaluations right now. This is going to take a lot longer to evaluate but we have some firm deadlines that we have to complete this by, so we're in the midst of that right now.

And with that, I think I've probably brought us back on time and I'm willing to

answer some questions.

DR. NELSON: Thank you, George.

DR. MILLER: A couple of questions if I may. With the reduced number of FTEs that you've been reporting on throughout these presentations…

DR. GEORGE LUXBACHER: Yes.

DR. MILLER: Do you have a reduced staff that is doing these evaluations or do you have outside contractors who are doing the same?

DR. GEORGE LUXBACHER: So while we have reduced staff internally, a reduced number of FTEs, we have less subject matter experts within the programs. When we do the evaluations of these submittals—we rely on subject matter experts at Spokane and Pittsburgh as well as we have a small—at the OD level, we have myself and one other person that are engineers dedicated to reviewing these, and then we draw upon other subject matter experts from within the program. So we have no problem doing that.

We have a bigger problem, we have something—and I've talked about this at several other meetings so I'll just update you a little bit—we have what we call a contractor officer representative, and they manage the technical aspects of the contract. It's very difficult for us to find contractor officer representatives that are subject matter experts, because there's very little motivation for people to get that level of certification—it requires 60 hours of training to get your initial certification and then to maintain it, you have to, every two years, you have to have 20 hours—and that is a bigger problem for us today is trying to find people within the program.

So for example, on this group of programs right here, we're talking about funding, for example, we're going to fund nine contracts out of this group of fifteen full proposals we have received, and at least six of those are in one topical area. And that particular program area within the Mining Program only has a handful, one or two, contract officer representatives that I can give those contracts to. We're working through that difficulty. That's more of a problem than evaluating and picking them.

DR. MILLER: A second question if I may. When you talk about underground communications with mines, there are military implications to that as well.

DR. GEORGE LUXBACHER: Right.

DR. MILLER: That historically have been tied in, for example…

DR. GEORGE LUXBACHER: Yes.

DR. MILLER: To communications with submarines for example.

DR. GEORGE LUXBACHER: Yes.

DR. MILLER: How do you coordinate and what do you do in terms of the level of technology that now applies that previously didn't, or what have you learned from the military applications?

DR. GEORGE LUXBACHER: So what happened out of that is when the MINER ACT was implemented,

communications became mandatory. NIOSH did a tremendous amount of work with the military. So we have a medium-frequency radio system, a Kutta system, that actually came out of a military application. We continue to work with the military. Once MSHA determined what was acceptable from a regulatory compliance standpoint, there's very little motivation for manufacturers or mining companies to move beyond regulatory compliance. When we started talking of a next-generation communications system, wanting to look at that, and instead we received proposals for minor enhancements, not what we expected. We were hoping to move to a more digital environment for mine communications similar to what they've done in Europe and in Canada. The differences in Europe and Canada relate to the regulatory environment for communications, for one thing. There's several differences, but we did not receive the proposals we thought we would through this, and that's a little bit of a disappointment and we'll probably try this again. We'll probably rewrite this topic area and try to be a little bit more focused on what we're interested in and we'll see if we get something.

DR. NELSON: Okay, let me ask you a question. At the department heads meeting at SME in Denver, I conduct a survey of what's going on in the departments. And in 2015, we had almost 400 students expected to graduate, US-wide, with a bachelor's degree in mining. This year, the number was close to 200, instead of almost 400. And a similar reduction occurred in the PhD students that were coming through. So, we have a whole pipeline problem. I am wondering if that is of concern to NIOSH and that perhaps a future training opportunity might be something that encourages the whole pipeline including undergraduate participation in mining, because that's where the problem is. We're having a decrease in the number of people applying into graduate study. So this is an issue, or perhaps maybe even something like what National Science Foundation does, which would be once you get a project, training project started, PIs could request a research experience for undergraduate supplement that would actually bring undergraduate students into the project and a way of increasing the throughput. So have you thought about any of those things?

DR. GEORGE LUXBACHER: Jessica and I have been talking about what we can do from a grant standpoint because some of these things you can't do—the nature of the BAA mechanism that we use, because it's the most practical mechanism for us—does not lend itself to that. Some of these things can be done easier through grants, and Jessica and I have been talking about getting ourselves more engaged with the grant program. For example, I'm not sure the U60 grants are as effective as they possibly could be, or that's a proper mechanism. I think there are some other things we can do. We also talked about some other grant programs that we could possibly use. So we're looking at that from that standpoint. If you remember my slide last year where I showed what SMEs are doing and what other people were doing—I think we have contributed more than any other institution in the United

States for faculty tenure. I've heard this from so many young faculty.

DR. NELSON: What I'm saying is that there's another issue.

DR. GEORGE LUXBACHER: Yes.

DR. KOGEL: Yes, so I will talk a little bit about something that we are proposing to do that I think will address this.

DR. NELSON: Good.

DR. KOGEL: And it is also a huge issue to us, just simply from, for selfish reasons, because of the workforce impact for us.

DR. KOGEL: I mean, we're all drawing on this very small, diminishing pool.

DR. NELSON: Yes, for everybody.

DR. KOGEL: So we've got to do something.

DR. GEORGE LUXBACHER: And so in this last round of capacity build, we pointed out that we would also like to talk about internships and take advantage of several programs that NIOSH, CDC and HHS have for internships and things like that. And we highlighted that in our capacity build, BAA solicitation—and I haven't read every one of these yet. I've thumbed through them, and I'm in the process of going through all 24 in detail, but thus far I haven't found anybody that's taken advantage of that, that they want to build an internship into the capacity build over that five-year period.

DR. NELSON: Yes, some people need green lights, many of our faculty do. And so it's really important to give green lights if that's what you are looking for.

DR. GEORGE LUXBACHER: Well, let me find the one slide here that just shows you the problem we have when we go through these. You can see, so there's one institution that submitted five proposals. There's another institution that submitted four proposals. We have a decision to make based on what happens out of this because in two years, the ground control will expire and we'll have to decide if we want to continue that. And this has been interesting. If I was to do this again, should I limit the number of proposals from a given university?

MR HORN: Young students or PhD students don't perceive the mining industry as an expanding industry, and therefore the level of opportunity over time diminishes in terms of career development.

DR. NELSON: I don't think that it's necessarily the expanding industry. I think that it's an industry that they choose to not enter. And I'm not sure that it's because of perceptions of non-expanding. I think it's perceptions of what you do when you're in mining. And we can change that but…

DR. GEORGE LUXBACHER: Yes.

DR. NELSON: But various organizations that have tried to do that have not been effective at changing that perception.

DR. MILLER: It sounds like hard work.

DR. NELSON: Yes, good thing we like hard work.

DR. KRAMER LUXBACHER: It sounds like it's not high-tech work is actually the problem. Not so much

that it's hard work.

DR. MILLER: We're having the same issues in construction.

DR. NELSON: But I'll tell you, the DARPA Challenge starts mobilizing people, they get very excited about this and want to do it. So there's ways of doing it, but it's in spite of rather than in line with the industry.

DR. GEORGE LUXBACHER: I can tell you two years ago when we met with DARPA in DC to talk to them only about Project Amoeba, and they brought up the SubT Challenge, and they were so enthusiastic, and the seed was planted to bring that here to Pittsburgh. We think that this will get a lot of coverage in the local paper. This is good, positive coverage, and they are running high-tech stuff in our mine. I think there's going to be tremendous PR out of this. So it took us two years to get to this point, but we've been working with DARPA to get them here, as we really felt that this was really a great opportunity.

DR. NELSON: We will take a 7.8 minute break and reconvene soon.

[Break.]

DR. NELSON: Okay, we're going to reconvene. So I invite Maryann to give us an update on her Division.

UPDATE FROM THE NATIONAL PERSONAL PROTECTIVE TECHNOLOGY LABORATORY

DR. D'ALESSANDRO: Good morning. Thank you for having me today. My name is Maryann D'Alessandro. I'm the Director of the NIOSH National Personal Protective Technology Lab. And our mission at NPPTL is to prevent work-related illness, injury and death; to advance the application and state of knowledge for personal protective technologies and that is the area where we support the mining group, specifically in escape respirator technology.

So today what I'll talk about, regarding escape respiratory technology are the regulations we currently have in place and the status of the transition, Long-Term Field Evaluation program and breathing air supply research.

So first, on to Subpart H to Subpart O Regulatory Transition. What I wanted to do was put up a timeline here. You may remember back in 2012, for those of you who were involved back then, and I think I reported on this over the past several years—in 2012, there was a regulatory transition where Subpart O units were put into place and there was a three-year window for which Subpart H units could continue to be sold.

And what happened from 2012 to now is that there was some issues with that, because there were not enough Subpart O units that met the miners' requirements that came into market. So MSHA and some other stakeholders came to us and asked us if we could waive that three-year requirement and continue to sell Subpart H units.

So we put together some—in October 2018, I won't go through all the years of what happened, there are so many different things that happened over the years,

the most important part is that in October 2018, we put out a Federal Register Notice saying that we were proposing to permanently lift the sunset date for those Subpart H units. And between October 2018 and April 2019, that regulatory action took effect and now those Subpart H units—which are the older units—will be able to continue to be sold.

And there are three components to this final rule, FR-2019-04-19, you can see it—the link to it at the bottom of that area, circled in grey—the grey area circled in red. So the first piece is that any new approval that will be issued has to be a Subpart O unit. We are not allowing any new units that are Subpart H. That's the first part.

The second part is that those Subpart H units, where they exist in mines, they are being able to continue to be used and they will have no termination date on those Subpart H units. However, if a manufacturer wants to modify those Subpart H units, any modifications have to meet the Subpart O requirements. So the way we positioned this rule is that we would like manufacturers to meet the more rigorous requirements, because we believe that those products and those requirements provide more safety for the miners. Any questions on that rule or anything? Okay.

All right, so when you look at what units are out in the mines right now, the Subpart H units that are out in the mines are two Ocenco units, a 10-minute unit, the M-20 and the 60-minute unit, EBA-6.5. And the 60-minute unit from CSE, the SRLD, which is considered a belt-wearable unit. So both the M-20 and the SRLD are the belt-wearable units that were no longer belt-wearable when we came to the Subpart O units, with the exception of the 10-minute unit was still belt-wearable. So these will continue to be sold and are still in the mines.

When it comes to these Subpart O units, we have changed the way that those are described from 60-minute to CAP 3 and from 10-minute to CAP 1, because now the way these units are evaluated is by capacity rather than duration. So I have a little note here at the bottom to make that clear, to remind you of that. So Ocenco has two units, so essentially they have taken their existing units under Subpart H and modified them to meet the requirements of Subpart O. And CSE Corporation has designed a new unit, the SR2000 which is a bit different than their SRLD and it's a little heavier, so it's no longer considered belt-wearable. But the Ocenco units are unrecognizably—they look very much the same. You can't see the difference between those units and the Subpart H units. So now there are six units being able to be used in the mines.

We did have another manufacturer enter the market, Avon Polymer Products, and they had a 10-minute unit, but they withdrew that from the market. They were banking on getting a Navy contract, and they did not win the contract, Ocenco did. And so as a result, they didn't have any—they were hoping if they won that Navy contract, that that would be the beginning of their sales and then they were going to try to penetrate the mining industry. But since they lost the contract, they just

withdrew the approval, unfortunately. It would have been interesting to see another manufacturer in the business.

So when we look at what units are out there and how many of them throughout the mines, you can see the distribution here from the MSHA inventory, and this is as of April 2019. Last year, I reported those dates that you have in May and you can see that the Subpart O units are continuing to increase. You've had 110 CSE SR2000s last year, now 475. Ocenco's almost three time as many, and you see a little bit of bump in the M20.3s. But you also see that the other Ocenco units continue to rise, as well, and the CSE SRLD, as well. However, the Draeger units, which are the other Subpart H units that are in the mines right now, they are becoming obsolete. So Draeger has told us that they no longer intend to sell those units. So we will just have the CSE and the Ocencos.

So on to the Long-Term Field Evaluation and those numbers will help us see what we're going to be doing with the Long-Term Field Evaluation. The Long-Term Field Evaluation Program is led by Gary Walbert, who is an engineer and I'm grateful for his input on these slides. So the objective of the LTFE Program is to sample the mine escape respirators that are in the field, and these are in their non-deployed configuration. So they're as worn on the miner or as cached wherever they are located, not in their open, deployed condition, because once they're open, they can no longer be evaluated.

And previously, what we did is we would identify units for random collection, and we would oversample the numbers that we needed, because it often was difficult to find the units we were trying to retrieve. We then traveled to select mines, across all of the MSHA districts across the country, to gather those units. And we perform a manufacturer's visual inspection at the mines and if the units do not meet that manufacturer's visual inspection, we do not bring the unit back to our facility. Because if it were to be evaluated, the manufacturers themselves would say it is not in a condition to be evaluated and should have been pulled from the mine.

So historically, we have not done anything with that information. We got to the mines and the units that we see do not meet the requirements, what we want to start doing going forward is to actually do a more detailed assessment at the mine, so we could provide some feedback to those mines, letting them know what the maintenance and training issues might be for those units, even though we do not intend to test them, but provide a little bit more information.

In our last report, we just indicated that 7.5% of those units that we attempted to collect were not able to be collected, because they did not meet requirements. So those are units that should have been removed from the mines and that's significant 7.5%, and I think it's important to get that information out there, have some type of alert or one-pager that we put out to the mines, in the future.

So then after we collect them, we bring them back and then we perform another

visual inspection at our site and oftentimes, the manufacturer witnesses those visual inspections, as well, and provides input into whether or not those units continue to meet the requirements. And then, if they do not meet, then that's a second time when we will say we don't test those units. And then we conduct the testing and then assemble the report for distribution.

So the latest ones that we have put together are LTR-1, 2 and 3. And you can see the sampling periods there range from—started in 2009 and finished in 2017, and all of these units fared pretty well with all of the requirements and we had no reason to believe that any long-term time with this equipment in the mines would cause any problem. The one issue that we did see is that in the LTR-3, the inspired levels of CO2 were not within—only 92.5% of those units met those requirements. Since these were Subpart H units, this is not a requirements of Subpart H, but in the Subpart O units, this is a new requirement. So if that were—if these would have been Subpart O units that were evaluated, that could have been an issue.

And I have the links here to the latest report and then also the report where we evaluated 500 of the CSE SR100s that were pulled out of the field, back in 2011.

So now what we're planning to do—we've been, you know, digging through the data and looking at what makes most sense to get information out there to the mines as quickly as possible and we have developed a new strategy. It has been reviewed by MSHA and by PMRD and we are awaiting final comments to begin implementation of this strategy. And what we are going to be doing is we're going to do two types of activities. We're going to determine if the Subpart O devices conform to the requirements.

This is our conformity assessment piece, which is actually part of our regulation. But then we would also like to—as a more research piece, compare Subpart O units and Subpart H device protections to either validate or invalidate the improvements made under Subpart O devices. So we are going to first target mines that have the Subpart O devices and we have a distribution here by state, where those Subpart O devices are located right now. And then we are going to sample them and sample Subpart H, with matching independent variables, looking at the manufacturer and it's device technology, looking at deployment locations and exposure time. That's time that these units have been in the field, in the non-deployed configuration. Again, for conformance we're going to test the Subpart O devices to the approval requirements we have and then for research, we'll test both the Subpart O and Subpart H devices, to see the impact that these independent variables may have had on the protections that these units are providing.

So the timeline for implementing this new strategy is that we finish the draft protocol and it's under review right now and then, we are hoping to begin the peer review very soon and we have some peer reviewers identified, but if any of you

are interested or if any of you know of anyone who might serve as a good peer reviewer, please let me know. We could use a few more.
And then, once the peer review is complete, the hope is that the protocol will be revised, and collections should be able to begin in the July timeframe. And then testing in the August/September timeframe, completed by January 2020 and then, report preparation with a report published by September 2020.
So you see the timeline is much shorter than our timeline in the past. We're hoping with only having two mines, we're collecting about 60 units each, 60 units of each type, at the mines and we are going to also use controls, as well, the new devices. And with this type of structure and strategy, we believe having one year is a reasonable time to get the reports out and get useful information to the mines, that hopefully will be very useful for the mines where the units were. But then in time, as we continue to gather this information, can be translatable to more generalizable after we collect more data from other mines. Any questions on the LTFE piece? Okay.
And the final piece is the breathing air supply research, the close-circuit mine escape respirator components. You may remember several years back, these components were being developed to be integrated into a backpack configuration and several years back, that backpack configuration was terminated. So right now, we just have the components that are being developed. So there are about five different pieces that I'll talk about. The liquid oxygen storage module, the facepiece in the docking valve and the oxygen delivery system, the cylinders. And then working with PMRD to encourage manufacturers to build this system into a configuration. And Rohan Fernando is the project officer on these efforts and is in the room, as well.
So the liquid oxygen storage module research is a collaboration with NASA and NASA is the one who has work underway in this area already, so they were a natural fit to take on this cryogenic work. And what they have done is evaluated a number of materials, to determine what would be the best material to use in configuration, configuring the Cryogenic Flux Capacitor.
So over the past year, that's what they have been doing, evaluating different materials for this purpose. And they have narrowed it down and now, this year, what they're going to do from the one that they have is now design the LOXSM and hopefully, then be able to integrate it into a device and into the breathing unit, to be able to evaluate it. And the next piece is the facepiece for mine escape and the facepiece is a half mask design, you can see here, and it has a bite-bit inside, that the user puts over their lips. And then it also has the T-DOK that connects to it and the T-DOK allows you to be able to switch out one unit and switch to another, without compromising your breathing zone. And it also has an integrated speech diaphragm and right now, this is in the production and test phase. So we are going to be testing this with the Automatic Breathing Metabolic Simulator first

and then see how we can—we may be able to use human subjects in the future. And this is a contract with High Valley Design. And the next piece is the Valve Integrated Pressure Reducer for mine escape and this pressure reducer ties into the cylinders, prototypes that were reduced. This was a collaboration in partnership with the Navy and this allows this pressure reducer to be incorporated into those cylinders, into the overall breathing system and breathing design. And these cylinders, now, is where we have made great success. There are a number of patents and permits that have been issues, so we have a permit for the 10,000-psi cylinder that has been granted. So this cylinder is able to be used, which is great because prior to this, our limitation was 3000 psi, so this should allow us to have a lot more time, once these are integrated into a system. Now the 5000-psi cylinders, there is a permit granted for use up to 3000 psi and they still are undergoing more tests, to move it up to 5000 psi. But this one is used or this one is available and once it's in systems, it will be a great benefit to the mining industry or any industry who decides to use it.

And the next piece is the RFI. George talked about all of the RFIs that—and Broad Agency Announcements that he has been putting out and there is an RFI that was drafted recently, to promote integration of these components. Since we no longer have a platform to integrate all of these components, that's something that's needed now is now that all of these are almost at the point where they are complete, now we need someone to be the systems integrator and that's what the...here for potential projects is design and develop CCERs for mine escape using the cryogenic capacitor and all of the components that were developed, as well.

And then a few other potential future systems, as well, but our main focus right now is this LOXSM, I think for the next year and the integration. So what I was hoping to do—I had four questions. I know that's a lot. That could probably take the rest of the afternoon, but if you want to look at one question or if you want to get back to me on any of these responses, and also the peer reviews. So I have five questions. I'd be open to any thoughts you may have in any of these areas, if there is time.

DR. NELSON: So you have to read the questions first.

DR. D'ALESSANDRO: Okay. So first is what suggestions does MSHRAC have about the revised LTFE strategy? And that is looking at Subpart H and Subpart O units and comparing them and going to—rather than going across the country to collect all of the units in a random sample, going to two mines at a time and comparing the H and the O and doing a more focused report, which would allow us to have the report within a year, rather than multiple years, which has been historically what has happened. So that's that first one.

The second one is, right now, we post everything on our website. Are there any other ideas on disseminating the information that we put in the reports? And then

the Liquid Oxygen Storage Module, that's not my expertise, that's Rohan is here in the room, though, but the intent is that this Liquid Oxygen Storage Module will be much reduced in size and I view it as a high-risk, high-reward type of activity, research activity, where if it's successful, it could significantly reduce what and SCSR would be, if it's integrated into the system. So if anyone has any expertise in that area and can offer any comments. And then evaluating these components as a system, rather than just components, as we no longer have the backpack configuration option.

DR. NELSON: So when do you think the O models will be it and H models will be discontinued?

DR. D'ALESSANDRO: Well, as I mentioned, now there is no sunset date for the H. I think maybe they never will be, but what could possibly happen is this LTFE work, comparing the Os and the Hs, could show the benefits of them, or it might not. If it shows the benefits of them, then you would think that miners would want to have the more protective devices, rather than the Subpart H units. So this could be time.

DR. NELSON: So to me, I'm not sure I quite get why O and H are being compared, as the main focus of the work, instead of just evaluated for performance against the requirements, which it seems to me is the most important part is—

DR. D'ALESSANDRO: We're doing both. Yes. It's part of our regulatory requirement to evaluate them for performance, for a requirement.

DR. NELSON: But is it regulatory that you have to compare O and H constantly.

DR. D'ALESSANDRO: No. No. That is our—we are doing that as—again, as a way to show the benefits of Subpart O or to show that they aren't more beneficial than Subpart H.

DR. NELSON: Well, that was my suggestion. Jefferey, you want to say something?

DR. BURGESS: Isn't one of the problems with the Subpart O devices the fact that they're too heavy and uncomfortable for the miner?

DR. D'ALESSANDRO: Yes, right now, that is part of the problem.

DR. MILLER: And that was a problem that existed before, in terms of integration too, because miners were reluctant to use the respirator, because of the discomfort.

DR. D'ALESSANDRO: So but they still are out there, so...but the hope is that if Subpart H units are going to be modified to meet the Subpart O requirements, if any modifications would take place, then perhaps they would also be belt-wearable and reduced in size and some of this technology could lead to reductions in size, also.

DR. BURGESS: So Maryann, you said that a major finding of your work so far with the LTFE was the identification of over seven percent of units that are out there that aren't suitable even for testing. Therefore, when you were asked a question about dissemination efforts, I assume that that's one of the focus areas that you have in mind?

DR. D'ALESSANDRO: Yes.

DR. BURGESS: So I don't have a great answer, but I'm wondering whether the companies that you work with could be involved in the solution of getting that information out there, because it would be to their benefit to sell replacement units. So could they be

part of this dissemination strategy, to reach out and perhaps even assist in evaluation somehow?

DR. D'ALESSANDRO: That's a thought. Right now, they do come and witness tests, but they don't—they're not involved in the collection but that's an idea. Thanks, Jeff.

DR. BURGESS: And is there some type of information that you could send out, that would help them to easily identify units that might not be suitable for additional storage?

DR. D'ALESSANDRO: That's what we have to do a better job at. So in the past, since the focus was bringing back those ones that met requirements, we would note that they didn't meet requirements, but not take enough notes to provide them any good feedback. But going forward, that is the plan, that we will write detailed information about what the conditions are of the units we're finding, so we're able to provide good feedback to the mines. And then maybe generalize that information to provide it to others, as well.

DR. BURGESS: Thank you.

DR. D'ALESSANDRO: Okay, thanks.

DR. NELSON: Any other input for Maryann? Well, should you subsequently have input, please get it to her.

DR. D'ALESSANDRO: Any peer reviewer ideas? Okay.

DR. NELSON: Okay, thank you, Maryann.

DR. D'ALESSANDRO: Thank you.

DR. NELSON: Thank you. Okay, Respiratory Health Division, Dr. David Weissman.

UPDATE FROM THE RESPIRATORY HEALTH DIVISION

DR. WEISSMAN: I'd like to thank Jeff and Jessica for inviting me to come and give an update to the group on what we've been doing in the respiratory health division since our last meeting.

So I'll start with a little bit of an introduction and then we'll talk specifically about the Coal Workers' Health Surveillance Program which is one stream of surveillance information we get about pneumoconiosis in coal miners. Then we'll talk a bit about other surveillance efforts that we do outside of CWHSP, that add to our understanding of lung disease in coal miners. And then just a few words of conclusion.

So just to start out with, I just wanted to remind everybody that coal mine dust doesn't just cause CWP. Coal mine dust can cause a spectrum of diseases. It helps to think about them as two groups. One group of diseases are interstitial lung diseases, fibrotic lung diseases, so CWP, silicosis, mixed dust disease and then dust-related diffuse fibrosis, which has a bit of a different radiologic pattern. It looks like IPF. And the second group of diseases are diseases that would be best characterized as obstructive lung disease. So coal mine dust causes COPD. It's an independent risk factor from cigarette smoke, emphysema, chronic bronchitis. And a lot of what I'll be talking to you about today will relate to the first group of

diseases, the interstitial lung diseases, but it's important not to forget about the others.

And again, just a bit of background, just to remind folks when we do radiographic screening for pneumoconiosis, here's a picture of a normal x-ray. You can also have simple pneumoconiosis, which is characterized by the presence of small opacities on the x-ray. In this picture, you see someone with small, rounded opacities. And then, over time, those opacities can conglomerate together, and you can get large fibrotic masses. We call that progressive massive fibrosis. So just that bit of background.

So now we'll talk a bit about the Coal Workers Health Surveillance Program and give an update on that. So here's a review of what we currently do. So coal miners are required to have a baseline respiratory health evaluation at entry into coal mining and then to be offered follow-up evaluations at about five-year intervals. The evaluations that are offered currently include work history, respiratory health questionnaire, chest x-ray and spirometry. Spirometry was added in the 2014 rule and recently implemented.

Surveillance testing is provided in two ways, through local medical facilities approved by NIOSH and also through directly by NIOSH through NIOSH Mobile Outreach. NIOSH receives processes and reports the test results. We do a standardized evaluation of chest x-rays, to evaluate the presence and severity of changes of pneumoconiosis and that's done by NIOSH-certified physicians called "B Readers" and I'm mentioning that because I'll say a little bit about B Readers later on.

So in 2018, we provided about 8200 chest x-ray screening examinations, which was 10% more than 2017. The last couple years have been really busy for us. In the past, prior to the rule including surface miners, we would typically do around 3500. So we've more than doubled our screening examinations offered. In addition, we've been standing up spirometry. We did 2665 spirometry tests and we've stood up 32 approved spirometry clinics around the country in 11 states. And you can see the little map there, as we've stood up spirometry with screens of the obstructive lung diseases that I talked about, that are associated with coal mine dust.

In terms of our mobile outreach, we're currently completing an effort to revisit the hot spots that were originally described by Antao et al. in 2005. And you can see them here and especially here in Appalachia. Last year, we largely focused on Appalachia. This year, we're doing western states and our mobile unit is currently on an extended survey out west, where they're going to have 31 days of screening offered at mine sites and 11 days of screening offered at community sites. And really a special thanks, there are many mines that are allowing non-employees to come to the mine, to be at the unit if it's in their area. So special thanks for that.

In terms of an update on overall findings, many have seen this graph before, and

this was published in 2018. As you can see, here's this upper black graph shows the proportion of participants with radiographic evidence of pneumoconiosis over time, going back to the Seventies to the current. And this upper line are those with 25 years or more of tenure. Tenure is a really important factor to think about in pneumoconiosis because it typically takes decades between first exposure and development of disease, at the levels of exposure that we see in our country. But at any rate, you can see here in Central Appalachia, if you just look at that, you can see among this long tenured group, we've reached the point where about one in five have some radiographic evidence of pneumoconiosis after working that long. In the US as a whole, it's about one in 10 and if you look in the US, excluding Appalachia, it's about one in 20. So there's a substantial problem with pneumoconiosis and it's especially in Appalachia, although it occurs elsewhere too.

Now, we've heard about silica and the potential role of respirable crystalline silica. One type of small opacity pattern that is seen especially with silica exposure—although not exclusive—are r-type opacities. And Dr. Hall, who is in the audience here, published a paper since the last MSHRAC meeting, showing that the proportion of individuals with R opacities in Central Appalachia has continued to increase over time, as opposed to the rest of the country. So the x-ray pattern supports the importance of crystalline silica in what's happening in central Appalachia.

DR. NELSON: You know, the last two slides, by giving percentages—is it possible to actually look at numbers? Because everything being a percentage means you can't see relatively what's happening in the workforce, across ages and—

DR. WEISSMAN: Sure and point well taken and if you actually look at absolute numbers of things like PMF, absolute numbers of increased—and you have to think about things in relation to the total mining population, of course. You know, compared to the Seventies, Eighties and even the Nineties, the total mining population has gone way down.

DR. NELSON: Right.

DR. WEISSMAN: And the absolute number of severe cases have gone up, so that makes it even more impressive.

DR. NELSON: Right. And I would appreciate that, at some point. Thank you.

DR. WEISSMAN: And I'll put in a plug for our CWHSP query system. We actually have an online query system, that people can come to and actually directly, easily, pull down that data, just from our website. So that's easily available to folks. So I'll switch gears a little bit. I'd mentioned B Readers as part of the CWHSP earlier, because B Readers are the physicians that look at the x-rays and use what's called the International Labour Office Classification System to assess the presence and severity of pneumoconiosis changes. NIOSH originally stood up this program in the 1970's because of variability in the way that physicians evaluated chest x-rays.

And we're continuing to work on this program.
We're working with the International Labour Office to update their classification system again. We're on the verge of putting out an updated classification that uses digital radiographs for standards, as opposed to the old-fashioned film radiographs that were used before. We've moved our certification examination for B Readers to electronic format and we're on the verge of putting out a completely new examination that uses modern, digital chest images. And work is also in progress to update the physicians' training syllabus. And the B Reader program really is important. This is a paper that was published that compares A Readers—who are physicians who haven't done the B Reader Certification Examination successfully—to B Readers. And you can see that A Readers are less likely to call a field normal, so they're more likely to look at normal structures and misinterpret them as disease, and they are more likely to call the presence of disease than B Readers. So having that training is really important, to have findings that are specific, that you can believe that if the classification is done, that it actually really does show disease.

DR. MILLER: That was a big push-back in the late Seventies and Eighties, in relation to a uniform definition of what black lung really was and whether in effect, the diagnosis really applied to the circumstances.

DR. WEISSMAN: Yes and it's important to have consistent evaluation of chest x-rays over time, so that we can compare what we see now to what happened in the past. It's really important to miners who are getting evaluated for benefits programs, so that determinations are made based on what's on the chest x-ray, not based on what doctor looked at the x-ray. And so having that consistency is really critical and it was a big, big problem when the program first stood up in the Seventies. Another—

DR MILLER: Can I just ask you a question? Yes, on the B Reader Program, is there value in using other modalities at this point, like CTs and things, in earlier identification for objective disease, if that would be helpful to the workers?

DR. WEISSMAN: Sure, so technologically, if you do a CT scan on a heavily-exposed miner, it's going to be more sensitive and probably more specific. So you can certainly pick up disease with a CT that you wouldn't pick up with a chest x-ray. The downside to it is that the amount of radiation that you give to the person being screened is quite a bit higher. So it's basically, depending on the literature, either 0.05 or 0.1 millisieverts radiation for a regular chest radiograph and CTs that are done for lung cancer screening in our country typically are about one or two millisieverts. So a whole lot more radiation and at the population level, you don't want the price of your screening to be causing iatrogenic lung cancer over time, especially when you're giving radiation to young people. So you want to minimize the radiation. The potential technological solution to that is there's something called ultra-low-dose CT that's available now. And ultra-low dose CT you can do with almost the

same radiation as a regular chest x-ray. The problem is it hasn't penetrated into the US market very much yet. There's only one CT—brand of CT machine that's out there that does the advanced reconstruction of images, that allows you to reduce the radiation that low. So it's not generally available yet. When that becomes generally available, if it becomes generally available, that solves the radiation problem, but we're not there yet.

The other issue is cost. In the US, a CT costs more than a radiograph. Another issue with it is portability, so putting a CT on a mobile unit like what I showed you, it wouldn't go on that mobile unit, it's so big and heavy. You would need a truck to kind of drag it around. So it's not as easily kind of transportable. So those are some of the issues.

I guess another issue with pneumoconiosis is it's generally a slow-moving kind of disease. So the time differential between the minimum amount of disease you would see with a chest radiograph and the minimum amount of disease that you would see with a CT scanner, whether that would affect the outcome of a patient, I'm not really sure. It's not like lung cancer, where catching the lung cancer as early as possible makes a huge difference in the person's outcome. Because if you catch it early and you get it out, then you get a much better outcome. Pneumoconiosis isn't exactly like that. So those are sort of my thoughts.

DR. MILLER: Are there international standards now, with regard to pneumoconiosis that we apply, or we agree with going forward?

DR. WEISSMAN: There's an ICOERD System, it's an International Classification for High-Resolution CTs for occupational disease that's very parallel to the ILO system for chest radiographs. There's a fair amount of stuff that's been published on it and it seems to perform pretty well. So if I were to do a study today, like an epi study or something like that, I would definitely use that ICOERD system. I don't know if it's ready for regulatory purposes, for the reasons I talked about earlier, I don't think that we're ready to be doing CTs on healthy people right now. But if we ever do kind of get to that point, that's the system that I would build off of. Okay.

So another bit of activity with CWHSP is that we received a Congressional charge this year, to provide a report to Congress on potential barriers to participating in the Coal Workers' Health Surveillance Program. And because of concerns that it's a voluntary program and not everybody who is eligible to participate participates. And also, it's only available to active coal miners. It's not available to people after they retire, when actually the bulk of the severe disease occurs.

So together, stakeholder input, we posted a request for information in the Federal Register. We got eight comments by the January 14, 2019 deadline. The comments are all available on the Regulations.gov website and many of the folks that are in the room here were those who contributed comments. So thank you. And we've prepared the report for Congress and it's currently working its way through the highly efficient federal review system, and it will be hopefully available

soon.

Okay, so other surveillance efforts. So it's important for us not only to look—to do the CWHSP and do our own surveillance, but also look at other data streams. So here's one example of that. This is a paper by Doney et al. which just came out, which evaluated MSHA exposure samples over time. And I just pulled this one figure from it, and as you can see, if you look at dust samples from Central Appalachia versus dust samples from the rest of the country, you consistently have a higher percentage quartz in the samples, and that goes along with kind of what we're seeing medically.

Another bit of data that supports that we currently have a problem with pneumoconiosis is lung transplant data. This is from the UNOS National Lung Transplant Database and as you can see, over time, the number of transplants that were coded either as specifically for CWP or for pneumoconiosis unspecified—which we believe is largely CWP because it's from the same regions and same demographics of patients, that's gone up over time. So there are more people being transplanted for that indication. Yes?

DR. KRAMER LUXBACHER: So roughly—I know you can't give me exact numbers—but when you look at a patient who has end-stage CWP, how many, or what percentage of those would receive a transplant? Is it a very small percentage?

DR. WEISSMAN: It's a very small percentage. Here, I'm going to jump back to that slide, and you can see the vertical access here. You know, these are relatively small numbers here, okay? But it's a signal, you know, It's a useful signal. Lung transplant is only done in people with very end-stage disease, people go on a list, they have to wait, you know, to get a compatible lung. So you know, there are people that die on the waiting list. People have to have funding that's available for it. They have very strict criteria. The centers that do transplants, they'll only do a transplant on someone that they think will have a good outcome. So other factors figure in. But it's another signal. It's another indication that there's more of an issue than in the past, because lung transplant has been around for a long time now.

Okay, so workers' compensation data. So the number of applicants, the number of claimants has really not changed hugely over time. But a recent paper by Almberg et al. showed that although the number of claimants over time has been fairly stable, the proportion with a proposed decision in order, to provide compensation based on the presence of PMF has gone up. So that's another indication that PMF has been worse in recent times. And here's another figure from that paper. Here's coal mine employment over time and here are awards related to PMF. This drop here is because they had only partial data for 2016. So again, another stream of data, showing that severe disease PMF is more of a problem than in recent times.

Another stream of data that can be looked at is mortality data, and mortality data is easily available online through CDC WONDER, you can just put in the

diagnostic code and pull out the numbers. So here are the number of folks who died over the years with CWP listed as causing or contributing to death. And you can see this total number is going down, down, down. And you can see the hot spots where the most people die with that listed on their death certificate—again, you can see that's Appalachia here. And so the recent issues that we've seen really haven't shown up as death statistics yet, but of course, that's not surprising, because people can live for many years after being diagnosed with CWP, even severe CWP.

The one bit of signal we're seeing in mortality data—and this is a busy graph, but it was recently published by Mazurek et al.—is this line right here, which shows the years of potential life loss per decedent related to coal worker's pneumoconiosis. So for each person who dies back here in '99, they lost eight years of life and now in more recent times, they're losing 12 years of life. So that suggests that people are getting disease younger or they're getting disease that's more active, that moves faster.

So a bit more supportive data comes from our evaluation of clinics. And this was a report that I think came out prior to the last MSHRAC meeting, which identified 416 coal miners who were at a clinic in Western Virginia receiving care for PMF. And I won't talk about that study, but what was published since the last MSHRAC meeting were detailed interviews with sort of a convenient sample of 19 miners from that group with PMF. And this isn't generalizable, I want to just say that this is what went wrong for these 19 miners and I can't say how generalizable it is. But among these 19 miners, 18 reported being involved in cutting rock, using continuous miners. And I think that's really important, given Todd—you know, Todd, you mentioned that continuous miners are now being advanced for cutting through rocks in other parts of mining. So I think silica exposure is a really important concern with that approach. Many of them reported cutting through substantial amounts of rock, so cutting through rock of 12 inches or more, using the continuous miners. Fourteen reported that they didn't consistently follow the appropriate ventilation controls in their place of work and 13 reported that dust wasn't sampled properly. In fact, nine reported that they would do things like put their dust samples in the air intake or the power center, because they were under pressure to have samples that had low amounts of dust in them. Again, I'm not claiming this is generalizable. This is just what went wrong for these people. Eight reported maintaining better workplaces, better work practices when MSHA or corporate leadership was present.

Okay, so it's pointing to the importance of the local line supervision, right at the point of mining. And many of them reported using respirators. Fifteen of them reported using respirators intermittently when needed, whatever that means. So whether that means they wore the appropriate respirator at the appropriate time or not, I can't tell you, but a large proportion used respirators. One reported using his

respirator always. Three reported never. Nineteen of 19, none of them participated in CWHSP, getting surveillance at the recommended intervals, and seven continued working after their first abnormal radiograph. So they had an abnormal radiograph, they knew they had pneumoconiosis and they kept working anyway. And the reason for that, generally, was economic, no other opportunities to make money, to support themselves and their families. So this gives you a flavor of what went wrong for these 19 miners.

So I'll finish up with one last dizzy data graph and this table comes from a paper by Yorio et al., which looked at MSHA data. It looked at MSHA reports of disease and compliance data. And what they wanted to do was to look at whether management practices or citations for engineering controls by MSHA were related to risk of being in this database. So in their analysis, for each violation of management practices, there's a 12% increase of showing up with pneumoconiosis in the MSHA database. Now the effect was much greater for mine type. There was a big risk associated with underground mining relative to surface mining, as you would expect. And also region, being in Appalachia was a big risk, too. But also for each violation, 12% increase in risk of pneumoconiosis, when you looked at management practices. When you looked at engineering controls, for each citation there was a 10% increase in risk of pneumoconiosis. And again, you know, big effects, underground more risky than surface and Appalachia more risk than the rest of the country.

So I'll just finish up with a few thoughts. And one thought is that dust-induced lung disease continues to be a really important contemporary problem for US coal miners. Another thought is that the problem is more prominent in Appalachia and exposure to respirable crystalline silica and possibly other silicate minerals related to cutting through rock, like with continuous miners, is likely an important contributing factor. And then the last thought is that prevention continues to be a really important priority, all types of prevention. So I'll finish up there and take any questions.

DR. NELSON: Thank you. Thank you.

PARTICIPANT: You showed a slide, I believe, that compared the MSHA compliance data in Appalachia versus non-Appalachia, and it showed higher percent quartz, even though it varied somewhat over those 30 or 40 years, it didn't seem to be going—

DR. WEISSMAN: Higher.

PARTICIPANT: You know, way up or way lower. How do you think about that, in terms of how you square that? Do you think that maybe the miners are working more hours in Appalachia or what? I would expect to see the quartz levels, the percent quartz levels fall.

DR. WEISSMAN: And there's another—

PARTICIPANT: And I've got—another part of that is how do you square that with the pneumoconiosis coming down to around the year 2000 and then rocketing back

up? I'm having a hard time putting that all together.

DR. WEISSMAN: Well, I think a lot of people are having a hard time putting that all together. Another figure that I didn't show you from that paper—and by the way, that paper is published and it's available now—another figure I didn't show you were the absolute levels of respirable dust and respirable crystalline silica and those have both gone down, down, down, which again, isn't consistent with the increase in disease that we've been seeing. And I think you really have to question the numbers. I mean, if you have somebody that shows up with PMF or very advanced small opacity disease, their lung has been their personal sampler, unfortunately. And if there's a disconnect between what's in their lung and what is reported from sampling, I believe what's in their lung.

PARTICIPANT: Are you looking at other possible ideologies besides just the coal dust, standard coal dust and silicas or maybe some other elements that are involved?

DR. WEISSMAN: That's a great question and I have concern that the other silicate minerals that are aerosolized when you cut rock, they're not just innocent bystanders and in the PEth reports that had been done, there's been very limited human pathology done looking at lung tissue samples, you know, either from autopsies or explanted lungs or biopsies. But when you look at those lung samples from people with severe disease, they're full of dust and not just crystalline silica, but also other silicate minerals. So I have concerns that we have a different type of exposure now then we've had in the past, because of changes in technology, because of changes in what's being mined. And I think the role of those other dust components really needs to be better understood.

PARTICIPANT: Yes.

DR. MILLER: So David, you mentioned kind of the lack of participation in the Coal Workers' Health Surveillance Program, including that one survey which showed pretty poor consistency of participation. What's kind of your general gestalt, both in terms of the report that NIOSH is doing and in general?

DR. WEISSMAN: So I think that the level of participation that we get, considering this is industrywide, is actually enough to be informative. It's 40%. But that means that 60% of people aren't getting early detection and getting the opportunity to wire that into their thinking about the work that they do. People give a lot of reasons. Confidentiality is a big concern. You know, I think a lot of this is driven by economics, because people want to live in their communities and a lot of these coal mining communities, they're in rural areas and people have a lifestyle and they want to stay. They don't want to go and that's the best paying job. That's the engine for them to be able to pay for their house and pay for their car and send their kids to school, and they don't want anything to happen that would threaten that livelihood. And people love to mine coal. It's part of the culture. People see themselves as coal miners. They're very proud of what they do. So anything that would threaten that lifestyle, there are people that don't want to do it, especially

when they're in their prime earning years. So confidentiality is a concern. Some people worry about compensation. There are some state where if you have disease documented earlier in life and you don't do something, you lose the ability to get workers' comp later in life. So there are other people that just kind of don't want to know about it. And I think those are kind of some of the major disincentives that people have.

DR. BURGESS: David, in that regard, have there been discussions with workers' comp systems in the states that are involved? Did they have a role in this process, in terms of helping to increase the number of screenings or facilitating screenings in other fashion?

DR. WEISSMAN: Yes and the main places that we've kind of dealt with have been places that have been a little bit problematic. So for example, in Kentucky, they recently changed their workers' comp rules to require that only pulmonary people could screen. So we've interacted to try to do a course, to get more pulmonary people who are B Readers. But you know, in terms of interacting with them to sort of reach out to the coal mines, I think that's a great idea, but we have not done that.

DR. NELSON: Okay, any other questions or comments? We have one.

MR. GREEN: A comment and a question and I know you've heard this before and we'll talk about it again this afternoon, I'm sure when Dr. Kogel gives her presentation. But as you know, the industry is now on-record and it has been for half a dozen years as urging mandatory surveillance of all coal miners. And there has been resistance to that on the part of NIOSH, and I heard your reasons for perhaps not doing, and I'm not suggesting they're your reasons but they've got reasons. So where does NIOSH stand right now, with regard to mandatory surveillance of all coal miners?

DR. WEISSMAN: I can't speak for NIOSH, but I can speak for myself, okay? And I'm happy to do that. And I guess, if—I see the root of the issue from the miner standpoint as being the economic issue. So if we were to do mandatory surveillance and if we did mandatory—it wouldn't make sense to do mandatory surveillance and then not use the information, right? So if we did mandatory surveillance, I feel it would be really important to have generous job removal benefits for people, which we don't have right now. And we don't want a situation where you know, people work and they're in a bad environment and then they get disease—maybe not through their own fault, right? And then they have to totally bear the burden of being removed from a workplace, because they have disease. So I think having good job removal benefits for people, to allow them to transition if you were to use that data would be very important.

MR. GREEN: No disagreement from me, personally, but even the common statute allows voluntary removal of miners to a less dusty area with no loss of pay, so there is the beginning of a system here. And I personally agree with you, that there has to be some sort of compensation factor to deal with this. So it's a very difficult

discussion and I'm sure we'll be talking about it for quite some time.

DR. WEISSMAN: And Part 90 benefits are another place that are underutilized. Again, out of fear of potential long-term consequences of becoming a Part 90 miner. So someone who is in the prime of their working life, if they elect Part 90 and the mine they work for shuts down, then they worry about their ability to become employed at another mine. So Part 90 has been problematic, as well.

DR. NELSON: Thank you very much. We will take a break for lunch and come back at one o'clock sharp.

[Lunch.]

DR. NELSON: Okay. We are reconvened. Looking forward to the Associate Director's comments here, in particular because the last presentation that we heard left some of us feeling that something needed to be done. And some of that is going to come up in the response to the National Academy recommendation. So we invite Associate Director Kogel to take the podium.

NIOSH RESPONSE TO NAS RECOMMENDATIONS ON MONITORING AND SAMPLING APPROACHES TO ASSESS UNDERGROUND COAL MINE DUST EXPOSURES

DR. KOGEL: Thank you very much. I hope everybody enjoyed their lunch and a little bit of sunshine and some heat. This is a very important topic and I do think David's presentation really was a good lead into what I'm going to talk about. He raised many different issues, many of which were also echoed in the National Academies' recommendations to NIOSH.

This is also going to be a very word-heavy presentation and we all just ate lunch. So I don't know how to make this stimulating, honestly, so I guess that's an apology up front. As you know from the last MSHRAC meeting, for those of you that attended it, we had a presentation from Cecile Rose on the recommendations in the report itself. And there were 13 different recommendations that came out of it. So since the report was published we have been considering the recommendations. And, as Dr. Howard mentioned this morning, a lot of work has gone into crafting responses to those recommendations. RHD has been involved along with us in responding to these 13 recommendations. And so what I'm going to do, is to go through each recommendation and briefly touch on our response. Now, the committee has the recommendations and so I'm hoping that everyone has actually read through them. And, because you have the recommendations in full, my plan is not to go through them word by word because that would be very painful and I can't do that in 30 minutes. But I just want to hit on each one. If there's something that comes out of what I present that you would like to make a comment on, please do. That's really the purpose of this because we want to get your feedback.

So with that as my entree into this, I want to start with this slide. There was a common theme throughout the report and throughout the recommendations, if

you've read them. And that is the recommendation for NIOSH to work with industry, with other government agencies, with academia as well as manufacturers, to try to address the many issues that are related to respirable coal mine dust exposure. And in response to that, one of the things that we are committed to doing is to establish another partnership. And partnerships have served us very, very well and I think this is an obvious way for us to meet the spirit of these recommendations in this common theme. We will do this Respirable Coal Mine Dust Partnership in a similar way as to the Diesel Health Effects Partnership. And it will be done in collaboration with MSHA.

The other thing that we're going to do is, you've heard this morning about how we are somewhat resource constrained in terms of funding and in terms of FTEs in the program. And we have a lot of ongoing work that we couldn't continue if we tried to address each of these recommendations within our program with our own internal resources. So what we are doing, we're already implementing it, is we are fully utilizing our external or our extramural contracts and grants program to address the recommendations. George talked a little bit about that during his presentation and I'll give a little more detail on that in mine. So those are just some of the general things.

So the first recommendation, I'm not going to go through word by word, is to identify the key challenges that mine operators face in implementing optimal beyond compliance approach to respirable coal mine dust exposure monitoring. I'm going to talk about the recommendation and then I'll tell you what the NIOSH response is to that recommendation.

For that recommendation we will engage the Respirable Coal Mine Dust Partnership. And we planned to form that partnership under the NORA Mining Sector Council which is something a little bit different. But that allows us to bring in many, many more resources and it really makes sense to do that. And then, through that partnership, we'll examine the current sampling practices and use that as a way to identify various beyond compliance sampling.

PARTICIPANT: Do you have some indication that MSHA is interested in participating in a partnership like that? Because the feeling that I've had is that they're reluctant to deal with dust issues at this point in time.

DR. KOGEL: MSHA is onboard with this. And I should have mentioned, thank you for raising the question, these responses have been reviewed by MSHA and, they're interested in doing this with us and they're committed to it, so, yes.

We'll also study the overexposures that occur just so that we can better understand what the potential causes and preventions might be. And you'll see this in almost every slide. This is topic that has also been included in our BAA solicitation for FY 2019. And I'll get to that at the end of the presentation.

Any comments on this first recommendation and the response?

DR. NELSON: Not be completely deflective but a lot of this has to do with silica, right?

DR KOGEL: Yes.

DR. NELSON: So I don't understand why this is only coal mine and why it is only MSHA. Because it seems to me that there are similar kinds of exposures that happen in other industries, like the construction industry, which may also involve OSHA. So I'm just wondering or is that going to be a peripheral vision on NIOSH's to think about the, maybe "broadening" is not the right word, but whatever it is, of exactly the kind of dust and industry.

DR. KOGEL: Yes, so, currently, since this is in response to the Respirable Coal Mine Dust Committee that was the consensus committee through the National Academies, that's why coal mine dust is the focus. But I think what you bring up is absolutely true. This is going to crosscut construction and many, many other industries where workers are exposed to quartz. And quartz is part of respirable coal mine dust. So there will be things absolutely that do come out of this that I think can translate into other industry sectors and other workers that have exposures.

DR. NELSON: Right. So saying just NORA mining sector, in order to capture that, maybe to broaden at that point and maybe bringing some other stakeholders.

DR. KOGEL: So I think, and let me respond to that, I don't disagree with that but I also know that this is a mining specific problem that we have to answer because that's our mandate in what we do. And it's a very complex issue, so even within the mining sector itself, to understand all of the relationships and the exposures and the challenges is going to require that we focus on mining initially. And that's how our approach usually is, is we take the mining focus initially, we solve the problem from the mining perspective and then we take it out to other industries. And so I think that's how this one will go as well. I don't think we can solve the problem globally at this point. And that's not really what we're endeavoring to do here. But I don't want to miss the opportunity to take this information to other exposed workers that could benefit.

DR. NELSON: And there may be new technologies elsewhere that can be brought in.

DR. KOGEL: That's right. And we're always looking at that. So I think these are great discussion points. And we always want to keep in mind the importance of looking outside of our focus area.

DR. MILLER: And I think this is probably discussed, but, the study focusing on one percent overexposures, would, in my mind, you'd want to compare that to the regular, or the non-overexposure situations and what's different about those.

DR. KOGEL: Right, the control folks.

PARTICIPANT: And so is that part of the study design?

DR. KOGEL: Yes. And right now I'm giving you the high points but, yes, that would be part of the study design.

Okay. Let me go on to Recommendation #2. For Recommendation #2 the recommendation is to conduct studies to evaluate the exposures of miners that are not wearing CPDMs. And so let me go on to the next slide.

There are a number of different things that we plan to do with regard to this recommendation. Again, we will be engaging the Respirable Coal Mine Dust Partnership. And just to remind everybody about our partnerships, we invite anybody who's an interested party or stakeholder to be involved in those partnerships, so they're very broad based.

One of the first things is that we will verify that the designated occupation miners who are wearing the CPDM utilize the information and the experience that they gain while wearing the CPDM to modify their exposure. So we're going to do a study to understand that. We're also going to look at situations where an increase in coal mine dust exposure might be occurring that is outside of the miners' influence of control. And then we'll also conduct studies that verify the other mining occupations, in addition to the designated occupations, are not exposed to high levels of respirable coal mine dust. And then the last one on this slide, again, is the BAA solicitation; using the BAA solicitation for FY 2019 to invite proposals to address this particular recommendation.

Any comments or questions on Recommendation Number 2?

Okay. I'll go on to Number 3. As you can see, I'm really trying to abbreviate these. For Recommendation Number 3, that recommendation is that NIOSH and MSHA should carry out a systematic examination of the content and implementation of training and education programs related to respirable coal mine dust exposure. And then there's more details about what these studies should be examining. I'm not going to read that here but you've got that in your packet.

So, in response, we will collaborate with MSHA to develop outreach programs. And we use a variety of different methodologies. And the goal will be to communicate hazards of dust exposure, how to effectively implement and maintain dust controls and also to help miners identify when exposures might be occurring. We will also, through various outreach activities, communicate the importance of participating in medical monitoring and also job transfer programs. And both of these of course were part of what David talked about in the previous presentation.

In addition to that, we'll also build on prior work that we have engaged with our stakeholder outreach, as well as our new Respirable Coal Mine Dust Partnership, to do research and efforts around training and organizational interventions. This will include on-the-job training, also assessing the effectiveness of educational outreach, that we do as well as MSHA. And some of what we will be focusing on is improving the knowledge uptake and also behavior change within the mining setting.

Any questions or comments on Recommendation Number 3?

Yes.

DR. NELSON: I'm still thinking about the delay required in order to get the assessment of dust.

DR. KOGEL: The analysis.

DR. NELSON: It seems that the most effective educational tool is rapid measurement and then response. And so I've sort of expected, when I read this somewhere, to see this really high priority on real time information being generated so people can respond quickly.

DR. KOGEL: Quickly. Yes, and it doesn't really come out in what I've talked about before with these particular recommendations, but one of the recommendations is for us to continue to develop the End-of-Shift Silica Monitor which we have now renamed the Field-Based Silica Monitor. And yes, that is a priority and that is part of these recommendations. And that's certainly one of the activities we'll be doing. And of course there's the CPDM itself and there's at least one recommendation in here around the CPDM. But, yes, I agree with you that it's very important that miners have that immediate feedback as far as exposure.

DR. NELSON: Just as a goal, real time would be a goal.

DR. KOGEL: Right. And the CPDM is what they're using now. And the End-of-Shift is not necessarily real time, it's end of shift. But that is a big improvement. And then through also extramural funding we have opportunities to, through the new technology BAA, hopefully incentivize and fund organizations to do other types of technologies. And that will be in here too.

So, okay, I will go on to Recommendation 4. This recommendation is to study the particle size distribution in mines today of respirable coal mine dust. And also the relationship of modern day coal dust and what is deposited in the lung. So our response to this is that the Alpha Foundation has funded a $1.8 million three year grant. And that's led by Dr. Robert Cohen at the University of Illinois at Chicago School of Public Health. NIOSH is a partner to this study, and through this study I think there will be a lot of really important research and data that will come out of it addressing exactly this topic, including characteristics of the dust particles that are deposited in lungs of contemporary mine workers, to look specifically at that things such as size and composition. And that's information that we really don't have today so this is very, very important work. And also we can compare this with characteristics of particles found in lungs from samples in the 1990s. So I think that will do a very good job of directly addressing this specific recommendation.

Also, research is underway to understand respiratory toxicity of contemporary coal mine dust. And, again working with MSHA, we're developing a project to evaluate samples collected from coal mines throughout the US. And also we're conducting surveillance of chest radiographic patterns in underground miners that implicate crystalline silica exposure. And so that work is ongoing and will address this Recommendation Number 4.

Before I go on, any questions?

DR. MILLER: So I think this is really important work because you can look at the particle toxicology here. And so you're going to combine it with animal-based studies and

the work that Bob is going to be doing which will be on deceased lungs? Or is it going to be on just biopsies? Or what's the…?

DR. KOGEL: David, it is deceased, correct?

DR. WEISSMAN: Sure. It will be a combination of the contemporary lung—it will be lung tissues from people getting transplantation, and autopsy. And that will be compared to the old National Coal Workers autopsy study.

DR. MILLER: And then, those animal studies, are those inhalation studies? Or do you know what you guys are thinking? Or is it too early?

DR. WEISSMAN: It's still too early to say. I think those are currently being developed. Although the collaborations are being put in place to get the appropriate dust samples, as Jessica was saying.

PARTICIPANT: Okay.

DR. KOGEL: All right. We're about halfway through and I have ten minutes left, but this is great feedback. Recommendation Number 5 is to develop a real time crystalline silica monitor. And Priscilla, this is the one that you were saying is so important. And this is also where they have suggested that we continue our efforts in our End-of-Shift Silica Monitor.

We have two extramural contracts that have been awarded, one to the University of Illinois Chicago, and then one to Thermo Fisher. And those are ongoing. This is, again, through our extramural program. The University of Illinois Chicago contract originally has silica measurement in it. But we have dropped it because they're trying to do two things at once, both extremely challenging. One was to make it smaller and the other was also to do the silica measurement. So that has since come out.

And, as I mentioned, we're continuing to develop our field-based respirable crystalline silica monitoring approach. I think at the last MSHRAC meeting we had a presentation on it and so that work continues. And there continues to be interest and uptake by the industry in that as well.

Any questions, comments on that Recommendation?

DR. BURGESS: This isn't specific to this NAS recommendation, but I was wondering whether there might not be a useful addition to this evaluation looking at the toxicity to the lungs in an individual that's exposed. And I'm specifically thinking about some of the serum pneumoproteins so I'm looking at David right now. And so the serum pneumoproteins are things that are very sensitive to changes in lung permeability after exposure. And so that it might not be a bad idea, to fit along with some of the animal studies or so on, to see whether there's a certain level of exposure of a certain type that would lead to direct lung damage during a shift.

DR. WEISSMAN: And as you know, those are used in places like Japan and in European countries, you know, those blood biomarkers haven't been much used in the US. So looking at them for mechanistic purposes but also looking at them as a potential surveillance tool I think would be very appropriate.

DR. BURGESS: We had done some previous work with firefighters and they worked quite well for showing direct toxicity from smoke exposure. I'm not sure that people have been using them for dust exposure but I just raised that as a potential opportunity. You're looking at the exposure measurements and at the same time you could look at a health-based outcome that may help you. And in this particular case it would be a couple of blood draws per person per shift.

DR. KOGEL: Thank you. That's a great suggestion so thank you for providing that. Let me move on to Recommendation Number 6. And that's to facilitate the development of a less costly and a less ergonomically stressful real time respirable coal mine dust monitoring device.

In response to that, this work is largely funded through our Extramural Contracts Program. I already mentioned the University of Illinois at Chicago work and the Thermo Fisher. In addition to that we've awarded a contract to Biomarine. And they're looking at a different type of sensor to miniaturize a device and also provide a lower cost solution so that it could be used by many miners in the underground mining setting. And then also we included it in our solicitation for FY 2019. So this one is extramural at this point.

Okay. Recommendation Number 7 is to explore the broader use of area monitoring devices for gathering trend information on respirable coal mine dust, in terms of both concentration and as well as particle characteristics in underground coal mines.

In response to that we are pursuing the development of lower cost dust monitors that could facilitate area monitoring. Our past research has shown, though, a lack of correlation between area monitoring and actual individual exposures. And that's due to dust gradients in coal mines. So we really feel that the primary approach should be to focus on worker exposure rather than on the area monitoring. But the use of area sampling to gather the data on things such as particle size distributions would be very useful. So we will be looking at that and assessing that and how to move that forward. And this has also been part of the BAA solicitation for 2019.

So any comments or questions about this one?

DR. NELSON: If you have a source of dust, I mean, coarser material is found near the source, finer, away, so are you going to be able to…? Is that documented that there is that particle size distribution gradient away?

DR. KOGEL: Yes.

DR. NELSON: And is there hypothesis that it's the finer material or the coarser material that causes more problems?

DR. KOGEL: I think the finer material is the material that causes the more problems, yes.

DR. NELSON: Because it almost, I mean, I think the mineralogy would change based on grain size too, so that's interesting.

DR. KOGEL: Yes. And Drew and Jay are here from the Dust Branch. In some of this area

monitoring work—did you look at changes in the mineralogy in those studies? Or was that primarily just particle size?

MR. COLINET: Particle size. And there's so much variation in particle size in a single mine. Looking at that over time, I don't know that you would be able to differentiate the particle size (inaudible @ 00:26:28) that.

DR. KOGEL: Right.

DR. NELSON: Yes.

MR. COLINET: But there's been work done that's looked at the difference in mineralogy and particle size. And they've looked at whether you get concentrated, for example, silica in smaller particles. It was done years ago by Penn State and other institutions. So there's research on all that.

DR. NELSON: But if it was years ago, they might take another look at it.

DR. KOGEL: Well, it's time, yes.

MR. COLINET: You definitely do see a change with particles, yes.

DR. NELSON: Yes. I would expect something systematic there. And with new kinds of cutting you're going to have maybe new relationships.

DR. KOGEL: Right. And these are exactly the sorts of issues and details because we have a good understanding of things from the past and work that was done in the Bureau of Mines days. But we haven't updated that work and so some of this is going to be redoing some of the studies that were done in the past. And there are hypotheses that changes in mining methods and equipment have changed particle size distributions in the types of particles that miners are exposed to. So we need to look at all of that too. And we need to look at it systematically. So that's the sort of thing that this is addressing.

DR. NELSON: Good. Exactly.

DR. KRAMER LUXBACHER: One thing that I was going to say about the area monitoring is I think it is critical because it's so useful in assessing engineering controls, where it's difficult to do that over multiple shifts and multiple operators. So I think it is really very important even though it doesn't necessarily get you at why someone develops disease.

DR. KOGEL: Yes. I think that's a great point. And I think we need to look at how does the area monitoring fit into the solution into the bigger picture, versus the individual miner exposure monitoring. And so we really want to assess that, and so that we can make some really good decisions about what should be used for what types of information and how to use both types of monitoring to get the fuller picture, so that's a great point.

MR. WRIGHT: Well, first full disclosure, I was member of the NAS committee and I want to talk a little about why we made this recommendation. It's not that we don't think that individual exposure is better to measure. We think it's much better. The problem is, at least for some of us, maybe not everybody, I'll say a little less diplomatically what we tried to say diplomatically in Recommendation 2, we don't trust the data.

And I think there's good reason for that. When you put one of these devices on a miner you know what his or her exposure is. And they can be easily moved to an area that has less exposure, sometimes doing the same job. And that's a good thing. That's one of the reasons why these devices are useful. But you can't call that representative monitoring. And so I haven't talked to hundreds of coal miners but I've talked to a number and nobody believes that there's 99 percent compliance. Everybody believes that the situation is somewhat worse than that. And part of why we wanted to have at least some area sample is because you at least get a better picture of what's happening in different areas in the mine. So that's kind of the genesis of this recommendation.

DR. KOGEL: Well, thank you for your very direct explanation. That's helpful. And so, like I say, we're going to be assessing it and hopefully we can develop a picture. There may be a reason why the picture is different with the area monitoring versus the personal exposure monitoring and this may be part of it. So I think that's going to be very important information.

All right, we move on to the next. This is Recommendation Number 8. And this is actually looking at what I just brought up, and that's changes in mining technologies, and trying to understand how those may or may not have contributed to what we're seeing in terms of miners' exposures and disease today. So in response to that recommendation we will include this in our future research proposals. We would really like to get this in front of the new partnership that I have mentioned. And with the help of this partnership which will of course include industry. And to really do this we need to have good industry stakeholder buy-in on this. So with that partnership we can then start putting together some really good research proposals around exactly this issue. Any comments on this from the committee?

Okay. Recommendation Number 9. Again, something we were just speaking to. This recommendation is to conduct a comprehensive assessment of the respirable coal mine dust particle characteristics including their variability. And this will be important for targeting future exposure studies. And also as part of this it's recommended that we look at the source for contributions of material to the respirable dust in the mine environment. And that would include the rock dust as well as any of the strata that's being mined through to reach the coal seam. And then also the third part of this recommendation is to assess how the respirable coal mine dust characteristics have changed over time. So this is a really important assessment and a lot of things will have to happen to answer all three of those. And we have some things that are in progress and some things that we're committing to do to start addressing this.

So some current NIOSH investigations are taking place that are evaluating some of the temporal changes in characteristics. These are not changes over time but changes that are happening within the mines. This is work that's just started,

using SEM and thermogravimetric analysis, looking at coal as well as carbonate and non-carbonate mineral mass fractions on coal mine dust filters.

We also have a large number of gravimetric filter samples that are in storage. These go back to the early 2000s. And so, these are being inventoried, and we're looking at them and making plans as to how they can be used for research to address some of this recommendation.

We're also collaborating with investigators who were funded by the Alpha Foundation. Again, this is to look at size and composition of dust particles depositing in the lungs of contemporary mine workers. This is the study that I had mentioned earlier. And then also this was included in our FY 2019 BAA solicitation. Any comments?

Okay. I'm going to go on to 10. Ten is to link medical surveillance programs directly with exposure monitoring programs. And, this one is something that, to really do it well and to carry out the kind of study that needs to be carried out, that has the rigor that's needed and is well designed and will require epidemiological studies, will be something that is very high in cost. And so we have to enter into this one very carefully and thoughtfully. This is another one that I think needs to come before the partnership. And we need to, with the partnership's help and with their support, we will probably have to have additional funding to be able to really do this one correctly. That's where this one is at the moment. But hopefully through the partnership we'll be able to really refine this to the point where we can go back and hopefully get some additional funding to do the kind of work that we feel needs to be done to address it.

Any comments on 10?

MR. WRIGHT: The other problem is that there's kind of a feasibility problem with this, in the sense that a lot of coal miners don't get tested, don't get monitored until the end of their career because they're simply afraid of what the consequences would be. So people are willing to wear the devices and to get exposure measurements. But linking those with medical data that doesn't exist, because the miner hasn't signed up for it, is going to be kind of tough.

DR. KOGEL: Yes, we talked a little bit about this whole issue earlier today, actually, that comes in another recommendation too, I think.

DR. KOGEL: Recommendation 11. So that's to really try to understand the disincentives for participation in the NIOSH medical surveillance programs and MSHA Part 90 Program. And so we did talk about that earlier, or I should say David did. And so, as far as our response for that, David already mentioned the Request for Information was posted in the Federal Register. We have received those comments. And we're reviewing those comments now. And, from that, there will be research that can be generated based on those comments to help understand this in more detail. So there are two links. I think these are the same ones that you might have had up, David, more or less. So that is our response to Number 11.

Any comments?

Okay. I'm going to go on to 12. So 12 is to conduct a comprehensive assessment of the requirements for exposure monitoring. This includes both respirable coal mine dust as well as silica mass content, and in major coal producing countries. So the idea is to understand what other countries outside of the US are doing and learn what we can, maybe even harmonize data across those countries. And so the response to this one is we will reach out to our international partners to start doing this. And I believe that, yes, that's the response to that. Any comments on this?

Okay. Recommendation Number 13 is an overall recommendation. They're fairly wide ranging in terms of what they hit. And so the last recommendation is really around making sure that we set priorities because the committee, I think rightfully, recognized that we can't do all of this at once. And so we're going to have to set priorities. And so this is something else that the partnership can help with. And so there are some things, as you've seen are already underway, and then are other things that are probably high priority that aren't underway that maybe need to be pushed up in priority. So I think the partnership can really help us determine what that could be and how that should look.

The other thing is that we should continue to pursue our experimental underground mine which that I talked about this morning and that's the Lake Lynn Replacement Mine. And then, the last piece of this is to seek opportunities for conducting collaborative research. And certainly that's an important part of what we would like to do. And we're going to be doing a lot of that through the extramural program.

So, as I mentioned, we're going to be putting together a Respirable Coal Mine Dust Partnership. We will hopefully have an experimental mine online in the next three to five years. And in the interim we are doing underground research at the Bruceton Experimental Mine, and also in Poland at the Barbara Experimental Mine. And we are exploring opportunities for cooperative grants. I'll talk about that in a later slide. But the corporative grants would facilitate collaboration across industry, government and academia.

So I just want to say a little bit more detail about the extramural contracts grants and the FY 2019 solicitation. This first slide is for the new technology BAA. You might recall from one of George's slides he showed that there were a number of different focus areas in the solicitation where we say we would like to receive proposals related to them.

This was the first focus area that he had listed on his slide. And it was around non-regulatory personal measurement of coal dust and/or silica. And basically we asked companies or universities, organizations, to submit proposals that would develop other means of measuring coal dust and, or silica. And we even suggested that it might be a non-mass based approach, unlike the CPDM which is

mass based, because we felt that might open up new technologies. They couldn't be used for compliance but at least it would allow us to push the technology forward.

And that's what we put out there. In response, we had three universities provide full proposals to this particular request. And the final funding decision is pending. And I think, looking at what's come and really how complex this issue is, it may be that we're going to have to go out later with an RFP for this, as opposed to a BAA. Because, as George described this morning, the BAAs, we take what we get. We don't have a lot of control over how the work is done or what's done. We can say, "Hey, we would like something." but it's really that we're very hands-off. Whereas, with an RFP, we have more hands-on and more opportunity to direct the research. So we'll see where that one goes.

This was also in George's slide but this is broken out in much more detail. One of the topic areas was basically—and recommendations from the National Academies' report. We invited proposals that related to Recommendations Number 1, 2, 7, 9 and the bottom two are 9. And I've just tried to highlight what those are.

So Recommendation 1 was to identify key challenges that coal mine operators face in implementing an optimal beyond-compliance approach. Recommendation 2 is to evaluate the exposures of miners not wearing CPDMs. 7 was the use of area monitoring devices for gathering trends and information. Then, 9 was comprehensive assessment of the particle characteristics in respirable coal mine dust and then, also, improving analytical methods for evaluating the source.

So that's what went out. And what we got in response was four universities that did provide full proposals. These are undergoing evaluation or have been evaluated and final funding decisions are pending.

And so what we hope to do, and George talked a little bit about this, it's really important that these universities, where possible and within this mechanism, work together. And we've asked them to have, and they've agreed to, joint kickoff meetings as well as annual review meetings. And that really strengthens this whole idea of collaboration and I think makes the research more efficient, so that universities aren't duplicating research, and they're working together. That way we can move much more quickly to a solution. And we can have better focus, on the research.

Some of the things that we're hoping will come out of this is possible sharing of industry contacts as well as samples, maybe even field sites for doing research. Each university has different strengths in terms of their equipment and facilities and their analytical capability. Hopefully by bringing them together we have a broader range of solutions that can come out of it. Obviously sharing knowledge is an important part of the collaboration. And we do think this will probably lead to some kind of contract modification so that we can make sure that we're focusing

the strengths of each of the universities appropriately.
This one is also from FY 2019. Now I've gone from the new technology BAA, to the capacity building BAA solicitation. And you remember that it was a broader focus area. Instead of as in the past where we had ground control and we had ventilation, this time we went out and said we want to do mine system design research. So it's more broadly based. And because of the broader focus area, we had three of the proposals that were received that were related to dust control and three were related to respirable coal mine dust assessment. So these will be addressing some of the recommendations.
And this is the last thing I wanted to share with you. This is something we alluded to this morning and this is proposed. You can see it's written here "proposed under consideration." I really wanted to bring it in front of this committee to get your feedback. What we're proposing is we would like to establish a Respirable Coal Mine Dust Occupational Health and Safety Cooperative Research Grant, which would then be used to establish a Respirable Coal Mine Dust Research Center or Centers. This is something new but it's also a reincarnation. And the reason I say it's a reincarnation is that this concept is very, very similar to something that was in place back in the Bureau of Mines days. And some of you in the room may be aware of these. And this was the Generic Mineral Technology Center for Respirable Dust. It operated from 1983 through 1990. And it funded research at a number of different institutions. You can see them listed on the slides.
There were a number of volumes that came out of this. These are annual bound volumes of reports. And they're actually quite impressive. There was a lot of really good high quality science that came out of this. And they also had conferences. There was one domestic conference and two international symposia.
Kind of getting back to our pipeline discussion this morning, in 1989 it supported 53 faculty members, 21 master's students, 26 PhD students and nine post docs. So I think this is something that, if we do move forward with this concept, it would be something that would really be a shot in the arm, I guess I would say, of respirable coal mine dust research. And it could tackle many, many of the recommendations in this proposal. And so I think it's something that we would like to see move forward, something that is of interest. Dr. Howard is supportive of this. And so, if it's something that we move forward with, which we are planning to do but I would really like to have your input and thoughts on it, we would hope that it would be something that is very similar to what was done in the Bureau of Mines days and maybe could even go beyond that.
So I just wanted to leave you with next steps. Obviously we'd like your feedback. So once we've gotten your feedback we will finalize the response document to the National Academies and we will then share it with the committee. It will also be posted on the NIOSH website for everybody to see. And then another next step is

to form the Respirable Coal Mine Dust Partnership. So that's something that I think we would do fairly quickly.
So that's it. Comments, questions?

DR.BURGESS: Jessica, very nice presentation. Thank you.

DR.BURGESS: For your last grant, the center grant…

DR. KOGEL: Yes.

DR. BURGESS: I recommend that you consider it as a U60 mechanism and that you include the DRDS and HELD in the cooperative nature within NIOSH.

DR. KOGEL: Yes, absolutely. I agree. We've actually met with OEP and we've had this conversation and that is exactly the path that we're going down. So thank you for bringing that up.

DR. MILLER: Yes, and just a comment. So last year we had heard about NIOSH's efforts to reinvigorate the elongate mineral particle roadmap. And I think it would be great if there were some harmonies here between these two efforts, especially understanding what we're talking about here is particle toxicology and…

DR. KOGEL: So you're talking about specifically with the centers, bringing the EMPs as part of the centers.

DR. MILLER: Yes, some of that and some of the work that's going on. Because we're trying to understand what it is about these particles and the disease that's coming from them, both in terms of, there's the shape, which is some of them are elongate, some of them are spherical, and what's happening here. So I think there would be great value of those investments.

DR. KOGEL: Yes. So I guess one thing I should point out is we named it "Respirable Mine Dust" to be broader than just coal so that we can bring in crystalline silica, EMPs, coal mine dust, anything that's dust.

DR. MILLER: That's great.

DR. KOGEL: Yes?

DR. NELSON: So you could also leave out "mine."

DR. KOGEL: We could leave out "mine" too. Yes.

DR. NELSON: Yes. So what level of funding do you have in mind for these centers?

DR. KOGEL: That's something we're working through right now and we're going to start funding it initially from some of our funds. And, I think we're going to have to go out to get extra funding above and beyond what we currently have.

DR. NELSON: So are you thinking a couple hundred thousand or a couple million?

DR. GEORGE LUXBACHER: At the time this was funded the generic centers were funded at about $2 million a year for all this. And when you look at what we're funding right now, for example under our capacity builds, we're funding—for example we could make a decision that we're going to use this to replace the grant controlled capacity builds. I'm saying it's a funding issue. Initially at least, we could divert those funds towards this or something. So I think you're in that same—

DR. KOGEL: The same ballpark probably.

DR. GEORGE LUXBACHER: You're in that same ballpark. You're probably $2 million a year or somewhere around that.

DR. NELSON: I think at least the one thing that I'd caution about is, when you form your teams that a small number of universities come together and they're going to work on this, that's where the money stays. And the ideas and where it goes is limited by who's there. And so, the basic idea that you don't necessarily know where it's going to go in terms of research, you really would love to have as much flexibility as possible to bring in the best people in whatever direction. So, even as NIOSH is planning to be flexibly reshaped, there are ways of making these centers more flexible towards partnering and partnerships than not. So I just suggest you think about that.

DR. KOGEL: Yes, that's a great suggestion. And yes, so the idea is we will start funding it from funds that are already available to us, to really start, get the momentum going. Because, if we have to go out and get funding and get this thing stood up, it's going to be three years, four years, who knows? It's going to be a much longer timeline. So we feel it's really important to commit to it and get it going now.
It will mean diverting some funds from some other programs. But once we show the value of it then hopefully at that point we can go out and hopefully get some more money. Because I think two million is a good starting point but, depending on how many universities and how successful this is, I think we could easily double that.

DR. NELSON: And you have to get industry involved.

DR. KOGEL: Yes.

DR. NELSON: They have to be invested as well in this.

DR. KOGEL: Yes.

DR. GEORGE LUXBACHER: That was the key under the generic centers. If you remember how they were established, you actually had industry sitting at the table helping to determine the research and everything. And it was critical because this was some great work that was done back then.

DR. KOGEL: Yes. Anything else? Any other discussion?

MR. WRIGHT: Yes. I can't speak for the whole committee, but speaking for myself, I think this was a very comprehensive, strategic and generally excellent response to what the committee came up with. And I think NIOSH is to be congratulated for that.

DR. KOGEL: Thank you. Well, I want to thank the committee too, because I think the committee did—the report was an excellent report. And, this is work that needs to be done. And to have this report to kind of help us focus around the topics. So, thank you very much for that feedback.
Art?

DR. ART MILLER: I have a comment. Something that Mike said earlier- and that is we don't trust the data, right? Except we trust the people's lungs, right? The lungs tell the story.

DR. ART MILLER: So my question is, are we dealing with any way to address the issue that miners

are voluntarily doing this?

DR. KOGEL: Sampling? Is that what you mean?

DR. ART MILLER: No, they're voluntarily using their lungs to give us the data that we need. So if they die so that we know somebody is dying. They're the canaries. Why are they doing this? I mean, are we addressing that? Because I hear a lot of aerosol science which I love but the real problem is cultural in some ways.

DR. KOGEL: I think David said it too. I'm going to say what David—I can't speak for NIOSH but it's an economic problem, it's a social problem, it's people making personal decisions maybe not having all the information. And some of these recommendations actually are about educating people so that people can make better decisions. But still they're in a situation where they've got a job that they don't want to jeopardize and so they're going to make decisions that maybe aren't the best decision for their health.

As NIOSH, we can help develop engineering controls. We can provide training. We can develop information and then convey that information to the miners. We can do all of those things. And all of those things will hopefully take people a step closer to not being in that position. But that's the process and that's kind of the area where we play and what we can do. But I sense and understand your frustration with that.

MR. WRIGHT: This may be a controversial comment but I think we have to avoid the assumption that miners are making irrational decisions.

MR. WRIGHT: You're a 45-year-old coal miner. That's all you know. You've got a family. You live in Central Appalachia. And your choice is, yes, I'm going to go get tested and Part 90 says they can't fire me. But they can figure out a way. And that's one choice. The other choice is to stay employed and to continue to feed your family.

MR. WRIGHT: Even I'm not sure how I'd make that decision. I'm not sure how any of us would. And that's the problem. But I don't think we ought to assume that coal miners are stupid or uneducated or making irrational decisions. They're making very sad decisions but ones that are I think compelled by circumstance.

DR. KOGEL: I think you're exactly right. And I think that's what David was saying this morning. You weren't here. But they're stuck with a very tough decision. And, like David said, it's a lifestyle, they're very proud of what they do and so they make these decisions. And I couldn't agree with you more.

And so I think when I talk about bringing knowledge to people it's not in that context of we think if you have our knowledge you're going to make a different decision. I think we have to have that sensitivity and understanding that it's a very, very complex personal decision that people have to make and how do you work within that. And, really, you've got to work with the whole system, not just the miner, so—

DR. NELSON: Okay. Well, thank you very much.

MR. GREEN: Just a very brief observation or two. One, I think this is a very good work plan,

Jessica. Congratulations to you and your team. I think putting this project in NORA is a brilliant decision because what you're doing, and I think you've said it, is what you would bring in, or it should bring in, other folks other than coal mine people. And the time has passed for other folks in the mining industry to breathe a sigh of relief and say it ain't us, because the fact is it is us. It's everybody in the mining industry, everybody in the extractive industry. The NORA mining sector is a good place to start.

The only other comment I would make is that in your next steps I think you left out a vital step and that is, in order to get buy-in from NORA or the mining industry, you have to tell them what the recommendations are. So I would urge that after you get feedback from MSHRAC that you put this out for input from the public, meaning the industry, labor. You have to have buy-in from everybody before this can be successful. So kind of a Register notice that puts all this stuff out there for public comment. I'm not suggesting that you stop doing anything in the meantime but get it out there and a simultaneous public interest process and let's get going.

DR. KOGEL: Great. Thank you for the support and thank you for the suggestion, Ed.

HEALTH ADVISORY IN THE MINING PROGRAM WORKGROUP

DR. BURGESS: I've been asked to briefly speak about a miner health program—we're calling it HAMP—workshop, that we are planning for September. So a little bit of background behind this. During the last meeting that we had, this issue of the strategic plan for a miner health program was raised. I volunteered, wasn't voluntold, to help lead this process as a workgroup within MSHRAC. So I'm going to give you a brief update and hopefully we'll get some of our time back here too.

So if you look at the miner health program it's got a number of different components. Obviously the research, community engagement and evaluation. And part of the need within NIOSH, the way I understand it, anyhow, is they want to continue to get feedback from partners, from stakeholders and partners. So they've had a number of workshops but they would like to have another to help guide this miner health program as it moves forward.

Dr. Jerry Poplin had been a participant in this and I wasn't sure if he was going to be able to join or not online.

DR. POPLIN: I'm here, Jeff.

DR. BURGESS: All right. Thank you, Dr. Poplin. So the workshop goal was to establish a 1-2 day, workshop, and that could address, as it says, in a minimum of three questions. So, what do we not know and how can we go forward and establish communication about what's needed. And then also the issue of how do you evaluate this program. So I think that's critical. You've seen your examples elsewhere in the NIOSH Mining Program of excellent evaluation tools. And so we want that as well for miner health.

So the desired outcomes of this workshop would be information that would help,

as previously stated, guide the miner health program strategic plan and ideas about appropriate communications and evaluation tools. So we put together, this kind of a “this is prior to “ and then “during” the workshop, and then afterwards, a timeline. And you can see that, separate from our group, NIOSH has been working on outreach and drafting of their strategic plan. We have the workshop set for September. And then we’ll report back in too MSHRAC and then create a workshop report just as you’ll see Kray doing in a moment. She’s much further along in terms of the automation workshop which has already been held.

So, with that, I’m going to go, and actually if we could, Kyle, if you could take that, I left it right there, if you can move that around, I think just for the MSHRAC Committee itself, I just had some handouts here quickly, if they could look over it. And I’ll say what we’ve done so far, as I mentioned, is to find a time for this program. So it’s going to be September 5th through 6th in Seattle, Washington. And I wanted to thank Kray for suggesting that we set the time immediately. So that was her recommendation based on the previous program. So we did that. It’s going to be in association with the University of Washington, using their facilities. The only difficulty is there’s a maximum size of the room of about 50 people. So it’s going to be, by requirement, a slightly smaller program. And so, if you look at your handouts there’s a list of individuals that have been invited to attend. And they span from academia to government to industry trade and union. And so the first thing I’d like to have is any input from the group, either at this time or afterwards, anytime today or tomorrow, about additional individuals that should be on this list. Are we missing anyone and are we properly balanced between the various groups? So that’s one question for you all.

And then, also, if you could then move to the actual outline of the program itself. So it’s going to be a day and a half, a full first day and a second day as a half day. And it has various program areas. So I’m going to read those out to folks who don’t have this. But there’ll be just a general overview that will be provided by Dr. Poplin. So I’ll introduce the objectives of the meeting and then Dr. Poplin will talk about the miner health program. And what we wanted to do was focus on things that weren’t being currently covered by NIOSH.

So, for example, the whole issue of respirable coal dust is a huge issue but it’s already being covered by current NIOSH activities. So we wanted to look at this as kind of new issues that we would address. So some of the things that we have beyond the current existing programs include mental health and substance abuse, so Kyle would be doing the facilitation and also presenting some of the work that he’s done. And not all of this has to be examples from mining. It can be examples from other areas that could be applicable to mining.

Then we have the concept of wellness and comprehensive worker health, so Ron Bowersox, who’s not here with us today, would be the facilitator for that. And we actually have a presenter from Pine Bluff Sand & Gravel, thanks to Kelly Bailey

who's been instrumental on this group in helping to identify industry partners that could present some of their experience. So we like this because it's a smaller group, so it's not just all large mining.

Then one that came up that was interesting, and I think probably bares some discussion, is the issue of welding. So I don't know how much that had come up in the previous groups before but Kelly had mentioned that it was an issue for Vulcan, one of the groups that was going to be presenting. And when I talked with FMI they said that this was actually one of their top issues. So welding has been around forever but there's still a lot of issues with it. And I think, personally, I believe that with the increased focus now on the toxicity of manganese, which is common in any of the welding rods, that actually there's information now that would lead us to believe that perhaps there's greater toxicity than we appreciated previously. So that's a topic.

Then there's heat, which is a current issue, and fitness for duty. So I think that kind of fits together. It's not just heat but how do you use information about the way that people respond to determine what is fitness for duty. And then we'd finish up with the idea of data sources and surveillance and their utility.

So, with that, I'd like to ask, if I missed anything about the concept of this meeting and the topics to be covered.

DR. POPLIN: Nothing really. I'll just wait to hear what comments and questions we have but you covered it well.

DR. BURGESS: Thank you. So questions, comments, anything from the group? Yes?

PARTICIPANT: Yes. When I fund workshops, research workshops, I always like to have a few people from other countries because they really bring a different perspective. And it appears that this is entirely US-centric. Is that on purpose?

DR. BURGESS: That is true so far in terms of, I think part of the issue in the previous workshops that we had was that some of the best science was from other locations. And so I think Dr. Robin Burgess-Limerick, for example, did some fantastic work. He was willing to come. I think he paid his own way, if I understood correctly.

DR. LUXBACHER: He did. He had some other work he could do while he was here. But this was a large chunk of the work he was doing.

DR. BURGESS: Exactly. So I think that budget is an issue. People have to really provide their own way for this. So that could be an issue for some of our international collaborators. And then I think, for each of the topics, do we have someone who can cover it well here versus someone internationally. But I'm all for international involvement. And so, if you have specific suggestions for individuals that could talk on topics, let me know. One thing I think that is important is everyone's presentations are short. So we're talking 20 to 30 minutes at most. And so that's a long ways for people to come for a very short presentation but we only have a day and a half to cover a number of topics. So that's another thing that we're sensitive to.

Yes. Priscilla?

DR. NELSON: So my two cents are that mental health and substance abuse are, from what I've heard, pretty major. And I think an hour and 15 minutes for the total thing isn't going to do it. So I don't know what you want to do about that but my initial instinct is these are really important and very prevalent. And I don't know who you're going to have to talk about what but they're not the same thing.

DR. BURGESS: I'm going to look to Kyle and he can—

MR. ZIMMER: Well, I think the way we're going to approach this is more what you can do with the workers. So it's peer type programs to get members, or our union members, the help that they need. So we're going to give an overview of the basic problem, which has been well defined forever, and we're going to talk more about nuts and bolts programs that you can put in place to help people that are in crisis.

DR. NELSON: So, I can understand your perspective. But maybe there's another part to this, that isn't so focused maybe just on the worker, but on what kind of a program actually operates and what are the research things that need to be done in order to be associated with it. Because I feel like this is a workshop that, I mean, it's a general hearing, but it's also exploring things that NIOSH has not currently claimed as part of its research agenda, but which is potentially could as it relates to worker safety. So there's something about this workshop that can actually inform NIOSH about what's possible for NIOSH to do.

DR. BURGESS: So Priscilla, based on our previous experience with the workshop that Kray had put together, what worked really nicely was a combination of industry presentation and a research presentation. So we'll be going forward with that. And we actually do have industries that have put together wellness and substance abuse programs that they'll present. And then we'll have, from the academic side, either NIOSH investigators that do work on this area, or university, other academic presenters, on those topics.

So, and the program before seemed to work well. I mean, we identified priorities and then at the end we went through a process of ranking them and then providing them to NIOSH. So you end up generating, through this period of a day and a half, a lot of topics of interest for the group, even if they're not explicitly covered completely in here. So I believe that, following the successful previous model, that we'll come up with something that is useful to NIOSH. But also realizing, at the same time, that we can't cover any of these topics in adequate detail. That will have to be done for the future.

Yes, please, Ed.

MR. GREEN: One topic that might be useful is the health effects of graveyard shift work. I know that both IOC and the National Toxicology Program are having that issue and—

DR. BURGESS: I'm sorry. What was it again, Ed?

PARTICIPANT: Shift work.

MR. GREEN: Shift work.

DR. BURGESS: Shift work.

MR. GREEN: Graveyard shift work in particular. That's common to my industry especially.

DR. BURGESS: And I'm looking through if I missed something here on—

PARTICIPANT: You could kind of go with the fatigue stuff too.

DR. BURGESS: Yes.

DR. KOGEL Yes.

DR. BURGESS: So did—

PARTICIPANT: Yes, that's on the data sources surveillance utility section on the second day, just underneath or at the bottom in a critique and shift work discussion.

DR. BURGESS: Yes. So, sorry, I knew it was in there. And so that is something that we are going to bring up. And the shift work is an important issue. And certainly talking about other countries, I mean, the Australians have done lots of work there.

So one thing I think, too, that's important is we were looking at things that were focused more on health, rather than injury, outcome. So that's not something that I said previously. And, before I forget, because I'm prone to do so, I wanted to thank everybody else who's worked on this. So Kyle Zimmer, Ron Bowersox, Marifran Mattson, Aubrey Miller, Kray Luxbacher, Kelly Bailey, Mitch Krueger, Chris Rose and Jake Rukavina, those are all folks from industry who have joined us. And then, of course, Jerry Poplin. And then Jeff Welsh, who has been really helpful in terms of providing support for this as well.

MR. GREEN: It seems that you have only two hours of general discussion. That really seems to me to be totally inadequate. I mean, if there's any way to even get another 45 minutes or an hour, I think that could be really beneficial.

DR. BURGESS: It's a point well taken. It's something we had discussed but we can certainly bring it back and see if we can increase the amount of time for discussion. Absolutely. Yes, Mike?

MR. WRIGHT: Yes. I'm really reluctant to add even more suggestions out of this but I want to follow up on something Ed said. When we survey our members, which we do every time we do a safety and health conference, or a workshop or anything, we often start by asking people: What is it that's making your members sick or hurt? And about half will identify particular factors, a particular chemical or machine guarding or something like that. But at least half identify work organization factors. Not just fatigue, not just overtime but things like inflicting job demands, excessive job demands, workplace stress and a whole host of other things. And that kind of sits in an area that's sort of between wellness, on the one hand, and specific hazards on the other, but to workers themselves. And this is true across the board. It's not just miners. It's really every population we talk to you'll get the same response, from nurses, for example.

It's a lot about work organization. And it's not just safety, it's also health. So, it's probably too big a topic to bite off for this workshop, but I hope as we go forward we will really do a lot more thinking about the impact or work organization on health.

MR. ZIMMER: Jeff, I had planned to tie in, I call it "lifestyle issues," Mike. Everything that you've hit on is what I call lifestyle issues in our workplace. And what we've done with the operating engineers is actually created a four day peer training program for that. And we—

MR. WRIGHT: Yes, I've seen your stuff. It's really quite good stuff.

MR. ZIMMER: We have hit on exactly everything that you've said.

MR. WRIGHT: Except, this is not so much things that are within the worker's control. These are the way that management structures the workplace.

MR. ZIMMER: Absolutely. Absolutely.

DR. BURGESS: So, I was going to ask—

MR. ZIMMER: This will be a starting point in a conversation, I feel.

PARTICIPANT: Yes.

DR. BURGESS: So, I agree. It's going to definitely hit on this mental health and substance abuse topic. And, as well, for the wellness, I was going to ask Kelly Bailey if he had any thoughts in terms of the Pine Bluff Sand & Gravel operation, if they talk about some of the work organization issues as well. Because he's seen their work. Correct?

MR. BAILEY: Right. It deals with handling stress. And but it's a program for, mainly focused on health or wellness, your blood chemistries and so forth, giving feedback. And your exercise program, your smoking cessation program, all those kind of things to help the workers improve their health. Stress is one factor of that. It's got multiple areas it's trying to cover in there. They're doing it on a every six month basis with their whole company. So it's pretty comprehensive.

DR. BURGESS: So I think it would cover some of the issues. But, if you have a suggestion for a particular mine site or company that does this really well, we'd love to hear from it. And we can reach out to them and see if we can find some time for this. We still have some flexibility and we have a lot of folks already committed. But certainly we can discuss it in the group, and, if we had a particular location, again, that could talk about how they've done it successfully, that would be much better for us.

MR. WRIGHT: Let me sort of be explicit about what I'm talking about. And the best way to do it is to illustrate it with an accident. We had a steel plant, which about 10 years ago, had a bad accident in which a device called an AXI compressor blew up. Nobody was badly injured. It was sheer dumb luck because it practically blew up the building. And, when we looked at it afterwards, we discovered that what had happened was management had reduced the number of operators of the AXI compressor. So, now, where one person who was responsible for one AXI compressor, now he or she was responsible for two. And the problem was that, you can do that if nothing goes out of whack, but as something goes out of spec you've got a problem because you can't run the one while trying to fix what's wrong with the other.

And we found that, it was not only a problem in terms of an ultimate explosion like that, but people were going home with just enormous levels of stress. And it affected their families and everything else. Because they knew what would happen if something went wrong. And, in fact, it did.

The first response by the company was, "We'll teach you how to handle stress." And our response was, "No. It's fine to learn how to handle stress but let's talk about what creates the stress." So, I've seen a lot of workplace programs about handling stress, about handling fatigue. But the problem is we don't always get to the root cause of it, which is what's causing the stress, what's causing the fatigue. And that's both a safety and a health problem.

DR. BURGESS: I think it's an excellent suggestion. And what would help us move it forward would, again, be finding some location that does what you just described well. So if we have that I think it makes it much easier for us to present this as a model and help generate research ideas out of it.

PARTICIPANT: Yes, we'll see what you do. Yes.

DR. BURGESS: Thanks.

All right, anything else? All right. Thanks. Kray is next.

DR. NELSON: Okay. Thanks very much. And we're on to Kray and metal mining automation.

METAL MINING AUTOMATION AND ADVANCED TECHNOLOGIES WORKGROUP REPORT AND DISCUSSION

DR. KRAMER LUXBACHER: So, out of curiosity, how many, including our guests, heard this update at our meeting in Tucson? I know that everyone but Mr. Horn did, on the committee. Not so many? So I thought I'd give you sort of a brief background on what we did and how it's informed what Jeff is doing also. And then what I really want to do is, I'm still late with the report, which I was late with it in Tucson, is, I want to talk about how we create a report, I'm determined to use this time well, that is very easily translatable to NIOSH's mission and strategic goals; not something that they have to spend a lot of time taking our recommendations and seeing how they fit. So that's what I thought I would do after I give you a little bit of background, is talk about the three strategic goals and how these recommendations can fit nicely in those.

So our workgroup is shown here. These were all the people that helped with the planning. And they were very, very helpful and especially Todd and Jeff. So our charge was to answer these three questions: What extent will automation and smart technologies be implemented in metal mining, and in what timeframe? And, by the way, this is the first such workgroup under the auspices of MSHRAC as far as I know.

Right, Jessica?

DR. KOGEL: Yes.

DR. KRAMER LUXBACHER: So this was sort of an experiment. What the related emerging health and safety concerns? What gaps exist in occupational health and safety research

related to automation and smart technologies?

So what we did was facilitate a stakeholder meeting that was held in Colorado last September. We had about 40 attendees and a good cross-section of people from academia, from NIOSH, from industry. And we just facilitated this workshop. We were planning it much more quickly than Jeff is, so I applaud him for getting ahead of the curve. I think we had our first meeting at the end of May and then we held the workshop in September.

The red is me grimacing because this should be done by now, the actual draft report, and it's not. But, as I said, we were charged in May. We did our polling and planning of people and what issues they thought needed to be presented. And that was one of the big work tasks, actually, as you can see with Jeff's discussion, is what issues do we need to spend our time talking about. They should be issues, obviously, that are relevant, but that are also relevant to NIOSH.

When we talk about emerging technologies in metal mining, designing the next Caterpillar cabless truck is not what NIOSH needs to be doing, or not where their skill set is, you know? So talking about what's really relevant to NIOSH is important too.

As I said, this was held in Colorado with about 40 attendees. And I keep forgetting I have a TV right in front of me. It's just habit to look back. This was our agenda which is very similar to what you see from Jeff. And it does seem that we didn't have a lot of time for discussion. But that four to five there at the end actually went over I think that first day. And we had a very good discussion that day and actually we didn't need all the discussion the second day. People were sort of getting exhausted because there had been so much good discussion the first day. And after every one of these sessions there was also discussion. So there was quite a bit of interaction. And this was day two. It was a half day also.

And, by the way, all of our outcomes from the discussions, we were sort of taking notes in real time and those are all posted to this website, if anyone is interested. I can also give it to you later. So we have some work product at least.

So back to this first charge question of "What extent will automation and smart technologies be implemented and in what timeframe?" what we really found was not a clear answer to this, but that the US industry is moving carefully. And I don't want to say "slowly" but it's not the Wild West in terms of automation. They're moving very deliberately in terms of health and safety, really. When you ask them why they're moving so deliberately they say, "Because the failures we've seen have been because we moved too quickly and we didn't have our workers onboard and we didn't have our workers well educated."

So one of the things that I showed before and I'm showing now, was sort of these pink outlines. These were, they say 14 questions. I took this straight from Dr. Robin Burgess-Limerick's presentation. He came from the University of Queensland to present this and he developed these very thought provoking

questions around the automation. There were actually 18. And all of them will be in the report. But what I did was sort of highlight the ones that I thought were especially relevant for NIOSH. And certainly this is just a recommendation so not something that they have to decide are the ones that are especially relevant.

I won't read through them all because we went through them all at the last meeting. But one of them was isolation from maintenance, how can it be ensured and confirmed. And we talked about this at great length, particularly in mines that are fully or nearly fully automated, where you have entire automated sections and you essentially need a gate to keep people out of those sections when they're operating.

The next one that I thought was very interesting in a number of ways is "How do we train or retrain our line managers and workforce within an automated system?" Some of the interesting things that we heard about this were, operators who had been on moving equipment and were moved to a control room, they asked for certain things. Sometimes they wanted some haptic feedback: Was the equipment rumbling? They wanted sound. They wanted to be able to hear the engine. And what they found later was they didn't actually need all the feedback they thought they did. But it was provided upfront and then determined they didn't need it. So understanding what kind of feedback remote operators really need is critical. And then how to train them to work with that feedback is also critical.

Utility and limitations for virtual simulation. I focused on this one because I think NIOSH has been very deliberate in investing money in virtual simulation. Especially here in Pittsburgh, you've got a very impressive lab and a lot of great expertise, which is actually even more impressive than the lab, is having people with that knowledge. So I think this is an area where NIOSH can really contribute.

"How do we ensure unanticipated consequences of automation and consequential risks are identified and managed?" And this one is a tough one but also one that I think NIOSH can play a role in, because you can very easily survey and observe these unintended consequences across the industry and across commodities and share this information out, which I think is an important role for NIOSH.

DR. NELSON: Kray?

DR. KRAMER LUXBACHER: Yes?

DR. NELSON: That top one there is really focused towards training and competency assessment.

DR. KRAMER LUXBACHER: Yes?

DR. NELSON: But was there any discussion beyond virtual simulation and VR, where it goes beyond training and competency?

DR. KRAMER LUXBACHER: Most of it, I have to be honest, was around training operators because they're going to be in a totally different type of operation than they are now. Not in a cab in a piece of equipment that's moving underground but in a control room where you're the… Oh, Kyle is not here. His example about the accident where

people were overloaded cognitively is going to be an issue. So I think that that's where we talked a lot about virtual simulation, and looking at people's cognitive responses when all is well when they 18 screens in front of them and when things are not going well and they have 18 screens in front of them, what is the happy medium there. But we didn't talk much else.

Do you have something particular in mind?

DR. NELSON: Well, yes. I'm just wondering what was discussed at the workshop.

DR. KRAMER LUXBACHER: Okay. If you have something particular in mind I'd love to hear it.

And then appropriate risk management framework and—

Yes. Oh, I'm sorry.

PARTICIPANT: That's okay. I have mines who produce autonomous forklifts. And the transition from a warehouse which is dissimilar from being a mine, in terms of training people to operate the warehouse, has been much more difficult because of a lack of feedback. And so what they see on the screen, even in simulation, doesn't really show what the reality is if the machinery breaks down, for example. Or if there's a glitch of one kind or another and the machines don't line up properly and you have a problem. Have you looked at that at all?

DR. KRAMER LUXBACHER: We haven't been that specific. I think, and I'm no expert in virtual simulation, and, reality, but I think that that's probably also a matter of how you craft your training modules, and how you craft the feedback that you're giving operators so that they do get a realistic understanding of what's happening.

PARTICIPANT: But that's harder. It's a lot harder than just saying…yes. Yes.

DR. KRAMER LUXBACHER: Oh, it is harder. Just to say it is one thing but it's very difficult to do. But we did get feedback that the operators thought they needed was not what they needed. The sort of haptic rumbling, or the noise or whatever, was not necessarily what they needed.

PARTICIPANT: But you also have a fear factor in there too of, "Oh, my gosh, am I doing something now that will affect my job in the future? And, will I be able to do the very things we talked about under other circumstances?"

DR. KRAMER LUXBACHER: Right. And huge generational differences that were talked about.

PARTICIPANT: Huge generational.

DR. KRAMER LUXBACHER: So, hiring a 20-year-old into a system like this, they might be very adept at it because of gaming. But, taking someone who's been operating equipment for 20 years, they may not be as adept or as comfortable with it. So that's an issue too.

The next was appropriate risk management frameworks and tools to guide implementation. And this was great to have Robin Burgess-Limerick, again, here, because they've done so much work around risk management framework. I would also say they've done quite a bit around fatigue and risk management so I'll see what I can pull for you on that. But that is also a nice area for NIOSH to play in, I think, because it's quite an international spectrum of people doing risk

management and how they approach it. And then applying it in the US to our specific regulatory system is difficult so I think that's a nice area for NIOSH too. And that is not to say that none of these others are important. These are just sort of the ones that I grabbed. And so if you're looking and you say, "You really should have grabbed this," then please speak up.

So these were the areas that we identified in terms of priority from the workshop attendees, from the 40 attendees. And so we were constantly sort of taking notes. And we'd start out with one really big long list and then Jeff and Kyle were helping to sort of move the things to the top that everybody thought were most important. So these were what we ended up with. "Tracking degree of automation in the commodities with best practices." I don't know that we have a good handle on this now. Certainly I can't identify an operation that's entirely automated in the United States but there are lots that have some degree of automation. And "What are those best practices of the ones that do?"

"Human-computer interfaces…"

DR. NELSON: Can you just tell me this really quick? What is meant by "automation"? Is this AI? Is this…? I mean, what exactly do you mean by automation in that sense?

DR. KRAMER LUXBACHER: It is robotics and artificial intelligence. And, actually, I asked the same question when we were planning this and NIOSH actually has a specific definition for automation and robotics that we are using. So, I can't recite it to you, I don't know is anybody here from NIOSH can, but there's a very specific definition. And it is fairly all-encompassing in terms of AI, robotics, that kind of thing. So, it could be a robotic arm that's lifting something from here to here; it could be an autonomous haul truck; it could be a system of software that's making decisions.

DR. NELSON: So I guess, to me, automation doesn't necessarily imply intelligence.

DR. KRAMER LUXBACHER: No, it doesn't.

PARTICIPANT: But it could.

DR. KRAMER LUXBACHER: But it could. And that is sort of the NIOSH definition as I read it. I don't know if you all would agree with me.

PARTICIPANT: Generally the replacing of the human by some automated process or machine.

DR. NELSON: Well, that's fine. My feeling is automation does not imply something being intelligent. And to me the ultimate goal is to have something that is intelligent and trusted which is another part that's not…

PARTICIPANT: It's in the next stage.

DR. NELSON: …a part of automation. So, I mean, automation to me is just making something go mechanically or, you know, with—

DR. KRAMER LUXBACHER: I agree. And I think, where we are in the world now, we don't have something entirely intelligent. Otherwise NIOSH really wouldn't need to do this work because there would be no human interaction, right?

DR. NELSON: Right.

DR. KRAMER LUXBACHER: So that's sort of the critical piece, is where are the humans interacting

and to what degree. And you can't define that until you start looking at specific operations and applications.

DR. NELSON: And that's where virtual reality starts coming back in, to actually build relationships between intelligent devices and people.

DR. KRAMER LUXBACHER: Right.

DR. NELSON: Right? And so there's my thought process.

DR. KRAMER LUXBACHER: No, it is tricky to navigate that area.

So, "Human-computer interaction, including practice cognitive overload and feedback strategies." And again, that gets to Kyle's example in a big way.

"Unmanned vehicles for improvement of health and safety." And this can be anything from unmanned vehicles like the multimillion dollar haul truck or the little unmanned vehicle that the mine engineers created. And we heard a lot about both actually. And it was kind of neat because we had lots of people there who were just personally very interested in automation. And so you had chief engineers who said, "Well, I made this little buggy that can go around the mine and do this for me." or "explore this area." And that was neat to hear.

"Characterization of the efficacy of automated systems in terms of health and safety." And this was critical too because what does constitute a near miss and how do we measure it? And there's been some work on this done in the automobile industry for self-driving cars and what constitutes a near miss that perhaps we could translate to mining. But those are important because we would expect there would not be many severe accidents but when there are they would result in an extreme loss of trust.

"Technology transfer and leading practice from automated transportation and mining systems, especially for small operators." So for those of you who didn't know the background, we were sort of questioned about why we were looking at metal mining in particular. And we weren't talking about coal and we weren't talking about aggregates. And the reason really was that we felt this is the area of the industry that's quickly, or most quickly, assimilating automation into their mining practice, and using the most advanced automation; primarily because they have the capital to do it. And then those things are being translated into coal which has a different regulatory system, of course, which makes it a little harder. And being translated into the aggregates, stone, sand and gravel, industrial minerals, industries. So we want to look at how we can translate those better.

And then "Mine design for safe automation" whether it's greenfield or brownfield. Looking at the Resolution Mine, of course, is the ultimate in greenfield sites for automation. But most of our sites in the United States are brownfield. They're bringing in automation after the mine is established. And so the mine wasn't necessarily designed for it.

And we also talked more broadly about risk management and sensing and situational awareness. And I'll leave those there because what I would really like

to spend my last few minutes doing is looking at how these meet the NIOSH strategic goals. And so, if you recall, there are three goals and they're fairly easy to remember because they're safety and they're health and they're disaster, right? Jessica or George or Jeff could probably recite them exactly for me. But essentially what you're looking at is occupational illness and disease development, reducing the risk of that, reducing the risk of a traumatic injury or fatality, and, reducing the risk of—what was the third one?

PARTICIPANT: Disaster prevention.

DR. KRAMER LUXBACHER: Disaster. Thank you.

So what I wanted to do was look at how these priorities that we identified fit under those three strategic goals. And that's kind of what I want to end up crafting our recommendations around. So, that means I'm asking you to work for it after lunch which students never want to do and probably you don't either. But so the first is going to be, again, health, health and disease. And these are all reducing the risk when I put "health and disease."

PARTICIPANT: Kray, can it be increasing the risk too? Increasing the risk of—

DR. KRAMER LUXBACHER: Oh, yes. Yes.

PARTICIPANT: Increasing or decreasing risk.

DR. KRAMER LUXBACHER: I was looking at NIOSH's goals are to reduce risk, yes.

PARTICIPANT: Are, okay. I thought you meant these.

DR. KRAMER LUXBACHER: No, no, no.

PARTICIPANT: You're right.

DR. KRAMER LUXBACHER: But, you're right, some of these could actually increase risk. But I was looking at putting them under, if this is NIOSH's research goal is to reduce the risk of disease development.

PARTICIPANT: It does here, yes.

DR. KRAMER LUXBACHER: So as you look at the eight areas that we identified as priorities, which would you put under the Strategic Area 1? And certainly they don't have to go under only one area.

DR. BURGESS: So, I'm sorry. Number 2 was just emergency or any traumatic?

DR. KRAMER LUXBACHER: Number 2 is any traumatic injury that—

PARTICIPANT: "Any traumatic" as in—

DR. KRAMER LUXBACHER: Injury or fatality.

PARTICIPANT: Okay.

DR. KRAMER LUXBACHER: And Number 3, then, is—

DR. NELSON: Disaster.

DR. KRAMER LUXBACHER: Disaster. Thank you. It's on the tip of my tongue every time.

DR. NELSON: Well, it appears Number 3 has something to do with health and safety.

DR. KRAMER LUXBACHER: True, but 1 and 2 are—

PARTICIPANT: The same, health and safety.

DR. NELSON: Well, you can make anything match anything.

PARTICIPANT: Yes.

DR. KRAMER LUXBACHER: They all could. One thing that I think of immediately is when we talk about human and cognitive, or, human-computer interaction, I think of that as, certainly the outcome is safety, but for the individual operator it's a health and disease issue. Because, just because we took somebody out of the mine, we've then put them in a chair in an office sitting for, not necessarily eight hours a day, maybe 12. What have we done in terms of health? We may have improved it in some ways and also damaged it in others, right? So I would say under—

DR. NELSON: Well, I always think of human-computer interaction is when it's the most dangerous to be around. I mean, if we went all computer, all robotics, you're okay, human is there.

DR. KRAMER LUXBACHER: Right.

DR. NELSON: It's in-between that you run into the problems.

DR. KRAMER LUXBACHER: So it's also safety. I'm going to go ahead and put "safety" here because so many of them are shared. And I'll just go ahead and start the page for disaster. So what do I say here for Number 2? Operator health. But where we have safety, cognitive overload. Is that reasonable? That's kind of what I'm getting at. The silence is deafening. It's like teaching at 8:00 a.m.

DR. KOGEL: Well, I would add to that, Kray, in terms of… So it's not just cognitive overload but I think you also have a piece to it that's engagement and satisfaction from your job, so that there's a lot… I would put that in operator health too. So that you have the mental health component that might kind of feed back into your overall health.

DR. KRAMER LUXBACHER: And I've got my back to you up here. I apologize. Maybe I can do that better. Thank you.

I think one sort of covers all three, it's sort of overarching, degree of automation.

PARTICIPANT: At which point in time?

DR. KRAMER LUXBACHER: Now and going forward. So I would say now and in the future. We were talking under the auspices of the workshop in the next 10 years. I don't know if that's a recommendation for NIOSH, though, where we look at now to 20 years. That's just sort of feedback I'm looking for.

How about unmanned vehicles? Disaster response? Really all three? But disaster response is pretty critical for an unmanned vehicle, right?

DR. NELSON: Yes, it's for all three.

DR. KRAMER LUXBACHER: How about "efficacy of automated systems"? What's a near miss and how do we measure it?

DR. BURGESS: I would just put everything, 1 through 8, on Number 2, I mean, honestly. I mean, you could make an argument that each would fit under these categories. Because they're all going to reduce the potential for injury.

DR. KRAMER LUXBACHER: That's reasonable.

DR. NELSON: So, but health, also mental health. I mean, we have "automated system," is that

level of trust associated with what's going on around you? I don't know if that's what is embedded in that concept of efficacy of automated systems.

DR. KRAMER LUXBACHER: I think it could be. It's a theme that came up over and over again with the workshop attendees, was any failures they'd seen were related to trust in the system, or, their failure to educate workers.

PARTICIPANT: But who would bear the responsibility of the failure?

DR. KRAMER LUXBACHER: The operators. They bored the responsibility when they explained it. Is that—

PARTICIPANT: But that's, I mean, if it is an automated system then in fact the system should operate on its own initiative. And the operator, at best, is reacting to what's going on, either on the screen or before (inaudible @ 01:43:18) the mine.

DR. KRAMER LUXBACHER: It depends on level of automation. So if it's a fully automated system there doesn't need to be an operator at a screen. In true fully autonomous systems. That is not… We are not there in mining.

PARTICIPANT: No, we're not even close.

DR. KRAMER LUXBACHER: No. So we're talking about the spectrum of automation in mining when we talk about the entire topic, really.
Yes?

MR. WRIGHT: This may sound like a contrarian view but we've been trying to teach people not to trust, robotics especially. Because, at a certain point the programming of the robot becomes complex enough that its behavior becomes, to some degree, unpredictable. That's like a fundamental mathematical truth, right? That's not just bad programming.

DR. KRAMER LUXBACHER: If it's truly intelligent, yes.

DR. NELSON: I'm not sure that it's a truth like that. "Belief" might be better than "truth."

MR. WRIGHT: It's called, well, no, there are two results. One is called (Gruden's @ 01:44:21) theorem and the other is the stopping problem, which were recognized. And then this is a much broader thing. The place where this comes in is we had a guy badly hurt by a robot in a, in this case a tire building. And the first response was "Let's fix the programming." And we thought that was good. But we also insisted that, because this robot could go through all kinds of different movements at different times, that at some point you needed to keep people out of the possible paths of the robot because you couldn't always predict things. So we've been trying to say to people, when you design one of these robotic systems you've got to assume that the robot could do something unexpected. And, therefore, the point is you've got to plan for that. You can't trust that the robot is always going to do what it's programmed to do. Does that make sense?

DR. KRAMER LUXBACHER: Yes. It's sort of how you—what you teach people to assume about the system.

DR. NELSON: Well, this is completely pertinent for people as well.

DR. KRAMER LUXBACHER: Yes, you're right.

PARTICIPANT: It's just a degree of uncertainty of the actions, whether it's a human being or—

DR. NELSON: I'd say the probability is higher that a person is going to go amok than a robot. That's my bias.

MR. GREEN: Kray, further to Bob's and, Mike Wright's observations, the responsibility is daunting. Under the Mine Health and Safety Act, the operator is liable regardless of the cause, and the definition of "operator" can include not only the person, the company that's operating the mine, but it also can include the manufacturer of the machinery. And I can recall, several years ago, taking Caterpillar in to visit with MSHA production when they were developing their autonomous trucks. And MSHA was blown away by the technology. They were so excited they couldn't see straight. But the very next day they decided they were not going to allow it as a substitute for manned control because they were just terrified of the implications. Now that's beginning to change.

Now, was anybody from MSHA involved in the Colorado meeting?

DR. KRAMER LUXBACHER: No.

MR. GREEN: That's going to be an important stakeholder to get buy-in to this.

DR. KRAMER LUXBACHER: I don't know if that falls under my recommendations to NIOSH.

DR. KOGEL: So, Kray, I think we invited them, correct?

DR. KRAMER LUXBACHER: Yes.

DR. KOGEL: And they did not come, for whatever reason. So that should fall under one of the recommendations, I think.

DR. KRAMER LUXBACHER: Okay.

PARTICIPANT: Yes. That would be a good one.

PARTICIPANT: Hi. This is Melanie. Can I ask who was invited?

DR. KRAMER LUXBACHER: Melanie, I will have to look and get back to you. I honestly just don't remember.

PARTICIPANT: Okay. Thank you.

DR. KRAMER LUXBACHER: As you look at this list is there any place where you see…? I've already mentioned simulation, virtual simulation in reality. But do you see a place where NIOSH has extraordinary capacity or skill? Or where NIOSH is really missing skills that need to be developed to address these issues?

PARTICIPANT: Kray, can you start, say that again? I missed the beginning.

DR. KRAMER LUXBACHER: Yes. I think everybody is a bit brain dead this time of the day. So I mentioned virtual reality, right? You've got great capacity to do work in virtual reality. As you look at this list is there a place where you see, "Oh, we have great capacity for this." or a place where you see, "we truly need to develop some capacity," in infrastructure, in people or in both?

DR. NELSON: So let me, just for argument's sake, I know then the BAA or the idea of mine design is introduced. But in fact in a lot of the work done by NIOSH it's not the overall system mine design in its complexity. And you can't do safe automation unless you're coming at it as a whole system perspective. So, I mean, I think

that's a place where the partnership between, say, owners, who come at operations from one perspective, and academics, that come at design from a sometimes different perspective, can partner.

DR. KRAMER LUXBACHER: So like a systems perspective.

DR. NELSON: Yes.

PARTICIPANT: But you also need confidence that the algorithms you put together are going to operate within the framework of what you want to accomplish.

DR. NELSON: And not just the algorithms, also the sensors themselves and the sensor networks.

PARTICIPANT: Yes.

DR. NELSON: I mean, once you start doing that, you're designing for safe automation, it's probably a different system than designing for not automation. And now you're making some fundamental changes which may have precipitating consequences and cascading through.

PARTICIPANT: I agree.

DR. NELSON: So it really requires careful thought.

DR. KRAMER LUXBACHER: Well, and with a brownfield site especially it's a bit like saying, "Here. We have all the components for a really good rescuer but we don't know what package we want to put them in." right? It's similar.

DR. NELSON: So, the virtual reality combining with mine design, if you've got the algorithm of the sensors, it's certainly a demonstration of what could be possible which right now isn't really around. It would be good to have that demonstration.

DR. GEORGE LUXBACHER: I anticipated that, one of the capacity builds, one of the universities would submit a proposal about how would you do greenfield development for full automation.

DR. NELSON: Yes.

DR. GEORGE LUXBACHER: Didn't get that. But I had fully expected that—

DR. NELSON: I was busy, George. I couldn't do it.

DR. GEORGE LUXBACHER: But I truly thought we would get something like that because you have—and it comes down to the Europeans have done so much along this because they have a little bit more flexibility. But they've done so much more than we have in this country. Resolution, there's a couple of these mines that are going in now that are going to be, have the potential for this. And it would be very interesting to tie all that together.

DR. KRAMER LUXBACHER: I think the problem is, when you look at a large site like that, for an academic it's hard to find the right niche because it's extraordinarily expensive work that's being done well by the company and by the Komatsus and the Caterpillars and that kind of thing.

DR. NELSON: But at the same time if you want… A lot of them, the design programs, they're very limited in what they design too. I mean, it's usually net price, or value or something else. And in this case you're designing for something else. It's not

necessarily dollar signs driving this. There's something about safety that is a priority and safe automation.

And now, if you design most of our mines for safety being priority one, you'd have a different mine, for the most part and so, I mean, I think it's… Nobody knows how to do that.

DR. GEORGE LUXBACHER: I'm not sure that's true.

DR. NELSON: You see. No, and that has to be a relationship built, between NIOSH and the owners and academics, to really think through what does that mean.

DR. GEORGE LUXBACHER: Before we were asked whether we could think of other industries or other agencies that have been involved in this kind of rescue activity. And as I was sitting there I thought of DoD and I thought of police. And they've engaged in rescue activity through robots within certain space parameters where they've successfully developed a robotic solution to a catastrophe.

DR. NELSON: Yes.

DR. GEORGE LUXBACHER: So that it does exist out there.

DR. GEORGE LUXBACHER: Let me point out the difficulty in doing that, because NIOSH has been working on that particular area for a number of years and when you start talking… So what we focus on, MSHA Mine Emergency Operations, right over the hill here, they have their robot that's a permissible robot. It's this huge thing that weighs 1500 pounds. It added like 800, 900, pounds to it to make it permissible because you had to put batteries in a permissible enclosure and everything.

So we started to address this and we've developed several different solutions, none of which are permissible. So it's questionable whether they'll even be used in the event of a coal mine disaster, which is your more prevalent type.

DR. GEORGE LUXBACHER: Yes.

DR. GEORGE LUXBACHER: And so the design parameters are very difficult. And then the question is how do you care and feed this. So we developed several robots. We would spend the majority of our contract budget just continuing to care and feed things if we wanted to do that. And they're not even permissible, so they can't be used. It would take a decision on MSHA's part to even use them.

I'm just saying there's a lot more complexity. It's easy to say they do this in a DoD environment or anything but as soon as you step into a coal mine with potentially explosive atmosphere things change.

DR. KRAMER LUXBACHER: Well, and a lot less money available too. I mean, the DoD environment, funding-wise, is a bit different.

PARTICIPANT: Right. They can throw anything.

DR. GEORGE LUXBACHER: Yes.

DR. ART MILLER: In terms of NIOSH's capabilities, we started the automation technology team in Spokane and actually this workshop has kind of came out of that team, we're on the learning curve on several of these things. And the one, the number 8 one, we're actually doing. And you'll see some comments on that this afternoon in my

presentation.

PARTICIPANT: Okay, great.

DR. KRAMER LUXBACHER: And this is a good point, a follow up to George's comment, actually, because sensing is an area where you can contribute without trying to invest in a robot that, like you said, you have to feed and clothe for 20 years. If you develop a great sensor that has multiple applications I think that's a much better area for NIOSH to operate, rather than to say we're going to develop the next advance driverless haul truck.

DR. NELSON: Somebody has got to address the complex systems in their fullness, all right? Because we keep reducing. Reduction is down to something we can solve, whereas the system stays complex. So, I mean, I think that maybe where there's most going into such a complex system might be the transportation systems of the world. Because, when you do multimodal transportation system optimization, the car is the sensor kind of thing, learning as you go, this is… They're getting closer to embracing the complexity that I think we would want in a mining operation out of a multimodal transportation system. So we could probably maybe even open a conversation with them.

DR. KOGEL: So, Kray, when I look at your list, and I think sort of building on what Priscilla is saying, the mine design for safe automation is the place where we need to be working. But that's this very complex system. We need to understand that system. Everything else kind of falls under that, almost, to me. And so if you focused on 6 you're doing to do all the others.

DR. KRAMER LUXBACHER: That's a good point.

DR. KOGEL: But I think it's a big thing to try to get into.

DR. KRAMER LUXBACHER: Yes, I agree with you, 6 does kind of cover all the others. But I would hate to just throw 6 at you.

DR. KOGEL: Exactly.

DR. KRAMER LUXBACHER: And I think that's why there are the others, you know?

DR. KOGEL: Right. And that's why you need the others.

DR. KRAMER LUXBACHER: Yes.

DR. KOGEL: But you almost need to look at 6 and decide, okay, really that's where we're headed, that's a long term goal, is how do you design a mine for safe automation and safe and healthy.

DR. KRAMER LUXBACHER: Right.

DR. KOGEL: And then below that then you have to start breaking out kind of the subtopics that would go into that. And I think there are probably many more than what we even have here because it's huge.

DR. KRAMER LUXBACHER: Oh, I think there are subtopic after subtopic under each of the eight.

PARTICIPANT: Exactly.

DR. KRAMER LUXBACHER: And I'm not going to go into too much detail because I think that's your business what those subtopics are for NIOSH.

DR. KOGEL: So, anyway, don't give us just Number 6, but, yes.
DR. KRAMER LUXBACHER: And if I don't have a report to you at the next meeting I hope you will fire me.
PARTICIPANT: Okay. Good.
DR. KRAMER LUXBACHER: Any last comments on this or areas that are missing?
DR. NELSON: So for the next meeting first thing is to have Kray's report Item Number 1 on the agenda.
DR. KRAMER LUXBACHER: That's right. Or my letter.
DR. BURGESS: Kray, to help guide our next session after this on health, did we have any evaluation of the participants in terms of whether the workshop met their expectations and needs?
DR. KRAMER LUXBACHER: I don't think we did and that's a really good idea. I wish we had done that.
PARTICIPANT: Thanks.
PARTICIPANT: Can we still?
DR. KRAMER LUXBACHER: Yes.
DR. NELSON: When you send your report out for them to review it—
DR. KRAMER LUXBACHER: Yes, I'll send the report and then I'll just say, "Here's a survey you can participate in."
PARTICIPANT: And then when you get that, please provide it to us as one last thing for us to do.
DR. KRAMER LUXBACHER: Yes. I'll be happy to. Yes, that's a good idea.
MR. HORN: But I don't think you're going to be able to get private industry to design a mine that's automation friendly. You've got to find an existing mine. And one that comes to my mind would be a salt mine, for example, which has chambers and space for movement. I mean, the cost would be prohibitive.
DR. KRAMER LUXBACHER: Well, the only people that are doing it that way right now are the metal operators, so the Resolution Mine. Some of the big mines in Australia have been designed specifically for automation.
MR. HORN: Oh, really? I didn't know that.
DR. KRAMER LUXBACHER: But they had money to spend and very remote areas to mine in so it made sense economically that robots would be cheaper than "fly in, fly out" in those areas.
DR. KOGEL: Resolution is probably, as far as a US kind of case study for a mine that's designed specifically for automation, that's probably the only one that really exists. Everything else right now is brownfield and nothing comes close to what's happening with Resolution.
DR. KRAMER LUXBACHER: And my sense is that NIOSH has a good relationship.
DR. KOGEL: We do, yes.
DR. KRAMER LUXBACHER: And I think that's critical because you can track what they're doing as they go, and lessons learned and best practices and that kind of thing.
DR. KOGEL: Yes. Even just doing that may be very valuable if we can partner with them to do that.

DR. KRAMER LUXBACHER: Yes?
MR. WRIGHT: A quick question. Are these mines, like Resolution, on the surface or underground?
DR. KRAMER LUXBACHER: Underground.
PARTICIPANT: Okay.
DR. KRAMER LUXBACHER: Resolution is. Some of the mines in Australia designed specifically for automation are surface. And so what they've looked at are things like the road design, the turning radius, all this kind of stuff that might be slightly different in the driverless truck.
Anything else?
DR. NELSON: Okay, your time is up. All right everybody, we are on schedule, just as Kray promised.
PARTICIPANT: Thank you, Kray.
DR. NELSON: Okay. We will break until 3:15.
[Break.]

INDUSTRIAL MINERALS MINING SECTOR—STATUS REPORT

DR. NELSON: So we were promised Robert Glenn, but instead we have Kelly, and we're very happy to have you, Kelly.
MR. BAILEY: Thank you very much.
DR. NELSON: So we are reconvened, and the floor is yours.
MR. BAILEY: Okay. Thank you very much. Good afternoon. You're going to be blessed with the shortest presentation of the day because I'm a rock, sand and gravel guy. I'm not an industrial mineral guy. So you can't ask me any questions. If you do, Mark Ellis can answer.
DR. NELSON: Oh, we can ask you but you may choose not to answer.
[Laughter.]
MR. BAILEY: Well, let me start off, this is a project similar to the one that I did for stone, sand and gravel that Bob Glenn is working on and I'm helping him out. And this is our charge, if you will, try to answer these questions for this particular mining sector, and it's a lot more complicated, I found out, than rocks because there's a lot of different colors in this mining commodities, But what are the current challenges and how are they identified, and are they being addressed by NIOSH is the focus of the research on the priority issues that may vary within those commodities. So it's a lot different also than stone, sand and gravel. And our emerging challenge is being met and is NIOSH equipped to service the mining sector, this particular mining sector? What does it need to help it? And are the challenges different in the east versus west? That was more of an issue with stone, sand and gravel, but the mineral commodities are all over the place. So that is something worth looking at. And is the research investment appropriate? So that's the mission that, eventually, there'll be a report that addresses these five-six questions, but that won't be today.

Now, who's all in this? The number of mines is the number over here for the different commodities. The ones with asterisks on them are our attempt to combine like commodities. So you'd have like, for instance, in the common clay you'd have common clay and common shale or the industrial clay you'd have the clay ceramic refractory group, the fire clay, the bentonite, the kaolin, the ball clay, they were all kind of grouped together. So in all, there were 50 different SIC codes that we went through and identified the mines that produce those different commodities.

DR. NELSON: Is dimension stone included in this?

MR. BAILEY: No, dimension stone is not. It's a different animal all to itself. It was not included. They don't consider themselves industrial minerals, that's right. They really are kind of out on their own. They really ought to be looked at separately. These 50 SIC codes, after we did the consolidation of like commodities became 35, and I think there still is some consolidation work that needs to happen, but someone needs to help me with that. So these are the larger number of commodities, but you can see these are the number of mines in the United States, in all 50 states. And there are a number of mines that only one or two mines in the United States that produce, and it must be really important. There's only one graphite mine, and I was kind of surprised by.

DR. NELSON: Are any of these considered critical minerals?

MR. BAILEY: I would think some of them are.

PARTICIPANT: Barite is on the list of the 20 critical minerals that the Department of Interior identified.

DR. NELSON: That's because of its specific gravity and density?

PARTICIPANT: Right. Yes, and it's used in oil and gas extraction.

MR. BAILEY: Yes. And kyanite, which I have no idea what that is, but there's two mines to do that.

DR. KOGEL: Kyanite.

DR. NELSON: Kyanite.

MR. BAILEY: See, I can't even pronounce.

DR. NELSON: It's a beautiful blue mineral. It's got hardness, two different hardnesses in different direction.

DR. KOGEL: And it's mined in North Carolina.

MR. BAILEY: Anyway, so what remains to be done with all this? So what I've done is I've identified all these mines and went through, and there were a number of mines that didn't have a commodity listed, about 300 or so—340. And I went to work with MSHA and trying to find out. I went to the retrieval system and many of those mines had invalid mine IDs, and I was kind of surprised that I got mine IDs that were invalid from MSHA. And what we found out, working with them, is that a lot of people had a gleam in their eye about starting to mine. They got an ID and never did anything. And there was a number of those, so we got rid of those. So

that first one's done, pretty much.

Then we're grouping those commodities together, and I think we're real close to having that done. And I'm going to work with Bob's group on Wednesday afternoon this week and try to look at getting the man-hours for the different mines that we've identified for these different groupings. Then we'll get all the injury and fatality inspection citation data for those particular mines and combine them into these groups, and then look at the rates for each of those and identify the most common injuries for the different types of commodities. All that data is going to be folded in with what Bob has worked on in his questions with the different industry sectors, and so forth. Some of these commodities are so small that you're really not going to have very meaningful data and it's going to—well, this is only one mine, I guess you characterized it pretty well, but it's not going to be much of a data point, but we'll still have to work on how we're going to analyze that particular small sets of data.

So that's my report. I hope that we can get you the final report presented at the next MSHRAC meeting, but it won't be me. Thank you very much. I told you it was short. Question.

DR. NELSON: But it would be really interesting to know more about which of these might potentially be, and not even—which are critical minerals in the United States in terms of if we don't have the mines for those materials that we're inputting, where is the resource and could we have the mines?

MR. BAILEY: I think China holds them. I'll ask that.

DR. NELSON: Yes.

PARTICIPANT: I have another question. Would it make sense to look at the way these different commodities are mined? And what I'm thinking about is I've been in surface gold mines before that look identical to an aggregate's operation except for the final step where they take it out and sprinkle cyanide all over it or whatever they do.

MR. BAILEY: Right.

PARTICIPANT: But I mean it's exactly the same. It's blasting, crushing, mucking, and all that sort of thing. But would it, is there a way or would it even make sense to combine those and then look at the statistics from a, you know, open pit mine, underground, you know, whatever—however the stuff is mined? I have no idea.

MR. BAILEY: Yes, the data that I have doesn't indicate whether it's surface or underground unless it's in the name of the mine, you know. So I guess, you could go back and get that, but I don't have which ones are surface or underground. I think where a lot of the differences are is in the processing. You know, once you get it out of the ground how is it processed and, you know, some of its going to be, you know, treated with chemicals and others are going to be just ground to a fine, fine powder. I mean, it's going to be the processing, I think, is where the differences show up, and it may have more significance from the health side than, necessarily, the safety side.

PARTICIPANT: The extraction.

DR. KOGEL: Yes, and I was going to say that I think the differences are both in the processing, but also in the geology of the ore, and that's, also so if there's potential for different types of exposures depending, on the particular material that's being mined. So like Kelly pointed out, I think, in his very first slide, it's extremely complex. And so when you start trying to logically group them, there are a lot of ways you can approach it and it will work for some things and not others. And I told Kelly when we did the last industrial minerals handbook, I think we spent most of the four years that was preparing it trying to figure out what was an industrial mineral. So it's very complex.

MR. BAILEY: Very complex.

DR. NELSON: So do you work at all with the USGS in any of this area? I mean…

DR. KOGEL: Yes. Yes.

DR. NELSON: Because they've got—I know they're going to move on to campus at Colorado School of Mines in the near future. And so we're going to have our own little session on minerals.

DR. KOGEL: Yes, so they don't have any industrial minerals geologists in Denver any more. I think their last stone, sand and gravel person retired too. That was Reger, so.

MR. BAILEY: I know that also it's similar to what I saw in the stone, sand and gravel, there's a number of misclassifications of what they actually do produce. And, you know, most of the crushed and broken sandstone really ended up making industrial sand, you know, of course, you know, when you go look at their website or dig a little deeper that, you know, they should be in that category and not necessarily crushed stone. And I think that's an issue that, really, the origin of it is, perhaps, in how they get originally designated, you know, some form somewhere that's too vague that allows that kind of misclassification to go in. And that's a really a serious thing because if you have a lot of data that is saying that the—when you look at the injury and expose your data and what have you, and it's misclassified, you know, you're aiming over here and you should be aiming over there, and that's just because of the misclassification. So there needs to be a better process, I think, to get the quarry or get the mine labeled correctly, you know, what it actually does produce. And some people say well, I just dig out the earth in question, you know, so…

DR. GEORGE LUXBACHER: The MSHA data should be broken down by surface and underground. When you said, Kelly, you couldn't get surface or underground distinction, the MSHA data includes surface and underground.

MR. BAILEY: They list it separately?

PARTICIPANT: It's listed separately.

MR. BAILEY: I was not aware of that.

DR. GEORGE LUXBACHER: You can sort the mines by surface and underground. We're focusing just on active mines or were you focusing on all mines?

MR. BAILEY: You know, that was a very interesting issue, also that I went through, is that these were are all active at one point between 2013 and 2017. So that's the group I'm looking at. And it's interesting when MSHA—when a mine is abandoned then all the years prior are listed as abandoned, and I saw that I said well, how can an abandoned mine have injuries? And so I went to MSHA and I said, you know, help me sort that out. And they have the ability to identify the mine status when it changes. So I went through all those 1100 mines and figured out if they were abandoned, when they were abandoned, the date, and then, you know, was it an intermediate processing or active processing prior to that? So I got all that straightened out. And some mines were abandoned twice, you know, they'd start and stop, start again, and so forth.

DR. GEORGE LUXBACHER: So I did a detailed analysis of the oil shale mines because I was interested in oil shale at one point, and the bulk of the mines are misclassified. They're not oil shale mines. So I'll get that to you and Bob. Bob asked me about that before and I forgot all about it. But, anyhow, I looked at those in specific because there's not nine oil shale mines in the US

MR. BAILEY: there's not?

DR. GEORGE LUXBACHER: No.

MR. BAILEY: Well, I don't know diddly squat about oil shale mines. So…

DR. GEORGE LUXBACHER: Yes. I did a lot of analysis on that one. I could tell you what's right and what's wrong. But the problem is MSHA puts this in and it goes in, and it's memorialized. It stays there…

PARTICIPANT: It's memorialized.

MR. BAILEY: Yes. I mean, they don't have an eraser over there. I know that.

DR. GEORGE LUXBACHER: Well, I think it really is such a minor thing in terms of what they do that it really doesn't matter whether the commodity—whether it's coal or metal/nonmetal, that's what they care about, but if you go through the data you'll find coal mines classified as metal/nonmetal and you'll find metal/nonmetal classified as coal as well. So you do find these little glitches in their system.

MR. BAILEY: If you get too many of those little glitches, and you end up with your analysis being wrong.

PARTICIPANT: Yes.

MR. BAILEY: That's serious.

DR. KOGEL: So I was just going to say one more thing about the oil shale. The reason it's in there is because it's nonmetallic, and so that's why it's in there. You guys should just take it out because it's not an industrial mineral. I would just take it out. Don't worry about it.

MR. BAILEY: Well, there's not that many in there.

DR. KOGEL: And since there's less than nine anyway.

PARTICIPANT: Well, the one that's active is, actually, mining…

DR. KOGEL: Is it an oil shale?

PARTICIPANT: Is mining clay for brick.
DR. KOGEL: Oh, well, that one is an industrial mineral.
PARTICIPANT: But somehow it's in there as oil shale even though it's not…
MR. BAILEY: Oh, well, I took them at their word on that one. So you have to tell me which mine that is. I'll stick it in the right column.
DR. NELSON: Is there one opening back up in Colorado?
PARTICIPANT: I don't think anything's opening. Somebody's opening?
DR. KOGEL: An oil shale or a clay mine?
PARTICIPANT: I think it's—it was originally an oil shale.
DR. KOGEL: Oh, okay.
MR. BAILEY: Thank you very much. Mike?
DR. NELSON: Thank you, Kelly.
MR. WRIGHT: If the Mountain View rare earth mine comes back up is that metal not—I'm sorry. Is that metal or mineral? It's a little of both, I think, if you look at—because…
MR. BAILEY: What was it?
DR. KOGEL: It's rare earth.
MR. WRIGHT: Rare earth. Is that metal? Because most of them are…
MR. BAILEY: I think it's metal.
MR. WRIGHT: Most of those are, technically, metals, but not all of them.
MR. BAILEY: I think the…
DR. KOGEL: Yes, so that's another debate in the industrial minerals world, and if you go back, again, to this handbook I was referring to, there are some things that will show up in industrial minerals, and then other times it'd be classified as metal. I would put it as a metal and not as an industrial mineral, but usually we would make that decision on end use. So really it could go one way or the other.
MR. BAILEY: Like lithium and magnesite, you know…
MR. WRIGHT: Yes, they're metals.
MR. BAILEY: They're listed as industrial minerals, but I don't know. They sound like metals to me, so. Okay, thank you for your time.
DR. NELSON: Okay. Thank you, Kelly. Okay. So we are moving on toward powered haulage, Jennica and Art Miller.

POWERED HAULAGE AND MACHINE SAFETY RESEARCH DISCUSSION AND PRIORITIZATION

MS. BELLANCA: So Art and I are tag teaming this. We have—talking about two parts of the problem. So feel free to ask questions as is or like wrapping up together because the project work really parallels each other, and you'll kind of see as we jump in but feel free to ask questions as we go. So I'm Jennica, this is Art; beautiful sidekick right here for right now, and he's going to steal the show very soon. So I'm going to start out with just stepping way back and talking about how we kind of have been, lately, talking a lot about powered haulage. It's really been a key problem that's been brought up by MSHA. It's, historically, been a problem in the mining industry in terms of catastrophic fatality events. It's a very large event that

gets a lot of press and it accounts for 50 percent of those fatalities. In 2018 it was 48, but so we're still going along that trend despite the fact that we've been working on this problem for many decades. And MSHA is really focusing on it from three factors: large vehicles crushing small vehicles, seatbelts, and then as well as belt conveyors, and that's kind of coming in the sort of the outside forces of why we're really looking into this issue.

So Art and I are going to talk about two projects that are addressing this from two different sides. First, I'm going to talk to you about a project that's looking specifically at characterization of haul truck health and safety issues. And the high-level view of this particular project is that were interested in studying health and safety issues very specific to haul trucks to better understand why these issues continue to occur despite work in this area and many different things. And, again, it's a leading cause of fatalities. It's really one of the most prevalent in the mobile equipment of powered haulage and, still, has that high catastrophic event. We're also looking to study it because it has a high potential for impact. So we are looking and hoping to identify research, technology, and implementation gaps so we can help the industry move forward; decide where we, NIOSH, should prioritize as well as other people. And some of the work is going to help us produce some user requirements. So we're going to get a good starting point for us to move forward in terms of our systematic evaluation.

DR. NELSON: Do you include automated trucks in your study?

MS. BELLANCA: Yes. So automation is something that's going to be talked about. I'll kind of talk through the overview. I mean, this is really—the goal of this is to take a step back and say, systematically, what's going on here? And automation plays a large role on that and we're looking—I'm waiting anxiously for the report. We're using the future mining report as a guide. We're looking to present this work Mine the Future conference in November. So that's definitely a key part to what we're looking at here as well.

And then, so just more numbers for you guys. I'm sure, you know, you're kind of aware of it, but the specifics of the problem are, you know, 6 out of the 28 fatalities in 2007 were haul trucks, 4 out of 27 were '18. So this is a big problem in terms of fatalities and catastrophic events. Some of the previous studies were done at NIOSH identified that some of the—a lot of the issues stem around loss of control of these vehicles as well as one of the other major key issues that came out in terms of quantity were burning. So ground control issues around these vehicles. It's also really important because it affects a lot of people. Haul trucks account for about 45 percent of all mining equipment. So it's kind of a big problem that affects a lot of people. And worldwide it was estimated about 44,000 trucks.

So again, kind of as I was saying, we're looking to take a systematic look at powered haulage by focusing in on haul trucks, and we're focusing in on three major areas for this first (in time @ 00:20:30). Accidents and injuries, operators

perspectives as well as interventions. And we want to answer a couple of questions while we're doing that. We're really interested in gathering information about what has already been done. We want to be sure that we're not duplicating things that have already been done and maybe, you know, some of the stuff just needs to be resurfaced and presented back to the industry. We're also looking for where the industry needs and wants help. So a lot of it you'll see as I get going is outreach to the industry, making sure we know what's going on and not just what we think, but what they think as well. And identifying what information we're missing.

We're also looking to dive a little bit more specifically into what does the operator need to know and when, and what technology needs development. You saw kind of in some of the previous studies we've identified loss of control as a major issue going back, you know, to the operator and what the technology and how that interfaces. So we plan on that being a key part of the project.

And, lastly, we hope answering all these questions really help us identify the big question of what are the research areas. Very similar to what a lot of everyone has talked to us about. We want to be able to prioritize what's going on and focus in the right areas. We feel like because we've done a lot of work in this area we need a more systematic approach before moving forward, and as much as we can incorporate what everybody else is doing to take a systems approach, will help us be more effective in what we do.

So to give you the high level plan of what's going on, we actually started this project end of January, really February. So we're just a couple months in, but our goal is to take a quick, basically, tour around the industry and talk to people, and get an idea of what the problems are so we can develop like an initial roadmap. And this is very similar to the workshops that you guys have done and different ideas. So we're trying to go on visits, look at things. I'll talk a little bit more specific about that in detail. Then we're going to, actually, participate in some directed research activities where we're focusing in on the mineworkers themselves and what the operator needs as well as evaluating the technology, and bringing it all together to be able to update the roadmap with some of the specific research activities that we'll have had time to do within this project scope to be able to give better understanding to the industry moving forward.

And some of that specific is jumping in the first part in terms of targeting the industry. Every good project starts out with an analysis of the data that we have. So we're looking in fatality reports. And we're focused on fatality reports here for a key reason, that all the accidents don't have enough information to sort of lead us into it and this is just one of our supplemental pieces of information. And we're, actually, working with Robin Burgess-Limerick to be able to reanalyze some data that he had analyzed for us before, but we're taking a more specific focus on haul trucks. And what we're finding really matches what had been previously found, is

that a lot of the initiating events, the potential causes and hazards relate back to the operator. So that's kind of interesting to us moving forward. And then we're doing additional coding to be able to narrow in more on task equipment. And this is really helpful for us to understand as we're going out and talking to our industry stakeholders about, you know, we're talking about this type of accident, this type of accident. So we're really getting our base knowledge as we talk to people and work with what's happened in the past.

Alongside we're taking—alongside of that dive into the data, we're looking to do a current deep-dive into technologies. We're looking at this from five main areas. So this does include automation, but so include machinery control. So we're looking at different control systems on the other pieces of equipment that haul trucks might interact with. So whether it's the dozer or they have some sort of automated system, we think that's kind of important to understand the other equipment.

We're looking at the navigation and safety technology, so that's related to the haul truck as well as all of them. Fleet management and dispatch, communication around the system maintenance as well as just business intelligence, in general. So from very specific technologies to systems and to kind of having an idea and a picture. So this will help us feed into, you know, what are some of the gaps that may exist now.

And then sort of the third part for initial industry focus is stakeholder outreach. And we're doing this to remind visits and discussions. We've been able to leverage previous contacts as well as stakeholders that have actually reached out and had comments to the MSHA RFI and we're hoping that the NIOSH RFI also has similar success. They've been willing to talk with us on the phone and we're trying to arrange visits. We could always use help arranging visits, by the way. So you know, just to talk to them; what are your problems? How are you looking at technology in what you're doing? And as we move forward we're going to visit them and have more detailed discussions, and we're doing that by going out to the expo events, working with our industry partners as we move forward.

Another key tactic we're taking is we're looking to get an expert report. We have contracted with Jonathan Keyes, who is actually the project manager of the automation out at—of the HP. So it'll be great because we'll get to meet with him and talk about—have like a really good understanding about how automation can work or it was working in the United States, and how its implemented from a big company, but that pairs well with our industry discussions because then we you get an idea of what small mines talk about, too. So we're not just talking to big people, we're talking to small people to make sure that we have as good of an understanding as well—of everything as possible.

And, lastly, you know, MSHA is an important player on this, so we're making sure to keep our communication open with MSHA.

DR. NELSON: Let me ask. Jonathan Keyes, is his contract to do the industry survey which is

what it sounds like here?

MS. BELLANCA: No. So his contract is just to work with us and help develop an initial stakeholder report. And what our goal—oh, sorry, go ahead. Did you want to…

DR. NELSON: No, I'm looking for who is providing input on the Mine of the Future and trends, and where will we be in 20 years.

MS. BELLANCA: Okay. Let me clarify. So we're working with him to get like a what is the pulse of the industry right now. So he has a lot of firsthand personal experience working with a big company. We can then take his report and, actually, take it out to different mine operators and say, what are your thoughts on this? And, actually, our goal is to get it, basically, reviewed by different industry stakeholders to say here's one man's opinion—you know, here's one opinion that we contracted out. What's your opinion? What do you want to add to that? And we're building a picture that way in addition to our contacts, specifically, you know, observations in the field. And then what our plan is to do is to sort of summarize all of this. It'll all be in the initial roadmap which we plan on coming out with, hopefully, October 1st, but we also plan on giving a presentation at the Mine of the Future conference which is in Australia. And as we're setting that up we are looking to set up meetings with stakeholders to be able to have time and discussion to review on that and get their feedback as well. So we're not just limiting what we're looking at for the United States, but we want to get perspectives outside. So that's really a review point for us, and using the conference as a networking opportunity to do so. Does that make sense?

DR. NELSON: So I just looked at this slide and it seems really trying to characterize what's happening now and maybe near-term trends, but…

MS. BELLANCA: Yes.

DR. NELSON: So not the 20-year mine…

MS. BELLANCA: No, no, no, no. Yes, sorry. Let me just—yes. I just have that because that's the conference we're using and people, you know, are looking at that. And the reason that we found that that would be a good—well, we believe that that would be a good venue because it would support what we're doing moving forward. Because as we kind of learn, I mean, that's kind of the rest of the presentation, is, you know, automation is the future. You know, Kray talked a lot about it and they're moving forward. And I think that as far as we've started to talk to people, you know, they've kind of said that the industry is moving towards automation. So we thought that the Mine of the Future conference is really sort of a good place to see where are we going, but then like have understandings of like what all the other solutions are, if that makes sense.

DR. NELSON: Okay. Help me to understand. How long in the future is your roadmap going to be mapped?

MS. BELLANCA: Our roadmap? So at this point, I mean, we are three months into this project, so I'm not 100 percent sure as to what that range is. Our goal is to make a tentative

roadmap for research to 5-10 years. The main goal of the roadmap is for NIOSH researchers and prioritizing research. We're not looking to stand beyond that. I don't think that that's possible to do given the time. So I think five to ten years is a good estimate in terms of start and key point, like what should the next focus be, and then where we can build on that given project cycles.

DR. NELSON: So you'll be asking the mine visits and the manufacturers for their concept of the five- to ten-year window.

MS. BELLANCA: Right. Well, so we're asking them right now, is what are your problems now and what do you need help now? And then kind of that leads on to as you develop these moving five to ten years in the future, where do you see automation coming in and filling in that, but we're also just are your now problems. Because, I mean, so maybe let me take a step back, is given all the now problems we can't address all the now problem right this second, if that makes sense. So even though we are asking them as now problems and understanding we can still map forward in the future to sort of prioritize that as five to ten years in the future. Does that make sense or no?

DR. NELSON: Yes. But, you see, I look back at your project, and I'm not trying to be obtuse.

MS. BELLANCA: No, no.

DR. NELSON: All right. You have industry block, initial roadmap on September 30th. Then the industry is done, and a year later you've got the updated roadmap. So it seems to me that it's valuable to ask industry where they think that five to ten years at some point.

MS. BELLANCA: Yes. Yes, for sure.

DR. NELSON: All I'm saying is on your slides you don't say that. So…

MS. BELLANCA: Yes. Okay. No, I will make sure that that's very clear, you know, in what we talk about and. I can give you—I mean, the questions that we're asking lead to that. We're not, specifically, couching that, but I think that that's a really good point to make sure that we, specifically, couch that. And then, I mean, also to that point while I say it's done, it's not really done, right, we're always interacting with the industry. These are just our major focus areas in terms of what we're doing. In collecting data we'll always be engaging with them. If that makes you feel better about it. I don't want you to think that it's done with that. Sure, Jeff.

DR. BURGESS: I have a few questions around international partnerships. So Robin Burgess-Limerick will be analyzing some data for you. Are you planning on looking at power haulage accident rates and trends in Australia as compared to the US? First.

MS. BELLANCA: That was not part of the plan, but I think that that might be interesting. I know he did do that in a different data set. We're still working on the level of like what we want to publish on and pull that together because of the six months timeline to create a priority list. We're just trying to identify the problems to get started here.

DR. BURGESS: So Dr. Jerry Poplin had done a comparison of lost time/injury rates in Australia

and the US, a long time ago. So he identified a clear difference in rates and changes in rates over time in Australia due to their risk management legislation. And I'm wondering because of their focus on risk management, whether they might have been able to reduce some of the causes of powered haulage accidents. So that would be one thing to consider. And, separately, and I've said this in previous meetings, too, we have a lot of international partners who are looking at similar issues. This is not a purely American problem. So it would be really nice to figure out what they're doing, what questions they're asking, and taking advantage of their activities in the partnership to identify problems and solutions at the same time. So I would recommend that you consider how you want to reach out to international partners and how to, effectively, use that to inform your process.

MS. BELLANCA: Okay. Yes, that's a great—thank you. That's a great solution, I think so. All right. Well, so we'll just go past these. Some of our initial discussions I've talked about, not just autonomous trucking, but high-tech solutions and medium tech solutions being adopted by the industry. There was a lot of—there's a lot of discussions so far about, as we brought up before, capital investment, I mean, really hard. Because, obviously, these people are people that already have mines. We are talking about Brownfield Investment. They also spent a lot of time talking about low-tech solutions that worked for them which is really interesting. Because as we're engaging with the stakeholders we're interested in identifying their problems and their solutions to see if there are solutions out there moving forward. And another one of the big points that they brought up was not to undervalue training and expertise as we move forward in looking at technology and how it affects these problems. You know, skill and responsibility will always be there, eliminating the human is near impossible in any given situation. So and there's always the possibility of manual override. So I think we need to understand that and see how the people fit in as opposed to just designing technology because it's cool, how does it fit in and work with the human which is kind of what fits in our secondary approach of looking at the mine workers. And this will come after sort of our initial thing, but what we're doing is we're looking to follow a situational-oriented design and be able to, actually, create a goal and decision of hierarchy of haul truck operators by talking to them and observing them in the field. So this gives us a technology agnostic view of the mine operators. And then in pair of that we're performing a technology readiness assessment to be able to look at the maturity level of the technology. And this is sort of the follow-on piece. So again, the whole idea is, first, let's take a big picture and talk to people and understand what are their issues, where are they going. And then let's take a focused look at the operator, a focused look at the technology, and then bring it back together because it's really important to pair these pieces to be able to understand what's going on. And, you know, in this vein we're advocating for it's important to

understand the user system and technology to avoid unintended consequences. That's why we're trying to take a mixed-methods approach as this follow-on to update our roadmap, and then that will lead to user requirements which, hopefully, can be used in the future based on the problems that are identified sort of in this first pass solution, bringing it together. And then, you know, the goal and our focus, because we're starting out with fatalities is really to get people to begin working in priority areas to help reduce accidents and injuries. That's really the focus. It's a safety-focused project in this particular case.

So in general, that's sort of the look at the project, and we'll look at where we're going. Art's going to kind of come in and take a step back to look at, not just powered haulage, but machinery, and then lead you into his conveyor project. That's taking a similar sort of look in a different way, and they've got some really cool stuff already going.

DR. ART MILLER: As Jennica said, my name is Art Miller which is important because it means it's Miller time. You're almost there. So I'm going to segue into a machine safety. If you look at the MSHA data for the combination of fatalities and severe injuries like debilitating injuries and deaths, combined, you see that in the last seven years forty-one fatalities involve machinery and surface mines. And if you look at all those severe injuries and fatalities together, a lot of them are due to people involved in cleanup or maintenance. A lot of them are in sand and gravel, stones, sand and gravel mines. A lot of them are entanglements and conveyors, specifically, and crushers. And then a lot of them have something to do with equipment starting up or not being properly tagged out.

So those are kind of some themes as a backdrop from the MSHA data. If you take the MSHA data and chop it up a little bit by activity, first, on the left you see that the bottom bar is machine maintenance and repair which stands out above all the others. And if you go by machine on the right, conveyors stand out above all other things. So that kind of helps focus our work. Something else focusing our work is MSHA's recent activities. RFI, just this past year, about mobile equipment and conveyors, and service and underground mines, they focused on three important items which is guarding, LOTO, and then improper crossovers in proximity to hazards, and those were brought out in that RFI which kind of adds fuel to the focus of our work. And they also brought out the regulation on workplace inspection which will probably have something to do with the way that we do our research as well. We're focusing, as a bottom line, on inspection, on guarding, LOTO, and proximity in our view of conveyer safety.

So this is an overview of our project. It's got four aims the first one is really all about situational awareness. It's about taking real-time sensor data and integrating it, and providing it in in a useful way to the workers. The second aim has to do with using all that big data that we're gathering using those various sensors and analyze it, and trying to make sense out of some historical trends

and also using that to prevent catastrophic failures, to prevent unneeded maintenance or planning maintenance, that kind of thing. The third aim has to do with clean up. A lot of the people who are getting entangled in conveyors are, basically, cleaning up around the conveyors. So we're looking at, specifically, at clean up issues and then technologies that surround them. And our fourth aim has to do with R2P and training.

So our first aim really has to do, as I mentioned, with situational awareness, and we're approaching this in three different ways, focusing on machine guarding and LOTO, and also unauthorized entry. And we're going to capitalize on remote sensing using wireless technologies to do this. And our solution is really a kind of a 24/7 monitoring system that has three main parts, its hardware, its sensors out there to monitor access points and those kind of things, it's machine guarding sensors. and its management of LOTO using smart locks and new LOTO protocols, and that kind of stuff. And it's also very software intensive because we're using this—well, obviously, it could be on-site. It could be just a system that operates on-site, but mostly we're looking at Internet web-enabled systems that require cloud processing and, specifically, focusing on user interfaces that are user-friendly like cell phone savvy adaptable, that sort of thing. And, finally, the application of this kind of technology, the way that it's used, the way the user uses the interface. I'm thinking cell phone because that's what I'm thinking. But the way the user uses that cell phone to get the real-time data and to track the LOTO and to fill out forms, and that kind of thing is going to be the focus of our monitoring system.

And this is just a really quick cartoon about the Internet of Things. It starts out with these little blue squares which are sensors and every sensor could be measuring anything that you can measure using a small sensor, temperature, pressure, proximity, location, status of a lockout, anything like that. That is transmitted then by radio through a very small radio, about the size of your pinky, to a gateway and the gateway processes all that data and then sends that, potentially, to the Internet. The beauty of all that, of course, is it's archived and organized, accessible on the Internet, and easily interacted with from just anywhere where you can access the Internet.

And one of the things we think about this approach is that it has the ability to give sort of real-time access to any information that's going on in the site and, specifically, we believe that the power of alerts. When something reaches a threshold, whatever it is you're monitoring, if it reaches a threshold condition, that information can go out to the person who most needs it at the time. Another thing that we're trying to—we're implementing, actually, and testing is the ability to do online forms. In this case it's paperless confined space entry. So rather than having the paper process that is completed for a combined space entry at our current site, we have paperless forms and this allows us to connect those, also

with thresholds that trigger if the form—if the maintenance isn't completed in the confined space in a particular length of time. The boss will get an expired notice saying hey, somebody's still in the confined space.

There's some implementation challenges to the way we're doing this. There's lots of different types of wireless sensor networks and they're not all the same, they're not all created equal. And if you're going to use the Internet you have to get to the Internet. So a lot of these remote sites may or may not have cell coverage, may have to use a satellite, for example. The latency of the network is a big issue. Depending on your network and depending on your Internet connections there's always going to be some amount of lag from the time something happens till the user receives information, and sometimes that can be an issue and it has to be managed.

Another big issue we're running into with the Internet of Things is proprietary products. These days there's a lot of Internet of Things stuff happening, but almost every company has one little product. You got their cloud-based service. You apply to it, they love that—the monthly fee that you send them, and then you're locked into that one little sliver, and that doesn't work very well when you're trying to do lots of things and integrate them all into one user interface. So we're wrestling with that. And, finally, data management and security is always a big issue.

We have an Internet of Things site with a partner near Spokane. And this is kind of an overview of how our system works. In the upper left-hand corner is what the landing page would look like to be on your cell phone. You see the landing page and all those little dots represent little sensor networks. So if you just tap on the dots it opens up a cartoon, like you see here on the right, and that cartoon has all the sensors, also with little cartoons. In this case it's the lockout verification, restricted access, and then the bearing temperatures. And, if on the cartoon, you click on any of those things you can call up information either immediate information or historical archived information, and then you click back on reverse and you go back, and you can choose another section of the mine to look at.

One of the things that we think about this system is that it will be used for maintenance planning and it will make the workers on the site more aware of their surroundings.

Our next future work on this project, what you just saw mostly was funded under a pilot project which was done on the CDC Innovation Fund, and just now within the last month or so we got funded to do future effort on this project, and the first thing we'll be doing is evaluating this monitoring system that I just showed you. We'll be, also addressing what's the right kind of data to be collecting on any particular given site and how to present that to the user. We'll be doing a lot of evaluations whether this thing is actually—can be used to make better decisions or to reduce injuries and, ultimately, hopefully, it will improve the situational awareness of

workers, and we need to, however, prove that that's, actually, the case. And we'll be working a lot on this in the very near future with the existing system that we have in place. We hope to find a partner to develop a product from this where they would install sensor networks and have a user interface that they can get various mines to use.

The next step—and these kind of go hand-in-hand with the aims of our project—is failure mode analysis and being able to prevent disasters or prevent things from happening in the future by predicting them. And so we'll be looking a lot at failure modes in the industry, specifically, to conveyors and looking at the accident data to try to tease those out. And we, actually, have a pilot project, specifically, focused on evaluating accident data. And then looking at different failure mode analysis methods to try to tease some information out of the data including machine learning algorithms. Well, I said we'll also be focusing quite a bit on cleanup-related injuries because cleanup is a really key point to where people are getting tangled in conveyors. So we're looking at, eventually, developing engineering controls to assist in that.

And, finally, our last task is toward the end of the project. It's the four-year project. We're one year one right now. Will be related to training and R2P of anything that we develop during the project. And this is kind of an overview of what I just told you. We will be developing new tools for situational awareness. We'll be focusing on guard placement, entry, unauthorized entry, kind of proximity type technologies, LOTO status. We'd like to, actually, introduce intelligent LOTO which doesn't exist right now, and it could be a pretty big thing if we get it working properly. And then address planned maintenance. It's a big issue with a lot of companies. And then that cleanup piece that I mentioned. And that's kind of where we're headed with that work. Open it up to both of us for questions.

DR. NELSON: So could you explain to me a little bit more about cleanup accidents? So are these people who are assigned to a job that they've not been trained for, so they—or what is it that causes cleanup accidents?

DR. ART MILLER: I'll know that a lot more in a few months because we're really digging into the root cause analysis of all the injury, and we have a pilot to do that, but my gut feeling on it is, from just reading a few of the narratives, is it's the people who decide they're going to take their broom and sweep up over there underneath that conveyor where that dust went, and they probably were told that that's probably not a good idea, but they just, you know, they need to get that pile of dust out of there, for whatever their reason is, and the broom gets stuck in the conveyor and away they go. That kind of injury. And it kind of stems from—and then, actually, a lot of people manually shovel under conveyors while they're running, and it's fine and there's, you know, if you're far from a roller it's not a big deal, but far from a roller how do you define that, right? Shovel six feet long and you turn, and then it sucks your shovel in. So those are the kinds of things. And other ones are when

they think that the power is out and they go to do a repair, and then the power starts up unexpectedly. Those are the most common ones.

PARTICIPANT: So Art, you and Jennica had a combined presentation. Is this a community of practice and how are you informing each other's projects?

DR. ART MILLER: That's right. We're having a meeting tomorrow night, right? It's not formalized yet, but we're informally communicating a lot on—because, actually, I'm bugging her because we really need human factors expertise in my project, and her and her team have a lot of experience in that kind of thing. I work with engineers who are engineers and we don't think in the world of human factors very well. So we're trying to make that switch a little bit for our current project.

PARTICIPANT: Well, I think it's great because you're located in two different locations.

MS. BELLANCA: I mean, it's also really helpful for us to work together in terms of understanding part of our industry outreach. So Art didn't talk about it as much in this presentation, but as he is going out working with people, that's another key thing that he's doing. I mean, but the hard thing is like the projects are in a different stage, right, because Art started with the iPhone. So he's got a lot of head start in terms of that, but they're inextricably linked to the way MSHA categorizes their injuries, right? So conveyors is powered haulage, and even though they're separate it's kind of important because they go hand in hand, too. So he really helps me, you know, from the technology side as well and planning side. So I find it really useful to work together to talk about things like that, plus getting access to different types of mines out there as well. And Todd's help with Jonathan Keyes and Derek. So that's really great for us.

PARTICIPANT: I think it's great to see you guys working together.

DR. ART MILLER: Any suggestions? I think both of us are really interested in that. We're both at the beginnings of new projects. And, for me—I can't speak for Jennica, but, for me, I'm out of my element a little bit. Well, parts of the project are within my element, but parts of it are not within my element. So very open to input on what you just saw and, you know, things that we might do or not do within those projects. Anything that comes to mind would be helpful.

PARTICIPANT: Back to another question of proximity monitoring. So that, clearly, would connect both of these projects. Are you working on that together?

MS. BELLANCA: Yes. I mean, I think that we've talked about it. Well, you know, we're sort of gathering information and I think it'll be a good relevant point to keep going back and forth because, I mean, at least, in my experience there's not a lot of talking back and forth between it, ironically. Like when you talk about powered haulage with the vehicle proximity, there's a huge community in conveyors rarely in like in place rarely get brought up, but it really does have a lot of overlap. So I think that's a really great point, and we'll make sure to do that, incorporate it.

DR. ART MILLER: Our team is also collaborating with EMSSB on their proximity. In fact, we're just kind of (inaudible @ 00:52:19) right now about writing a paper together in the fall,

evaluating some different approaches. I mean, the thing about proximity is there's lots of different ways to measure proximity, and then the application is different in every case. I mean if you're a haul truck driver you want a rear-view camera and radar or whatever it is you want, but if you're trying to keep somebody from sticking that broom underneath the conveyor, that's a different problem. It'll be different. The environment will be difference so the appropriate proximity system will be different. And we're, actually, going to toy with some sensor fusion ideas, too, where we're looking at multiple sensors that can help each other give more information to our smart system, eventually, that will process, you know, do edge computing and process things and give it to us. And we have some kind of crazy ideas on our mind, but we got three more years to figure it out.

MR. GREEN: With whom are you working at MSHA to keep them involved in this?

DR. ART MILLER: We don't actually have a formal contact with MSHA. And we've only just talked to a couple people, and I can't remember their names right now. But, yes, having a connection with MSHA in this is going to be key, for sure.

MS. BELLANCA: I mean, we're working with a lot of you guys on approval and certification. We have a really good relationship with Wes Shoemaker, and then we also know that Nancy Cleveland is the head of the task force for powered haulage. So we reached out to her and, hopefully, we'll be able to work with them. You know, they're mostly working on passing out training intervention. You know, that's their way. It's more like a campaign for talking about previous work and communicating about that. So that pairs kind of nicely with us understanding more of the why, and feeding them information, hopefully, soon.

MR. GREEN: The reason I'm asking is because the connection between what you guys are up to and what MSHA's thinking about seems, to me, to be pretty relevant, particularly, with regard to the Dave's attachment with this, one of them is monument issues. At some point I would urge you guys to brief him. I don't know if Melanie Calhoun is still on the phone with us, but this is an issue...

MS. CALHOUN: I'm still here, Ed. I just got back again.

MR. GREEN: All right. Melanie, I was just simply asking whether or not you guys ought to be listening to what Art and Jennica are up to. It's a fascinating presentation and it's right up the alley of your RFI on haulage and conveyor belts.

MS. CALHOUN: And I heard—I think it was Jennica mentioned that she was working—she had reached out to Wes Shoemaker.

MS. BELLANCA: Yes, that's correct.

MS. CALHOUN: I'm sorry, I can barely hear you.

MS. BELLANCA: Yes. Sorry. Yes, that's correct. Yes, we work with Wes pretty closely and then I know that—I believe, my understanding is that Nancy Cleveland is the head of the task force. Art and I also presented at the Proximity Protection Workshop where David (Taslow @ 00:55:34) was there. So he gave like a real quick overview. So he was aware, and we started conversations with them as well. So we'll keep

them in the loop to make sure we know who's going on and, hopefully, we can work more closely with the people on the task force moving forward.

DR. ART MILLER: Melanie, one of the things I'm, specifically, interested in is a contact that can help me address the potential for intelligent LOTO. So if you have anybody in MSHA that is interested to speak with me about that, I'd really appreciate that.

MS. CALHOUN: Okay. Actually, more than likely that person would, from a technical support standpoint, would be Wesley Shoemaker, but let me look into that a bit farther for you. Okay?

DR. ART MILLER: Yes, sure. I'm going to throw that same question out to this crowd. Anybody have any feedback? First, your question, Priscilla.

DR. NELSON: So based on what you presented, I don't see how you're going to get to a five- to ten-year roadmap, and I'm referencing slide number 6. And so I suggest that in the very near future you sit down and really lay out exactly where the input is coming from the three sectors that you've identified that feed into your bring it all together roadmap. Okay? Because I think if you do that you're going to see that this isn't the right schedule. You need to do some different things.

MS. BELLANCA: Okay. Can you give a suggestion on what you think is the right schedule?

DR. NELSON: Yes, sure, but I think you should lay it out first. Think really specifically, how am I going to find out the answer to that? Because you can leave it to yourself to think it up. That's not the way you're framing this. You're framing this as being a consultative kind of a thing. So when are you going to consult?

MS. BELLANCA: Yes. I mean, this is problem identification, right?

DR. NELSON: Huh?

MS. BELLANCA: I mean, this is problem identification. We're not going to solve—there will be no solutions in this project.

DR. NELSON: No, but you have a roadmap that you want to be for five to ten years which means that you're going somewhere. And so you need to identify where that somewhere is. And you can say I'm going to decide or you could say I'm going to consult with others to decide. So it seems like sometimes when you talk about this towards the last part of this is you're deciding, and then at the start it was industry and consultation was deciding where that roadmap was. So I think if you map out that—between now and September 30, 2020, how you're going to find all the things you want to have in your roadmap, you're going to realize that you may want to do things differently from the way you have shown.

MS. BELLANCA: Okay. Sure, yes. I mean, I'll definitely lay it down, and if you have more specific input I'm very open to it. I'd be very interested.

DR. NELSON: I think the next draft's yours. I'll be happy to comment on it.

MS. BELLANCA: Okay, great. Thank you.

DR. ART MILLER: Okay. So my loaded question is I'm going to describe what I think is iLOTO and you tell me if it's a crazy idea. So I take Jennica's cell phone. First, I hack the password, and then I unlocked this lock right on that piece of equipment, and then

Bob, he takes his cell phone and he sees that Art just locked that lock. Oh, crap, I got to adjust my motor timing. I'm locking it out, too. And then Jerry locks it out. And pretty soon we're all working on our stuff, and then I go to unlock it and, of course, I can't because Bob's got it locked. I say, Bob, get done with your stuff and unlock this darn thing. He unlocks it, he unlocks it, he unlocks it. Then I go unlock it and we're all happy, and we go back to work. Why won't that work? And, by the way, every single step that happened here is recorded and archived.

PARTICIPANT: Because the lock could be on some other thing.

DR. ART MILLER: There you go. The lock might not be on, actually, on the right thing. I'll work on that.

PARTICIPANT: Somebody's phone could be dead.

DR. ART MILLER: Somebody's phone could be dead. That's a good one, actually. That's a really good one. Okay. End of loaded question. I just thought I'd throw that out there.

MS. BELLANCA: I think with an electronic system like that somebody's always got to have ultimate override and that's the fear, right? If it's working perfectly you've still got somebody who has administrative authority over the system and could override it, and what if they do when they shouldn't have or—because the phone could be dead or whatever.

DR. ART MILLER: Right, right, right. Yes.

PARTICIPANT: But the phone has to become dead in between the time you locked it and the time you want to unlock it.

DR. ART MILLER: Yes, the battery the runs out of juice. I get that. That's totally—in fact, that's probably the most likely thing that would happen.

PARTICIPANT: You're cloud storming.

DR. ART MILLER: I'm cloud storming. Yes. Okay. We're done with that. Any other questions? It is Miller time.

MS. BELLANCA: Thank you, guys, so much for your input.

DR. NELSON: Okay. Thank you very much. So we could have some—let me just ask people rather than wait totally until tomorrow when you just simply don't remember, what have you heard about today that guides what you want to hear about in the future? Yes.

DR. KRAMER LUXBACHER: I want to hear examples of uses of the community of practices.

DR. NELSON: Some more about the community of practices and how they're evolving, or how they're being set up or…

DR. KRAMER LUXBACHER: How they're evolving or how they're being used, or what some best practices are, or anything.

DR. KOGEL: That's good. We could maybe even have some people from one of the communities present.

DR. KRAMER LUXBACHER: That'd be great. And even like—they're bound to be some unintended good consequences that come out of them. That would be interesting, too.

DR. NELSON: Yes, the transition from internal to internal and external in community of practice

would be interesting when you pull the plug. Anybody else have anything that they've heard about that we ought to have on the docket?

MR. HORN: Stuff that Kramer talked about in terms of automation and the way you accomplish automation, especially in metal mines.

DR. NELSON: Yes, so we'll have the report. That's the number one item.

DR. KRAMER LUXBACHER: That's right. I swear it's…

MR. HORN: But more than the report in the sense I'd like to know some of the thinking behind the report before you get there.

DR. NELSON: The thinking behind it, but also what NIOSH is going to do with the report. So I think that that's fine. Anybody else?

DR. BURGESS: Yes, the respirable coal dust research center, I'd like some additional information on how they intend to operationalize that going forward. It would be nice to be able to make some concrete suggestions when you have, perhaps, a bit more of a developed framework. Although, I'm not sure when you plan to put this out.

DR. KOGEL: Yes, so I won't say timelines, but by—so our next meeting's in six months. That's probably good timing.

DR. GEORGE LUXBACHER: Although, they promised us information on how to go about creating this…

DR. KOGEL: Which we haven't heard yet.

DR. GEORGE LUXBACHER: And that three weeks ago they promised us all sorts of information, and they've given us nothing.

DR. KOGEL: Yes. So what I will do is I'm going to maybe have OEP come speak.

PARTICIPANT: To follow-up on that, I would…

DR. NELSON: See, I don't really understand what CDC says you can or cannot do because, you know, it's not a federal law because at NSF we can do a lot of these things. So I feel like CDC sometimes think that you can't do something, but you really could.

DR. KOGEL: This isn't CDC.

DR. MILLER: So just to add on to what Jeff was saying, just to follow-up on the National Academies as that begins to roll out into a more concrete kind of frame in terms of the projects that are going to come forward with that. I'd like to continue to follow that closely.

DR. GEORGE LUXBACHER: By the next meeting we'll have issued, at least, five technology BAA contracts we can talk about and how we're trying to incorporate those, and if we elect to fund some of these capacity builds under dust we'll be able to talk about that, too. So we'll have significantly more we can legally share.

DR. MILLER: No, I think it's a great report. It's very comprehensive across a broad spectrum of activities, and just to kind of think it through and how it integrates with other ongoing efforts at NIOSH and in the industry will be interesting to see how that plays forward.

DR. NELSON: You know, I think every single meeting I've said this, is that I'd really like to hear more about extramural research in terms of…

DR. KOGEL: I think we're telling you what we can. Is there something specific?
DR. NELSON: No, no. Well, I mean, just to have the people who are doing extramural research to come and talk to the people about them.
DR. KOGEL: Oh, you mean have the contractees.
DR. GEORGE LUXBACHER: So pick a contractee.
DR. NELSON: Yes. I think that that would be good, to help…
DR. KOGEL: I mean, how many do we have, 20…
DR. GEORGE LUXBACHER: Twelve.
DR. KRAY LUXBACHER: Although, to me, I mean, it seems like we can give input to NIOSH about their research direction. It's a little more—what meaningful input can we give?
DR. NELSON: I could think of lots of…
DR. KRAY LUXBACHER: Well, meaningful in the auspices of this particular committee, I guess.
DR. NELSON: Well, I mean, for example, we're never—would you like to know when we think about the training programs and…
DR. KOGEL: The U60?
DR. NELSON: Yes. The U60 or the training.
DR. KOGEL: That is…
DR. NELSON: No, no.
DR. KOGEL: What are you talking about?
DR. NELSON: The graduate student training.
DR. KOGEL: Capacity build.
DR. NELSON: Capacity build. Because we've never really heard about the way those operate, the capacity build.
DR. KOGEL: I think Colorado School of Mines. We talk about them every time.
DR. GEORGE LUXBACHER: Every time. We went into great detail.
DR. NELSON: Well, we could talk more. But, anyway, I would also like to see something about the 10-year review.
DR. KOGEL: All right. We'll do it. So we'll have the recommendations then.
DR. NELSON: Yes. And an update on the experimental mine because that should be further along at that time.
MR. WRIGHT: So two pieces of—of technology. One is I'd like to know more about how the research is going on real-time silica monitoring. Just what's…
DR. NELSON: And that could be part of the NAE because that was number 11 or number whatever.
MR. WRIGHT: And the other is—we touched on it, the last presentation, proximity detection and things like haul trucks.
DR. NELSON: Okay. So maybe more information on the whole truck and the conveyors, how that project's going, maybe an update because we just heard a little start of it. I think David—So what I think in the conversations that we've had around here is that you will have a report into Congress; is that correct? When is your report due?
DR. WEISSMAN: Well, it was, actually, due about six weeks ago, but it's been in a review black hole

for about three months. So we expect it, probably, it'll be submitted, my hope is, in about a month.

DR. NELSON: So we might be able to anticipate that next meeting we could ask you to come or we would request that you come.

DR. WEISSMAN: Yes, it'll definitely be submitted prior to the next meeting.

DR. NELSON: Yes. And tell us more about your report, and then NIOSH would've you're report and could comment on it as well. I mean, your division would do that, and this division would then comment on it in terms of how they wanted to maybe respond to what is in your report.

DR. WEISSMAN: Is that a question?

DR. NELSON: No, that was sort of a statement. And then the end result is that right now the committee is sitting here in receipt of information without having made a recommendation or any kind of a comment. So we'd like to have it set up so that there might be an opportunity for us to comment on what you have found and put into your report and what NIOSH is going to do or feels that it's responsible for related to your report, and then we can talk about what we think.

DR. WEISSMAN: And what I propose is as soon as we deliver it to Congress and it becomes publicly available, that I give it to Jeff so that it can be distributed to the members, so that you have the benefit of as much time as possible.

DR. NELSON: Exactly. And then you could come and run through it, and then Jessica could comment on her response to that report, and then the committee can do whatever it wants to do.

DR. WEISSMAN: That would be great.

DR. NELSON: That would set the stage for the discussion.

PARTICIPANT: Wouldn't Jessica's input be governed what the NIOSH review was for the report?

DR. NELSON: Well, the report's already submitted, isn't it or is it NIOSH?

DR. KOGEL: We as NIOSH. We're not going to have a response to his report.

DR. NELSON: No, I'm not saying a response to. What I'm saying is he's making a report that bears upon what your division does.

DR. KOGEL: Well, his division is responsible. I mean, his division is the primary owners of that. We fund it, but they do the work. So we work together on it. So I don't know that we would be, actually, going back and responding to the report.

DR. NELSON: I don't know that responding is the right word.

DR. KOGEL: It will be a collective—it's a collective NIOSH report to Congress. So maybe, but I think, Priscilla, what you're wanting is to have an opportunity for this committee to see what the report to Congress was, and then to see if there's any follow-up regardless of who does the follow-up; right? Is there something…

DR. NELSON: We would ask about the follow-up. So you can ask this committee because they report to you whatever you want to ask them. Otherwise, what we want to do is to come forward with some kind of a—we have a feeling that there's going to be—that we're going to want to say something. So it would be best if you asked us for

it.

DR. KOGEL: I see. Okay.

PARTICIPANT: What's the committee's view on the report (inaudible @ 01:10:23), and in terms of what are suggestions where NIOSH with regards to that information?

DR. NELSON: And then we would tell you, and you could decide what you want to do with it because we report to you. You convened us.

DR. KOGEL: Yes. Okay.

PARTICIPANT: Quick question.

DR. NELSON: Yes.

PARTICIPANT: Which congressional committee does it go to?

DR. WEISSMAN: It's going to the Labor, Labor HHI.

PARTICIPANT: It should have just gone directly to Appropriations because the charge came through the funding bill budget. It's our understanding that the House Health Committee is particularly interested in this, and has historically held the committee meetings related to, like, fund-related issues. And so our anticipation is the appropriations committee probably won't call a hearing on this, but the health committee probably will.

PARTICIPANT: Good. The House, yes.

DR. WEISSMAN: And this originally came from the Senate budget language. So it's National Senate Committee is the one that was the origin.

DR. NELSON: Okay. That's good. So any other comments before we adjourn? Okay, when do they have to get here tomorrow morning?

MR. WELSH: We start at 8.

DR. NELSON: I know, but when do we have to get here?

MR. WELSH: Forty-five minutes ahead. 45 minutes. So we all have to be here at 7:15. Thank you very much. See you in the morning.

[Adjourn Day 1.]

DR. NELSON: Okay. MSHRAC is reconvened, and Jeff has some initial comments.

MR. WELSH: Good morning. This is our second day of MSHRAC. Is anyone on the telephone? Okay. I had a couple announcements before Priscilla starts the meeting today. Again, welcome. I wanted to mention is some operational procedures for our formal FACA meetings. We've strayed a little bit not only this meeting, the first day, but some of the other ones too. We have a period for public comment at the end of the second day of our meeting. And any interaction up until that time by the public and anyone that attends should be kept to a minimum, and I would like to abide by that rule for today and in the future. Unless someone from the public or the visitors are called on, there will be no interaction between the FACA committee and the public. And what we'll do for the our next MSHRAC meeting is that we will schedule a public time for questions and answers at the end of each day instead of just waiting till the end to take care of that. So I hope that works

with everyone, but we would like to get back to the rules of operation and engagement. So with that, we will do a roll call. I see Aubrey and Jeff and Dale and Priscilla, Mike, Tom, Kray, and Richard and Robert, and Kyle. So we do have a quorum. Melanie, are you on the telephone? With that, Priscilla, we can get started.

DR. NELSON: Thank you, thank you. Yeah, we tend to treat this a little informal sometimes, but sometimes going on the record it's good to just remember exactly what the operating rule is. And at the break this morning we'll try to bring up the DARPA video. It's less than five minutes long and you can see what's going on and what might be something that you could anticipate coming to the mine here for later on in September?

DR. KOGEL: In August.

DR. NELSON: In August. So that'll be great fun. All right. We have a full morning of presentations, and we invite Jay Colinet, to talk more about respirable dust. Thank you.

CURRENT AND FUTURE CONTROL TECHNOLOGIES TO ELIMINATE RESPIRABLE DUST

MR. COLINET: Good morning, and thank you. As she says, I'm going to talk about some of our recent and ongoing respirable dust control. My name is Jay Colinet. I'm a mining engineer in the dust ventilation and toxic substance branch. And we heard some of this from Dr. Weissman yesterday, the increase in CWP and PMF. He mentioned the CWP database that's available on the NIOSH website, and that's where this graph on the left was generated from, and it will give you the actual numbers of cases. And then the graph on the right is for those workers that filed for black lung claims in the federal program, the percent of those workers that were found to have PMF. You can see over the last 15 years or so there's been a steep rise in both of those. So the hierarchy of controls to combat hazardous exposures is familiar, probably, to most of us with the optimum solution being eliminate the hazard or substitute for the hazard. Well, obviously, coal was the hazard, so we can't eliminate or substitute that. Mines can choose to use administrative controls and workers can use PPE. MSHA doesn't recognize that for meeting the compliance with the respirable dust standards. So engineering controls are the focus. And that's also the focus of our branch. We develop, identify, evaluate engineering controls and also monitoring. You'll hear a little bit about that right after I speak, and we want to disseminate that to the industry and try to get it implemented as quickly and as widespread as possible. And three kind of summary documents that we've produced over the years are these best practices handbooks, and you can see at the bottom how many hard copies of each have been distributed and also the number of downloads over a three-year period from our website. So there is widespread distribution. And they, basically, summarize different control technologies that we found to be effective.

Getting into the control technologies, I'll start with continuous mining operations. A

few years ago MSHA and industry were kind of at odds over deep cuts. A standard cut in the mining operation is 20 feet. Most operations would like to take an extended cut which can be up to 40 feet, but they have to get approval from MSHA to do that and they have to show that they can control the roof, methane, and dust. Well, what was happening is if they would get out of compliance with a dust control issue, MSHA would revoke that deep cut approval and force them to go back to 20 feet. Industry came to us at that time and said is there any information available that shows that deep cuts are dustier than a standard cut? We knew of none, so we initiated a survey where we went to six different mines and evaluated the dust levels in the first twenty feet versus the last twenty feet. MSHA also followed up with that and said have you compared dust levels in 20-foot cuts with standard ventilation versus 20-foot cuts with a flooded bed scrubber? Which over 90 percent of the mines use flooded bed scrubbers. That had never been done also so we initiated three mine surveys to evaluate that. That data is summarized in these two reports shown down at the bottom there, and we found no statistical difference between dust levels in the first 20-foot cut to the last 20-foot in an extended cut. Likewise, for the standard cuts, with and without a scrubber, we didn't see any difference in the dust levels at the face. However, we sampled in the miner return and we saw statistically significant difference of 40 to 91 percent in the return. So it didn't impact anyone in the face, but anyone working downwind would definitely benefit from the use of the scrubber. And both of these publications, I think, have been used by both MSHA and industry to evaluate these applications for a deep cut.

One of the primary workers that go downwind of the miner to do his job is roof bolter operators, and they can get dust exposure, obviously, from drilling into the roof which can contain high levels of silica. As I said, working downwind of the miner most operations they go downwind at least once per shift, and also when they clean out the dust box. And you can see in the top photo there that was the traditional way. There was a dry vacuum system that would pull the dust from the drill bit into this collector box and, periodically, the operator would have to empty it. And back in the day they would just open that up, dust would spill out, they'd put a wedge in there, pull that dust out, and you can see he's right in that dust. It gets on his clothes, and it's not a good situation. Subsequently, about 10 years ago the manufacturer started to offer collector bags which are almost like a bag in a vacuum. You could modify this collector box. So you could put this bag in there and it would contain it in the bag, but you still had to remove that bag from the collector box. And there's a filter there that you can see in the bottom photo, right here, that, periodically, needs to be changed also and it's covered with dust. So a mine out west petitioned MSHA to switch from this dry system to a wet system where they, actually, put a water spray in the collector box right here and as that dust is drawn in, they spray that and it becomes a kind of a sludge, and it drains

out that hole that's shown in the bottom. They asked us to evaluate it. We did AB testing at their mine, and showed that this wet box reduced dust exposure by 27 to 60 percent during that cleaning period, and there was no difference in the dust levels up at the drill head. And this also eliminates any secondary exposure that you could get from handling the bag. The mine is still using this and we're understanding from the manufacturer, the equipment manufacturer that another mine has approached them about modifying their system.

Another way that you can protect the roof bolter operator, particularly, when they're downwind is with a canopy air curtain. What this system does is you have a blower or fan connected to a filter. So you pull the ambient air in, filter it, and then blow clean air down over the operator. So we tested that in the lab, and then we took it out to a mine site. And you can see we retrofitted that, obviously. That's not a manufacturer's installation. We showed 35 to 89 percent reduction in the initial mine survey where we used this technology. In the wide range of efficiency or dust reduction, is a result of the time that the operator—different operators spend under the canopy. Obviously, he's only protected when he's under that canopy, and if one person moves around more, he's not going to get as much protection. Fletcher, the leading roof bolter manufacturer in the mining industry, incorporated this into their canopy design which you can see in the photo at the bottom there. That's, actually, incorporated into their canopies, and they include this as an option on all new machines that they currently offer for sale. And they tell us that there's about 50 roof bolter operators operating now with this canopy air curtain technology installed. So that was a success, and we thought can we use this elsewhere? And in the surveys that we did for the deep cut we found that if blowing face ventilation is used, the shuttle car operators had about one milligram per cubic meter higher exposure than exhaust ventilation. That has, historically, been the case. So we wanted to look at ways to protect the shuttle car operators for blowing face ventilation systems. So we awarded a contract to Marshall University and they had Fletcher as a subcontractor to design a canopy air curtain that can be installed on shuttle cars. That's been done, and we've tested it to the lab and we got a 70 percent reduction at 120 feet per minute entry air velocity and 51 percent at 850. And the reason we went to such a high velocity is we wanted to protect them during the complete load, tram, dump cycle. And when they're tramming against the airflow you can get velocities that high. So we've done a preliminary installation at a mine in the Midwest, and we're scheduled to go back in June to do a full evaluation of that technology. At the Midwest mine it's, actually, mounted on a diesel ram car, but it's the same principle, and you can see that in the bottom photo.

As I mentioned, blowing face ventilation can cause a problem for shuttle car operators and, historically, it's been better for methane control because you get deeper penetration and it creates more turbulence and mixing it to face which is

exactly opposite what you want to do with dust control. You want to confine everything to the face, let the scrubber and the water sprays capture that dust before it comes out into the entry. So those are competing objectives. So we did tests in our gallery, full-scale continuous longwall gallery, which you'll probably see this afternoon, where we looked at a number of different parameters. The face ventilation quantity, we ran 8,000 and 12,000 CFM. We chose those because, historically, MSHA has limited the amount of airflow that they will allow you to use in blowing fence ventilation in relation to the scrubber. Our scrubber was 7,000 CFM on the minor. They, typically, only allow you to use up to 1,000 CFM above the scrubber airflow. They're concerned that you're going to blow dust past the scrubber. We also looked at curtain setback distances of 30 and 50 feet. Blocking sprays, these are the sprays on the sides of the machine that spray out and up to try to confine that dust to the face. Now we have a shuttle car model that we can include in our gallery testing, and this is—we ordered this shuttle car with two cabs. You don't see that underground, but we wanted to be able to test the standard and off standard cars at the same time, and minimize the amount of testing that we had to do. And we also did box and slap cuts as far as the test protocol. To minimize the dust levels, and this was just presented at SME in February, the 50-foot curtain setback in blocking sprays minimized the amount of dust reaching the shuttle car operators. That wasn't too surprising. What was surprising is the higher airflow, actually, had statistically significant reductions at both the shuttle car operators and in the return at 12,000 CFM, which I said, that represents a change what's previously been used and kind of followed underground.

Moving on to longwall mining. In our current dust control project we had a task to look at water-powered sheer scrubber that's where you use the water sprays to move air, induce it into the scrubber and scrub the dust out of the air stream. And subsequent to that the University of Kentucky was awarded an Alpha Foundation contract to design a fan-powered scrubber for use on the shear. They had the capability to design and build this, but nowhere to test it. They approached us about using our gallery. Typically, we don't do that because we have it scheduled, pretty much, full-time for our own work, but since this kind of fit right in with our ongoing project we thought it was a win-win for both. So we agreed to test in the gallery. They brought their shear in with the scrubber. And, coincidentally, it had inlets for the scrubber at the same place that we wanted to put our water-powered scrubber. So we thought it would be direct information that would have helped us in our research. Their scrubber was rated at 13,000 CFM and we ran tests at their max airflow and got about a 50 percent reduction in the return. We ran tests for our benefit where we turned it down to half, so about 6500 CFM because past research with water-powered scrubbers show you can move about 6,000 CFM with a reasonable amount of water and at a reasonable water flow pressure.

However, what we found there was when you cut that down you only got about a 20 to 25 percent reduction. Obviously, we would like to see more than that. So that's influencing how we're going forward with our water-powered testing. We're going to try to improve the airflow that we can get without significantly increasing airflow or pressure, so it would still be feasible for underground.

Another thing we've seen for longwalls during our surveys is that most mines now have shields that have sprays mounted in the underside of the canopy, and these are, typically, operated or activated by the position of the shear as it moves across the face, so it turns some on and then turns them off as it progresses across the face. Well, we saw there didn't seem like there was any plan for how these were being operated and activated. And, in fact, what this photo at the top shows these sprays were interfering with the sprays on the shear enforcing dust out into the walkway where the shear operators would be exposed. We thought there would be a better way to do this, and most shears have, what's called, a shearer-clearer or directional spray system on them, and it's designed to split the air right here and keep the dusty air confined along the face while relatively clean air is out in the walkway. We thought if you use these properly it would, basically, be an extension of this system. And the other thing we also saw is on a lot of longwalls as you're cutting you get coals falling off of the face and falling into the pan line which creates big dust clouds, and often times those clouds come out into the walkway. So we thought these sprays could combat that also. So we ran a series of tests in our full-scale gallery looking at spray angle, spray type, spray pressure, location, a whole series of tests. Those results are done. We're analyzing those right now, finalizing the analysis, and the results will be presented at Longwall USA next month. And, obviously, we want to try to take this underground and work with an operator on the sequencing of their sprays.

Another control technology for longwalls that we looked at is foam. Past research way back to the bureau mines days has shown that foam is better than water as far as distributing moisture, and even better than surfactants, in most cases. The problem is generating a good quality foam in applying it underground. We found that you have to mix the foam with the product to be the most effective. In one of the areas that we see increasing is a problem is shield dust. Back in the day when they were manually moved, shields would lag eight to ten shields behind the shear, and there was some time for the dust that was released to mix and dilute with the face air before it hit the shear operators. Today with the automation the shear is activating the movement of those shields and, typically, it's one or two shields right behind that leading drum of the—or trailing drum of the shear. So that concentrated dust cloud then is hitting the shear operators. So we thought if we can develop a foam the idea would be to spray that foam on the roof in front of the shield tips and allow the shields to move up, and then all that moisture would be distributed on top of the shields, wet the material and as it moved its

agglomerate and not respirable in nature. So we've looked at blowing or blowers, compressed air, different nozzle types, operating parameters, the combination of air and water pressure, different foaming agents, and have worked out what, we think, is a viable system. We also think it could be applied at stageloader pressures to help limit the intake air contamination. And, at this point, we're, again, looking for an underground mine site to take it out and testing.

The current dust control project that these tasks were under is ending this fiscal year. We have a new 2020 project proposal in. Foam will be one of the tasks that we're going to look at. We also thought it might be able to be applied on surface drills. Under the drill table there's a confined area there with a lot of dry material coming out, and if you could wet that, that would help a lot. We heard yesterday about the increased importance of silica dust. We're going to specifically look at water sprays to try to combat silica dust levels and reduce silica exposures. We're going to look at nozzle type pressures, additives in the dust composition in laboratory tests take the most effective type sprays out underground to try to do an underground evaluation. Flooded-bed scrubbers, I said, there's approximately 90 percent of continuous miners are equipped with those. They can be over 90 percent effective in removing dust, and one of the best controls they have. However, what we found in our surveys is after one cut the scrubbers were losing a quarter to a third of the amount of air that they pulled through the system because of dust being trapped in the filter. We want to look at ways to improve that operation, look at the material that's captured. Can we design a new filter that doesn't get it clogged as quickly, but still has efficiency? And then augment that maybe with other sprays or different types of filter panels or even surfactants if it would help release that from the filter. Do all of that and then try to work with the OEM to institute this into a new design for a scrubber.

Moving on to metal/nonmetal. We've probably done a dozen years of research or more looking at operator enclosures, cabs on mobile equipment, operator booths, control rooms, and putting filterization and pressurization systems to try to protect those workers. We found a number of key factors. Obviously, one being the filter, the airflow through the system, and a number of other factors. So we've evaluated filtration types. Everybody thinks that the HEPA filter is the best. You're going to get 99.9 percent efficiency, collection efficiency. However, what we found was in many mining applications that filter clogs up too quickly and you lose airflow, and airflow is one of the keys. How much air can you move through the cab? So we've evaluated what's called Merv, Minimum Efficiency Rating Value filters, and we found a Merv 16, Merv 15 type filters which may only start out at 95 percent efficiency, actually, for the long-term or better because they keep moving more air as they get coated with dust, their efficiency goes up and it's a, for most mining applications, a better choice. One of the other keys is to try to prevent wind from blowing dust into the cab. Al these cabs have some opening, some leakage. And

the way to combat that is to develop positive pressure inside the cab, and we've done that with a number of systems, but we also wanted to give the operator some idea of when their system isn't working as well. So we evaluated a number of different pressure type monitors and provided that information. All of the research that I've talked about, and more, is included in this summary publication here, this IC. Included in that is this protection factor model where the mine operators can look at different intake, recirculation, final filters, simulate leakage into the cab, and look at these different parameters and see what type of protection and how they can improve that protection by changing some of these parameters.

One of the technologies we evaluated was a dust suppression hopper, and that's for bulk loading into trains, trucks, and ships. You can see here with a rigid tube you get a lot of dust generated. The idea of this is this hopper fills up with dust before it's spring-loaded, and then the springs release and you get a solid ton of material coming out, and also as it's filling up the air that's contained within that product is forced out. So both of those are designed to minimize the amount of dust generated. This was actually developed in New Zealand. We came across that and we're preparing the minerals processing handbook. There really wasn't any data that showed how effective it was, but we put it in there. A couple of silica sand producers saw that information, were interested in the technology, decided to buy it, and asked us if we would like to test it. So we did studies at two different operations. You can see at plan A we had an 88 percent reduction with the fines and that's what's shown in this picture here. And then the second plant they were running multiple products and we had between 40 and 85 percent reduction based on that product size. We also let them know when they cut the feet off you had this trailing plume of dust that came out for 30 seconds to a minute until it completely receded. So we let them know that this is something you should be aware of and keep your workers away from there until that ends.

And, finally, RJ mentioned yesterday the second edition of the minerals processing handbook. We truly appreciate all the help we got from Mark Ellis and the IMA-NA. They're member companies, equipment manufacturers, MSHA. And there's a whole new chapter and significant updates to six additional chapters in the handbook. It was available online in March and we got the printed versions about a week ago.

The metal/nonmetal current project is ending so we have a new 2020 project proposal. One of the first things we want to do in this project is evaluate low cost dust sensors. The sensors that are, typically, used right now, particularly, the real-time reading sensors cost in the thousands. There are sensors out there that cost in the hundreds of dollars, but we don't know how accurate they are or how they would perform in the dust levels that you would see in the mining environment. So we want to look at those sensors, do lab evaluations of those, and then if

successful take them out and kind of do an area monitoring system of like a processing plant or something, and see if you can make that into a system that would alert the mine operator you have a problem and/or automatically activate a control technology like the fan or LEV system. Likewise, I said we have a lot of information on filtration systems for enclosed cabs. We would like to work with an OEM and make it into a smart system where it would alert the operator or if you have a variable speed fan, automatically adjust the fan as the filter loads to ensure that you're getting the same maximum protection.

And then, finally, the last task is to evaluate emerging technologies with the oil and gas boom, hydraulic fracking, a number of the silica sand operations that we work with or developing coatings for the silica sand, and we would like to evaluate those to see if they reduce dust at transfer points, loading areas. And then it was mentioned yesterday welding fumes. We know there are portable collectors like on the jobsite welding that goes on. We'd also like to evaluate those to see how effective they are in real-world applications. So we're going to continue to assist the industry, developing control technologies and instrumentation. Like I said, you'll hear from Emanuele next about the field-base silica monitoring. And I'd be happy to answer any questions you might have.

DR. NELSON: Thank you. Very thorough, organized presentation. Several places you said that you're awaiting field trial opportunities. To what extent is the lack of opportunity really holding back what can be done?

MR. COLINET: For both of those specific tasks we've recently just completed the lab study portion of that. So we just started to look for field sites, but with the implementation of the PDM, and we've heard yesterday, I think, that 99 percent of the samples are in compliance, companies are less likely to participate because they're not having or seeing problems. A lot of times when they're having problems they approach us and say what can we do, what kind of technology could you implement? So that portion of it has kind of waned somewhat.

DR. NELSON: But do you think—I mean, if you had more opportunity would things go faster and more better. Yes.

MR. COLINET: Oh, sure. Sure.

DR. NELSON: So I mean, none of this can be done in the experimental mine that is being sought now?

MR. COLINET: No, we need actual production for a number of those technologies. Like the shields. We have model shields over there that are very similar, but they don't move. We're not cutting any product, so you need to, actually, go to the site.

DR. NELSON: Okay. Any other questions? Tom.

MR. HARMAN: The west dust box collector that you showed on the roof bolter machine. What are the challenges there? Because you said that there was one mine that had tested that. What are some challenges?

MR. COLINET: Well, one of the challenges, you need to get an approval from MSHA, like an

experimental exception to try it out first. So because the roof bolter systems are approved as a system you can't even—if you have a hydraulic hose or an air hose that breaks you just can't put any rubber hose on there. It has to meet the specific system requirements. So to, obviously, eliminate the dry collection you have to approach MSHA, which the mine did, and they granted them that. So that's one of the things. The other thing is during this testing even in the wet system there is a final filter in there. and with the moisture that could impact that, and Fletcher has worked on a moisture resistant filter that is now available, so that would eliminate that issue.

MR. HARMAN: So from an engineering standpoint it's the filter absent the approvals process at MSHA.

MR. COLINET: Right. And they claim, we haven't evaluated it yet, that they have a filter that is moisture resistant.

MR. HARMAN: One other quick question. On the air canopy for the miner and the shuttle car operator, are those add-ons? Is retrofit possible for that or does it has to be OEM?

MR. COLINET: Yes. For the roof bolter, they did sell retrofit systems, but, like I said, they now incorporated that into their actual canopy. So I think now at this point you would just buy a new canopy with that system incorporated into it. But, yes, they are also designing it into their new machines.

MR. HARMAN: Thank you.

DR. NELSON: Okay. Thank you very much.

PARTICIPANT: Yeah, just a quick one. You mentioned the coated sands. I assume the coatings are not for safety reasons. They're there because they add certain properties to the sand that…

MR. COLINET: Some of them there's claims that, yeah, they work better as a proppant with this coating on that, but it's, also NIOSH has done a lot of work on hydraulic fracking sites showing significant silica exposures to the workers, and they're using different technologies to try to combat that, and this may be another technology that would have that benefit.

MR. WRIGHT: Do you know what the coatings are?

MR. COLINET: At this point they're all proprietary, but supposedly, you know, not toxic or harmful.

MR. WRIGHT: Yeah. We won't tell you what it is, but don't worry it's not toxic. Not the first time I've heard that.

DR. BURGESS: In that regard I'd bring us back to the capacities of how to do a number of types of testing like an in vitro level or beyond. So if you, actually, get to something that looks promising I suggest that you work with them to see whether those non-toxic additives are, actually, non-toxic.

MR. COLINET: Sure.

DR. NELSON: Okay. Thank you very much, again. And we move on into silica monitoring. Emanuele Cauda.

FIELD-BASED RESPIRABLE CRYSTALLINE SILICA (RCS) MONITORING APPROACH

DR. CAUDA: Thank you very much. Good morning, everybody. My name is Emanuele Cauda. I'm a general engineer in the Pittsburgh Mining Research Division. I'm going to talk about a field-based respirable crystalline silica monitoring approach effort. This is a brief update to this effort. Last year my colleague, Dr. Lauren Chubb, gave a compressive overview of this effort. So I'm just going to cover the significant updates in the last 12 months.

We are trying to bring a small laboratory in the field for the field analysis of respirable dust samples for crystalline silica, and precisely for alpha quartz. So this is a method that is portable, is field-based, and is non-destructive. That means we are not destroying the sample in the analysis in the field. And we made everything possible to make it user-friendly for non-expert to implement this analytical method in the field. This is a tool for proactive action. That means assessment of RCS silica exposure and concentration levels, identification of the need and implementation of work practices, evaluation of engineering control technologies. Everything that is beyond compliance or in support to compliance or engineering monitoring or self-assessment.

The monitoring approach is structured in three steps. The first step is a collection of respirable dust samples. The samples are then analyzed in the field by a portable infrared instrumentation. The data from the infrared instrumentation are transferring to an i/o software FAST. And then there is an optional fourth step. It is optional because we can send the samples out to the analytical lab for the standard analysis, and we can do that because the method in the field is non-destructive. So that can be done to verify the field analysis results.

So a few updates. For the sampling perspective, the four-piece sampling dust cassette is now available, commercially available by Zefon International. That's been since the fall 2018. This is a cassette that we design specifically for this application and it's user-friendly, and is compatible with most of the samplers used in a mining industry. But we realized that in the coal mines the coal dust sampling cassette set is still quite common. So operators can use the field-based method with the coal mine dust sampling cassette as well, that is compatible, even though the equivalency of the results is not as good when samples are collected with this cassette.

Moving to portable instruments. The infrared instrument, we just finish at the end of 2018 a study comparing the analytical performance of four commercially available instruments. We tested under several metrics to verify the analogy of the same samples over and over, and we are going to publish that, pretty much, the results of the four instrument are equivalent or non-significantly different. That is a good news because it means an operator decided to pick one of the four instrument, but still getting the same results. Data transferred then to the NIOSH software FAST, the stand for Field Analysis of Silica Tool. The software is now available since September 2018 in the NIOSH webpage. And, really, the main

feature of the software is to translate the raw data from the portable instrument into meaningful monitoring information. So silica concentration sample by sample. But a software is much more than that. The software can be used as a database as well. The data can be store, transfer, share, and also the software can work as organizational tool. Means we can sort results, so they can be post-analysis, and that makes it really a big monitoring tool and not only an equation.

So for the most important feature, which is transforming the data of the portable instrument, they start to really get the data from the instrument terms of silica presence and present for the minerals. And that information from the operator in terms of sampling time, flow rate in the type of sampler, and sample by sample is possible to get the silica concentration in the silica mass.

What FAST cannot do is to give you the percent of silicon sample because we don't have the gravimetric data in the field. But it's possible to add optional metadata in terms of where the sample was collected, whether it was collected by a worker or area sampling, and, also data from the lab. So there can be added data from the lab after a few weeks. So it's possible to verify the analysis in the field. And that's for organization of the data and tracking.

So one of the main question is how accurate is this methodology. When we tested the methodology in the lab using the four-piece cassette, the one that is now commercially available with high-purity quartz samples or coal dust samples. We have a very good agreement between the portable instrumentation results in the MSHA P7 method. We could do the analysis, the comparison sample by sample because, again, the methodology is non-destructive. When we tested the samples collected in the field in coal mines using the coal dust sampling cassette, and we compared it with the P7 method we still get good estimation of crystalline silica in a good correlation between the field portable method and the standard method, but because of the deposition of the dust on the filter is unpredictable, we don't have the same equivalency sample by sample that we will have if the four-piece cassette was used. So we predicted by the use of the four-piece cassette we can get even better results sample by sample.

FAST is another option as well, which is the possibility to create a site-specific correction factor. In a site-specific correction factor is quite helpful, especially, when there are possible confounders, mineral confounders in the dust. And so we don't have a good quantification of silica. And that has been tested, has been published by our team in 2018 with two papers, and we rely on the idea that we can do the analysis in the field and then in the lab. So we can create a correlation between these two data points—that data set. And the correlation coefficient can be used as a training set. And so when a second set of data is collected in the same side, we can adjust the data using the correction factor. And so the occurrence, on average, is much better. We realize that this is not perfect, and so we are working at the moment improving the quantification models sample by

sample. And we are doing this with the information that we had from bulk dust material that we heard from mine operators in the last four or five years, and we're working on principle component analysis which is a multivariate analysis kind of methodology. Really, in the future to have an idea when an unknown sample is analyzed, to come up with the list of minerals in that sample. Maybe not the amount of minerals, but which minerals are there. And then by using calibration models that we are working at the moment in the lab testing pure mineral, in the (inaudible @ 00:44:41) of each mineral, we are going to better and more accurate quantification of quartz sample by sample.

And this is going to be included in the future in what is going to be an automated process. So a FAST 5.0, 6.0. Definitely not next year, but in the next few years. And to accomplish this we are increasing the number of bulk dust samples we have. We have around 100 at the moment. We aim to get 500 in the next four years. And we're working steady in the lab with specific experiments testing the effect of each single mineral found in the dust, and how to address the presence of that mineral and the confounding effect.

So this is, pretty much, what we're going to work in the next—this year, next year, and probably in the next couple of years at the lab level, really, to work and refine the quantification models for alpha quartz using pure minerals and linear multivariate approaches from a quantification model perspective. And from the field perspective we are going to collect more bulk, the samples, trying to engage with mine operators to receive material from mine operators. And we are also working, especially, for example, for aggregate operations in combining together the field-based monitoring approach for quartz together with Helmet-CAM, so to get the benefit of both technologies. We are working on a document, an iOS document at the moment. It was going to be a user guide for the implementation of this technology, almost like an R2 document. In probably more in 2021 we're going to have a new NIOSH method with this analytical method. That would really wrap up the idea of this technology and the possible implementation. And with this, I'd be happy to take any question that I can answer. Thank you.

DR. NELSON: Thank you. Do you obtain any information on particle sizes in conjunction with this study?

DR. CAUDA: No, not particle size directly. The infrared methodology analyzed respirable dust samples. So from a particle size perspective we are using respirable dust, but at the moment infrared it doesn't really discriminate in terms of particle size within the respirable dust. So no, that's not the goal of this.

DR. NELSON: But could that be determined from the samples that you take back to the laboratory? I'm just curious.

DR. CAUDA: Also in that case, that when sample is sent to the laboratory the sample at that point still contain the dust. So theoretical, there are methodologies to extract the dust material, and then the analytical lab could do probably some particle size

analysis. Yeah.

DR. NELSON: Thank you. Dale.

MR. DRYSDALE: When you're doing the testing in the field you, actually, just stick the whole cassette in the device; is that correct? You don't have to open it up.

DR. CAUDA: with the new cassette, the four-piece cassette, because it's a four-piece we need to remove the top and the bottom and the sandwich in the middle goes in portable instrumentation.

MR. DRYSDALE: Okay. Would it be possible—is there any technical reason why you couldn't then reassemble that, you can mid-shift and then put it back on the cyclone, and continue throughout the day. So you could have several…

DR. CAUDA: It is definitely possible. Once we, actually, analyze over and over the same cassette sometimes in the lab for quality insurance. So to repack the cassette they start sampling again, absolutely. I don't know if anybody ever talked about that idea, but yes, it can be done, sure.

PARTICIPANT: So you can test based…

MR. DRYSDALE: Give you a better—closer to a real time.

DR. CAUDA: The good thing is because there are now some samplers that can sample a 4.2 liter per minutes, for example. At 4.2 liter per minutes you can get enough material and sample on a filter, even after a couple of hours. And so you can really do task monitoring. And that's why somehow we decided to move from the idea of end-of-shift silica analysis, because end-of-shift seems to imply the idea that it needs to be put for eight hours. Obviously, it can be used for end-of-shift, but it can use for much more. It can be used with Helmet-CAM for one hour get a sample from the real-time dust monitor, and in the portable instrumentation. So it's really much more powerful than end-of-shift only.

MR. DRYSDALE: Okay. Second question. Do you know if the price of the various units are coming down? I think they were in about the $20,000 range last time we talked.

DR. CAUDA: I think the lowest—we start from $12,000 to $20,000. They are very variable, but those are the four instrument that we know are commercially available. So that's pretty much the range.

MR. DRYSDALE: It doesn't take a lot of lab samples before you—the cost of a commercial lab analysis, it doesn't take too many before you hit the price tag of one of those field units.

DR. CAUDA: And the feeling is because they are portable instrumentation, we know, for example, of operators they are thinking to have one instrument only at the corporate office and from an office at department, and then move it to the different site every week or every other day. That's something we do as well.

MR. DRYSDALE: It's great work.

DR. CAUDA: Thank you.

DR. NELSON: Okay. No other questions. Thank you very much.

DR. CAUDA: Thank you.

DR. NELSON: We invite Wes DuBose to come up and talk about hand-arm vibrations.

TRANSLATION OF HAND-ARM VIBRATION TO THE HEARING CANAL

MR. DUBOSE: Good morning, everyone, and thanks for having me out this morning. My name is Weston DuBose. I work as an industrial hygienist for the Spokane Mining Research Division of NIOSH, and today I just wanted to talk to you about a project that my team and I worked on evaluating the transmission of hand-arm vibration to the hearing anatomy in miners.

So I'll start off by quickly addressing the current knowledge on noise-induced hearing loss in the industry. Unfortunately, hearing loss still persists in the industry despite efforts from public health research institutions, academia, and regulatory agencies to mitigate the number of total reported cases. The good news is that we have seen a decline in the numbers over time. However, that decline is not uniform across all industry sectors. With that said, collectively, miners still accrue the worst level of impairment among all industry sectors and because of this phenomena is important to investigate and explore all potential pathways and potential options to explain why this might be happening. One way of doing that is examining the other mechanisms that could increase the risk of acquiring hearing loss.

So independently, noise and vibration are well-understood in terms of their exposure effects, hand-arm and whole body vibration research is geared toward preventing MSDs while noise research is, obviously, geared towards preventing hearing loss, but their symbiotic relationship is less understood. So there is existing literature out there suggesting that vibration exposure may act additively or synergistically with noise, shifting our hearing threshold, and changing our susceptibility to noise-induced hearing loss, but currently we only address these as independent hazards, and little attention has been given to them as a type of mixed exposure group.

So based on the body of research there are a few propositions out there attempting to explain how damage to the hearing anatomy might occur. These hypotheses that I provided, particularly, the third one on the screen have built a framework for accomplishing the objectives of this study, which was to evaluate if, and how, hand-arm vibration is absorbed through the hand and is radiated throughout the skeleton to the hearing anatomy. And there is recent research out there examining vibration transmission throughout the human body via the skeleton, but it's important to note that these studies are more geared toward preventing symptoms of hand-arm vibration syndrome.

So there's little research, especially, in mining that attempts to evaluate hand-arm vibration transmission and whether it could, potentially, cause temporary or permanent damage to hearing. Therefore, our research objective was to see whether we could first capture this type of vibration transmission data under actual drilling conditions as a proof-of-concept. So if you take a look at the operator

model here you can see that the body sensors are placed in positions that depict vibrations transmission to the hearing anatomy. And we wanted to build a measurement system that was capable of replicating the common method of hand-arm vibration transmission data collection, and as a proof of concept extend that one step further to include measurements at the shoulder and also around the ear. So we take a look at this from the 30,000-foot view. We conducted pilot research in three phases. The first phase included a comprehensive literature review. Here we looked at the different measurement methods that were employed in previous studies in terms of collecting the head-arm vibration data. We also identified the materials needed to build the prototype. Then during the next phase we conducted a series of beta tests in our research facility. This including impulse response tests to identify a transfer function; simulative grit tests using an electrodynamic vibration shaker table, and larger scale grit tests using a commission jackleg drill. So once the beta tests were completed and we received IRB approval to conduct human subjects research, we completed the field monitoring phase of the pilot with our study participants.

So following approval from the IRB we were able to recruit four mining engineering students from a local university. We had the opportunity to utilize their underground mining research facility. This is a facility where they provide on-site training for their students and they also have a facility for them to conduct independent mining research. So we had three days to collect all of the measurement data and during these measurement sessions we asked the students to perform jackleg drilling and bolting tasks while being monitored by the prototype device. And this proved to be the least invasive method of data collection since these tasks fall within their normal scope of their daily class activities. And once data collection was completed we ended up with 121 measurements taken overall.

So the prototype monitoring system utilized four miniature accelerometers as sensors to collect the data. Three of the four sensors were used as body sensors with the sensitivity of 1,000 millivolts per (g). The vibration levels were measured on the subjects wrist, shoulder, and the mastoid bone which is the bony part right behind the earlobe. This was a wearable device, so the wrist and shoulder sensors were adhered to a long-sleeved compression t-shirt, and the third body sensor was positioned at the mastoid using an adapter that was fixed to the earmuff cup. And we added an extra layer of compression to the body sensors using ACE-type bandaging as well. The fourth sensor was clipped directly to the jackleg's drill main cylinder and had a sensitivity of 10 millivolts per (g) to account for the higher vibration levels experienced. And as far as the actual data collection goes, measurements were collected by a data acquisition unit or a DAQ that was placed into a lightweight backpack that the students wore while performing the drilling tasks. And we captured that data using MATLAB-generated software.

And, again, I just wanted to stress on the fact that this was a proof-of-concept study. Therefore, the sensor attachment methods and the DAQ storage methods are something that we're hoping to improve on. And for this study our techniques, they were far from perfect, but we were still able to collect pretty interesting and reliable data using this type of method, and should we get the opportunity to build on this research these are something—or these are methods that we're hoping to revise.

So with our analyses we used a frequency response function model to test the raw output and assess the dose response relationship between the vibrational output of the drill and the response of the hand/shoulder/ear system in units of acceleration or gs. From there we created time averages of the data at two frequency domains. We started with the 8 to 100 Hertz domain because at first glance the data showed that the highest magnitudes of our vibration were captured within this range. We also found in our initial observations that 30 Hertz was the most percussive frequency within the 8 to 100 Hertz domain. Therefore, we looked at this frequency in isolation. Additionally, we wanted to see how the numbers behave in higher frequencies as well, so we chose the 8 to 1,000 Hertz frequency domain since that is the spectrum use for ACGIH and ISO standard sampling. So we also generated observational notes of the data from video footage that we recorded during measurement sessions, and we used these as a reference when analyzing individual participant data.

So if we take a qualitative look at the data, we noticed that the average magnitude of vibration of the wrist and shoulder sensor stayed about the same, but this figure represents a 10-second average of the vibration acceleration data captured at each sensor for all participants on—and this is on a logarithmic scale. So if I pull up a laser pointer here, these are separated by tasks and grouped according to the sensor location, that being the drill, the wrist, the shoulder, and the mastoid. The dots represent all drilling tasks which you can see here, and the boxes right next to them represent all bolting tasks. And each of these points represents an average of the 10-second averages measurements that we took during sampling sessions. And we also include the standard deviations for each data point using the arrow bars. So we can see that there's also—or there is an order of magnitude difference between each of the measurement sensor points, and this depicts the progression of the hand/shoulder/ear system. So for example, we use the wrist. You can see that there's an average of around three to four gs, and while the shoulder sensors average—or while the wrist sensors average around those three to four gs, is you look here with the shoulder sensors, they average around 0.2 to 2.4 gs in terms of the vibration levels that were captured by the prototype. So the amount of difference might be greater than you think between these sensor measurement points, but overall the data capture was fairly consistent across all the sensors as you can see with the different clustering of

the different measurement groups. Beyond the drill, which could vary an amplitude due to the amount of throttle being applied by the operator, we saw the most sense of variability at the wrist sensor. The visual you see here could be a bit deceptive due to the scaling of the graph, but on average the wrist sensors captured around 4 gs of total vibration and had an average deviation of 1.1 gs.
So when we took a look at the 8 to 1,000 Hertz domain to make a comparison we noticed that on average the magnitude of the wrist and shoulder sensors behaves similarly to the 8 to 100 domain. Meanwhile, the mastoid sensor did not behave like the other senses at the higher frequencies. And on average the magnitude of the vibration of the mastoid was, actually, higher.
So if we go back one slide you can see that at the 8 to 1,00 Hertz domain the average increased to about—or the average stayed around 0.8 gs which is right under here below .1, but if you shift over to the 8 to 100 Hertz domain you can see that the average increased to about 0.18 gs. You can see more of an overlap with the shoulder sensor here.
So there are a couple of ideas as to why this could have happened. For example, the mastoid is fixed to the earmuff cup in a way that creates a coupling effect that makes the sensor act—or the earmuff cup act as a live part of the sensor which will amplify vibration if the resonant frequencies of the earmuff cup are realized while we're taking measurements. However, this is only one guess as to what could be going on here. Again, that's the nature of these types of pilot studies when you have unexplainable events like these. It's important to address these types of events should we get the opportunity to do future iterations of research.
So we defined that mastoid data as an atypical deviation from the general trend observed, and we wanted to see if examining the individual participant data could help us explain this since the event occurred to some degree with all participants.
So we took a look at the 8 to 1,000 Hertz domain for the wrist, shoulder, and mastoid sensors for one particular participant. This participant here experienced this event the most frequency—or most frequently among the sampling group. We grouped this data according to the number of drilling tasks as you can see 1, 2, 3, 4, 5, 6 here, and we saw the same story here for that. In each of the drills that the participant performed, the shoulder and mastoid levels were much closer in proximity to each other than at the 8 to 100 Hertz frequency range. Particularly, with this participant the majority of his drills had almost identical shoulder and mastoid levels. So we did end up referencing those videos that I spoke about previously that we recorded just to see if they could help us any further, and we did see that when the drill was positioned closer to the body or the participant was drilling at or above his head the mastoid and the shoulder numbers were more similar to each other. With that said, we cannot attribute the data fluctuations to this event alone, but moving forward it's important to take into account things such as drilling technique, position, ergonomic, and anthropometric data when trying to

capture this type of data.
So lastly, we wanted to see if we could characterize the amount of damping that's occurring at the wrist, shoulder, and mastoid substructures. So we took a look at the 30 Hertz frequency in isolation and tried to quantify the magnitude of vibration being transmitted to each of the sensors. We did this by calculating the average percentage of vibration being transferred into each sensor in relation to the average vibrations captured by the sensor placed on the drill cylinder. So if you take another look at the jackleg operator model here, the A, B, and C markers represent the wrist, shoulder, and mastoid positions. The blue bars on the right side over here, the blue one represents the wrist sensor, the orange bar the shoulder sensor, and the green the mastoid. And the box above shows the average drill sense of vibration values at the 8 to 100 Hertz frequency.
So again, you can see the progression of vibration transmission going from the wrist to the mastoid. And if we use participant 1 as an example, we saw that the wrist sensor received about 50 percent of the drills 66 g output while the shoulder sensor received about 5 percent of that 66 gs and the mastoid sensor point 7 percent. Overall, transmission was pretty consistent at the shoulder and the mastoid sensors across all participants with minimal variability, but the wrist sensor was subject to the most variability, as I spoke about earlier. And we didn't explore exactly why this might have occurred, but we believed that the sensor distance from the drill as well as operator technique may play independent roles in the amount of vibration being transmitted. In either case, a big takeaway from this graphic alone is that the percentage of vibration being transmitted to the mastoid sensor is pretty low, but it's not zero using this method of data collection.
So altogether, we first see that it worked. We were able to accomplish our objective of measuring vibration as it translates through the hand/arm/shoulder system to the hearing anatomy. The transmission of hand-arm vibration is largely a low-level and low frequency event. And this aligns with findings made from previous research using this measurement technique to capture hand-arm vibration data. At these frequency transmissibility on the shoulder, wrist, and mastoid was reduced based on the increased distance from the hand or the point of contact, but at higher frequencies we did see that our sensors behaved differently, especially, at the mastoid sensor. So while we see that the hand-arm system does display damping properties that reduce the amount of vibration being absorbed, the damping properties of the shoulder and the hearing complex are less understood.
So at this point we cannot confirm whether the vibration transmission directly impacts noise-induced hearing loss in terms of causing direct damage to the hearing anatomy. We did see that the levels captured at the mastoid were low, but we cannot demonstrate whether those levels are significant enough to impact human hearing. But, with that said, that's not part of the scope of this particular

project and as a proof of concept we do believe that this is a step in the right direction toward better characterizing this nature of a type of mixed exposure. And further research could help answer a few those abnormal events that we observed while collecting these data. However, further research can't be done unless we bring in that subject matter expertise that will help direct the path of future research. So in order to do that the findings from this research are being disseminated, as they are now, to gain insight on how we can best address the limitations that we saw in this pilot. This includes what I spoke about earlier with our sensor attachment and placement strategies, and the collection of ergonomic, anthropometric, and biomechanical data. This also addresses—it includes addressing the unusual mastoid data that we saw at those higher frequencies. This also includes things that I didn't discuss as much in depth. This includes better characterizing the vibration transmission thresholds of the shoulder, neck, and the hearing complex and using measurement models that isolate mechanically-induced vibration from acoustic noise. So if you see those last three bullets at the bottom there, those outline potential paths that we could go with follow-up research. Once we're able to improve upon the measurement strategies, the prototype design, and our monitoring capabilities then we can begin to address this in terms of exposure, and we could talk about whether this type of low-level vibration exposure could still, potentially, lower the threshold and increase the risk of hearing loss in miners.

So with that, I'd like to open up the floor to you all and give an opportunity for you all to provide some feedback and, hopefully, discuss some other potential pathways of where we can go with this if you have an opportunity to do so.

DR. NELSON: Thank you.

MR. DUBOSE: Thank you.

PARTICIPANT: Am I correct in assuming that even with hearing protection the vibrations could affect the mastoid area and, in effect, hearing loss would not be limited because of the increase in the number of vibrations affecting the mastoid?

MR. DUBOSE: Correct. That was kind of the idea we we're going with and running with, with this is because of that type of mixed exposure. While you can attribute a lot of hearing loss to acoustic noise and accruing it that way, even with the use of hearing protection you're still vulnerable to the mechanical vibration that's induced directly from the drill. So there is the potential there to cause some form of damage. Yes?

DR. LUXBACHER: I think this is really good research. You've got some good data.

MR. DUBOSE: Thank you.

DR. LUXBACHER: And I just wonder if you have seen anything in the biomedical literature. Like is there a physical model of the mastoid human ear that you could vibrate long-term to kind of simulate, you know, long-term exposure?

MR. DUBOSE: Yeah. So I guess, based on what I've seen, the original data or the original models used to evaluate this type of data are based in animal models, so mouse

models, and they usually do like drill surgery or they have reactionary drill surgery to gauge if they accrued any type of damage to the hearing anatomy. As far as human studies, there hasn't been as much. I know that they've attempted to do pure tone audiometric and then pure vibration, and then comparing the two and seeing if one acts more strongly than the other in terms of that, but I haven't seen anything, not as far as real-time monitoring that they've been able to do to provide instant feedback.

DR. LUXBACHER: I think, too, you might get less variability if you had expert operator which I'm sure you've probably thought of.

MR. DUBOSE: Right. Yeah. Using the students…

DR. LUXBACHER: Having been a student who tried offering (inaudible @ 01:11:25) once.

MR. DUBOSE: Right.

DR. BURGESS: So Wes, fantastic presentation.

MR. DUBOSE: Thank you.

DR. BURGESS: A few ideas. So you mentioned adding dosimetry. I think that's a great idea. So in addition to standard dosimetry you might want to think about in-ear dosimetry, particularly, since they're wearing muffs, so that you could have those two together. It might be interesting to see how the vibration was picked up by the dosimeter. You know, just having the jackleg versus your hands on the jackleg. So and then the other thing is, you know, you mentioned additional expertise, but specifically thinking about audiometry testing and temporary threshold shifts, I don't know if you could see even just a little bit, you know, maybe it wasn't a true temporary threshold shift. It didn't meet the standard, but you're seeing some change with audiometry testing. So do you have like a booth in Spokane at all?

MR. DUBOSE: We do not.

DR. BURGESS: Okay. So there are some technologies that, supposedly, obviate the need for a booth that you could kind of look into. And for, at least, for the purpose of, you know, getting started you could use that technology instead, and then like, you know, explore how much a booth would be, and so on. Is there anybody else in Spokane who's doing hearing loss?

MR. DUBOSE: Not to my knowledge, not in terms of…

DR. MILLER: It might be like occupational health or something out there that do audiometry as a routine, and maybe can even look at, you know, specific frequencies of, you know—that would be interesting because you're going to look for temporary threshold shifts with some of the specific frequencies.

DR. BURGESS: But I strongly suggest that you continue doing this type of work because, as you pointed out, hearing loss is a chronic problem in miners, and we really haven't made advances the way we should. This is a difficult area, but that's all the more reason for you to be working on it.

MR. DUBOSE: Thank you.

DR. NELSON: So I would be really interested in learning about any frequency dependence on the

damping. Because that could, actually, inform machine design, in some cases. So think about that rather than doing the broadband, you know, 8 to 100 or 8 to 1,000, just look at the frequency dependency. I think that might be very interesting.

MR. HORN: Have there been any studies done on surface workers who use jackhammers regularly and absorb the same kinds of vibration?

MR. DUBOSE: there's been studies on just regular pneumatic tools that they've been using. I'm sure the jackleg—or the jackhammer has been part of that. A lot of just handheld tools and work using mechanically-induced vibration has been observed, yes.

MR. HORN: And how does the compare with your—the research that (overtalking @ 01:14:28)?

MR. DUBOSE: Well, we experienced similar results with that, and just that the progression of vibration going from the wrist. They haven't directly looked at the hearing anatomy, but they've been assessing things such as the wrist and the shoulder, and the neck just in terms of musculoskeletal disorders, and trying to prevent those.

DR. NELSON: Any other comments? Well, thank you very much, Wes.

MR. DUBOSE: Thank you.

DR. NELSON: Okay. Sean Warren, weak rock in Nevada.

GROUND CONTROL CHALLENGES IN ENVADA WEAK ROCK

DR. WARREN: So my name's Sean. I'm now in Spokane the last couple years, but from Nevada and Oregon previous. What I'm going to show you today is, basically, I want to show you some of the challenges that we're dealing with in Nevada and, specifically, kind of the weak rock. And what better way to do that than to bring some of that here to you. So this opening slide here is an opportunity to kind of show you how we support ground there. This is a rock (holder @ 01:16:13) and it's rehabbing a (inaudible) in a drift and experiencing squeeze. And we use 8-foot versions of these. And these are expandable bolts. So it's a friction bolt, and I'll just pass it around. And what it does is if you put the 8-foot version of this into the hole, and then it's expandable (inaudible @ 01:16:36), so about 4,000 psi. And this bolt gets much larger. So at the risk of getting your hands dirty, I'm going to pass some of this around. And so that is inflated to this, and then this is the bolt inside. So but we'll get to that later.

Okay. So the mining that we're doing is out in Eastern Nevada (inaudible @ 01:17:05). So those little dots there are a lot of goldmines out there (inaudible) mining district, (inaudible) sixth largest increase in the world behind the United States and above Australia, China. And, historically, down where near Reno is, is the Comstock Lode, which was the early 1800s, and that—I'm sorry, and into the mid-1800s.

So Nevada came into this in the United States, it was the silver space, and now (inaudible @ 01:17:39). And so this is what it looks like. We have a lot of these.

On the left is an open pit mine about 1500 feet deep. Those benches are 60-foot benches. Down on the lower left you can see some outside (inaudible @ 01:17:59) and on the right is a head frame. That's about a 3,000-foot deep mine right there, so for underground mine. So we'll be focusing on the right-hand side, underground mine. I used to work in an open pit (inaudible @ 01:18:16).

So underground mining conditions in Nevada, we're down to about 3500 feet. Pretty weak rock as I'll show you as in fractured and clay content. So that's (inaudible @ 01:18:35) variable ground conditions. And then I'll get it into the corrosion, but that's kind of its own topic. So in (inaudible @ 01:18:43) mechanics we have these end spectrum soil and rock mechanics that (inaudible @ 01:18:48), and like all the stuff in the middle Nevada rock is really it doesn't fit into either category. Can everybody hear me okay?

PARTICIPANTS: No.

DR. WARREN: No?

PARTICIPANT: I think they wanted you to use the mic.

DR. WARREN: Oh, okay. That's kind of a new thing. How's that? Can you hear through that?

DR. NELSON: Yes.

DR. WARREN: Okay. So Nevada rock. That's the stuff in between rock and soil. And so here, this picture is of a driller. This is two and a half-inch exploration core. That's a 10-foot stick right there. That's good ground. That's easy to keep open underground. More two and a half-inch diameter core. This is moderate quality of rocks, say, 4- to 5-inch joint spacing. Pretty easy to keep open still. And then this is the stuff that is tough to keep open. So this is Nevada rock, and I brought a little jar of it here. That's how it comes out of the ground, and it rattles. So that's in a face, and you take a rock hammer to it or a drill to it, it comes down. And then there's some clay stuff too. So there's the (inaudible @ 01:20:25) conditions.

People we're working with Goldstrat—or Barrick, a lot of Barrick, Hecla, SMD recently. The Lee Smith Mine. They had a fatality in October. We're going there in a couple weeks. Ground fall related. So they called us, and so we're going there. Bolt manufacturers and developers, and then a lot of consultants. Remus, recently, (Economis @ 01:20:55) passed away recently, but he was a very good—and then, of course, the University of Nevada Reno we're working with as well.

For people not familiar with underground mining I'm going to go through the cycle here. It's helpful to illustrate sort of the ground control challenges and where they happen. So first the drill and blast. We're still doing that in Nevada then you know the drill and then we haul it so sometime after you blast until you support the ground the ground has the characteristic weak rock in Nevada, most hard rock mines. Then, you know, then when ventilate. We drill and load. And then we haul it. So sometime after you blast, until you support the ground, the ground has to support itself. And if your rock looks like that jar of gravel there, that's asking a lot. So sometimes we run into things like this. So this is characteristic, weak rock fall

in Nevada. You can see the bolts there coming out and the wire mesh, and the shotcrete that we also use to support the ground. The little bits in between the rocks. The sign on the left there is something you'll see the miners kind of communicate to themselves underground, kind of letting them know to watch out. So the rest of this talk is basically forming hazards associated with weak ground. Being exposed to the face, heading collapse, just ground falls from weak rock like a picture and then squeezing ground so first two are associated with headings advanced and cycling and hanging drill glass ground support then the last three four our long-term challenges that take place after the so here's the picture and the squeezing ground. So the first two are associated with heading advance and cycling the hitting drill/blast, ground support. Then the last—three and four are long-term challenges that take place after the heading's been advanced. So kind of dividing over the two sort of separate categories.

So here's a picture of two geologists at the face, and it's unsupported. And you can see kind of that rock mass is broken up. And, you know, if you're—this is a geologist that is taking a sample. So they might be hitting it with a rock hammer right there or if you're running a jackleg you're right at the face. So this ground can come out on you while it's happening. So I did some digging and, intuitively, we would know this, but most of the ground fall incidents occur at the face. And so this is an area we'll be looking at in the future, I think. But you can see exposure there. That's the first hazard, is unsupported ground. How do we fix that? We mechanize. We get boulders and jumbos instead of jacklegs, and then we're starting to use drones to send into areas where we don't want send miners, particularly, open stopes, but we've been experimenting with using them at the face for heading inspections, and things like that, because there are some mines that are going autonomous and they're trying to get people out of the active face area for the same reason. Rattling ground. So that jar rocks, that's what the rock looks like, and there's some rock bolts that are just—they're not in the ground anymore because the ground came down. So this stuff can rattle, and if you get a chimney or a heading that's running up through your workings, if there's workings above then they're in danger. So stopping a chimney can be a challenge, and not letting it keep going in the first place is the best way to keep that from happening. So we've been experimenting with rapid setting shotcrete. So here's a—this is a—shotcrete is used to hold the little bits in between the rock bolts up to the rock bolts, and this is a shotcrete sprayer spraying some forms on the upper left here, and then we're testing them, the compressive strength of it, over time at the mine underground at certain time intervals to try to estimate or predict how fast a shotcrete sets up before it's actually supporting ground. So the lower—its curing time, shotcrete curing time on the X-axis and its strength on the Y-axis. And you can see that lower right curve with no accelerant, shotcrete after five hours is on the order of 10 psi which is jello, pudding, basically, not providing a ground

support. What we want to see is 1 MPA or 150 psi in one hour. Because you have about an hour before that ground starts coming down. So that's the reason for that. And we're getting there. So that's how we're working raveling ground.

And then, so groundfalls, we've been working with different empirical design methods. One of those methods is that our dead weight analysis. So the graph on the—or the picture on the left is just another groundfall, shotcrete wire mesh, and rock bolts on the ground. And then our assumptions in the ground support philosophy here is that that red triangle on the right is a wedge of ground that needs to be supported, dead weight wedge, and the height of that is 1/2 width, and then the blue lines are the rock bolts. And so it's a factor of safety calculation where it's the support capacity divided by the weight of the wedge. And there's a number of bond strengths between the bolt and the rock, and that kind of thing go into play, but this is a tried-and-true method for weak rock ground support. It was Remus's idea, Dr. (Economis?), and it's been implemented worldwide. We've recently released a data version of this. This is on GitHub right now. So we're getting feedback from operators. So this is all the inputs and, basically, this is available to the industry now.

And then the last thing I'll be talking about is squeezing ground. So is squeezing around is time-dependent convergence or the excavation getting smaller with time. So that big, huge beam there for that underground conveyor is not in a good place right now. It's not your eyes. So I mean, that's not good for the conveyor, for one, but so in this case the ground came in. This picture is a buckling slab. So if you have like a transformer on top of that, electrical transforming, you know, equipment on type of that, and then bolt heads being peeled off kind of like banana peels. Here is what's left of that bolt on the upper right. So if you don't have your tinnitus shot be careful. So these things pop off, and that's when we get worried is when the bolt heads start popping off because then the ground support can't do its job anymore. And down on the lower right is shotcrete shear. So these are time-dependent processes that we're studying.

This is some of the work we're doing. Bolt trials. We're working with industry to test and develop new bolts. That was Jennmar and Minova. And in this picture we're installing this one right here last fall. This is a new bolt for Nevada designed specifically for Nevada rock. It's a hollow—I'll get to this, actually. But we're doing empirical studies and instrumentation. So this is the bolt. This one's Jennmar's version. That's the piece I cut off after we installed the bolt. And the idea behind this bolt is that it can maintain 30 times capacity or 60,000 pounds through 6 inches of elongation. So that's time. Stretching bolt is time for us. So we put these in last October, and then so what—I'll get into some of the…

DR. NELSON: Can you go back? Describe that bolt. Is that a mechanical anchorage or are these grouted or both?

DR. WARREN: These are grouted. So it's a hollow bar. So it is its own drill steel, and you put a

sacrificial bolt on the end of it because in the weak ground you drill the hole, the hole might just collapse on you. So you can't get the bolt in there. So it is its own drill steel and drill bit on the end. This part that you see is bonded by bonded by epoxy so you inject through the hollow bar the epoxy, and then it comes down. And then the smooth section—not this bolt—is debonded, so that part can stretch. So you have several feet of bolt that can take strain and elongate.

DR. NELSON: So then you post tension or do you just let it passively tense?

DR. WARREN: We torque them down about 100-odd pounds. And so this is a brand-new bolt. Minova has their version of it, too. And so this is us testing it in the lab for shear. So they hadn't tested it for shear, and we're doing third party. So on the lower left there is what's left of the bolt after going through the guillotine process there which is the upper left. We put the bolt in detention with, and then take our UCS uniaxial compressive strength and just shear it through. So…

DR. NELSON: Do you ever over-core to see exactly what's happening with the epoxy, whether it's penetrating the rock?

DR. WARREN: We haven't. No. I mean, we just…

DR. NELSON: What kind of rock is this? I know it's black, but what is it?

DR. WARREN: Oh, limestone, broken up clay.

DR. NELSON: So can you tell the difference between squeezing and swelling with some of that rock? Is there any moisture movement? Can it also be swelling?

DR. WARREN: It could be, yes. But, usually, I mean, we're adding—because you're drilling and you're using fluid in the drilling process, so that's another art of its own to use the least amount of water as possible when you're drilling. But, I mean…

DR. NELSON: But the control for swelling and squeezing are not the same.

DR. WARREN: That's correct. And this stuff usually dries out over time from the ventilation, usually is what we see. So it starts out wet, and then as you mine down it tends to dry out.

DR. NELSON: Does it shrink when it dries out?

DR. WARREN: Yeah, it desiccates. Yeah. So the shotcrete helps with that. The clay ground can definitely be swelling. The other stuff is non-plastic, that gravely stuff, so it's shearing along the joints. Yeah. So we're doing laboratory testing on this as well, and then so here's some of the data from that, you know, shear displacement of two inches. It can take six inches in elongation, and there it is breaking at 60,000 to 70,000 pounds, or 80,000. So it's a strong bolt compared to these guys, 12 tons. Those are 30-ton bolts. And then here we're doing empirical studies. So if you measure the width of the drift over time which is time on the X-axis and convergence on the Y-axis you can see that Decline 1, the blue line on the left has converged over two feet in about five years. And some of those production drifts are closing in about an inch per month.

And so this is a risky slide here, but this is brand new, unpublished work here. We're trying to predict squeeze rate. So on the X-Axis we have ground quality

RMR. So left 20 low gravel clay on the—up in the 20 area, and then support pressure is, basically, capacity of support system. So what we have is the one inch per year line right in the middle there. That's where the empirical data—and, oh, and each of those black dots is a case history. So what we're trying to do is predict squeezing rates based on support capacity and ground quality.

PARTICIPANT: But you're still doing extractions, right, at the same time while you're holding up the walls?

DR. WARREN: Yeah, we're mining through it, and then—yeah. Well, this could be in the long-term openings as well. (Inaudible @ 01:33:55) that are open years are long-term openings. Production openings are open less than a year to months, or maybe a couple years. And so this is the way we're going in Nevada, even—we're starting to employ tunneling techniques because we're being—it's getting expensive to keep rehabilitating and re-driving everything over and over again, and it's kind of dangerous, frankly—it is dangerous when those bolt heads start popping off. So we're going to these tunneling methods, lattice girders, and things like that, oval headings.

And then future work we're going to be continuing with the empirical studies, bringing some time-dependent modeling into it. I mentioned safety at the face where a lot of injuries are happening and fatalities. Road headers in the lower right there. Road headers are in Nevada. The ground, we can just advance it with a road header now. We don't have to drill and blast. And then corrosion. So I brought a kind of corroded bolt here. Something I picked up off the ground. So it's pretty acidic conditions as well.

So thank you for your time. I appreciate it. And I'm open to questions, comments, recommendations.

PARTICIPANT: So how did you adjust for kind of your bolt patterns? Because, I mean, when you have bad ground they kind of adjust, right? Put more bolts in. I mean, how do you—does that come into play in your research?

DR. WARREN: Absolutely. Yeah. So support capacity is a function of bolt spacing and bolt capacity. The support capacity system. So absolutely. The miners, you know, this is a panel of wire mesh, it's 6 by 9, and good ground they'll put four bolts in it. Medium ground, five bolts. And bad ground, nine bolts. The engineer's involved in that as well, but the miners are, you know, they have different ground support designs at the mine for different ground conditions.

PARTICIPANT: So are you just taking whatever they do, pretty much, and then, you know, just evaluating in practice or are you, actually, having any input into the patterns that they're using in the spacing?

DR. WARREN: Yeah, I mean, I used to do ground support design in Nevada, so I'm really familiar with this. And, yeah, it's—we're both evaluating what they've done and how it's performing, and we're also—well, not NIOSH, but, you know, consultants and people are recommending bolt patterns, and it's mostly it's a see what happened,

you know, put it in and see if it worked based on what our experience, you know…

PARTICIPANT: Well, there's been a long line of research at NIOSH around that whole pattern. So you're kind of continuing that to a certain extent then.

DR. WARREN: Yeah, I picked up the—me and the rest of the team picked up the—I mean, I came out of Nevada to Washington to do research in Nevada. So…

PARTICIPANT: Cool. All right. Thanks.

PARTICIPANT: What's the level of stability that your desiring to achieve? I mean, how long?

DR. WARREN: Well, that's why predicting is so important. So a long-term (inaudible @ 01:37:18) can't take squeeze more than, you know, (inaudible) inches of deformation. So that's (inaudible) per year, that's six years. But like in the infrastructure, really, (inaudible) it's attached to the wall. Like you saw (inaudible). So production, we have squeeze rates in production (inaudible), and they're fine because they're only open several weeks. And then (inaudible) which, basically, you know, (inaudible). So the tolerance to squeezing is very variable compared—it's a function of what you are going to do with that (inaudible @ 01:38:06).

PARTICIPANT: When you talked about the accelerated shotcrete I think you tested up to 10 percent accelerant. What is the limit of accelerant you can add? Are you looking at different accelerants?

DR. WARREN: Yeah, so it's 10 percent by way of cement. And there are negative effects with putting accelerant in there. The long-term strength goes down as you get early strength. So you started to approach the limit at 10 percent. So water content is a huge problem. If you have too much water, not enough water, logistics is really the ticket in shotcrete. So we've been testing different accelerants, different accelerant types, BASF. In that study we were using a new one the BASF had come out with, and we're comparing it to some of the older ones. So yeah, 10 percent. Once you start going past that you're going to sacrifice in long-term strength, and then that can kind of keep yourself afloat there.

PARTICIPANT: So to get to that target it'll have to be some new accelerant, you think?

DR. WARREN: I think that'll be (taming @ 01:39:19) logistics. I think the rest of that's going to come because like slump test for shotcrete, if it's really watery and it just, you know, it'll—that takes forever to set up. So they, typically add too much water to it because it sprays easier if it's wetter. So drying out the shotcrete to, you know, resemble water content is—it'd be working against miners there, against their logistics. So…

DR. NELSON: So I, actually, think you need feedback too funnel nozzle men out there, nozzle people out there because I'm not sure that the mining world is as versed in shotcrete. I'm trying to understand. This kind of material that you showed, how often is that encountered?

DR. WARREN: Routinely.

DR. NELSON: So the RQD, effectively, is zero.

DR. WARREN: Right. And so in the case history database that I put together about 400 case

studies like I think around—well, way more than half the RQD is zero.

DR. NELSON: So the standup time of this is zilch, right?

DR. WARREN: Right. If you put the Barton chart up there (inaudible @ 01:40:26) collapse.

DR. NELSON: I'm trying to understand exactly what the bolts are doing. And the shotcrete is just trying to retain because there's no way that you're restoring the Sigma 3 confinement which is something that sometimes shotcrete is thought to be. I think I need to go out to Nevada.

[Laughter.]

DR. WARREN: Right. I mean, you saw stick rock there. I mean, that was a job. I showed up at that mine and we were going to drill that through for design, and they told me that me that might have the worse rock in Nevada. And then we started pulling out those sticks out of the ground, you know, what?

DR. NELSON: Has anybody thought about maybe doing some ground improvement like grounding?

DR. WARREN: We do. So when it gets to be sandy conditions, like beach sand, then we do pressure grout the face because we have rigs come in and trap miners, things like that. So we pressure grout the face, spiling. I mean, it's the ore body that's bad. The infrastructure—it's the ore-forming process is what is hard on the rock pass. It's hydrothermal alteration (and faulty @ 01:41:38). So that means acid and clay. So the acid turns some of the minerals to clay, (inaudible @ 01:41:46), specifically. So typically, the worse the ground, the higher the grade, which is a good thing because it's really expensive to support this ground. Thousands of dollars a linear foot in bad ground, you know, several thousand dollars a foot. Good ground, much less than that. So we hit clay, we hit gravel, we hit good ground, and it's variable, highly variable. I think that's all. Oh, I had one fresh bolt head. One that's not peeled off. But, anyway, so yeah, these—I mean, that's what's left of that bolt. That's all I have. I'll get all my stuff out of the way here.

DR. NELSON: Any other questions or comments? Okay.

PARTICIPANT: Yeah, this is a little off subject, and it's a different kind of bolt, but we've seen counterfeit bolts in oil refineries. It's a real problem. Is there any concern about that in the industry?

DR. WARREN: So you're getting fake bolts from like China or something?

PARTICIPANT: Yeah. Yeah, are these things all made in the U.S. or are they…

DR. WARREN: Well, depending on the manufacturer, (inaudible @ 01:43:07) are made in Sweden. Jennmar's are made in Salt Lake City. But I don't know where the cable bolts are coming from and I don't know where the rebar—well, we don't really use rebar too much down there anymore. But it's interesting problem.

PARTICIPANT: Rebar's not a big problem, but the bolt, at least, in some of this big equipment in the oil industry is really you don't want it to fail.

DR. WARREN: They're not the same quality, right? The bolts aren't the same quality.

PARTICIPANT: Yeah, they're, actually, counterfeit. They're marked as if they're a certain grade of

steel and as if they're, you know, they've got certain characteristics, and it's not. And as result of that it costs about a third to make, and they sell it for the same price, of course.

DR. WARREN: Well, we do a lot of quality control testing underground on (inaudible @ 01:43:59) tests. So but I thank you for pointing that out. I haven't even considered that.

DR. NELSON: Okay. Thank you very much. We will take a break now, and reconvene at 10:10.

[Break.]

DR. NELSON: Okay, the committee is reminded to sign in today, if you didn't do so. Before you leave, you have to sign in. Then you can sign out. I also—I have a point of clarification. Here I've been sitting here thinking that we as MSHRAC were giving advice to Jessica, but in fact, we are not giving advice to Jessica. Our audience is John Howard. So as we frame our advice, we should think about having him as our client, whatever. So, point of clarification.

DR. NELSON: What we have for the next period of time is some rapid-fire pitches, I think. Yes, yes, rapid fire. And we will have public comments at 11, if anyone wants to make a public comment, please let us know. So Brianna, you ready?

DR. EITER: I am ready.

DR. NELSON: Okay.

EXAMINER AND HAZARD RECOGNITION UPDATE

DR. EITER: It's a little late for Shark Tank because this is the fifth year of this project. So my name is Brianna Eiter. You already bought it, so. I'm giving a pretty quick overview of the Hazard Recognition Project and our primary translational output, which is a software product called EXAMiner. So as I just said, this project started five years ago. It's based in hazard recognition and at the time that the project started, there was an uptick in fatalities in the metal/non-metal mining sector, specifically in surface stone, sand and gravel. And at that point in time, one of the focuses for NIOSH was to update and modify their rule related to workplace examinations. NIOSH, our focus was to study how mine workers recognize hazards. So we opted to do this in the laboratory, at first. So our work started with the research study that was focused on understanding factors that affect mine worker hazard recognition. All of this work took place in our virtual immersion simulation laboratory, which some of you may have already been to. This afternoon, you're going to get a tour, if you haven't.

So all of this work took place in the VIS lab. We studied mine worker hazard recognition. We took what we learned from that study, we took the materials that we developed, we took the methodologies that we used, we identified key core competencies that are critical for hazard recognition and we developed a software product that we call EXAMiner.

EXAMiner has been delivered to the mining industry. It's being used right now. EXAMiner gives mine workers the opportunity to practice searching for and finding hazards, in the comfort of a room like this or a conference room,

something like that. EXAMiner gives users—trainers, health and safety professionals—the opportunity to create materials, using panoramic pictures, panoramic images that we've included. It also gives people the opportunity to create custom materials, by going out, taking pictures, using your phone, taking panoramic pictures, uploading those pictures into the software, and you can create materials that way, as well.

EXAMiner has been available since February 6th on our website. It's currently a beta version, and you can see some of the use metrics that we've been able to collect since then. Since that date—these slides are just a little bit old—so we've had probably over 400 downloads in about three months. So we're seeing fairly good use and the use metrics are actually a conservative estimate, because these only reflect use metrics for people who have opted in to share this information with us. And we all know what the mining community is like, people are less likely to opt-in to send information to the government. So we're having some pretty good feedback, some pretty good use feedback from the mining industry.

At this point, we're out for external stakeholder review. We've gotten the majority of those reviews back. We're waiting on just a few. We have sat down as a group, made decisions about how we're going to approach these reviews, how we're going to update the software, based on the feedback that we've been getting. We're moving forward with that. Once we complete that updating process, we'll send out for cross-clearance. We have, I think, four or five DLOs that we're going to share EXAMiner with for cross-clearance. And we are also currently out doing an evaluation, to evaluate the effectiveness of EXAMiner as a hazard recognition intervention.

So to do this evaluation, we've developed an intervention framework where we're looking at not just mine worker reaction to the software—so do you like it—but we're really also looking at how effective it is at measuring behavioral change. So how good are people at recognizing hazards? And then how does that information and how does that learning translate out to the field? And we're collecting information about these aspects of the evaluation from mine workers, because it's critical to monitor how is it that they recognize hazards?

But then also we're collecting information from trainers, from health and safety professionals onsite, from frontline supervisors who are out implementing and then also superintendents. And we're really doing this using a variety of methods. So the software actually collects information. We have surveys that we're giving out to collect information from mine workers. We're conducting interviews and looking at changes in potential standard operating procedures, different aspects of production, things like that, to determine the effectiveness of the intervention in the field.

We're getting feedback from stakeholders, both from these evaluations and from

some of the reviews that we've been collecting. And then we've been out in the field delivering and collecting information from people throughout the course of implementation. And so far, everything that we're hearing is positive. People really appreciate the software. They appreciate the information that we've included in the software. So not only do we have a variety of hazards reflected in the panoramic pictures that we've included, but we spent a lot of time adding information. So every hazard is connected to some aspect of the CFR, so that people can really learn and understand what hazards are.

And we've gotten information about use. So one company threw a pre-conference workshop that we did, in the fall, has reported back that they've trained through annual refresher training, all of their 600 mine workers. And we actually had a phone call with this company a couple of weeks ago and we're giving them information and helping them take their own panoramic pictures, so that they can create site-specific information and material, which they can then use next year for their annual refresher training. And then once they have that knowledge and that ability, they can use it in the future, as well. So we're seeing continued use.

And we're also getting information about use outside of mining. So the Portland Cement Association has contacted us. They are adopting—they've met with MSHA and we're going to present at their meeting in the fall, to talk a little bit about how they can implement and incorporate into their health and safety plans. So the community is supportive of use. One key stakeholder, MSHA, they're using it at the Mining Academy, to do their retrain for their inspectors. So all of their inspectors are going through retrain. So they've adopted, and they've provided some input on how we can improve the software, so that it will be even easier to use in the field.

And I will wrap-up by directing you to our webpage. So the cover page for EXAMiner is listed here. If you haven't seen the software, I'm going to demo it this afternoon over at the VIS lab, so if you're on the tour, you can see that. If not, you can download it yourself. Check it out, if you want to send us some feedback, we're willing to take that, to try to make this something that's more useful for the industry.

And then if you're on our page, I suggest you click on the "Core Safety" video. So the NMA made a segment on their CORESafety TV, highlighting the benefits of the features that are incorporated in EXAMiner. So if you want to check that out, that would be awesome. And I'll take questions. Thank you.

DR. NELSON: Thank you. What's next for this team?

DR. EITER: What's next for the team? So on Monday of next week, my colleague (John Rica @ 00:10:42) and I are going out to do another evaluation. And then, we are going to really be wrapping up the project. So the five years ends—

DR. NELSON: But is it moving on to a future project, maybe with VR or moving in that direction?

DR. EITER: Yes, that is—that's where we're moving next. So I have a project proposal in now

and the goal—one of the goals is to hopefully incorporate EXAMiner into that next project, as well. Because we've gotten such great feedback from stakeholders that we're really looking to improve what we have with a Version 2 that's...I can't promise what it will do, because (Greg Kohl @ 00:10:42) and his team don't want me to overpromise at this point, but we are looking to gamify in some way, yes.

PARTICIPANT: So Brianna, fantastic presentation. Have you looked—you talked about evaluation and the way you were doing evaluation, but you didn't present any kind of your evaluation outcomes specifically. And I was wondering specifically about that one company in the southeast that had 600 employees. Just as a case study, did you look at their MSHA reportable, to see whether there's been any change in that company? I know it's just one and it's a case study, but still, that might be an interesting outcome to look at.

DR. EITER: We can do that. We haven't, because I don't have any other data from them per se except information about their use. What I'm hoping is that they'll let us—we're working with them to create their own site-specific materials now. So I'm hoping that they'll let us come back or come down and talk to some people and at least give them...we have evaluation forms for their mine workers, to get some of that base information, so that we can then look at, in the future from that. But we could look at their reportables. I know the company, yes.

PARTICIPANT: I think that would be—in addition, it might be very helpful.

DR. EITER: Yes.

PARTICIPANT: Again, it's a single case study, but those could be very helpful in showing outcomes, as a result of your work.

DR. EITER: Yes, we have that for the company—we're still working our way through the evaluation, but we have worked with a company and we have a full evaluation from them and that's something that we're looking at, as well. So it is actually part of the evaluation framework.

PARTICIPANT: Thank you.

DR. EITER: So that's to be delivered soon.

PARTICIPANT: Great.

DR. EITER: Yes.

PARTICIPANT: Have you looked, or do you have any plans to look at the effect of retraining on the same individuals, to see that, you know, one training session gives them X level of however you measure it and then a second one might bring it up? And then what happens over a period of a year, does that fade? What's the optimal retraining time for an individual? Is that something that you've thought about looking at?

DR. EITER: We haven't included that into this project proposal or into this project evaluation cycle, but it's interesting that you bring that up. For the next project that we're going to do, it's actually something that we're looking at. We're looking at kind of continuous exposure. That's what we're calling it. So a daily exposure to some bit

of knowledge that people need to—that project is really focused on self-escape—so to kind of know and understand the layout of the mine that they work in. So we're looking at continuous, so every day or some sort of periodic exposure, to look at how that exposure affects your kind of knowledge and understanding of where is it you work and your ability to get out. So not for this project, but definitely for the next project.

DR. NELSON: You might think about maybe just sort of looking at the heavy, underground construction industry and trying it out on them, through SME or UCA, trying to just see if there's—it might be very useful for them, as well.

DR. EITER: Okay.

DR. NELSON: And if you need any help getting a connection, I can give you that.

DR. EITER: Oh, fantastic, thank you.

DR. NELSON: Sure. Any other comments?

DR. EITER: Yes, Mike.

MR. WRIGHT: Yes, this could be useful in a lot of industries, you know, beyond mining. Is there any way to sort of download it as a framework, into which people could insert their own hazards and their own photographs and things?

DR. EITER: As is, you can do that. So the front picture is of a surface mine, but once you get into it, the upload your own picture, build your own hazards into the software is all commodity or site-type agnostic. You don't—it doesn't have to be a picture. It actually doesn't even have to be a panoramic picture. You can take smaller shots that you already have available and upload those, as well.

MR. WRIGHT: So even a manufacturing plant or a service industry—

DR. EITER: Yes, anybody can use this. We have been—

MR. WRIGHT: That's great.

DR. EITER: ...working with DSR. So we've been helping them with some of their mast climber work and the construction sector has expressed interest and is picking it up, as well. So it is not just for mining. I know a steel company that's using it. So yes. We can change the picture.

DR. NELSON: Okay, well thank you.

DR. EITER: Thank you.

DR. NELSON: Thank you very much. Next up is Tom Dubaniewicz?

MR. DUBANIEWICZ: Yes, that's pretty good.

DR. NELSON: Okay, and I want you to know that until last week I had never seen a lithium battery blow up. But inadvertently, at our industry advisory committee last week—Jessica was there—we had a bunch of students having a drone that they were demonstrating and—that was it. So we saw the lithium battery die.

DR. KOGEL: It's a flamy death.

DR. NELSON: A flamy death.

MITIGATING FIRE AND EXPLOSION HAZARDS OF LITHIUM-ION BATTERIES

MR. DUBANIEWICZ: Hopefully we'll have a flaming death for you this afternoon. We planned a

demonstration for you, to see if we can get one to ignite. All right, good morning. I'll be providing a brief update of the project Mitigating Fire and Explosion Hazards of Lithium Ion Batteries. This is a new start for FY 19, and it's scheduled to go three years.

Okay, lithium ion battery technologies are enabling the development of battery electric vehicles, for use in underground mines. And these BEVs are being developed as a replacement for diesel-powered equipment. And so we may have the opportunity to reduce or eliminate diesel exposures for thousands of underground miners.

But with the introduction of any new technology, we need to be aware of the potential adverse consequences and with lithium ion batteries, that includes fire and explosion hazards. The Global Mining Guidelines Group recently published a recommended practice for BEVs and in that document, it indicates that battery thermal management and fire response presents a significant knowledge gap in the industry. There is also interest in developing BEVs for use in gassy mines, and from that perspective, MSHA approval certification personnel have questions about the potential for pressurized explosions within explosion-proof enclosures that are used to house the batteries.

So for this project, we have two research objectives. The first one relates to fire response and for this one, we want to characterize fire and lithium ion batteries to determine the appropriate fire suppression agents and to develop ventilation models. The second objective relates to explosion protection and for this one, we want to characterize factors that influence lithium ion battery ignition pressures as a function of confinement within sealed enclosures to develop design recommendations for explosion-proof or flame-proof battery enclosures. We anticipate that the fire response findings will impact a future edition of the GMG recommended practice for battery electric vehicle. And for the ignition pressure findings, we anticipate that will impact future editions of standards for explosion-proof enclosures or flame-proof enclosures used to house batteries.

Okay so during the first phase of the project, we're going to use an accelerating rate calorimeter to characterize battery fires and explosions. We're going to be studying three lithium ion chemistries under this project. These three chemistries were identified in the GMG recommended practices document. LFP stands for iron phosphate. NMC stands for nickel, manganese, cobalt and LTO stands for titanite. So we're going to use the ARC to measure heat release rates, to characterize the fire hazard. The ARC comes with a gas sampling accessory, so we can sample some gasses and have those analyzed to see what kind of components were in there. And we can place sealed enclosures within the ARC, so that allows us to measure ignition pressures within those sealed enclosures.

Okay, I have a very short video for you here. This is from a shakedown test not long ago, where we placed a lithium ion cell inside of the ARC and we're slowly

heating up the ARC which is heating up the battery.
And it was a very quick and explosive event. And I'll just show that to you one more time, real quick. Don't blink.
So these cells can fail rather energetically under certain circumstances.
And this is an example of some of the data we're collecting with the ARC. The blue graph, here we're slowly heating up the ARC until we can sense that the battery is starting to go exothermic. And eventually, we attain thermal runaway where we get that sharp peak in the temperature. And then for this particular test, we ran this one within a confined canister, a sealed canister, and we measured an ignition pressure of 293 bar that equates to 4,200 pounds per square inch. And keep in mind at MSHA explosion-proof enclosures are rated for about 150 pounds per square inch. So we get some rather high ignition pressures from these batteries, especially when they're very well-confined.
In the photograph on the right, on the right is a picture of the canister, what it looked like before the test and on the left is the canister after the test. And as you can see, it completely exploded and ruptured. That's a stainless-steel canister.
Okay, so what makes lithium ion batteries susceptible to thermal runaway? Well, we can start off with the chemistry and the fire triangle. So the cells contain chemicals that act as fuels, mainly the electroplate and anode. What a lot of people don't realize is that the cells also contain an oxidizer. So the cells can burn without the contribution of oxygen within the atmosphere. They can burn from the inside out. And certain types of cells have a metal oxide cathode, and these are generally considered some of the more reactive chemistries. You may also have cells with a metal phosphate cathode. Phosphate binds the oxygen strongly and so -- they are weaker oxidizers, though, so they're less prone to going to thermal runaway.
The third leg of the fire triangle is the heat source. So the ARC provides an ambient heat source, which can be used to ignite the cell. The cell may also ignite from an internal short circuit, which brings us to the construction of the cell. The drawing on the right is a drawing of a cell, showing the layers of anode and cathode. That's the minus and plus terminals of the batteries, and these materials are arranged as sheets that are wound around each other. And in between these sheets of materials is a very thin piece of plastic called a separator. The separator is only about 15 micrometers thick, so any kind of defect or damage to that separator can introduce an internal short circuit and possibly cause a thermal runaway event.
And the third C I have there is higher versus lower. Let's say you have a very small battery with very low capacity, and let's say that battery shorts internally. Perhaps there might not be enough electrical energy inside that small battery to attain temperatures high enough to create thermal runaway. But as the battery gets bigger and bigger and bigger, you have more energy contained within the

battery and in those circumstances, perhaps an internal short circuit can create very high temperatures and produce a fire explosion.
Okay, we're just starting out with the project. Here's a summary of future work. Again we're going to be measuring ignition pressures as a function of confinement. We expect very high pressures within smaller containers and lower pressures as the containers get bigger. We're going to use the ARC to measure heating rates of cells in battery packs, to characterize the fire hazard and analyze combustion gasses coming off the cells.
And then next year, we're going to enter into another phase of the project. We are going to conduct larger scale tests in a fire suppression facility. And then with all that data, we are eventually going to model fire contaminants spread throughout a mine, using the MFIRE Program.
And as I mentioned before, this afternoon, we have a demonstration planned for you, where we hope to set off a battery for you. And so this is what the ARC looks like with the enclosure opened for the demonstration this afternoon. This is all going to be sealed up, so you can't really see much, but this is what the ARC looks like. And with that, if there's any questions, I'd be happy to answer them.

DR. NELSON: So who else is doing testing on lithium batteries and their behavior? I mean, I can't believe that NIOSH is the only organization doing these tests.

MR. DUBANIEWICZ: Yes, some of the DoE labs or some military labs. A lot of work is being done with Sandia. I've been out to Sandia a few times. Chris Orendorff is heading up that effort right now. Pete Roth did a lot of work before he retired from there. But yes, there's some work being done in military labs and DoE labs.

PARTICIPANT: What about DoT?

MR. DUBANIEWICZ: DoT, they're working with some of the military labs, as far as I saw. The FAA is actually doing some work with an ARC for airline-related safety issues. The DoT—I believe they're working with the Navy, having the Navy run some tests for them.

DR. NELSON: So to what extent is all of this coordinated?

MR. DUBANIEWICZ: Actually, there is a Federal Lithium Battery Safety Group that gets together once or twice a year, where researchers get together, to share results that they've been getting. It's a government-only type of meeting. It's not open to the public.

DR. NELSON: Thank you. Any questions.

PARTICIPANT: Yes, I've got some contacts at DoT who are working on autonomous vehicles, who might be—I can set you up with.

MR. DUBANIEWICZ: Sure, that would be very helpful.

PARTICIPANT: The name that comes to mind immediately—actually, two names, but one is Lawrence Smith, Jr.

MR. DUBANIEWICZ: Okay. I'm not familiar with him. I've met a couple of folks from DoT through this Federal Lithium Battery Safety Group, but that name doesn't ring a bell.

PARTICIPANT: A woman by the name of Laura Gennaro.

MR. DUBANIEWICZ: Okay. Yes, I'd be very interested in you getting those contacts. Thank you.

DR. NELSON: Okay, any other comments, questions? Well, thank you very much, Tom. So we're slipping and tripping and falling. Mahiyar.

PREVENTING SLIPS, TRIPS, AND FALLS AT SURFACE SSG MINES

DR. NASARWANJI: That's right. Good morning, everyone. So I'm Mahiyar Nasarwanji. I'm going to be giving you a quick update on the Slips, Trips, and Falls Project. This is our last six months of the project, so I can kind of just talk a little bit about the work that we've done. Before I start, I just get to talk to all of you about it, but it's the team effort and they're the ones who've done a lot of the good work that I'm going to be talking about.

The last time I spoke to you, which was a few years ago, this is the slide I ended with. And I want to start off with this slide today, just to kind of give you an idea, in terms of the three areas that we are focusing on primarily: environmental hazards, shoes or the shoe and floor interface and then mobile equipment, and basically talk to you about progress and impact we've had so far.

So the first part of the project was looking at environmental hazards that were present at mines, and as part of this, we actually did a hazard assessment of a bunch of different mines to identify slip, trip and fall hazard in the environment. And as part of this, mines actually made changes to their parking lot. In this particular case, you can see their parking lot before and after. They actually had a graveled parking lot. They've also installed designated walkways throughout the mine, which was one of the recommendations we had after we went to this mine. And a few of the other mines that we went to have also made similar changes or are planning to make similar changes, based on the recommendations we had from others there, as well.

As part of developing the hazard assessment, we created a taxonomy of hazards, which is a list of hazards, basically. And as part of the development of the taxonomy, we came up with a few simple steps that needed to be taken for ladder safety. So what we did is we created the infographic you can see on the left here. We did it in 2017. CORESafety pretty much picked it up in 2018, copied it word to word and they also basically have a video of it where they basically demonstrate the same infographic again in 2019, as well.

Moving onto shoes, we were interested in looking at metatarsal boots and seeing if that influences gait. So what we had people do is walk up and down incline walkways and stairs. And as anticipated, we kind of found that there were differences with the different inclines that you might use. So say zero degrees was different from 10 was different from 20. That's kind of expected. But if you started looking at the boots themselves, we did not find differences in gait parameters between the metatarsal boot and the regular boot, in most metrics, except for a very few, such as hip range of motion, knee range of motion, ankle range of motion. And these differences were primarily between the type of boot we

tested—which means the hiker style versus the wader style and not between the ones which had the metatarsal boot and did not have the metatarsal guard in it, as well.

We also wanted to look at a longitudinal effect of boot wear in the mining industry and this was never done before. So this is a sample of a new pair of boots given to a mechanic at the beginning of the study. We tracked the wear over time. So this is after three months, you can kind of see significant wear as a percentage loss of material on the heel and the arch-ball and ball of the shoe already.

And this is after six months, when the miner actually returned the boot to us, you can see that on the heel, there's about 44% loss of material there, similar on the arch-ball and the ball, as well. The reason why this person returned the boot was because water was getting into the boot. And this is important, as I'll talk to you in just a couple of seconds.

We started analyzing some of the data and the trends we're seeing is that it actually might be occupation dependent, the wear. So we're seeing that maintenance workers might have more wear, as compared to some others. As part of the project, we're also supposed to do slip testing. So based on ASTM standard, we actually slip the heel across different contaminants, which we've shown here on the bottom right. And what we found—at least for the tests that we've done—is that there was no difference between the new boot and the used boot, for that particular heel test, on the particular materials we tested on.

I also mentioned that the water was getting in, and we felt that it might change the electrical conductivity of the boot and compromise the electrical properties of the boot. So we actually just tested three of them right now. Out of the three, one of them failed. And this basically means that there's a path that the current can take from inside the boot to outside the boot, which basically means that could compromise electrical conductivity. So the plan is to basically send all the boots we have back, as well, for electrical testing. And if you come to our lab, I can tell you—we can talk a little bit more about details about what we did in this part of the project, as well, and give you additional information on this, as well.

Finally, we're talking about mobile equipment. As part of this study, we did an analysis of front-end loader injuries over 20 years. We also interviewed mobile equipment operators, themselves, and we basically came up with a bunch of recommendations that we now have in a simple, interactive graphic, basically. This is available online right now. It was picked up by SSG Review and they've actually written a little bit about this. And on our website, on the NIOSH mining website, itself, it's actually receiving pretty good attention. In total, we had about 40 hits in March. The most recent month, we've had about 115 already on this particular infographic. And not only that, but one of my colleagues, (Janisha @ 00:34:39) gave a presentation at Penn State and a mine has actually picked up some of the recommendations that we gave and trying to implement them.

The one on the left is a fixed solution, where it's basically a platform. You board the equipment either at the bumper level or at the level of the cab. In this case, it's the bumper level. It eliminates the need to use the flexible rung steps which we found was a problem. And alternate solution is to use a staircase, which is shown on the right. This mine plans to buy two of these system for the D10 loaders and this way, you can eliminate the need to kind of follow the path up into the cab and use the stairs which are a lot safer, based on what we found.

Finally, out of the 25 publications we have so far, these are some of the easy-to-use tools that we have for the mining industry. The "Simple Solutions" document, we've distributed about 500 of these already. Miners tend to love the stickers we have down there for repair, revisit and report. We've given out about 300 to 400 of these already.

And the one last thing is all this information is going to be available on a slip, trip and fall prevention for mining website. And this website will be updated regularly, based on additional information that we might have from this project and can be updated in the future, as well. And this website has only been live for the past six months or so but we're already starting to see increased traffic onto this particular website, as well. So that's really it for me. I tried to keep it short, to leave a little bit more time for questions. So I'd be welcome to take any questions from anyone.

DR. NELSON: Thank you. Questions?

PARTICIPANT: So same question as before for Brianna, have you evaluated the effectiveness of this in the workplace, what are your plans for that? And do you have any kind of case studies already?

DR. NASARWANJI: So the thing is, in terms of the mobile equipment, we are actually working with the company that is actually trying to implement this right now. We have some estimate of the return on investment from them. They had nine injuries last year. each injury cost them about $33k. The fixed solution cost them about $11k to implement. So one third of one injury would basically pay for the system. In terms of the designated walkways, etcetera, we still haven't seen any particular change there right now, but hopefully, we can get some data from that mine, to kind of show the effect of that.

PARTICIPANT: Great, thank you.

DR. NASARWANJI: Any other questions?

DR. NELSON: Apparently not.

DR. NASARWANJI: All right.

DR. NELSON: Thank you very much.

DR. NASARWANJI: Thank you so much.

DR. NELSON: Yes. Okay, built-in-place refuge, Dave?

UPDATE ON BUILT-IN-PLACE REFUGE ALTERNATIVES

MR. YANTEK: Good morning. My name is Dave Yantek and I'm going to talk to you about our build in place refuge alternatives research. This is part of a project that's a five-

year project. We're currently in year four. So we're going to talk about four major areas related to refuge chamber usage: heat and humidity, breathable air, stopping/door blast resistance and communications. And because of the amount of time we have, I'm going to quickly go through some progress we've made and what we're working on currently.

So the main reason for refuge chambers is to protect miners in the event of a disaster, and so one of the big issues with that is heat and humidity buildup. Anybody that's gone camping, you're inside of a tent or a different structure that's small. We have metabolic heat that will heat up the inside. We'll sweat, increases the relative humidity. So some of our work has looked at that heat and humidity issue and specifically, recently, we've been looking at a cryogenic air supply that's used to provide cooling and possibly breathable air.

So in 2018, we evaluated this in our mine that you'll see later today. We preheated our test environment to 85 degrees Fahrenheit, to represent a warm, Southern mine, because that's pretty much the worst-case conditions and that's the target for this type of product. For your information, regulations require that you cannot exceed an apparent temperature of 95 Fahrenheit and that's a combination of about 83 degrees dry-bulb with a 90% relative humidity. And so what we found is that with this cryogenic air supply, this 30-person build-in-place already that we have underground would be allowed to have an occupancy of 12 miners, which sounds bad, because it's less than half. But when you consider that without that same cryogenic air supply, in less than eight hours, we are at 105 degrees Fahrenheit for the apparent temperature. And so realistically, you would only be able to put a couple miners in there, instead of 12, without this unit.

So what we're working on currently, we've tested this cryogenic air supply in our mine a few times, with some different numbers of our simulated miners, which I think we've talked about in the past. That's how we put our heat and humidity in. But we really haven't done a controlled study, looking at the amount of cooling versus (00:39:59) nitrox, so liquid/air flowrate. So we're currently working on a test to look at a new heat exchanger, which is shown there on the left, versus the old. And so we're going to be testing that on the surface. Our beginnings of this new surface lab are in Building 152 that you'll walk past on the tour. So it's a big, red shipping container that you can't miss. We're also looking at actually evaluating the breathable air part of this. So this project—

DR. NELSON: Can you just give me an idea of how much that unit costs?

MR. YANTEK: I know how much the contract was to develop it. I really can't give you a good number on the cost. I mean, the contract was a few hundred thousand dollars, but you're building a unit that's one or two. It's a one or two-off. So nothing on that device is standard. So we have a 2000-liter...so I'm going to attempt to use a mouse to do this. So this dewar here is a 2000-liter dewar. Typically those are vertical, not horizontal. So that was developed specifically to fit into our mine. So

in an actual operating coal mine, that may not be that unit at all. It may be a vertical storage unit, which are more common. So there's a lot of things that we've done that were specific to this particular unit.

So one of the things that has not really been determined is how much of the breathable air for a refuge chamber this cryogenic air supply can provide. So it was developed for that function and the cooling was sort of an afterthought. However, this was developed by a contract—a group of guys that work for NASA—and they just are okay with the idea of cryogenic air supplies, whereas the mining industry is a little skeptical. So we're trying to come up with a way to actually mimic operation of a refuge chamber on the surface and use devices to consume oxygen to represent people.

One concept is to use the oxidation of iron powder. This is actually set up in Building 152, as well. It doesn't look promising, so I'll just leave it at that. I don't think that this method is going to be pan out, but we needed to try it, because it has less safety concerns than the other method.

So here's our whiteboard sketch of another method to burn propane. And so this involves lots of things that from a safety perspective, we have to implement to do this safely, things like sensing the carbon monoxide, percent LEL or propane that we intend to burn and other gasses. And so this is again going to be using this shipping container laboratory we're developing. And so we'll walk by that area, but if there's any questions, I can kind of go through what our plans are on this device.

We've also been looking at relief valve blast resistance. And so relief valves are a key part of the breathable air supply system. They prevent contaminants from the mine from getting inside of a refuge chamber, in the event of and/or a fire. And so we're working closely with the MSHA Approval and Certification Center in Triadelphia. This is their facility. So we're taking an explosion-proof container—that's what's in white—and they dropped this test gallery enclosure over top of that. You see the pipe down here in the corner is used to pump methane in. they establish a mixture. They suck that into the XP box and then the ignition occurs from within the box. And so some of the devices you see here are related to measuring pressure and there's also an ignitor in there.

So we've tested seven valves so far. They were in the closed position, so we were loading them on the outside surface of the valve. None failed, so that's a good result. What we have left to do, we haven't tested any in the open position. There are no requirements for a specific way for a mine to design their air supply for a built-in-place shelter. So they could have a borehole air supply on the surface that's right there when they need it, or they could have a borehole air supply that has to be towed to that unit. Some can even make this borehole part of their normal mine ventilation plan. So we have to test valves in the open position, so that's coming up next. And we also want to tailor our blast pressures to more

closely meet what we would expect in a mine explosion that refuge chambers have to survive. Where right now, we're at about 8/10ths of a second duration, the design pressure per the regulation is 2/10ths of a second. And so we're developing this smaller enclosure for that testing.

You'll see this area, if you're on the mine tour. We talked about this back in the fall of 2017, where we were trying to develop this new method. We've run into some hurdles with our HSRB protocol that we had to get through last year, and now we're finally at the point where we're doing human subjects testing. And we've basically come up with a way that we can release tracer gas near this submarine door, which you'll get to see. So we use a real time SF6 monitor that allows us to—in the presence of mine ventilation—establish a flow of sulfur hexafluoride and then we can measure it with these monitors. So we can actually do this sort of real-time, where before we were using Vacutainer samples, which are problematic if you're trying to establish a concentration by releasing a quantity at a rate.

So our subjects will come to the test area. Once we have our concentration outside of our built-in-place RA at about 500 parts per million, you see the SF6 monitor and then the subjects will go inside, and we'll have the results pretty much within the timeframe we're doing the testing. Also we're looking at blast resistance of built-in-place RA doors. We're still pretty early in this work. So in 2018, we looked at a door that was actually in use in a mine. We own several of these and so on the left, this is results for a 15-psi positive load, which is what the regulations call for. The regulations do not call for a vacuum load, which is often observed in explosions. And so we wanted to look at, from simulation standpoint, is it possible that this vacuum load is going to cause problems for the door? So in both cases, the stresses predicted were higher than yield and so you have a potential situation where you may not be able to open this door, or it may leak. And so there's more investigation that needs to be done here.

And so ongoing work, the door on the left is the one that was tested. We've actually done some physical testing, to benchmark our FE model. We need to incorporate those results, so we can update and improve the model. And then on the right, we own another door that we've started modeling, as well. Dramatic differences between them. One thin and high stresses, the other one very heavy duty. I think it's about 5/8 of an inch thick, where the one on the left is more like 1/8. And so surprise, the one on the right has very low stresses.

We're also looking at, through-the-earth communications with respect to built-in-place chambers, so you can kind of imagine if you have an explosion that destroys your infrastructure for communication, you're not going to be able to use the typical radios. So what we're looking at it can we incorporate the TTE communication system within the built-in-place in its entirety? So we made a trip last year to a mine that was 2000 feet deep and they actually had to use roof bolts as electrodes, because they were having trouble installing ground rods in the

mine. And so that sort of sparked some other areas to investigate. So we were able to receive signals on the surface. We have a lot more work to do with this. One thing we want to look at is what's the effect of separation distance between the electrodes on the signal transmission through the earth. Typically, the research has been done with 200-foot separation distance. That won't really fit within a built-in-place shelter very well. So we would like to confine it to what is within a built-in-place, because now you're not putting electrical signals into a potentially explosive environment after an explosion. We also want to more widely compare roof bolts versus ground rods. We want to look at different types of roof bolts and see if we can get the necessary impedance values for our electrodes. And then finally, we want to incorporate sensor data transmission into the system. In the event of a disaster, mines are required to do monitoring within built-in-place shelters, and you need to monitor carbon monoxide, carbon dioxide, methane, etcetera. And so we want to be able to incorporate that sensor data transmission into the TTE system. So in the event of a disaster, even though your communications infrastructure might be destroyed, if you have a TTE system within a built-in-place, you can get data to the surface.

And so that is the conclusion of my slides. There's a project webpage here that's at the bottom and there's a lot of publications on there that are part of this project and some of our prior refuge chamber related research. So I'll take any questions.

DR. NELSON: What other countries are actively involved in this kind of research?

MR. YANTEK: I'm not sure how many people are really doing a lot of research. I know there's China, who's actually done a good bit with relationship to the heat and humidity part of things. I've talked to people in Australia, years ago. Most people around the world look at it that you're surrounded by fuel, why would you get in a refuge chamber? So there's only a few countries besides China and the US, that are even exploring refuge chamber use in coal mines. So it's tough to find a lot of good information, with respect to the coal part of things.

DR. NELSON: Okay. Well, anyone else have a question? No. Okay. Thank you very much, Dave.

MR. YANTEK: You're welcome.

DR. NELSON: And our last presentation then is Emily.

H&S MANAGEMENT SYSTEMS THROUGH SAFETY CLIMATE

DR. HAAS: All right, so I will end our meeting by giving you an update on our health and safety management systems and Safety Climate Project. When I talked with you at the meeting a couple of years ago, we were about halfway through our data collection, with our specific aim related to safety climate. And what we've been doing a little bit differently with the safety climate research is instead of going and doing these surveys at mine sites and saying that their safety climate or culture is good or bad, we've really been tying it in with their health and safety management system and really saying through our analysis, "What areas can you focus on

within your health and safety management system that will be most useful to you, that will improve worker performance and compliance onsite?"

So between 2016 and 2018, we went to 39 mines across 17 states and surveyed just under 2700 workers. So at the bottom, you can see our sample, it's just a little bit over 50% was in stone, sand and gravel. Industrial minerals, 34% and coal is at 13%. Since we finished this data collection, we've had a lot of additional interest, by all of these commodities. And we actually have a lot more in coal that we have, that's just not included in these final results.

So I'm not going to go too in-depth on all the different constructs that we measured, because I'll talk—you know, really high-level overview of some of the results in a couple of slides. But just to review, we thought it was really important to look at other high-hazard industries, to identify constructs to measure, as well as to look at those organizational factors that may influence workers' decision-making and performance, as well as those personal characteristics internal to us that are going to influence some of our own decision-making and performance on the job, as well. And we used these 12 factors to be able to predict workers' performance, in terms of their proactivity on the job. So taking initiative to identify and respond to hazards, as well as workers' compliance on the job. So following rules and recording any incidents. And then, as well as the outcomes on the job, so near-misses and then incidents that resulted in first aid or medical treatment or days lost on the job.

So the cool thing about the relative weights regression analysis that we were able to do is that again, we were able to help each participating organization understand their key drivers to improving worker performance on the job. And it took a while to figure out, you know, how's the best way to communicate this to health and safety managers and corporate mining companies? And we really came up with this matrix approach to, again, help them kind of focus on where they should be allocating some efforts. So we would really look at the results in this way. So we would tell them what their core strength were, within the survey results, that they can leverage, kind of what their competitive advantages were at their site or if they had a handful of sites participate. So this is when the constructs in the survey would have really high average or responses and they were also really important to workers, so really high predictors in the model, to be able to predict workers' performance.

Then you have those secondary strengths that we would say companies can maintain, but it was also an indicator of wasted resources. So the average was high by workers, but they were deemed kind of less important in that overall regression model. Then you have the secondary weaknesses with low gains, so although workers rated some of these constructs as really poor, they also didn't really factor in as being important in the model. So they could kind of put those by the wayside. But then where we really focused with the companies was those

critical weaknesses that needed to be fixed, meaning that the performance was poor. Workers were rating these constructs as low. That they came up as really important in the model, in being able to really predict workers' decision-making and performance on the job.

So to just give you kind of a high-level overview, this is all of the 39 sites together. The core strengths that came out from that personal characteristic, thoroughness was something that was rated really high and was deemed really important. So you know, workers finishing tasks until they were complete. You know, lock out/tag out is a good example of that. Coworker communication was (inaudible) that external organizational construct, that was also rated really high and was important. And this was always, you know, good for companies because people work in crews all day. So if their coworker communication is high—and it was also deemed important this was always a good win for them to have.

In terms of the secondary strengths that we said, "You know, your averages were good or pretty good, but you don't really need to be putting additional resources into this," health and safety training pretty much always came into this category. The average was always really high. When I say that, above a five on our six-point survey scale. And what was really cool was that a lot of times, we go to these companies and their answer is usually, "Training, training, training, we need more training." And after really talking with them and giving the more system approach and proving your everyday health and safety management implementation, they could really turn over a new leaf and say, "Training is part of it, but we actually have that down. How can we improve our day-to-day processes?" So that was one aspect. I won't really get into the secondary weaknesses low gain, because it's more important to really talk about the interventions that we developed with companies with their critical weaknesses that had to be fixed. So things like risk tolerance, worker engagement, supervisor communication and sense of control were the constructs within the overall sample that had lower averages. By lower, I mean around a four on our six-point scale or in a high three, because that's kind of in our disagree range on our six-point scale. Or maybe there was a higher average, but there were a few questions that workers really disagreed with. So an example would be in our risk-tolerance scale, at some sites, half of the workers would say that they took risks on a regular basis. So obviously, there was a need for intervention from that point.

So these were some of the areas that companies really started to focus on, because in our relative weights analysis it showed that if I improve these areas, I have a really high chance of improving workers' proactivity, compliance and reducing the chance of incidents happening on the job. So I'm going to give a couple of examples. One is with Carmeuse Lime and Stone. We worked with them quite a bit within the survey, and they developed interventions to improve worker engagement. Again, one of the things that came out in the overall sample

but also on each of the sites that we went to with them. So they discussed their—particularly just worker engagement results at what they called town halls with the workforce. And then they really determined that we have a lot of work to do in this area. So they developed and implemented a companywide engagement survey, that every worker participated in, regardless of if their site participated with us or not. They published their results and actions in their online newsletter that they publish every month, and this is the cover of their newsletter in July of 2017. And based on those results, they really leveraged a knowledge management program to better share information across sites and within each site, and they also enhanced cross-functional teams to reduce siloes. So the idea of cross-functional teams is applicable here—just like Jessica said yesterday—and at mine sites, to really enhance this idea of worker engagement on the job.

And actually, one of the participating sites that we worked with just reported that they worked over 500,000 hours with no reportable injuries. And when asked why, they said it was really from working with us and realizing that they needed to increase supervisor engagement and communication with their employees. I'm actually presenting the case study with this mine, with Carmeuse's Health and Safety Corporate Manager, at the National Lime Association Convention meeting next month.

And then, the last example I will give is some of our work with CRH. So we also worked with a few of their sites, particularly in the Midwest Region. And they really took it upon themselves to develop interventions to improve supervisor and coworker communication, particularly around risk tolerance. So one of the things that they did was they created a bystander intervention program that's been implemented at all of their Midwest sites, Midwest Region sites. And this was really based on our survey results that showed the communication between workers and supervisors wasn't happening a lot, that the coworker communication wasn't as good as it could be. So we actually published an article in Rock Product last August around this whole "See Something, Say Something, Do Something," where we published our results and then some of the results that they've collected at annual refresher training. And what was cool is that a lot of other associations picked up that article from Rock Products. So here was one, the Iowa Asphalt Association, where they republished it and then invited us to do a workshop at their association meeting in March. The same thing happened with the Illinois Aggregate Producers Association, as well. So that's gotten a lot of traction. We also presented this at the AG One Conference in February and there was standing room only, it was awesome. So we appreciated that opportunity.

The other thing that they did is created a lot of risk-tolerance videos. So there are kind of these 10 key factors that contribute to risk tolerance that we really worked with them to figure out and how they could combat that. So they interviewed a lot of employees that had experienced near-miss incidents and kind of attribute it to

some of these factors of high risk tolerance, kind of being overconfident on the job or becoming complacent. These videos are on YouTube and the videos were introduced by the Health and Safety Vice President for that Midwest Region and he referenced their work with us in the surveys and being able to create these videos. And other companies are linking to these videos on their website. Callahan Construction Industries is one of them. So it's really gaining a lot of traction. So these are just a couple of examples, again, really tying that link between safety climate and health and safety management systems and things that you can do on a daily basis, to really engage and involve your workers to be healthy and safe onsite.

So all of these results are included in our Report of Investigations, which is currently under review. Our Associate Director for Science has it right now, so after she reviews it and we respond to her comments, then we can send it on for external review and MSHA review. So if you're interested in a copy when it is available, let me know and I will make sure that we get that in your hands, hopefully by the end of the year. So I will take any questions that you have.

DR. NELSON: Great, thank you. Mike.

MR. WRIGHT: Yes, we've done surveys—not as comprehensive as yours but an Alpha-funded project, where one of the—well let me ask the question. When you've done surveys at the mines, have you compared the responses of managers with the responses of hourly miners?

DR. HAAS: Yes.

MR. WRIGHT: Because when we've done that, we've found very significant differences in the way they view practically everything about mine safety.

DR. HAAS: Yes, so we do have the hourly/salary differences and for most of the sites, there is a significant difference between salary and hourly, where the hourly perceptions are lower. A lot of companies request just seeing their hourly responses, so they can really focus on the needs of the hourly workforce. There are some items where salary does have lower perceptions. We have found that salaried workers always have higher production pressures than hourly workers, but that that can trickle to the hourly workforce, if salary is feeling that way. We did just do work with a company that didn't participate in this survey, but were starting to go out to their regions. And it was the first time for the five sites that we went to, the salary responses were all lower than the hourly.

MR. WRIGHT: That's interesting.

DR. HAAS: So we had a lot of conversations about that at their corporate meeting last week, to figure out why that could be, and they thought they were probably more honest than the hourly workers were. But yes, there definitely differences. But companies kind of know that and again, they really want to focus on their hourly results. So a lot of times when I would present results back to companies, rather than giving the average—I mean, I give that, but it might not mean as much as saying, "Forty

percent of your workers disagreed with this," we'll kind of give the hourly and salary breakdown, so we can see where the issue is that might need to be fixed onsite.

MR. WRIGHT: For what it's worth, the other thing we did besides the survey research is developed a tool about the effectiveness of a line safety and health management system. And the way we use it is we would get as many miners and managers together as we could and we used—we originally used what are called, I think, clickers, like every high school kid knows what that is. And now you can get software that will let you do that on a cell phone. And it's really interesting, because you can see the results right on the screen, right after you ask the question. And I remember one where we asked do miners believe that they can report hazards without fear of retaliation and—and about 20% of miners said they felt they could report without fear of retaliation. And about 95% of supervisors thought that the miners under their supervision could do that.

DR. HAAS: Yes. Yes that's where—we see a big gap with that, too.

MR. WRIGHT: And the CEO stood up and said, "Boy, we got a problem."

DR. HAAS: Yes. Yes, for sure, it's about 30% in our survey, where people feel like they can't come forward with a health or safety issue. In the next project, we are building in that real-time technology, so hopefully we can kind of address some of the things you're talking about in real-time, too.

DR. NELSON: Okay, any additional comments, questions? Thank you very much, Emily.

DR. HAAS: Thanks.

DR. NELSON: Great update. Okay, so we have now the opportunity for public comment. Is there any person of the public who would like to make a comment? Yes, please go to the mic.

PUBLIC COMMENTS

MR. ELLIS: I'm Mark Ellis. I'm with the Industrial Minerals Association North America and I've just got a couple of comments. One had to do with a comment that Dr. Burgess made with Dr. Eiter's presentation. You know, she had talked about having anecdotal experience looking at MSHA reportables. And one of the other sources of information that would probably be even better would be MSHA citations, because those are the inspectors' opinion as to whether or not a hazard existed or not and there's a lot more citations than there are reportables, so that probably would be a good area to look at. You also probably would be able to find some hazards that keep repeating themselves and obviously, if they're repeating themselves, miners aren't recognizing them. And so hopefully that would be something that you could build into the Hazard Recognition Program, to see whether you could have any major drop in that category of hazards.

The second thing had to do with the industrial mineral survey that you're doing. And one of the issues that came up had to do with the misclassification of commodities. You're really a customer of MSHA and probably a really important

customer of MSHA, in terms of the database that they have, because you're analyzing this at arm's length. You really don't have firsthand knowledge of what the commodities might be at the mines. And we were actually talking about it over dinner last night and I think that this would be a really easy project for NIOSH and MSHA to collaborate on, would be to verify the commodities at these sites. The inspectors are there either two or four times a year. you could get the operators to verify what commodities they have, to make sure that they're matching up with what the inspector is reporting. I know that there may be some information collection issues there for OMB or whatever, but by the time you're done, in a half-year, you'd have hit every operation in the United States, and you'd have a solid basis on which to say, "That's the minerals that they're producing. Here we can project where they are, and we know exactly what they are." So just a couple thoughts.

PARTICIPANT: And it doesn't change.

MR. ELLIS: Sorry, what?

PARTICIPANT: It doesn't change. Once you know the right one, you're mining that forever.

DR. NELSON: Thank you. Any additional public comments? Seeing no one who wants to speak.

MR. WELSH: Do you want to ask those on the telephone, too?

DR. NELSON: Oh, sure. Is there anyone on the telephone who would like to make a comment or ask a question?

MS. CALHOUN: I don't have a question at this time.

WRAP-UP AND COMMITTEE DISCUSSION ON FUTURE AGENDA TOPICS AND DATES

DR. NELSON: Okay, thank you. Okay, so we are completed with our agenda, except for this final wrap-up and deciding what kinds of comments—what we'd like to hear about in our next meeting which will be sometime like November.

DR. KOGEL: Yes, November and we should decide a location.

DR. NELSON: We should decide a location, yep. So I want to really comment that I think the presentations were all really good this time, very coherent, very crisp and we appreciated that very much, because it was a packed agenda and we didn't finish too late, so that was wonderful. Now, yesterday, we had—at the end of the day, we talked about a couple of the things that we thought we could hear about in November. Does anyone have additional items or areas that they would like to ask for presentations, in November?

MR. RUFF: Yes, we had the corrosion one that we're going to put...

DR. NELSON: Yes, the corrosion one.

DR. KOGEL: Yes, that was from last time, you had requested it, but we couldn't schedule it this time, because the person who's doing that research wasn't available.

DR. NELSON: Right, exactly.

DR. KOGEL: So I put it on next time.

DR. NELSON: Yes, I want to add, it would be good I think to have some kind of an item on the

DARPA experiment, because that should be done by then and maybe, after we're through with this. Okay, any other things that anybody wanted to have, based on today's presentations, any subjects? No?

DR. KOGEL: Priscilla, can I go back to something that you brought up yesterday—and that was you would like the opportunity for some input on the extramural—you were speaking specifically about, the capacity build, but we also would like to have input from the committee on the new technology BAAs which we do every year, we have a solicitation for those. And if we're going to get input from the committee for that, we actually need to get that from you sooner than later. We can't wait until the next meeting. So typically, what we've done is we've come to that meeting and shared with you what we thought the focus areas should be. But this time, we would like to hear from the committee, so that we can consider the committee's input, as we're selecting those topic areas. So I don't know if we want to do that, if anybody wants to chime in now with something that they would like to offer or if people would like to have some time to think about it and the committee could come back to us at some later date. I don't know if we'd have to set up a meeting for that, Jeff. Does it have to be as formal as that, to get that feedback?

MR. WELSH: Just an email, sure.

DR. KOGEL: Yes. So I just wanted to put that out on the floor.

DR. NELSON: I think that that would be good. So I was suggesting to Jessica that if she wanted input from the MSHRAC about anything extramural, we weren't really getting briefed on the extramural kinds of aspects. And therefore, we really couldn't comment on that. But that I think we could. So the idea in choosing what the topics or focus areas were going to be in the new technologies, that if we had input, we could offer it and that would be good. I mean, we don't want to compromise the review process but the sense of if you do want our input, we would be happy to give it.

DR. KOGEL: Yes. We would absolutely like the input at this stage, when we're trying to come up with a set of focus area topics would be very helpful.

DR. NELSON: So for your time what might be—

MR. HORN: Priscilla.

DR. NELSON: Yes.

MR. HORN: As one of the new people on the block, you said before that we report to whom?

DR. NELSON: John Howard.

MR. HORN: John Howard. And what happens then? Well, first of all, what do we report? There was a whole bunch of data discussed in these last two days. So what is it in fact that you report and what's the follow-up beyond that?

DR. NELSON: Well, my understanding is that we can actually report anything that we want to report.

MR. HORN: Yes, but how do…

DR. NELSON: What we historically have done is have minutes, right? Where issues are raised

and discussed, and the minutes become the context of the reporting back to the agency.

MR. WELSH: And one thing I do, I do an annual report and I take the recommendations from here and I report on how many of those were acted upon.

MR. HORN: Acted upon by whom?

MR. WELSH: By the NIOSH Mining Program.

DR. NELSON: So when we make a recommendation, he keeps track of it and reports back on what has happened. Now what's relatively new for this committee is the concept of a working group.

MR. HORN: Pardon me?

DR. NELSON: Working group. So we have two working groups. One's finishing up and one's starting, right? And we haven't had those before, so there is a report that comes out of that working group. It's been the charge that these working groups have to reach out to various stakeholders on certain topics and pull them together. And therefore, the report is the report from the workshop, as opposed to a report from MSHRAC. Right?

MR. HORN: So again, the working group is a subgroup of the larger one. So then the report of the working group then would go to whom?

DR. NELSON: The report of the working group comes back to MSHRAC.

MR. HORN: Okay.

DR. NELSON: All right?

MR. HORN: And then the—

DR. NELSON: And then we would have a presentation like we did at this meeting, for the working group to report on, and it would be discussed and any recommendations from that could be adopted as recommendations by MSHRAC to NIOSH, for action.

DR. KOGEL: Am I wrong in my understanding that we can do that in between meetings? So for instance, the report can go out to the entire MSHRAC to get some feedback, yes.

DR. NELSON: Right, exactly. Okay, any additional comments or issues that anyone wants to bring up? No? So next meeting location. There was some discussion for shooting for Spokane and then people said, "Well maybe in the spring, instead of in November." But I think it is time to get back to Spokane, one way or the other.

DR. KOGEL: So the way we've been historically doing it and, we don't have to stick to our traditions here—we've held the fall meeting or the November meeting in the West, somewhere in the West and we've held the spring meeting somewhere in the East. But that's something we can change, so...I'm just throwing it out there. I would agree that it would be good to get back to Spokane. We've never gone to Atlanta, so there's one NIOSH location we haven't been too, yet. So that would be I think another option.

DR. NELSON: Yes, it would.

MR. DRYSDALE: It's easy to get to and November is generally not too shabby, weather-wise.

DR. KOGEL: Right.

DR. NELSON: So Dale is pushing for Atlanta in November and then Spokane in May. So any comments on that?
DR. KOGEL: I'm in. I like it.
DR. NELSON: All right, we've got a vote for it. Any alternative? No? So there's your input.
DR. KOGEL: Okay. So probably what we'll do, Jeff, we'll send out a poll, so that everybody can weigh-in with dates, but we'll offer those two locations.
MR. WELSH: Any bad dates other than Thanksgiving week that anybody knows right now for November.
DR. NELSON: I have to check on when the end of classes are.
PARTICIPANT: The second week of November would work for me. The first week is bad. The first full week (inaudible @ 01:19:46).
DR. NELSON: First week is bad, so the second week is okay for you. The second week is okay for you.
DR. KOGEL: Sure.
DR. NELSON: Looks like maybe the second week should be looked at. I hope there is a clear second week in November.
PARTICIPANT: The end of the third week is bad for me.
DR. NELSON: But the second week would be okay.
PARTICIPANT: The second week's fine.
DR. KOGEL: That's the week of November 11?
DR. KOGEL: Monday is Veterans' Day.
DR. NELSON: Is that Election Day?
DR. KOGEL: But we can schedule around that.
DR. KOGEL: So we'd have to do it later in the week.
DR. NELSON: Okay. All right.
MR. HORN: At the risk of monopolizing, and it's again an observation of someone who hasn't participated before, but yesterday's presentations subject-wise seemed to hang together in a more orderly fashion than the separate presentations being made today. And if we could take a look—and I'd like to hear from other people, too, if they agree or disagree—maybe in terms of organizing the first and second days, we can think how it relates to specific policy initiatives that might overlap.
DR. KOGEL: Just another kind of detail, for the November meeting, it's a shorter—it's usually a daylong meeting, so it will be structured differently than this, anyway. But your point is well taken, and I think we can think about that for the next day-and-a-half meeting—
MR. HORN: It's not a criticism of any of the presentations.
DR. KOGEL: Yes.
MR. HORN: It's just in terms of putting ideas together, it might be more efficient.
DR. KOGEL: No, I think that's...
DR. NELSON: But I did like that several of these projects were finishing up. They were in their fifth year, so it was—and we had heard previously presentations at length. So it

was sort of nice to see the endgame, as to how far they had gotten on this one.

MR. WELSH: Yes, and what we did is that since we are at the PMRD location and the researchers are here, we added a number of short 10-minute, quick presentations to give you a quick update.

DR. NELSON: Do you want to see if he can play that video?

DR. LUXBACHER: I do like—occasionally, we do this back and forth when questions are posed to us by either the—by the people giving the presentation or whatever, I think that's a nice way to start discussion in areas where you need our input.

DR. NELSON: Yes. Right, because otherwise—and I think there is room for, you know, specific questions. Some of the people had specific questions but –

DR. KOGEL: I think there was one meeting where everybody did that.

DR. NELSON: Yes.

PARTICIPANT: It's nice.

DR. NELSON: I think so. Yes, that would be good. And if you had any specific questions as the AD. Good. Okay. Any final comments that anyone wants to make? Good. Then the meeting is adjourned.

[Adjourn Day 2.]

[END MEETING]

G L O S S A R Y

CDC	Centers for Disease Control
DARPA	Defense Advanced Research Projects Agency
FACA	Federal Advisory Committee Act of 1972 (Public Law 92-463)
HHE	Health Hazard Evaluation
HHS	US Department of Health and Human Services
MRD	Mining Research Division
MSHA	Mine Safety and Health Administration
MSHRAC	Mine Safety and Health Research Advisory Committee
NIOSH	National Institute for Occupational Safety and Health
NMA	National Mining Association
NPPTL	National Personal Protective Technology Laboratory
NSSGA	National Stone, Sand, and Gravel Association
PMRD	Pittsburgh Mining Research Division
RHD	Respiratory Health Division
SMRD	Spokane Mining Research Division
UMWA	United Mine Workers of America