MINUTES

MINE SAFETY AND HEALTH RESEARCH ADVISORY COMMITTEE (MSHRAC) MEETING
November 15, 2017, 8:00 AM – 3:00 PM
SHERATON DENVER WEST HOTEL
360 UNION BOULEVARD
LAKEWOOD, COLORADO 80228

COMMITTEE MEMBERS PRESENT

Mr. Ronald Bowersox, United Mine Workers of America, MEMBER
Dr. Jefferey Burgess, University of Arizona, MEMBER
Mr. Dale Drysdale, National Stone, Sand & Gravel Association, MEMBER
Mr. William Francart, Mine Safety & Health Administration, MEMBER
Dr. Kramer Luxbacher, Virginia Polytechnic Institute and State University, MEMBER
Dr. Aubrey Miller, National Institutes of Health, MEMBER
Dr. Priscilla Nelson, Colorado School of Mines, CHAIRPERSON
Mr. Bruce Watzman, National Mining Association, MEMBER (By phone)
Mr. Michael Wright, United Steelworkers of America, MEMBER (By phone)
Mr. Kyle Zimmer, International Union of Operating Engineers, MEMBER
Mr. Jeffrey Welsh, NIOSH, Designated Federal Officer

COMMITTEE MEMBERS ABSENT

Ms. Stacy Kramer, Freeport McMoRan, MEMBER
Dr. Richard Fragaszy, National Science Foundation, MEMBER

NIOSH PARTICIPANTS

Tim Bauerle (In person)
John Burr (By phone)
Marie Chovanec (By phone)
Patrick Dempsey (By phone)
Pam Drake (By phone)
Audrey Glowacki (By phone)
Gerrit Goodman (By phone)
Dave Hanson (In person)
John Howard (By phone)
Jessica Kogel (In person)
George Luxbacher (In person)
RJ Matetic (In person)
Berni Metzger (By phone)
Jerry Poplin (By phone)
Drew Potts (By phone)
Chris Pritchard (By phone)

AB91-COMM-7-3

Robert Randolph (By phone)
Miguel Reyes (In person)
Todd Ruff (In person)
John Sammarco (In person)
Adam Smith (By phone)
David Snyder (In person)
Jack Trackemas (By phone)
David Weissman (By phone)
Dana Willmer (By phone)
David Yantek (In person)

MSHA PARTICIPANTS

Link Bowers (By phone)
Brandon Christ (By phone)
Roger Rude (By phone)
Michael Valoski (By phone)
Stanley Michalek (By phone)
Joseph Robinson (By phone)
Richard Stoltz (By phone)
Greg Rumbaugh (By phone)

Other PARTICIPANTS

Corrine Balcean – Teck Resources (By phone)
Mack Billin – Freeport McMoRan (By phone)
Mark Ellis – IMA-NA (By phone)
Jon Finch (By phone)
Ed Green – Crowell & Moring LLP (By phone)
Kristina Peterson- RTI International (By phone)

Mr. Welsh welcomed MSHRAC Members and attendees to the meeting. Mr. Welsh explained that MSHRAC members participating in the meeting must be free from conflicts of interest. He asked members to self-declare any conflicts of interest that may come up during the meeting and recuse themselves from any discussion related to that conflict, and they cannot participate in voting for that particular matter. There were no conflicts from members reported. Mr. Welsh conducted a roll call to confirm a quorum. He then turned the meeting over to MSHRAC Chair Dr. Priscilla Nelson for the introduction, announcements and approval of minutes.

Introduction, Announcements, and Approval of Minutes, Dr. Priscilla Nelson, MSHRAC Chair

Dr. Nelson read the minutes from the last meeting, May 2017 in Morgantown, West Virginia. There were no suggested changes to the minutes and they were approved unanimously.

REPORT FROM THE NIOSH ASSOCIATE DIRECTOR FOR MINING, Dr. Jessica Kogel

Since 2009 funding for mine worker health and safety research at NIOSH has been between $40 and $45 million per year. The bulk of this funding supports intramural research at the Spokane Mining Research Division, the Pittsburgh Mining Research Division, the Respiratory Health Division and the National Personal Protective Technology Laboratory. Funding decisions are guided by the Mining Program mission which is to eliminate mineworker fatalities, injuries and illnesses through relevant research and impactful solutions. Prioritization is largely stakeholder driven and is based on burden, need, and impact.

Over 50% of mining research funding targets the coal sector but there has been a gradual decrease in funding for this sector from 63% in 2015 to 57% in 2017. During this same time period funding has increased for the metal sector from 11% in 2015 to 19% in 2017, almost doubling over this time period. For nonmetal and stone, sand and gravel, the investment has been more or less flat. From 2015 to 2017, 51% of mining fatalities in the US took place in the coal industry. Injury rates show a similar trend with the highest incident rate in coal mining. The next highest incident rate is in nonmetal. The bulk of mining research spending is in the areas of respiratory disease, disaster prevention, and ground control.

Significant progress has been made on the Lake Lynn Mine replacement project. A site that meets the technical requirements has been identified and about four to six weeks ago a group of technical experts from PMRD, along with representatives from GSA, visited the site. The purpose of the visit was to determine the suitability of the site, visually on the ground, and to begin assessing the environmental impacts that might be involved. Three additional cores are being drilled. The core samples will provide information necessary for determining asking price. Funds are available through CDC for the purchase of a site, however those funds do not include the design and construction of a mine. This is a Greenfield site so, if we move forward with it, additional funds will be required in order to develop a mine.

Participant (Q) - Do you know what type of mine this is?
Dr. Kogel (A) - There is no mine. So we would have to actually construct it.
Dr. Kogel (A) - The timeline for bringing an experimental mine online is fairly long so we made the decision to go ahead with experimental work in Poland at the Barbara Experimental Mine where we completed nine large scale tests. The main goal of this research was to compare the effectiveness of untreated and treated rock dusts. Results of this testing will be shared at the next Rock Dust Partnership meeting in December.

In 2017 significant investments in the Bruceton Mine were made. The main goal was to bring the mine in compliance with modern safety standards. Projects included upgrading the electrical supply to the mine, installing an LED lighting system, purchasing a roof bolting machine to make the roof safe for workers in the mine, upgrading the communication and tracking system and, purchasing modern mine utility vehicles. Some other facilities upgrades that took place in 2017 include a mineralogy laboratory with a new state of the art X-ray diffraction system, a new IH lab, and an environmental chamber.

Staffing has not changed significantly since we last met because of the federal government hiring freeze. In the last couple of weeks Dr. Brenda Fitzgerald, the Director of CDC, has been given the authority to

hire. So we are no longer under the hiring freeze. However, any hiring that we will be doing is going to be done in a very strategic way. Despite the hiring freeze we have been able to make some critical staffing decisions and to fill some key positions. Eric Lutz who was Director at SMRD resigned in June. We were very fortunate to be able to bring in Todd Ruff as our new director. When Todd moved into the Director role we backfilled his position as the Associate Director for Science with Jeff Welsh. Jeff was previously ADS for the mining program and brings 40 years of experience within NIOSH as well. Jeff is still based in Pittsburgh but he makes trips out to Spokane on a quarterly basis.

We are taking a more sector specific approach to how we do our research. There are a number of reasons for doing this. It's very important that we look at the mining industry, not as a one-size-fits-all industry, but as four or five discrete sectors. This is very important in terms of communication. Each sector has similarities and differences. For example, each sector has unique aspects in terms of workforce demographics, methods used for mining, commodities that are mined, and health and safety challenges. We need to recognize these differences and we also need to be able to speak the language that's specific to each of these sectors. The first thing we have to do when we go onto a site to interact with our stakeholders is to be able to, not only speak their language, but earn their trust and show them that we understand their particular language and their particular culture. I believe that this understanding leads to better science. If we can communicate clearly, if we have credibility, we can also make better decisions about the data, identify what the real issues are, and decide how to focus our efforts.

We have launched a program to develop sector specific research plans. The first plan completed is for stone, sand and gravel. The next one will be for nonmetal. It takes about a year to complete the plan and it involves an assessment of the program that determines how well the program serves each sector. We've also hired managing specialists who are senior level experts for each of the sectors. These experts will assist with internal capacity building to make sure that everybody has been exposed to all of the sectors on some level. We're partnering with NSSGA to put together a workshop for stone, sand and gravel that will involve not only learning about the sector, but will also include field trips to mine sites as well.

We have updated our strategic plan. The plan consists of three overarching strategic goals with multiple intermediate goals that address specific knowledge gaps or areas. For example, for reducing mineworker's risk of occupational illness the intermediate goals that we are specifically working on are in the areas of exposure to airborne dust and diesel contaminants. The intermediate goals will change over time. The strategic goals will stay more or less constant. As we address an intermediate goal and solve a particular knowledge gap or problem, we then will bring in additional intermediate goals until eventually we meet the strategic goal.

Questions and Comments:

Dr. Burgess (Q) - What is the significance, Jessica, of the orange and blue checkmarks?
Dr. Kogel (A) - The checkmarks indicate how the presentations that you will hear today map against the strategic and intermediate goals.

Dr. Nelson (Q) - Jessica, can I ask just one question for clarification? You identified the sector specific lens that you intend to adopt. To what extent are these strategic goals and the IGs mapped into that same context?
Dr. Kogel (A) - We're in the process of doing that. We've completed a plan for stone, sand and gravel. That plan is then going to be aligned with the larger program strategic plan.

Dr. Miller (Q) - So just I guess give me the concrete picture. So if you were using, say, the reduced mine occupational illness for the sand and gravel sector, then you would just go through that and apply it to each sector the same way and then come up with your surveillance programs, etc.
Dr. Kogel (A) - Yes. and the other thing that might come out of that exercise as well is that there may be additional intermediate goals that are missing that will come out of a particular sector that we hadn't maybe recognized was important. So yes, that's exactly how it will look.
Dr. Nelson (Q) - Well, I can start off just briefly, Jessica. In early slides there sometimes you add "SSG" and sometimes you keep them separate. But there was a slide on the incident rate where you separated them. And are those additive so if you added those incident rates those would be comparable? As I recall, two of the coal incident rates?
Dr. Kogel (A) - No they are not additive.
Dr. Nelson (Q) - So it would be helpful to know. Because I believe we've gotten used to saying, well, that's comparable to coal. And the incidents, the percentages of incidents were high, right, for SSG? So the basic sense of resource allocation towards tracking that kind of an incident rate doesn't necessarily track across. So I wondered if there are plans to really think differently about SSG.
Dr. Kogel (A) - Stone, stand and gravel will continue to be a major focus for us.
Dr. Nelson (Q) - And that overlaps increasingly into the civil heavy construction work. There's a lot of commonality, so yes.
Participant (Q) - And that's the question I had. You had the percentages. Do you have the numbers of fatalities? Are you going to go over that this afternoon?
Dr. Kogel (A) - I don't think it's in the presentation this afternoon but I certainly can share that with you.
Participant (Q) - Okay. I would appreciate that.
Dr. Nelson (Q) - Yes, because it was in percentages. So if you knew the total over that two and a half year then you could figure out the numbers.
Participant (Q) - Right. That would be my question too because of certain industries have such higher percentage of individual workers in those employment sectors.
Participant (Q) - And you're seeing the percentages spike, especially SSG.
Dr. Kogel (A) - The percentages aren't necessarily spiking in stone, sand and gravel. I just think we haven't really focused on it.

Dr. Nelson (Q) - Let me ask about, first of all, this March we talked briefly about this workshop but I don't recall exactly the focus that was ultimately decided on. Is it appropriate for MSHRAC members, if available, to participate in that or not?
Dr. Kogel (A) - The workshop is going to be focused around our stakeholders and bringing them together to discuss the intent of the Miner Health Program and to get their input in terms of priorities and concerns. This is a multi-decade program that's going to start with a focus on western miners but will eventually include all regions of the US. It's important that we have really strong stakeholder buy-in, not just industry, but labor and everybody else who has an interest in this. This meeting will be our kickoff to the process.

Dr. Nelson (Q) - On the earlier chart you had intramural and extramural funding levels for the research, there was a pretty precipitous decrease in extramural funding. And there may be all sorts of reasons for that but I'm wondering about the plan. Because if you extrapolate from where you were it's going to go to zero extramural. So is there a target in your mind of what that profile ought to be looking like?
Dr. Kogel (A) - Changes in funding are related to the MINER Act and special appropriations that were made soon after it was passed.
Dr. Nelson (Q) - Well, I think early, back four or five years ago, it was up to 20 million and now it's more like five.

Dr. Kogel (A) - Over time I can envision a scenario where extramural funding may grow even if we assume that overall funding levels stay flat. This is because the intramural program may shrink because of retirements for example. In that case funds could be used to contract out some of the research that had been done in-house if we were in a situation where we no longer had the expertise within NIOSH. Our goal is to retain the expertise in-house but we also need to look at all possible solutions and one of them is to grow the extramural program which could make sense strategically.
Dr. Nelson (Q) - So if there's any clarity I think that the universities would greatly appreciate that because they don't understand what's necessarily going on and what the future might hold.
Dr. Kogel (A) - I should mention that extramural funding goes to both universities and private sector.

Mr. Watzman (Q) - While we're on the subject of funding, if I remember correctly the 2017 budget was north of 50 million. I think 57 or somewhere in that range. But you show funding of 42.4 million. Can you walk us through the delta there? Where does the other $18 million or so go?
Dr. Kogel (A) - The delta is related to funding that goes towards facilities and shared services provided by CDC such as IT.
Participant (Q) - Do you know offhand what your shared service cost back to CDC is?
Dr. Kogel (A) - I do not know offhand.

Dr. Nelson (Q) - You talked at a certain point about the future of the mining industry. And there's several efforts going on in the industry to define what the future of the mining industry is. So I'm wondering, are you going to come out with a statement as to your concept of the future for the mining industry? And is that going to be a part of the strategic plan that we might see next week or what?
Dr. Kogel (A) - Jeff is going to talk about the "Automation and New Technology Team" which addresses the future needs of the industry and how the NIOSH Mining Program will position itself to meet evolving stakeholder's needs.

Update from the Pittsburgh Mining Research Division, Dr. J Matetic

Good morning! I'm going to provide you with an update from the Pittsburgh Mining Research Division. I want to cover a few areas: Organizational updates, that means staffing and people; an overview of our current and past research portfolio; some new products and impacts that we've had since last MSHRAC meeting in May; and then, an overall discussion relative to any questions you may have.

This is what we currently look like since the last MSHRAC meeting, regarding our current staffing. You can see the number of staff has decreased by eight. This is a trend that continues. And, as Dr. Kogel mentioned, it's very difficult to maintain levels of staff given the current climate we are in regarding the hiring freeze. You do see we have 205 positions proposed. What that means is we're able to get to that level if we can. Actually our approved MASO package that was developed numerous years ago accounts for 260 people for the Pittsburgh Mining Research Division. The 205 number that has been agreed upon between us and NIOSH OD. Another key point here is how many people can retire within three years. And obviously the number has dropped since last MSHRAC because people did retire. But, as Dr. Kogel mentioned, the workforce, in the next five years, I believe, 50 percent of the mining program can retire. That doesn't mean they will. It just means they're eligible to retire. But we're looking at fixes. And these fixes are mainly to maintain the depth and breadth of the portfolio that we have given the constraints and barriers that we're dealing with.

We've developed a workforce development plan that we utilize for all researchers and employees within Pittsburgh. This plan includes 300 technical competencies that we've defined as needed currently and moving forward for our program. So we define these competencies, we rate these competencies, we have employees self-assess themselves and we have managers and supervisors meet with employees to make sure the ratings are in agreement. From there, as a program, we look at needs relative to the program based upon technical competencies. So this provides us an opportunity to try to sustain the depth and breadth of the program. But it also provides us a unique quality too, if there's something regarding stakeholder needs, meaning things that have to happen sooner than later, we can use these competencies to determine where we can place people because they have the competencies in certain parts of our program to improve or excel in the needs of the stakeholders. So we're currently using this right now in Pittsburgh.

This slide shows where we were in FY17, where we are headed in FY18. In FY17 three projects ended. And, as Dr. Kogel mentioned in one of her slides, we have added five projects to the portfolio in FY18. This slide represents the distribution of the projects related to industry sectors, you could see kind of the similar trend that Jessica mentioned in one of her slides where there has been an increase in stone, sand and gravel, industrial minerals, and metal, and a small decrease in coal from the portfolio comparing '17 and '18.

These are the five new projects. The first two you see there, advancing exposure monitoring, and, advancing strategies for controlling exposures to diesel, aerosols are carryovers, from '17 these two topics were actually one project. So we continued in '18 with those topics but we also separated them out to have two separate projects instead of one. I'll talk a little bit more about that. We're looking at a new project, investigating hearing conservation program elements and how they're used and how successful they are relative to noise exposure and hearing loss. This effort would be specifically conducted at stone, sand and gravel operations. And then we have two pilots, one looking at the minerals and materials research that we're planning on conducting, and also you'll hear more from Miguel Reyes today on the pilot regarding automation and the intended and unintended consequences in a health and safety sense related to automation as the industry moves forward.

These are the four aims, for the exposure monitoring project. One is obviously optimized silica monitoring. I think I spoke in May regarding the end-of-shift silica monitoring approach for respirable crystalline silica. That is ongoing. We're currently beta testing that approach at seven surface metal mines, one underground coal mine and actually an oil and gas frack site in Texas. So these operations are beta testing this approach and we're planning, in '18, to have the software completed and the approach completed to the point where we can distribute and implement this to all of industry.

We need to look at improving DPM sampling and quantification. That's a part of this project as well on the monitoring side. And also if you're not familiar, we have the regulatory authority to approve any new or "existing," dust sampling devices under 30 CFR 74. So that's always a part of a project within our portfolio. Moving on to the controlling exposures to diesel. Those are the aims that you see on the slide there. Develop exposure reduction technologies and strategies. We're going to take it a step further to develop those to the critically effected occupations. For example, LHD operators, drillers and blasters, scalers, truck drivers, etc., those occupations that have shown an increased risk in DPM exposure. So we're going to look at interventions specifically related to those types of occupations. We're also currently evaluating advanced engine technologies. We're actually doing that in our diesel laboratory in Pittsburgh currently. Once we look at that relative to the lab we'll take that in the field and measure the effectiveness.

Another aim is to Evaluate Canopy Air Curtains. We have developed canopy air curtains in the coal sector for roof bolting machines to reduce respirable coal dust. As Dr. Kogel mentioned, the curtains have been developed, in cooperation with the Fletcher, Inc. Currently there's 40 of those in the industry which represents, a 10 percent market penetration. We're currently looking at Canopy Air Curtains for shuttle cars in the coal sector. But we're also going to take that technology and look at how we can use that type of technology to remove or help in reducing DPM exposures. So that's part of this project as well.

We have conducted a tremendous amount of research, two decades, on disposable filters, filtration and pressurization systems. So we're going to look at advanced technologies in those areas to improve reductions in DPM exposures to operators as well.

Participant (Q) - Were you also going to look at standard gases at the same time?
Dr. Matetic (A) - Yes.

I mentioned we have a project that will be conducted at several stone, sand and gravel sites where we'll look at the hearing conservation program and the respective elements associated. There are several specific aims that this project will implement. One would be to develop spatial sound level maps of the operation itself. This will give operators/workers an understanding of where the highest noise exposures are relative to machines or operations at specific sites. We'll also evaluate hearing loss risk for stone, sand and gravel mines. That characterizing hearing loss in relation to noise exposure and determine an understanding of that relationship. This could be looking at audiometric interventions based upon the hearing conservation program itself. We'll look at identifying barriers to the solutions. There's always barriers, sometimes environmental, sometimes technical, sometime economical, that we need to look at to work with the companies to make sure that it is a viable solution and they will implement it based upon the exposure benefit. And we'll also look at all of the other stone, sand and gravel hearing conservation interventions going on and implement and include those into the overall approach regarding looking at the seven elements of the hearing conservation program.

Dr. Nelson (Q) - Do you take frequency information as well or just decibels when you're...?
Dr. Matetic (A) - Well, we do third octave band testing as well to get a sense of what kind of noise is being generated and what certain frequency or frequencies are dominant. So if there is a control technology that we might need to develop, we understand where the dominant frequency levels are and where the highest are to then try to attack it through a noise control solution. So it will be both just general decibel information from like a dosimeter, but then we'll also use meters relative to frequency and third octave bands to capture frequency information.
Dr. Nelson (C) - It would be interesting to become more familiar with the frequency content of noise in sand and gravel. Because I think part of the cancellation strategy is frequency-predominated rather than db but—
Dr. Matetic (A) - Right. And that's always part of the noise control approach. You have to understand your noise content and what frequencies are more dominating than others. Because if you don't understand those you have no idea how to implement a control to reduce noise at those certain frequencies. So yes, that information will be gathered as well.

Minerals and materials research. We have several aims. This is a pilot that will be conducted in FY18. One of the aims is to confirm the suitability of reference samples that we currently have collected in the field regarding anthophyllite asbestos and actinolite-tremolite asbestos. We'll publish the characterization

analysis of those samples. We'll then, in turn, release those samples to the public. And eventually we'll produce a white paper regarding the development of a roadmap for how we're actually going to move forward relative to this respective research.

Participant (Q) - What's the intent of the reference samples? How are those going to be used?
Dr. Matetic (A) - Well, we'll do the characterization of the samples. We'll, in turn...with help from RTI (contractor) produce those samples and then if people want to use those samples for further analysis they will be available. Those samples will be available to do so. Isn't that correct, Jessica?
Dr. Kogel (A) - Yes, and I think those came out of the NIOSH roadmap and then the NAS recommendations after the publication of the roadmap and the need for well characterized samples in a place where researchers could go and acquire those samples to use in their research. And so this is addressing that and it will be the kind of first steps towards creating a repository of well characterized materials for research.
Participant (Q) - Is this for the sand and gravel specifically or just general across—
Dr. Kogel (A) - It's for whoever—
Participant (Q) - Different type of mine environment.
Dr. Matetic (A) - Right.
Dr. Kogel (A) - Yes. For whomever would like to use these minerals for their research, whatever it may be.

We have a pilot looking at automation, as I mentioned. And this will be to understand the intended or unintended consequences that come out of automation in a health and safety sense for the mining industry. So the idea after this one year pilot would be to develop another roadmap on how we actually move into the future relative to research regarding automation.

This slide represents the outputs generated from Pittsburgh since last MSHRAC meeting in May, so that's about six months. There's 102 of them. You could see we do break those out into science and translational outputs. And I discussed at the last MSHRAC meeting the importance of the translational. This has been something that we've introduced in the program for the last, probably, year. And these translational outputs are important because these are the outputs that are getting to the people that need to actually use the intervention/the technology/the strategy to make a difference at the mine site itself. So you see the distribution, 58 percent and 42 percent. We're not saying that the science is not important. That is our number one priority. We need to maintain science integrity and science quality. And we have to develop those to prove the science before we can obviously translate that into a usable form for people to use. So this is just the distribution of those outputs. This is how they look relative to the different sectors as far as the last six months of outputs in coal, stone, sand and gravel, industrial minerals, metal, and, oil and gas.

I mentioned at the last—I think I actually presented an additional presentation at the last—MSHRAC regarding stakeholder interaction and partnerships. I can't stress enough the importance of these If we don't have stakeholder engagement/MSHRAC engagement we can't get to where we need to be. And these are highly important for the future of the mining program and the success and implementation of these different interventions/technologies/practices. Since the last MSHRAC meeting we conducted a Breathing Air Supply Partnership in June. We also at the same time conducted a Refuge Alternatives Partnership meeting which I believe Dave Yantek might mention or speak about. We also were part of Longwall USA where we provided six presentations and an exhibit there. We also attended and participated in the Bluefield Coal Show. We actually sent the hearing loss prevention unit there. If you're not familiar with that, it is a four person audiometric trailer that we pull to different mining locations, mine

sites, conferences, associations and we can audiograms right at the site. And we also use the trailer for the development and testing of worker interventions or worker empowerment tools to better improve their hearing protection regarding hearing loss. The Diesel Health Effects Partnership was conducted at MSHA Triadelphia this last September. In addition, we also conducted a webinar on methane control. That was attended by 70 people, both domestic and international.

Upcoming. The Underground Stone Seminar will occur December 6th in Louisville, Kentucky. As Dr. Kogel mentioned, we'll have a Rock Dust Partnership in Pittsburgh. It will either be December 4th or 5th. And there was a notice already sent out to interested parties. The SME conference is coming up in February. We'll have 28 papers and presentations that will be presented along with an exhibit at SME. I want to call out a thank you out to the NSSGA. We will be providing three workshops at their AGG1 conference in Houston, Texas in March. Topics that will be included is hazard and risk assessment, slips, trips and falls, related to MSD research that we're conducting. In addition, we will conduct Proximity Detection and Refuge Alternatives partnership meetings in the spring of next year.
As I mentioned, stakeholder collaboration is critical. We are tracking this. I won't go into it in detail in this slide because I think Todd and I will provide you with an update on domestic and international collaborations that each program is working on. So I'll show you that later today.

Some new products. The hazard challenge. I think you have heard about this, we presented the hazard recognition work last May. Right now we have an online application that people can use. It's called the Hazard Recognition Challenge. They'll go through four scenes, one at the shop, one at the plant, one in the pit and one on a roadway. And they'll have a 3D view of looking at certain situations and then identify the hazards. If they identify the hazards or not, the application will provide them with solutions to the hazards that they either have identified or not. And right now it's just been on the web currently. I think we've had like 200 looks at this already. So I highly encourage you to go to the website and do the challenge and tell me what you think about it. But this will lead to a standalone which we're going to call "EXAMiner." So the the EXAMiner will be the next output to the hazard rec piece that is shown here. Because we'll allow the user to implement their own pictures and then be able to conduct training regarding their own sites, utilizing their own pictures. This will be applicable to all mining sectors. This is obviously stone, sand and gravel but the EXAMiner will be able to look at all sectors so we're excited about that.

And I handed out some infographics to you around the table. These are just four that came out of current research being conducted at the PMRD. Remember, there has been some discussions at previous MSHRAC meetings, on Helmet-CAM and the success of that technology with the EVADE software. These are just some infographics that came out of the Helmet-CAM work that are around the table. If you care to look at them I brought some with me. So these are to the point, one-pagers, please take it to the mine site. Hopefully people take 30 seconds to look at it. And these are just examples of simple things that you can do to reduce exposures to respirable dust. And these interventions were determined through the Helmet-CAM investigations.

One of the things I'm doing in the program is to generate a process that provides relevant information at the mine level. And you'll see from our collaborations, I think in our current portfolio we have been to 220 different mining operations. And I was thinking if we're going to that many mines we should be taking something with us. And so we're in the process of putting together packages for different sectors that we can demonstrate quick simple fixes to common problem. Any researcher, whoever is going to these operations, can just grab this packet and get it to the right people at the mine site to maybe post on the

bulletin board, put on their TV, what have you, just to make sure that we're getting this information out there in different ways. Obviously we use social media, we use our website, but I'm thinking this is just another opportunity to take information to the mine sites for implementation. So that's something that we're considering.

Mr. Zimmer (Q) - Are these available online?
Dr. Matetic (A) – Yes, they're available online as well.
Dr. Burgess (Q) - Do you have a plan for evaluation of the effectiveness of these?
Dr. Matetic (Q) - Jeff, that's a very good point. We don't currently, but that's something we are currently working on. In the previous slide I showed you with EXAMiner and the Hazard Rec Challenge, we're developing a protocol to test effectiveness once it's completed. We should be, and that's a good point. I think we need to think about how we actually could maybe do that and implement that to a point where we could determine how effective that process was in getting the information out. So we need to think about that. It's a good point.

These are some impacts that I mentioned earlier. I spoke a lot about these already. The end-of-shift silica monitoring, EVADE and Helmet-CAM. EVADE and Helmet-CAM has now reached over a thousand downloads which is really awesome. End-of-shift silica monitoring is coming real soon, as I mentioned. The Canopy Air Curtain, the penetration into the market is great. Again, now we're looking at shuttle cars. And then eventually we'll look at potentially curtain technology to eliminate or remove some DPM exposures. The safety page, remember that? I showed you at the last MSHRAC meeting. This is a tool that's online currently as well, where you can look at injuries and costs associated and how operators and companies can reduce costs by minimizing injuries related to their specific operations. That has had a thousand downloads already which is really good as well. So we're excited about these products.

Questions and Comments:

Dr. Nelson (Q) - I would like to make a request, just initially. Your competency mapping, I would really be interested in, not the individual people, but overall, your list of keywords that you use for the competencies and how those are distributed. That would be interesting for me to understand exactly what the capabilities you have that you can draw on are.
Dr. Matetic (A) - Okay.
Dr. Nelson (Q) - And I could probably steal them for other purposes too, so if you could do that, that'd be great. And a suggestion. You have health and safety work, and IT, and so if you put that together—if you make it stand alone I think it's going to be limited because it's sort of incremental, but with all the work going on right now on predictive maintenance and lots of other data stream flows, the idea of working together with people, even though it's not in your mission, but—working together with people who are developing capabilities on predictive maintenance there might be a very strong piggyback or synergy possible in that context. So I mean, think about, not just solving the problem that you have, but the fact that there's a lot of things going on right now that you could work with and to.
Dr. Matetic (A) - Yes. Thank you.

Dr. Miller (Q) - I just wanted to kind of piggyback onto Jeff's comment a minute ago. But you have a number of products in line there. And thinking through the evaluative process of those as part of your kind of rollout might be helpful because you're kind of thinking more upfront. And whether you do something through contracts or even as people work through them then they could also plug into an evaluation program. Just trying to...so you can keep those metrics and feel about how is it working, are we hitting the

marks, are we getting it out to people, is it useful. And just we've been doing that with some of our programs too and it's hard to do but it's helpful if you can get into that space, especially as you're building them out.
Dr. Matetic (A) - Right. Thank you for that.
Dr. Burgess (Q) - So I wanted to declare at University of Arizona we have one of the U60 Western Mining Training Programs. But I think that there's great opportunities for you to make sure that you partner with those existing U60s in terms of some of your training, like hazard recognition. So I think it would be a great idea to look at complementary strategies so that you can kind of increase the reach, both of what you do and they do as well.
Dr. Matetic (A) - Exactly. Thank you. Yes.

Mr. Zimmer (Q) - I just wanted to complement you on the development of the materials that you've been putting out. Having reviewed a couple right here, one think that I think the safety industry has lost is the ability for the end user to take a quick look at it, process it, and make a decision on how it's going to affect his daily operations. And just this short, little, simple message on dust on cloth seats is so effective for a worker. And I just want to compliment you on how it turned out. It was very well done.
Dr. Matetic (A) - Thank you.

Mr. Bowerson (Q) - Yes, just a question on the diesel emission testing. Will that be underground, in surface, above?
Dr. Matetic (A) – Yes, we are focused primarily at metal mines at first but, yes, it'll be both.
Mr. Bowersox (C) - Good. That's good.

Dr. Nelson (Q) - EXAMiner. Are you thinking about the possibilities of moving towards a real virtual reality environment instead of the photo driven? The technology is there to do all sorts of things. I'm wondering if there might even be some kind of a survey, technology survey, or some kind of a pilot project that might see what you could bring in virtually.
Dr. Matetic (A) - Yes. While you were in Pittsburgh I assume you saw the VISLab. I just had a conversation with the branch chief that's responsible for that facility and spoke to her about how we can use that type of technology on mobile type phones, tablets, in a virtual sense. And she said, "Yes, we can do that." And we need to. Because it's a major investment that we've made regarding the VISLab. We have to get an understanding of how important it is moving forward, given, as you mentioned, all these new technologies that can be used in a virtual world other than just the facility itself. So we're already in discussions regarding that.
Dr. Nelson (C) - Good. Because the effectiveness of that is order magnitude more than not.

Mr. Wright (Q) - Could you talk a little more to me about the end-of-shift silica monitor and what exactly you're doing and how it would work?
Dr. Matetic (A) - Right now, like I mentioned, we're beta testing at seven metal mines, one underground coalmine and one oil and gas site. And it's using FTIR which we've proven through testing that is probably the most reliable method to do it with. So each of these sites has the instrumentation needed. So they'll take a sample, and in less than three minutes, they'll receive the results of the sample. And the results from lab testing has been very good in relation to the NIOSH analytical method and the methods that are out there that are proven to be successful. So by next year we're hoping that the software is going to be complete. This project that I spoke about will continue to make sure and conduct checks and rechecks regarding the method itself. But by next year we're hoping that all of this information is available so anyone at any site can take a sample, get the results in less than three minutes and have the ability to make

decisions real-time instead of waiting weeks for the sample to come back from the lab to implement any intervention.
Mr. Wright (Q) - (Inaudible).
Dr. Matetic (A) - Yes, it does. And in the software you will receive all the information regarding the analytics once the test is completed.
Dr. Nelson (Q) - How big is the instrument?
Dr. Matetic (A) - The instrument itself is, I don't know the exact dimensions, but it's smaller than a shoebox. So a sample would come in from the site, they would insert the sample into this smaller than a shoebox instrument and the instrument, given the software that we developed, will provide the information regarding the analytics of the sample itself.
Mr. Wright (Q) - (Inaudible).
Dr. Matetic (A) - Yes, it's a filter specifically designed for that method.
Mr. Wright (Q) - How does it handle situations where there is high concentration of non-silica dust?
Dr. Matetic (A) - That's all part of the testing, Mike, to try to... determine those confounders that exist. I don't know exactly how many tests we've conducted, at least a thousand tests, to try to look at the confounders and determine, in a quantification sense, what is the best method to use and this is how we came up with was the FTIR. And then moving forward from there continue to sample in a way to make sure that we continue to meet the expectations regarding NIOSH standards as well, regarding crystalline silica exposure.
Mr. Wright (C) - Okay. Thank you.

Update from the Spokane Mining Research Division, Mr. Todd Ruff

Good morning! I just want to take a minute and introduce myself because I know that I'm new to many of you. I started with the US Bureau of Mines in Spokane as a student intern while I was studying electrical engineering at Gonzaga University. I worked on my bachelors and master's degree there. At the US Bureau of Mines, I worked in automation, mine instrumentation, on the mine technology side of things. And went through the transition through NIOSH in the mid-Nineties. And after that I developed some expertise in collision avoidance technologies. And then I took a break in 2011, I went to private industry to work with a startup that was working on collision avoidance and other mining technologies for surface mining.

In 2016, as the new division in Spokane was forming, they were hiring for the leadership team there and I took a position as ADS, the Associate Director for Science, as Jessica mentioned. And then, Eric Lutz the current director, left NIOSH and I was very excited to have the opportunity to lead the division and have an influence on where we go over the next few years. So here I am and let's get started.

I have some overviews of where we're going in Spokane; less on the administrative and organizational side, more on the technical side. So I wanted to cover, just as a refresher, the four program areas that we concentrate on in Spokane. Those first two are really historically the foundation of Spokane's research. We have seasoned and internationally known experts in the ground control side of things, for both underground metal mining and western underground coal, with mining-induced seismicity, and stability work.

Here are some new areas that we're getting into. We have a new team that's addressing emerging technologies. I'll expand on that but we are looking at the technologies that are coming out and that are

used in other industries that have applicability to health and safety in mining. And then also looking at the new technologies being introduced to US mining, especially where we need to understand the safety implications.

Finally, as we've talked about before, the Miner Health Program. Studying miner health and chronic disease is also a new area that we've started up the last year.

We have 40 researchers in Spokane, split into four teams. And the teams are organized around those program areas I just discussed. So for each of these teams I'd like to go through some highlights, what the current projects are, some accomplishments and where we'd like to go in the future.

For the Metal Ground Control Team we have two ongoing projects. Durable support for western underground metal mines; this is looking at support technologies and ground control monitoring technologies for the underground metal industry. And then alternative mining methods started up last year. And that's looking at the challenges associated with going deeper and mining through weak rock mass. Surface mines, like in Nevada that are going underground, are encountering rock conditions that require some special attention.

So just quickly through the accomplishments. Jessica had mentioned that our mining partners depend heavily on our recommendations based on empirical methods in the field and testing in the lab, along with implementation and verification in the mines. Durable support focuses on new support technologies, such as rock bolts, and new combinations of technologies. For instance, bolts and mesh and shotcrete and what order do you install them. And also the mines that we work with are in narrow-veins and cut-and-fill stoping methods are prevalent. And there's a lot to do in understanding backfill strength properties and the safety of the mine design based around backfilling the openings.

I'd like to take a few minutes here in a couple slides to talk more about our ground control research and the implementation of an Internet of Things based sensor network for monitoring ground control elements. For the coming year the Durable Support Project has been developing test procedures and recommendations around individual elements of support. So they'll test bolts, they'll test mesh and shotcrete. But now we're having mines come to us and say, "What are your recommendations for installation sequence?" So we're going to combine technologies, but do we install mesh and bolts and then shotcrete over the top of that? Or do we do the shotcrete first?" This is something that we're going to be taking a look at over the coming year. The Durable Support Project also has a corrosion study component that's looking at corrosion of mesh and bolts. And we'll be expanding that work. It's primarily done at Greens Creek. They have real issues with the corrosion of their support. The Internet of Things based sensor network we'll talk about in a minute, but that's going to be expanded into additional mines. It's at Montana Tech experimental mine right now, running as we speak. But we see lots of applications with our other partners.

In hardrock mining we have mines talking about continuous hardrock mining and how the mine design has to change around that. There's potential here for 3D visualization tools to be used for monitoring and risk assessment for ground control.

Here is a quick overview of the Internet of Things based technology. When I started with the Bureau of Mines, I remember one of my projects, I'd go underground weekly at a mine site to collect data from a data acquisition unit that's hardwired to our instruments that are underground. Well, that's changing. We

can now get this data over the internet and monitor our instruments real-time. It's a great tool for research but it's also a great tool for the mine to get real-time data on their ground control and stability data. So the idea here is that you have instrumentation embedded in the support technology like in a rock bolt. I'll show a picture of how this looks. So that you're doing the data collection at the bolt and there's a radio in that instrumentation that talks over a mesh network to other instrumented bolts or sensors in the mine. So the signals are hopping from unit to unit. And so it does away with the hardwire connections. And then that mesh network carries the signals to a gateway that connects to the mine's communications infrastructure. That infrastructure then takes that out over the internet to cloud-based storage on the server. So from that cloud the researchers can then access the data in real-time and the mine has access to that too.

Here's a quick look at some of the sensors that we've developed so far in-house. So the gateway is off-the-shelf technology repackaged for the underground and reprogrammed. The gateway is mainly the data hub. It's bringing in the data and taking it out of the mine. Carl Sunderman was here maybe a year and a half ago and gave a presentation on this. Data collection hardware for a bolt that's instrumented with strain gauges can slip inside a split set. This is battery operated and can go a couple years, They periodically send data over the mesh network.

Another example of what we developed is a wetness sensor for the corrosion study to give us environmental data on the humidity and moisture in the air, or moisture on the actual sensor itself. Now we need to move to commercialization. We're getting enough requests from other mines to implement this type of thing—Stillwater is one of them, Greens Creek—we need to move towards commercializing this and get it out on the market.

The Mining-Induced Seismicity and Stability Team is concentrating on one major project, detecting and managing dynamic failure. The goal here is to make sure that we understand how geology is affecting the risk of bumps and bursts in underground coal mines. One of the challenges we had that has stalled this project early on is the downturn in the industry. We just had a hard time getting partnerships and we had to have those field partnerships to do the work. But that's turning around now. And it's not that they didn't see a need for this research, it's just the mines didn't have the resources to commit to an extra effort like this. But now the team has been doing a great job. We're going to hear more from Dr. David Hanson today. We have three underground coalmines that are participating in this project now.

Some of the other things that have come out last year was that a free and user-friendly finite element modeling product for underground coal, UTAH3PC, was co-developed with University of Utah and available through them. We also have a DRIFT software package. This is a software package that optimizes blast hole layout. And it also minimizes overbreakage. So that will be available soon and I'll give you more details on that.

We have certified drone pilots. So one of the inputs to our modeling and the risk determination for underground western coal is subsidence. And one of the things we're struggling with is monitoring subsidence in a real-time or a more optimized way than going out and surveying. So we're using UAVs and aerial photogrammetry to monitor subsidence.

One last thing, and I just like to bring this up because we have a lot of new engineers, young people coming in, and they want to use the tools that they used at school. And that's stretching our paradigms, especially in the area of software development. Because they want to use the open source programming

and online programming community to help develop software. That makes us a bit nervous but we are working towards this because we really want to be relevant and we want to use the latest tools. GitHub is one of those tools. It's an online community helping us develop our seismic data analysis software.

Another new team that I mentioned is the Automation and Technology Team. We have two new projects on that team indicated by the red dates there. New strategies for reducing airborne contaminants; that's looking at dust in mills. It's a problem. A lot of the mills have trouble meeting the MSHA limits for exposure to dust. This is looking at computational fluid dynamics and localized dust collection systems to reduce dust in mills and plants.

The second new project that we have on this team is—RJ talked a little bit about this and we're working with Pittsburgh on this— developing a field-portable DPM monitor. This is critical work in getting real-time data to make decisions about diesel exposure and how you mitigate that.

Participant (Q) - So Todd, how is that different than the current DPM monitor that was developed and is being used reasonably extensively?
Mr. Ruff (A) - What we're trying to do is first miniaturize the technology. We want to get it belt-worn eventually. I mean, this is down the road a ways but that's one of the goals. But the other thing is the method to measure EC and OC is a challenge. And so that's what we're working towards - a system to monitor both. So you get total carbon based on, not an estimate of the ratio, but actually a measured amount of EC and OC. But there's different ways to do that. We also recognize the potential of using FTIR and also perhaps LIBs, laser-induced breakdown spectroscopy, so we'll be looking at both. And this is an effort that's long term. Does that answer your question?
Participant (C) - Yes, thank you.

Moving to the Internet-Enabled Conveyor Monitoring System, this is a project that we have that's funded by the CDC, actually. It's supplemental funding. And this is working with the stone, sand and gravel industry to look at improving the situational awareness around the maintenance activities that go on at a sand and gravel pit involving conveyors and other processing equipment. And I'm going to actually share a little bit more about that.

Miguel is going to talk more about this but one of the new initiatives we are looking at is emerging technology, specifically automation. We have a collaboration with Barrack Gold as they look to implement automation on part of their truck fleet at one of their mines.

Goals for the coming year. Like I mentioned, we have full project funding now for these two new projects - a new DPM monitoring system and looking at dust in mills. We just got word that we had an additional year of funding for this Internet of Things based maintenance monitoring system. I'll talk a little bit more about that.

One of the things that I'm going to be very interested in is input from the committee in the future for ideas around emerging technologies. We will be working to form a partnership to work with stakeholders to identify safety concerns and research topics, around new technology that's in other industries and being introduced to mining, and also this question around the safety implications of automation. More on that later.

Here is some background on this Internet of Things system for maintenance monitoring. We're working with OldCastle materials, a central premix cement facility, near Spokane, Washington. And one of the challenges they have is around situational awareness during maintenance. They have lockout tagout procedures but they still have challenges. In fact, they had a fatality related to the equipment you're going to see here. It involved cleaning inside of a mixer when the system was not locked out properly. It was started up while someone was inside it doing maintenance. So this was a real hot topic for them. We came up with the idea, based on the technology that you saw for the underground mine instrumentation, same thing can be applied to other sensors in other industries, of course. In fact you see an industrial Internet of Things protocol out there already in processing and manufacturing. So this is just applied to the maintenance process. And it's meant to run alongside the existing lockout takeout procedures. It doesn't replace anything but it increases the situational awareness of what's going on during maintenance.

You see the plant there and then Dr. David Parks, he's the PI on this showing the user interface in the control room of the cement mixing plant. They shut down the equipment, lock it out at the end of every shift and they crawl inside the cement mixer to clean it out. And so we are monitoring the critical lockout points and the critical access points around that machinery. And so you electronically enter maintenance mode and the system, then, with wireless sensors we're monitoring the status of the main lockout, the main power switches, also access gates and doors to that area. And all that information is fed over a mesh network to a gateway that goes out on the cloud. And then you can access that information on a user interface, either on your smartphone or on a computer screen in the control room. That information is provided to the maintenance foreman. And so if someone was to enter that critical hazard area around that mixer and they weren't in a maintenance mode and things weren't locked out, they get text messages, they get alarms. Because you have circumvented or you have entered a hazardous zone without locking out the equipment. So that was the first phase that we've shown at OldCastle. They're very interested in expanding that to the conveyors and other machines onsite. So that work will continue into next year.

The Health Exposure Assessment and Monitoring Team has two new projects also indicated in red. Predicting the impact of heat strain; that was a pilot last year and this year is a full project, to expand the study to more mines and also look at the effect on cognition that heat strain may have on a person. And looking at ways to reduce the risk of heat illness.

We have a pilot project, translation of hand-arm vibration to the hearing canal. And this is a preliminary study looking at how vibration from equipment can translate up through the skeleton to the hearing canal. It's a mixed exposure issue. So you have noise traveling through the air to the ear. But we also are wondering about—and I know there's been a lot of question about—additional exposure from the vibration from equipment to the hearing canal. So that's the preliminary study to inform a larger research effort if it's needed.

Tim Bauerle is going to talk more about the fatigue modeling project.

Clinical and field data analysis of miner health is a pilot project also that's looking at alternative sources of health data. We can get the injury and fatality data from the MSHA database. But we need other sources, particularly from mining companies that collect health data and the state-based clinics that collect health data, in order to make this determination of a link between mining and chronic disease, if there is one.

We already talked about the Miner Health Program so I won't go into a lot of details here of what that is... Jessica covered this. But just maybe just a few more details on the activities and what we plan to do. We

had mentioned for this year already that we'll have this NAS meeting, March 2018. And we continue to define this program. The Miner Health Program is really the framework that we're going to use to organize this effort, help us define the research, provide the funding mechanisms and the mechanisms to reach out for partnerships.

Questions and Comments:

Dr. Nelson (Q) - The issue of corrosion is being pursued by the National Academy of Engineering, the committee, COGGE (Committee on Geological and Geotechnical Engineering) and—
Mr. Ruff (A) - We're on that, yes.
Dr. Nelson (Q) - COGGE had a workshop about two weeks ago/three weeks ago and I was not aware of any presence of the mining industry at that meeting.
Mr. Ruff (A) - Amy Chambers is our researcher and she sat in on that so I hope—
Dr. Nelson (Q) - Did she sit in on it?
Mr. Ruff (A) - Yes.
Dr. Nelson (C) - I think there's a whole lot more crossover for the steel in contact with earth materials.
Mr. Ruff (A) - Absolutely, yes.

Dr. Burgess (Q) - So one issue with your DPM, to consider for the DPM monitoring, is the existing unit has significant problems with drift at low level concentrations. So if you watch it, it will just kind of continue to go up. And so you have to reset it pretty frequently. And so I think that, if you could while you're developing it, consider the application for low level exposure settings that would be very helpful. Specifically, California has a regulation that's five micrograms per cubic meter so well below the 160 but there's a great need, I think, for monitoring at these lower levels even outside of mining. So please, if you could, keep that in mind and consider being able to measure low level exposures. I think it would expand the applicability of your unit well beyond mining.
Mr. Ruff (A) - And that's important because if you just do mining you may not have a market. I mean, if it's not big enough. So it's very important to look at other industry, for sure.

Participant (Q) - Your Internet of Things work. Are you installing additional communications infrastructure or are you running off the mine communication infrastructure?
Mr. Ruff (A) - Once we get to the gateway we connect via Ethernet to the mine's network and it goes out of the mine to the cloud server.
Participant (Q) - Or do the mines have wireless meshes that you're using, though, or—
Mr. Ruff (A) - No. Not yet. We're, in both cases, using wireless mesh technology to a gateway that goes straight to Ethernet.

Participant (Q) - I was thinking a little bit, too, about as you were presenting the discussion on health surveillance. And I don't know how the mines do it. But do they have hearing conservation programs or standardized surveillance programs, that then you could tap into and see and look at some of the technologies, and how they're being placed and the evolution of incidence rates of, say, noise-induced hearing loss, etcetera?
Mr. Ruff (A) - Yes. And that's what we're determining now, who is doing what, what's available, what data they're collecting and how useful that can be to our study. So that's something that this pilot project is looking into. Yes, many mines do. But how accessible the data is, is a question, and is it useful data

MINER Act Contracts & Grants Program Update, Dr. George Luxbacher

I'm going to start my presentation with a slide and end with a slide that show pictures of some current work. On this first slide you see the conceptual flow path for a miniaturized CPDM that also will include silica measurement; this is from an ongoing contract with the University of Illinois, Chicago. On the last slide, I'll show another picture of some other work we have going on.

I'm going to talk about both contracts and grants in my presentation. For contracting, we use Broad Agency Announcements (BAAs), Requests for Proposals (RFPs), and Interagency Agreements (IAAs), which primarily came out of an Interagency Working Group (IWG) a number of years ago. We also use Simplified Acquisition Procedures (SAPs) and Blanket Purchase Agreements (BPAs). This slide shows the number of contracts we currently have under those various different mechanisms.

Dr. Kogel showed a total contracting amount that includes some contracts that are done as part of the intramural program, not through the extramural program. As a result, there are a couple outside contracts that aren't included in my statistics. For grants, they are managed by the Office of External Programs (OEP). They utilize several different grant mechanisms, which include the Cooperative Research Agreements or U60 grants. I will address that a little bit later on.

This slide covers fiscal year 2007 through 2017 and provides a breakdown of our expenditures on a dollar basis. This comes back a little bit to a question Dr. Nelson had earlier where she noted that there were more expenditures in 2007, 2008, 2009, and that expenditures for external contracts have decreased lately. Those first couple years after the passage of the MINER Act were funded through an Emergency Supplemental Appropriation (ESA), one year (2006) at $10 million and the next year (2007) at $13 million. That funding was on top of NIOSH's regular mining research budget and was directed toward certain topics related to the MINER Act: emergency oxygen supply, communications and tracking, and refuse alternatives.

I gave some statistics last year at this time in my prior MSHRAC presentation. I just wanted to give you a little bit better idea of the universe of the companies and universities that respond to our Broad Agency Announcement solicitations. We've awarded 66 contracts over the period of time since the MINER Act. We've had 162 different companies and 30 different universities submit proposals to us. Those 30 universities, for example, submitted 168 proposals. The 162 companies, of which 158 are unique accounting for subsidiaries and changes in company name and nomenclature, submitted 314 proposals. To date, we have funded 68 proposals from companies and 27 proposals from universities under the BAA process.

One of the thrusts of the Broad Agency Announcement process is to try to solicit technologies that are in use in other areas and try to get those technologies applied within mining. It's particularly of interest then, that of the 158 unique companies that have submitted proposals, 129 of those companies were not previously involved in the mining industry. We've opened this group up to a new potential market and facilitated the ability to transfer technologies from other industries into mining.

If you look further at the 49 companies that actually were awarded contracts, 37 of those companies, or 76 percent, were not previously involved in mining technologies. So we did bring those entrants into mining. And at least 15 of those have companies have products they've attempted to market to industry based on

this BAA solicitation. I say "attempted to market" because we've come up with some interesting concepts and some interesting technologies out of this. But if it's not regulatory driven technology requirement, it's often very difficult to successfully implement and market to the mining industry.

Those products that have been marketed successfully would primarily be communications and technology solutions that the industry readily accepted because it was regulatory driven, plus they saw a productivity benefit to it. Some of these other technologies have a health and safety benefit but it's not regulatory driven. It's harder for them to make a business case particularly in the difficult market today so you don't see those adopted.

I thought it would also be interesting to see how many submittals from different companies. We have received 1.9 proposals per company and 5.6 proposals per university. Actually, if you break down the data, it's a little bit more interesting than that. We've had seven universities submit one proposal. But, if you go out further, we've had 11 universities submit five or more proposals during that 11 year period, which covered 10 BAAs. And you see that there's been at least 10 companies that have submitted five or more proposals. Those were primarily in communications and tracking. The universities, we just get a lot of submittals for a variety of research concepts.
I have also broken this down by number of years for submissions. You'll see that 113 companies have submitted in response to just one BAA. We typically have topic areas specified in the BAA, although we also solicit for any health and safety topic a submitter would like to propose. So we've had 113 companies submit just one time but if you go out we've had 29 submit two years, 10 submit three. We would like to see more companies submit multiple years. So our goal would be to get more companies in the health and safety technology market and push it out. With the universities you can see the universities submit multiple proposals for multiple years.

Just to talk briefly about the OEP grants, right now the only thing we're funding in terms of grants for on an ongoing basis are the Research Cooperative Agreements, the U60 grants. Those are primarily the Western United States Miner Safety and Health Training Programs. One of those is the University of Arizona and the other is at Colorado School of Mines. Eric Lutz, while he was the SMRD Director, was interfacing with both of these groups; Dr. Kogel is presently in that role but it will ultimately transition to Todd Ruff. If you read a description of the purpose of the U60 grants, the intent is to bring together the expertise of federal and non-federal researchers. For the Western United States Miner Safety and Health Training Programs, since their inception in about 2002 NIOSH has had minimal involvement. We are currently reviewing that role to better match the intent of the grants.

OEP is currently only funding the U60 grants. Contracts remaining from Fiscal Year '14, '15 and '16 are under no cost extensions while the reports are completed. There is one other CDC-funded project that refers specifically to obtaining MSHA certification, which is a Light-Alerting Personal Noise Dosimeter. I've included that here just to be complete although it's not included in the OEP tabulation as a mining project.

At my prior MSHRAC presentation in the fall of 2016, I referred to our upcoming BAA contract announcement for 2017. In response to that announcement, we received 47 concept papers. We review those concept papers and choose those, based on published criteria, to move to a full proposal. We requested 11 full proposals and out of that we executed five contracts. One contract is with Rohmac for the Mine Rescue Mule; we finished up their prior contract to design the unit and followed that up with a new contract to take the unit through MSHA approval and certification.

We had an interest in active and passive barriers for explosion propagation prevention in underground coal mines. The Alpha Foundation is currently funding a project on passive barriers. Under new contracts, we are funding two projects on active barriers, one at University of Kentucky and one at Missouri. We also funded an optical scaled version of a longwall mine at CSM to investigate explosion propagation and a new tension crack analysis system using drones and photogrammetry to identify instability on open pit slopes through University of Nevada, Reno.

This was an unusual year because four of our five awards went to universities. Typically it's reversed; we only award universities one or two contracts. We received a wide mix of responses to our BAA announcement, most that were not consistent with the aims of the program.

In the last year, we had four contracts completed. One of these was the robotic support vehicle that we turned into a new contract (Rohmac), one for a personal NO_2 monitor, one for a statistical algorithm using MSHA data for safety prediction and the final contract was for passive seismic tomography. For all these contracts we have a technical representative designated as the Contract Officer's Representative or COR. We split those between PMRD and SMRD.
For the passive seismic tomography contract, the COR for that project was out of SMRD and SMRD was able to utilize some of the ideas and concepts that were developed. This contract was somewhat unique in that the principal investigator on the contract (from Virginia Tech) is currently continuing to work with the Galina Mine after the conclusion of the contract, because Galina saw tremendous value in the tomography and in further development. The contract is resulting in open source software.

With respect to other ongoing contracts, we have five contracts dating from FY 2014 and 2015 that will be completed in Fiscal Year 2018 but within calendar year 2017; they're currently finishing up with final reports. We haven't given extensions on any of these contracts. Of the ten remaining ongoing contracts, two were initiated in FY 2014, two in FY2015 (one BAA and one RFP), and the remaining eight in FY2016.

We also have a Capacity Build BAA program that was established several years after the MINER Act. Looking at the root causes of several of the disasters that occurred, NIOSH realized that there was definitely, from both an academic and industry standpoint, a need for further PhDs and research, within mine ventilation and, later, on ground control. Contracts under the Capacity Build BAA are renewable for a five-year period. For ventilation we're on our second round started in 2014 – we are in year four right now. We hold an annual review of mine ventilation contracts on the Thursday after the SME Annual Meeting. To date this program is responsible for 18 PhDs and 32 Masters students. We anticipate that in Fiscal Year 2019, assuming we still have continuing funding, we will initiate the third round of ventilation capacity build contracts.

For ground control, we already completed the first round in 2011 and we are in year two of the 2016 funding round right now. We do our annual review of these contracts in Morgantown, West Virginia, the day preceding the International Conference on Ground Control in Mining. This program has resulted in 20 PhDs and 25 Masters students. Both of these programs are very significant. If you talk to the academic community they consider these capacity build contracts key support for their particular programs.

The statistics presented on the number of graduate students funded covers all contracts, completed and in progress. Our statistics, however, are not as good as we would like them to be. We're in the process of going back and re-contacting all the Principal Investigators and confirming our numbers. Another goal of

this is to provide support for faculty for tenure track advancement and, to a lesser extent, laboratory facility development.

There are some contract related activities that I'd like to mention. As Dr. Kogel noted, we're in discussions with Sarcos and Sandia and working with MSHA Mine Emergency Operations (MEO) to discuss the future path for our prototype robots: the Snake Robot (Sarcos) and the Gemini Scout (Sandia). We put significant money into these two units, but, at the end of the day they're prototypes, unfortunately, and if you actually had to use either one of them in a mine emergency situation neither one is functional to the degree that we would like.

So the question is: do we continue with further investment on these? Do we write them off as a prototype, publish some papers and let someone else carry the ball forward? Is there value to them? So we're actually reevaluating both programs right now. We've had extensive discussions with Sandia about the Gemini Scouts and Sarcos about the Snake.

It's unfortunate when you invest so much money on prototypes but there's a very limited market for these type of units. There's almost no one that would buy one of these robots as an off-the-shelf unit to hold in reserve for a mine emergency. So if we don't continue further development, basically it dies at the stage it's at right now. We have to make some decisions on these.

We also modified a University of Illinois, Chicago contract based on the panel discussions of the National Academy of Sciences Occupational Exposure to Respirable Coal Mine Dust Committee. We've gotten a lot of feedback with regard to the size of the CPDM or Continuous Personal Dust Monitor. We had an existing BAA contract with UIC that was going to develop a personal monitor for respirable and alveolar dust in underground coal mines. Alveolar dust was intended to look at the size fraction that primarily represents Diesel Particulate Matter or DPM. We decided that we could take the concept of that existing contract and modify it to address our stakeholder concerns by adding a detector module to differentiate between coal and silica. This contract leverages work that UIC has done on some past contracts to see if we can go forward with this rather quickly. The CPDM was a result of over nine years, of technical development before the commercial unit came to fruition. So it's going to take some time for this as well.

We've also opened up a dialogue with the Defense Advanced Research Projects Agency (DARPA) regarding through-the-earth (TTE) communications. TTE communications is one of those things that from a standpoint of being able to communicate without infrastructure in a mine emergency would be critical. Unfortunately it's very difficult to execute given the size requirements for an underground antenna and the limitations on power. DARPA has an ongoing program for the military for small antennas within tunnels for communications.

We're also talking to DARPA about their Fast Lightweight Autonomy program where they use drones in a GPS-denied environment, navigating autonomously. We have discussed the possibility of using the Bruceton Mine as part of their robotics challenge because it's a GPS-denied environment where they have flexibility in setting up a course. We've also met with the Alpha Foundation to discuss focus areas under their grants program. We also have a survey planned, by RAND, to look at barriers to the implementation of electronic technologies within mining.

The FY 2018 BAA solicitation was posted yesterday. These are the topics that we have identified for the BAA solicitation. We also have an "other" category within the solicitation. Based on past BAA solicitations, probably half the submittals we'll get (about 25 submittals) will be on other topics.

The first topic is a low cost personal gas monitor to assess breathable air, such that a mineworker can make a decision as to whether they need to don an SCSR and whether they're in a safe environment to transfer from one SCSR to another SCSR. The second topic was SCSR communications. You still have the problem where you try to communicate with the bite grip in your mouth and we're looking at other alternatives for communications. For the third topic, we duplicated a topic from last year: the miniaturized CPDM with silica measurement capability. We went through a lot of better definition this year as to detail, braking it into six different proposals that we are interested in. The first is a lighter, smaller and quieter CPDM, then a stand-alone silica monitor, then the CPDM integrated with a crystalline silica dust monitor, all directed toward regulatory compliance. We then repeated these three scenarios but in a noncompliance version. The original idea behind the CPDM was to give the worker an indication of the surrounding respirable dust level to permit personal decision making and intervention rather than as a regulatory compliance device. One of the comments made during the National Academy meetings was "We'd prefer to wear a CPDM 24/7. If our company would provide this to us we would like to wear it. Because we want to modify our own work behavior to account for the dust environment." That is the driver for a noncompliance version.

Another topic is application of unmanned aerial vehicles in a GPS-denied environment. Last year's BAA resulted in four or five submittals with regard to unmanned aerial vehicles and various different configurations, but none met our evaluation criteria. The major limitation underground is to operate within a GPS-denied environment with limited or no communications to permit the operator to see where this unit is at. We had a meeting with DARPA to discuss their results on work being done for the military and see a number of synergies. Our last topic is a restatement of one from last year that did not result in any viable responses, the development of the Helmet-CAM technology for underground coal mining, which would involve intrinsic safety/permissibility.

With respect to the BAA program going forward, we're looking at enhancements and would like to move toward more concrete, viable solutions; one path is through a better selection of BAA topics. Topics are chosen currently based on input from SMRD, PMRD and the individual researchers; we would like to expand that input so we can accomplish more with this particular program.

For the closing slide, there is a picture showing a drone. We had a contract with GE to develop a methane sensor that didn't require calibration and can function for a year. It's a very low power, fairly low cost unit that's developed into a wireless node that could transmit methane levels. This picture was taken at their demonstration site; the sensor was put on a drone and flown over top of a cylinder of methane gas emitting a small quantity of gas from the nozzle. As the drone was flown around, it was able to map the methane cloud coming off that cylinder.

Questions and Comments:

Dr. Nelson (C) - Just one comment: Colorado School of Mines is going to be issuing a challenge for both UAVs and ground robotics up at their Edgar Mine in 2018 or 2019, accessing the first robotic competition in high schools and continuing in college. So I think we're looking for people who have potential applications. And I'm not looking to you for funding of the prizes, we have a lot of companies that are

interested in the funding of the prizes, but the ability to speak to needs and what's possible and what different sectors are looking for in terms of this.
Dr. Luxbacher (A) - It's fascinating to look at what DARPA is doing on that topic. The videos of their FLA challenges are all available out on YouTube. They're flying UAVs into buildings where you can't control it, you can't see, traversing through the building, making its way to a target and then returning to the start point.
Dr. Nelson (C) - Right. We actually had UAV for quite a while last week up in Edgar. And if you've been to Edgar it's not as big as I would like it to be. But, and it bounced off and did just fine, off the walls and everything.

Dr. Burgess (Q) - For your capacity build categories, how do you determine that? And are you considering any other areas or just continuation of what you already have?
Dr. Luxbacher (A) - That's an interesting question and one we have been giving thought to. We'll definitely continue with ventilation as a capacity build topic. The capacity build contracts are limited to ABET-accredited mining programs, because we're trying to make sure those mining programs have with qualified faculty to teach ground control and mine ventilation. On ground control, we may broaden that particular topic.
Dr. Nelson (C) - That's very interesting. I'd just tell you that, if you're looking for a faculty member in mining engineering, what you can find are those in ventilation and geotechnical. And if you're looking for anybody else they're not coming through the system because the funding is there only in those two areas.
Dr. Luxbacher (A) - You are seeing the results of the first group of contracts we funded. This program has been critical, I feel, to the universities in terms of faculty development.
Dr. Nelson (C) - As long as you want geotechnical or ventilation.

Mr. Wright (Q) - I was really fascinated by what you said about the CPDM. I'm a member of the National Academy panel looking into the dust issues. I can't say anything about the panel's deliberations but I can talk about the presentations in open session where it was noted that there is a large increase in black lung disease. There is speculation based on limited evidence that what they may be seeing isn't from actually coal dust but it's the hard particle silica, and the speculation being that it's related to mining rock. I believe RJ made a presentation at one of our past meetings and I believe I heard that you were talking about a module that would go into the CPDM that would give you some real-time results for the silica. Of course that's really critical, that process is really critically important because silica is so much more carcinogenic than is coal dust. So you said that might be some time off but could you describe in a little more detail what's going on with that and the possibilities if we had such an instrument and used it, we could save some lives with it.
Dr. Luxbacher (A) - Mike, when RJ gave that presentation to your panel, he mentioned that we were already looking at miniaturization. And what he was referring to at that time was the University of Illinois, Chicago contract that we had already made a decision to try to modify toward miniaturization. We then started talking to the UIC researchers about the potential of putting silica into this too, realizing how long it takes, to actually develop a commercial product. To come up with a solution we started down the path talking to them about silica as early as possible. The UIC researchers are considering the use of near- and mid-frequency infrared spectrometry at a micro-machine level. This is all in the preliminary stages but UIC seems to feel that this is a very doable thing. Again, I'm not looking for a compliance device primarily at this point in time as much as we've directed this contract towards something that would give the miner an indication when he's in a high silica exposure environment. So that's what UIC is working toward and we felt this was an important enough topic to try to make it a standalone BAA topic once again in the

FY2018 BAA solicitation. So we're out there soliciting input and we'll see who comes back on this BAA round as well.

NIOSH Director's Remarks, Dr. John Howard

I would like to welcome MSHRAC committee members, and I thank you for taking time out from your busy schedules to travel to Denver and participate in this meeting. MSHRAC is a vital channel of communication that we rely on to give us advice about our programs. Today, I would like to briefly discuss some administrative items. The President's budget was 40 percent less than FY17. The House mark was $10 million less and the Senate mark was flat. So we don't know what's going to happen with the continuing resolution which is set to expire on December 8th. There's sort of rumblings from the House that they're going to do a shorter continuing resolution perhaps until the end of the year or the beginning of January. We're not sure. So the budget is still up in the air.

The other thing I wanted to mention is that we have new leadership at the HHS level. We had a secretary come and go. And now we have a new nominee, who is Alex Azar, who was the general counsel in HHS for the Bush administration. So we're familiar with him and he's familiar with us at NIOSH. And we have a new CDC Director, Dr. Brenda Fitzgerald, who is from the Georgia Department of Health. And she's been with CDC about six months.

The other thing I wanted to mention is we're very excited that the facility we have in Spokane now houses the headquarters of two divisions. Obviously the Spokane Mining Research Division has been there for many, many years. And also we have the Director, Deputy Director and Associate Director for Science for the Western States Division, which encompasses Anchorage, Spokane and Denver. So the Spokane building is really becoming a center of NIOSH research, not only for mining, but for other things in NIOSH.

I again would like to thank committee members for your service on MSHRAC.

Built- in- Place Refuge Alternatives, Mr. Dave Yantek

I will update the MSHRAC committee on NIOSH refuge alternatives research as part of the Advancement of Refuge Alternatives for Underground Coal Mines project. My presentation will first provide a brief discussion of the three mine tragedies that occurred in 2006 (Sago, Alma, and Darby) and that led to the requirement of refuge alternatives (RAs) in underground coal mines. Next, the types of RAs used in underground coal mines—portable tent-type RAs, portable rigid-type RAs, and built-in-place (BIP) RAs will be discussed. Then, an overview of the research areas within the Advancement of Refuge Alternatives for Underground Coal Mines project will be provided including RA heat/humidity, BIP RA air delivery and ventilation systems, BIP RA stopping/door systems, and RA communications methods. Following this introductory material, summaries of two research tasks will be provided: BIP RA contamination ingress and BIP RA purging.

Contamination ingress refers to the amount of contaminant that enters an RA as miners enter. BIP RA contamination ingress testing is examining the influence of several factors including airflow from a borehole air supply, mine ventilation, air locks, strip curtains, and other contamination ingress prevention strategies. I will discuss the test method used to determine BIP RA contamination ingress without mine airflow, without an airlock, and either with or without a borehole air supply. Sulfur hexafluoride (SF_6) tracer

gas is used as a surrogate for carbon monoxide, which would result from a mine fire or explosion. The tests were conducted as follows. First, enough SF_6 gas to create a concentration of ~200 parts per billion (ppb) of SF_6 was released outside the BIP RA. After mixing the SF_6 using fans, vacutainers were used to collect samples outside the BIP RA to establish the concentration of SF_6. Next, the BIP RA door was opened and a group of 5, 15, or 30 subjects entered the BIP RA. Once all subjects entered, the door was closed and the air and SF_6 inside the BIP RA were mixed. The fans were turned off and vacutainers were used to collect samples to determine the resulting concentration of SF_6 inside the BIP RA. The vacutainer samples were then analyzed using a gas chromatograph and the ratio of the resulting SF_6 concentration inside the BIP RA to the initial SF_6 concentration outside the BIP RA was calculated. This parameter is referred to as the contamination factor. The results show that the contamination factor for 5, 15, and 30 subjects was approximately 2% to 3% across all six tests. Assuming a post-disaster carbon monoxide (CO) concentration of 10,000 per million (ppm), the resulting CO concentration inside the tested BIP RA would be 200 to 300 ppm if the mine ventilation was off and there was no airlock or other contamination ingress prevention strategy used. The next step is to perform BIP RA contamination ingress testing with mine airflow using real-time SF_6 monitors in place of the vacutainers/gas chromatograph.

Purging refers to the process of reducing a contaminated space using fresh air. NIOSH is performing BIP RA purging tests to examine how the BIP RA ventilation system layout affects the average purge time, the purge time throughout the BIP RA, and the presence of "dead spots" within the BIP RA. Once again, SF_6 tracer gas was used as a surrogate for CO in these tests. Two borehole air supply flow rates, 750 cubic feet per minute (CFM) and 1,000 CFM, were used for these tests. Sixteen measurement locations were used within the BIP RA, eight at a height of 28" to represent nose height of an average seated male, and eight at a height of 62" to represent the average nose height of a standing male. The BIP RA purging test procedure is as follows. First, approximately 2 LB of SF_6 was injected into the BIP RA. Then mixing fans were used to stir the air/SF_6 mixture so that a uniform ~1000 ppm concentration of SF_6 was achieved within the BIP RA. With the mixing fans turned off, the BIP RA borehole air supply was turned on and the SF_6 concentration was measured within the BIP RA until the SF6 concentration inside was ~3 ppm or less at all measurement locations. Thus far, six different ventilation system layouts have been tested. Of the six tested layouts, for an airflow of 750 CFM the purge times varied from 26.0 to 27.2 minutes and for an airflow of 1,000 CFM the purge times varied from 21.0 to 21.9 minutes (note these values were updated with repeats of tests on configurations 1 and 2 that were conducted in December of 2017). The purge times for the six tested configurations discussed did not indicate the presence of dead spots. Six additional ventilation system configurations must be tested and analyzed to complete the purging tests.

In summary of what NIOSH has done so far with respect to BIP RA contamination ingress and purging, without mine ventilation 3% or less of the contaminant outside enters the BIP RA when subjects go in. To put that in perspective, if you had a disaster where there was 10,000 ppm of CO in the mine air and the miners went into a BIP RA without mine airflow and without an airlock, you might have 300 ppm inside. Without an SCSR, CO at this level would cause a headache after a lengthy exposure. This is not necessarily the worst case because NIOSH has to look at what happens if there is mine ventilation at the subjects' backs as they enter a BIP RA. With respect to purging, for the first six layouts tested so far, the variation in purge time is small and there do not appear to be dead spots from location to location. However, what is expected to be the worst layout, where the air intake and exhaust are in close proximity to on another, has not been tested yet.

Questions and Comments:

Dr. Nelson (Q) - Do you have a target for purge time?
Mr. Yantek (A) - We don't specifically have a target, but I believe the way the regulations are written, they have 30 minutes from the time an event occurs for the miners to get inside and to bring the CO concentration down to 25 ppm. So that's one of the reasons why we use 25 ppm. Built-in-place chambers must have a cache of SCSRs to guard against a delay in starting the air supply. So, the miners would have the SCSR they are wearing in addition to the SCSR cache inside the BIP RA. Built-in-place chambers are approved by district MSHA offices and so they have to have an approved plan for their built-in-place shelter.
Dr. Nelson (Q) - The rooms are empty when you do the purge?
Mr. Yantek (A) - The rooms do not have people inside, but we have simulated miners that we use for RA heat/humidity testing—what we refer to as our barrel people—in the BIP RA taking up the volume of actual people. So, we have 60 of our barrel people inside when we do purging tests.

Dr. Burgess (Q) - I was wondering, you mentioned the heat at the beginning, so does anybody have, like, a chiller where they force cold air down and is that something that you might consider looking at in the future?
Mr. Yantek (A) - The majority of what NIOSH have done since 2012 has been related to heat and humidity. We've done extensive testing without chillers and we've also started to do work with numerous cooling devices. Currently, we actually have two BAA contracts that are ongoing right now that George (reference to George Luxbacher's presentation) had on his list. One is for the development of a battery-powered air conditioning system and the other is for the development of a cryogenic air supply for refuge chambers. In addition to that, the air supply that we use for all of our work is a portable air supply that was developed by a company called ChemBio and it actually has a chiller and a heating system built into it. So, if you pump air from the surface down through that borehole, depending on what part of the country you're in, you may be pulling in 90°F air that has to travel down through the earth and it comes out at a certain temperature and dumps a certain amount of humidity in. That's definitely a factor that we've looked at.

Mr. Bowersox (Q) - I've just got a comment. I was at one of the mines that had a built-in shelter. It was a very nice setup. The depth, does that make a big difference as far as oxygen?
Mr. Yantek (A) - You mean as far as the oxygen that they are required to provide? The regulations don't call for any changes based on depth. They basically require 12.5 CFM of air per person so that they can maintain whatever amount of oxygen they need.

Dr. Nelson (Q) - How big a borehole does that mean?
Mr. Yantek (A) - The diameter of our particular borehole is eight inches. The current BIP RAs in US coal mines use 4-inch- to 6-inch-diameter cased boreholes. So, you can kind of envision what that looks like. If you have a mine, let's say, in Alabama that's over 1,000 feet deep, now you have a thousand foot deep borehole that you would have to pump air from the surface down to the BIP RA. So, if you're in Alabama and it's 90°F outside, and then you're pumping the air over a thousand feet down, it's quite warm in an Alabama mine because of the depth, so that could definitely present a problem with heat/humidity inside a built-in-place RA. Without some sort of cooling system in that situation, once people get inside, there could be issues with heat/humidity buildup.

Lighting the Way to Safety, Dr. John Sammarco

From my presentation, there will be two main things you'll learn. One is how we're using lighting to improve roof bolter safety and then number two is improving self-escape by using lighting, vision, and visual signs. So those are the two main topics I'll talk about and you'll hear the progress we've made in the lighting project concerning those two.

First, I'll talk about roof bolter issues. Fletcher came to us asking for help with lighting for roof bolters, which has been traditionally very difficult to implement things. First I'll focus on glare. There's a couple issues with the glare that I've outlined in red such as miners are too close to the lighting; there's such limited space to put the lighting; oftentimes they have to place the lighting right where the person is, so the light's in front of your face, essentially, and causes a lot of glare problems. Next, there are no lighting regulations for the interior workspace of a roof bolter because the regulations were written at a time where people stood around the perimeter of the roof bolter, and now we have walk-through roof bolters where people are now in the interior of the roof bolter, and they don't have any lighting regulations. So Fletcher really wanted us to help with that.

And so we did some studies and developed a light specifically for a walk-through roof bolter. We did the measurements of how much light there is in some of the interior spaces. The requirement is 0.06 foot-lamberts of light that we need for the exterior spaces. Anybody want to hazard a guess what the average value of interior lighting was in terms of a percentage. Less than 9% in the walk-through area of the roof bolter. So clearly there wasn't nearly enough light, less than 9%, and I think the minimum measurement was less than 3% of the required light level needed for the exterior areas.

So we developed a light called the Saturn light to specifically address some of these issues. And you think, well, we don't have enough light, we'll just increase the light. Well, when you increase the light, you increase glare, and glare is already problematic on a roof bolter. So we developed the Saturn light, it's with MSHA now for approval certification, and Fletcher has assigned a part number to it, so commercialization is underway. And some of the key things I'll point out about the Saturn is the size. One Saturn replaces two traditional luminaires used for mining. So the smaller the size you have, the more flexibility you have. There's less maintenance. And then the hours of life; there's over 30,000 hours of life, so the Saturn decreases maintenance issues. And we did a study way back and looked, yes, there are accidents happening during maintenance, changing out of lighting. And the Saturn requires 11 watts of power versus about 100 watts of power for those two lights that it replaces

I think this next slide will give you an idea of what the Saturn is all about. Here's the existing lighting on a roof bolter. We're looking at the rear of the roof bolter and up at the front. And this how it looks with the Saturn light—dramatic differences and yet we're not increasing glare. So we're real excited about this. Fletcher is real excited about this. I think we can make a huge impact on roof bolter lighting.

And let me jump to the results. I said glare is so problematic. Well, glare was reduced three levels with the Saturn light. Another measure we use, is hazard detection speed: how quickly can they see tripping hazards? That improved 57% using the Saturn light, a huge difference. I think this is even more important, the trip object miss rate that is how many times did they not see trip objects? With the Saturn, it was less than 1%. Anyone want to hazard a guess of what percentage missed trip objects it was for the existing lighting? 28%, which is huge.

But we haven't stopped with the Saturn light. Fletcher was interested in using the Saturn light for other applications and we actually had a mine that was interested in using the Saturn for lighting up beltways.

So the Saturn really wasn't designed for that, but we took it and tried it, and this is what it looks like here. And the short of the story is it wasn't good enough. So we went back and developed the Jupiter light, which you see here, is lighting up the whole entry. And we can use this on the roof bolter, we can use it for the front of the roof bolter, we can use it to illuminate the roof practically down the whole entry, and there's a picture of it. It only used 24 watts of power and it uses the exact same explosion-proof housing that's being used by the Saturn light. So we're real excited about this. We've just built the first prototypes and we plan to do some field evaluation with it next. So I think this Jupiter light that has huge commercialization potential for mining, not just for roof bolters, but also for continuous mining machines, lighting up work areas, you name it. And all that done with just 24 watts of power.

Next, you're familiar with the helmet cam. And we're leveraging some of the existing technology developed in NIOSH Mining and using it for our lighting research, and we are real excited about this. We have two brand new engineers, haven't been with us a year, and I put them on this to essentially replace the dust sensor with an illuminance sensor to measure eye level illuminance, and they delivered. So we have the camera and then we have the light sensor, and they 3D printed this mount for it.

And the next slide I think gives you a good snapshot. The video is blurred because we just took a screenshot. So this is showing the front of the roof bolter with the Saturn light and the front of the roof bolter with the existing lighting. And so on the bottom chart here, what we're seeing is how much eye illuminance is coming in as we walk around the whole front of the machine versus here's the eye illuminance—we have a huge difference when you walk around the front of the machine. So the more light coming into your eyes, the worse the glare. So within 30 seconds, we generated this information. And then I'll do a little short video just to give you an example. This is at the rear of the roof bolter, and again, this is the light coming in at eye level, this chart here, versus time. So we're walking and then we can see the illuminance, and then right there when they go down into this cab area, there's a huge spike of light coming in, a huge glare source. So literally, in minutes, we can walk around the whole machine and identify and quantify the glare sources.

Well, now I'm on to the second topic of self-escape. How do we improve self-escape? Escapeway markers are required by federal law, but there isn't a color code. There's very limited science to help establish what the color code should be. We started a project a couple years back, a pilot project, just to investigate: is color really a factor that we need to worry about? And as soon as we get to the next slide.

What we did is we built a smoke chamber at PMRD and we have an LED cap lamp. And can you see the green escapeway marker right there? All right, can you see the red? Now, some mines use blue. Can you see the blue? So we just tested the three most popular colors, and as a result this pilot project we have something that's useful for establishing a color code.

But we did more because we know that there's more colors than just three, there's a dozen colors sold out there, and so we did more human subject testing. We looked at different types of retroreflective material, different sizes, shapes, and so forth. And we've narrowed it down to these four colors. So actually fluorescent yellow-green gave us a 24-inch improvement in our distance of how far away we could see the escapeway markers. So these colors (fluorescent yellow-green, yellow, and white) are even better than green that was best in our pilot test. However, one problem we had when we did this additional testing was that the people had difficulty in actually identifying what the color was. These colors were the most detectable, but they couldn't identify the color very well. So we're doing research to determine, well, why can't they tell the color? And even if they can't tell the color, can they discriminate? So if we tell them, "Oh,

this is the primary and this is the secondary. Can you tell the difference?" That's really all they need to know or it'd be critical. So we'll have something new to report on that early next year. But the bottom line of this is we're establishing science-based evidence that a color code be established for the mining industry for escapeway markers.

Next, I'll talk about a lighted lifeline, and I have actually a little prop here showing the lighted lifeline. It's an optical fiber illuminated by a laser. And this is about the consistency or size of fishing line, but it would be embedded into a cable. And this one happens to be green and you can see I have a knot tied in it. And so it's designed to leak light, and so we're using this. So it's great to have a lifeline, but if you can't see in smoke as with, the traditional lifeline, then the usefulness is limited. We believe the lighted lifeline will have huge benefits for people.

There are multiple colors that we're looking at —We're showing green, red, and blue in smoke, and obviously the green seems to be most visible. This photo here is of the prototype cable where the optical fiber is embedded in, so this will give it robustness and do a number of other things for us. We'll be doing testing and completing testing on colors early January. And there's also potential value-added to having a lighted lifeline, we can do distributed sensing along the whole length of the lifeline to look at temperature, to locate fires, look at strain, if the people pick the lighted lifeline up and start flexing it, we could tell how far in on the lighted lifeline are they. So this would be phase two that we're looking at of adding value to— because it's going to be an expensive lifeline when you look at nylon rope that's being used now versus an optical fiber driven by lasers. These are some of the distributed sensing things that we'll be working on in the next year.

So I would just like to summarize. The Saturn light that we've developed has major improvement for roof bolters, and as I said, this could extend to other machines, of having trip object detection improved 58%, a 1% trip object miss rate versus 28%, and glare reduced three levels. Next, the escapeway marker color. We know which colors are the most visible and shortly we'll be finished with that research to establish the science that it is needed to establish a color code. And actually there's other uses for this, so think of color and what colors are most visible. What about signage in a mine? Why wouldn't you be using signage in a mine based upon this research? So I think we'll be able to leverage some of the work we've already done and do other things for improving mining. And then the lighted lifeline, we think it's going to greatly aid in self-escape. And here again too, you know, we have this technology, well, why couldn't we outline machines with this? Why couldn't we outline refuge alternatives with this? We actually have a prototype we're working on where it circles the helmet and we also have a prototype built of a vest with a lighted lifeline on it. So a lot of potentials that we could do with that.

Questions and Comments:

Dr. Nelson (Q) - Great. So thank you very much. One thing that I'd like to bring up again, the last time we met in May I brought the overture to the DOTs and in particular the Pittsburgh DOT that's not very far at all from Bruceton, they're very interested in people underground in tunnels when they're trying to do an evacuation, and they have questions on lighting. And I think this is a really strong suggestion, so if you haven't gotten over to see Lou Ruzzi to date, please do so because I think this is low-hanging fruit and really would work very well and suit their purposes.
Dr. Sammarco (A) - Exactly. And actually, in the interest of time, I didn't bring it up, but the Saturn light, we just had it tested to UL's requirement for tunnel lighting thinking: why wouldn't we use this for tunnels? And it passed all UL's requirements for tunnel lighting.

Dr. Nelson (Q) - So the Pennsylvania DOT office, Pittsburgh, Lou Ruzzi is the head of the DOT's AASHTO's committee that includes tunnels, so he is the key lynchpin.
Dr. Sammarco (A) - Oh, that would be great.
Dr. Nelson (Q) - And the other thing I'd like to say is there any way we can get and try Saturn, Jupiter, whatever it is in Edgar? It would be something—it might be interesting just to try to deploy it up there and maybe we can run some kinds of tests up there for you.
Dr. Sammarco (A) - Yes, that's a possibility, yes.

Participant (Q) - That power unit that you had, what's the length that would shoot the laser? Is there any...?
Dr. Sammarco (A) - Yes, the total length we can go is 8,000 feet with repeaters and we have a repeater every 300 feet. The repeater is an XP box with a laser we light from both ends, for a number of reasons; it gives us some redundancy. And so right now, between XP boxes, we're at 300 feet. And we've just made a change and I think we can get up to 550 feet, almost double, which will reduce the cost. But still, even looking at illuminating 300, 500 feet, just between two repeaters, is pretty impressive, I think. But yes, good question. Yes.

Participant (Q) - I can't remember the various categories, but the folks who are colorblind, are you factoring that into the visibility of these things?
Dr. Sammarco (A) - We are excluding colorblind people because we're trying to get the majority of the population, and plus color recognition is so difficult anyways, the lower the light levels get, the more difficult it is to recognize color. For the lighted lifeline, again, we're excluding colorblind people just because the majority of the population isn't—but I think the color won't be as much of a factor for the lighted lifeline as it will be for the escapeway markers. And there's other things we can do with the lighted lifeline. We can pulse it. We can send signals. We're looking into something called Li-Fi, wireless communication through modulated light. So I started getting off into other things, but there's so much potential there for that lighted lifeline and of doing wireless communications during an emergency.

SMART MINE/INNOVATIONS INITIATIVE – MINE OF THE FUTURE TEAM UPDATE, Mr. Jeffrey Welsh

At the MSHRAC meeting in Spokane last November, Dr. Kogel introduced a NIOSH team formed to look into innovation and mining in the future. At that meeting, I talked about envisioning mining in the future, and asked the questions: What will the future mining industry look like?, What occupational health and safety risks will future mine workers be exposed to?, What must be done to protect mine workers from these risks?, and What will be the role of NIOSH in mine worker health and safety?

Today, I provide an update from that team. We looked at mining globally, and where and what smart mining technology is being implemented. This slide shows a world map and some of the major locations where mining companies have implemented smart mine technology. Included are mines in South America, South Africa, western and eastern Australia, Sweden, and Finland. In Western Australia, an example is the Rio Tinto "Mine of the Future" initiative. At their surface iron ore mines a fleet of autonomous trucks, autonomous drill systems, drones, and autonomous trains are all controlled from a control center many miles away. They appear to be very advanced in the implementation of automation technology. Another example is the Horizon 2020 European Union Research & Innovation initiative on Sustainable Intelligent Mining Systems. It is a consortium of mining companies, equipment and systems

suppliers, and universities that are funding projects to develop innovative technology, and demonstrate it in mines in Sweden and Finland on different types of autonomous mining vehicles. Atlas Copco is managing the initiative.

In the United States, implementation has been much slower. Some mining companies have implemented mimic cutting on their longwall shearers, where the shearer is manually controlled for one direction of cutting and then the cutting for the opposite direction is automatic. Other mining companies are controlling their longwall shearers remotely underground. In surface coal mining, one mine uses a semi-autonomous dozer for mining operations, and another uses a remote-controlled dozer on coal stockpiles. Recently, several metal mining companies have started implementing smart mine technologies. Newmont uses a semi-autonomous LHD in their Nevada operation. Barrack Gold has a pilot study for automation and data integration in their Nevada operations. Hecla Mining Company is implementing tele-remote loaders, automated trucks, collision avoidance, ventilation on demand, monitoring and control using wireless data collection and other smart mine technologies for their operations in Idaho, Alaska, and Canada. Todd Ruff mentioned earlier today of the interest by Barrick and Hecla to participate and work with NIOSH on their implementation of smart mine technologies and potential worker health and safety concerns.

This slide displays a "Mining of the Future" landscape map of many of the companies, universities, and organizations that have so far played major roles in supplying, implementing, or guiding the adoption of smart technology in mining. It includes Mining Companies, Universities, Labor Representatives, Mining Associations, standards organizations, equipment manufacturers, big data companies, and sensor and technology companies.

Future mines will provide extensive real-time data. In underground coal mines, a number of parameters have been monitored including carbon monoxide, methane, air velocity, and the status of conveyor belts and fans. More recently, mines are required to provide electronic tracking of workers underground, and proximity warning systems on the continuous mining machines and other mobile equipment including scoops and shuttle cars. Mines have also monitored ground movement and roof support status, and the operating status of extraction and haulage equipment for preventive maintenance and diagnostics. Surface mines have also monitored conveyor status, and the operational status of other fixed equipment, along with machine condition monitoring. Ore processing plants and mills have various process monitoring, and are automated to some extent. Data from monitored sensors will continue to grow, with the internet of things, connecting anything, any time, and any place.

Mine automation today and in the near future; here are some of the different type of equipment that are being automated. Included are haul trucks, loaders, crushers, drilling rigs, and longwall shearers. These equipment are operated under autonomous control or by remote control.

With automation being introduced, mine workers may be exposed to new risks. Workers will have to be concerned with interaction with robotic mine equipment, information overload, rapidly changing operating environments, rapidly evolving technology, critical decision making, and new ways of doing things.

Western Australia has had automated equipment operating in mines for a number of years. They have experienced some incidents with automated equipment. Examples include: An autonomous haul truck reversing over a waste dump, a water truck colliding with an autonomous truck at an intersection, a blast hole autonomous drill rig reversing into the rear of a stationary blast hole drill rig, a grader colliding with an autonomous truck, and an autonomous truck backing over an edge. The Government of Western

Australia, developed a Mines Safety Bulletin No. 110 – Seeking safe mobile autonomous equipment systems. In that bulletin they have contributing factors for those incidents that are broken down into specification and design of safety systems, human factors, and process issues. An example of a contributing factor for specification and design of safety systems is "Detection systems are not included in the design."

Six research focus areas that could serve to guide NIOSH research direction and the expenditure of resources to achieve worker health & safety have been identified. Collectively, the six research focus areas comprise a conceptual framework that describes the most relevant research areas and the relationships that exist between them, and challenges that must be addressed to understand mine worker health and safety as it relates to automation and smart technologies in the mining industry. For each of those focus areas, the team looked at the definition of each, background information, health and safety implications, current research in those areas, NIOSH comparative advantage, outcome and risks, competencies required, and facilities to conduct research in those particular areas.

The team developed key recommendations for NIOSH. One is collaborate with mining companies with plans to implement automation & smart mine technology. Hecla Mining and Barrick Gold have shown interest. Two is participate on standards committees/groups addressing safety standards for mining automation, to learn what's going on and also to provide our input into the development of the guidelines and standards. Three is partner with universities & research organizations conducting robotics & automation research for mining automation applications. Four is collaborate with the NIOSH Center for Occupational Robotics Research & the NIOSH Center for Motor Vehicle Safety on common occupational health and safety issues. Five is develop staff, gain in-house expertise through training and/or hire. Priorities are: Human Factors, Situational Awareness, and System Safety. Six is initiate a pilot project to gain knowledge, develop contacts, to better focus for our direction.

Key points are: the next decade is going to see a rapid growth and new applications of robotics and automation, this technology holds much promise for improving worker health and safety, this technology has the potential to introduce new worker safety and health issues that will require new and refined prevention strategies, and NIOSH needs to proactively address worker health and safety associated with automation and smart mine technology.

SMART MINE/INNOVATIONS INITIATIVE – FY18 NEW PROJECT, Mr. Miguel Reyes

Today I will talk about our automation pilot project. In reality, we know automation is not new, it's not new to mining, and so we're looking at it more from the perspective of the health and safety implications, and really understanding that even though a lot of the decisions are made in terms of improving operations efficiencies, reducing costs of extraction, and driven by productivity in the mining workforce, we're looking at the intended and unintended consequences as a result of introducing automation technologies on a global scale.

I'll be talking about some of the previous research conducted under the NIOSH Mining Program, also looking at previous research conducted under the US Bureau of Mines, to highlight some of the expertise that we've accumulated over decades of research. Also looking at some of the automation that Jeff alluded to in his presentation that is being introduced and then fully deployed in the mining industry. With that, I'm going to take a little bit of a shift into technology integration, not specific to automation

technologies, but some of the lessons learned that we have been able to accumulate through years of research in engineering controls and technology innovation through our research portfolio. I'll talk a little bit about the comparative advantage and that's really alluding to defining NIOSH's role in introducing automation technologies in mining. We understand that we are not going to be the ones that develop the systems, we're not going to be the ones that do a lot of the innovation related to what's already being used in mines, but we do have a lot to offer in some of the expertise that we carry across our organizational structure, and I'll talk a little bit more about that. And ultimately getting to the project goals and expected outcomes for this pilot project that really was well-aligned with the results of the effort from the workgroup that Jeff just spoke about.

In terms of the previous research that I wanted to highlight, the NIOSH Mining Program, the US Bureau of Mines, has really looked at several areas that feed into automating mining technologies, specifically some of the ones that I've highlighted here have occurred over decades of research looking at automating continuous mining machines, guidance systems, teleoperation, control systems, and really looking at different technologies that could be applied to enable automation in mining. But the reality is, with some of the limitations we've seen in the past, there's been rapid growth in that area to now what we're seeing, these types of concepts and technologies being fully trialed and deployed at mine sites. And so these are just some of the examples, and Jeff did speak a little bit about these, in terms of remote operation of mining equipment. The picture on the top-right is the cab-less haul truck that was featured at Mine Expo several years ago, and also an automated longwall system for an underground mine. And so we do recognize that there are really good examples of automation. What we want to now start looking at is how does this impact mine workers as far as the direct interaction or direct use of these types of systems or working even in close proximity with these types of systems?

Some of the things we've learned through past research as far as technology integration is that it could be broken down into different components. And what I'm trying to highlight here is the differences between evaluating technologies, looking at system performance, looking how the performance of the systems are impacted by the environment in which they're incorporated or integrated into, and also looking at how to best improve the performance of these systems. In terms of the human factors, there's also a big interest in looking at change management. How is it that we introduce these technologies in mining environments? How is it that we develop a strong safety culture? And how we communicate the introduction of these technologies so that the mine workers can understand how they're going to be interacting with it, how it's going to change their day-to-day operations, and how those technologies can be leveraged to be able to improve their efficiency and productivity. And the third bullet there, looking at training and how do we leverage existing products or developed products, either through NIOSH or other efforts, that can be used to train the employees on how these systems could be used and should be used? And with that, we're looking at things like informational databases in the form of mobile apps or immersive technologies such as virtual reality, which was discussed earlier this morning.

And so we look at these components and say in previous research projects that we've looked at technology innovation and integration, we have a lot to offer in those areas. An example of that would be proximity detection systems developed to prevent pinning and striking incidents, and so from that standpoint, we've had a very focused effort looking at technology evaluations where stakeholders have reached out to us and asked us to investigate what affects the performance of these systems, how can we overcome some of the challenges that we're seeing from introducing them into the mining environment? And some of these technologies that you're seeing applied and transferred from other industries, how do those change when they're introduced into the mining environment? And that's a critical component to

what we're trying to do here. We're not limiting it to mining in terms of only focusing on what's being done in mining, but we do at the end of this want to come out with mining-specific criteria so that we do be able to recognize that there are very specific variables involved in mining that you may not see in other industries.

And so with that, I think with this particular project, the automation pilot, the NIOSH Mining Program developed a very concerted effort to not only look at one aspect of automation in mining, but to include subject matter experts and experience we've accumulated through years of research to be able to target several areas related to automation technologies. And so with that, there are several examples related to, as I mentioned, proximity detection systems, the PDM being another example, a lot of the lessons learned in terms of system reliability, sensor accuracy, data analytics. There's several efforts currently and previously completed under the NIOSH Mining Program that could really help position us in a good position to address some of the challenges that the industry is experiencing. So you look at the technology evaluation standpoint, the human factors standpoint, and how those can be merged to provide a more holistic approach to how you introduce those technologies.

In terms of the specific automation pilot, we will be looking, as I said, at other industries and some of the efforts that they're looking at for automation. We will be looking at other existing standards in other industries. One such example is the SAE standards for automating motor vehicles. We do recognize there's a lot of work that's already been done. We want to be able to leverage that and see how that could be transferred and applied to specific mining tasks. What we really don't want to do is just focus on fully autonomous systems. We know we're a long way from having everything in a mine being fully autonomous. There are some examples of that, but there's also several levels in between where you're automating certain mining tasks or automating certain parts of the operation, not others. The reality is that there will be a human element involved in a lot of these cases, and so one of the things we want to look at in terms of the health and safety benefits is how are the mine workers being affected at each of these levels? And so this is established and this is an example that Caterpillar has used in terms of defining those levels. And so that's kind of the big picture, what we want to look at, knowing that there's levels in between human control and fully autonomous systems that we want to evaluate. The main goal for this project is really to determine or provide an assessment of the industry and the technologies that are being implemented, at which levels they're being implemented. What are the challenges that some of the mining companies are experiencing? And really what are some of the successes? Todd alluded to it and Jeff mentioned it in terms of collaborations with mining operations where they're still in the decision making process. They're still trying to decide: what is the best approach to do this? Where there's others that have already gone through that. And so their main interest is understanding, well, the people that have already done it, what did they run into? What are their challenges and what are the things that drove their decision making in terms of how they're going about it? And so that's something that we want to capture across all commodities, both surface and underground. It's an optimistic goal in terms of not limiting it to underground coal or not limiting it to surface metal. We want to look at how it's being incorporated across the board, not just in the United States, but globally, to be able to develop, as I mentioned, mining-specific guidance and best practices and recommendations to what needs to be considered in doing this.

But the truth is, the most critical component of it is going to be the stakeholder collaborations. How is it that we're going to learn about what other industries are doing or other mining companies are doing? It's really going to be through the establishment of partnerships, which again Todd mentioned, being a big focus in emerging technologies. And so for this particular effort, we will be looking at speaking to mine operators, technology manufacturers, research organizations, and regulatory entities that have either gone

through the process of integrating these technologies or are planning on going through it, to learn more about how it is that those decisions are being made and really what are some of the knowledge gaps that maybe NIOSH can contribute to in terms of advancing that research? I do want to point out that this is not an all-inclusive list. Obviously Jeff had a slide in his presentation that included a lot more stakeholders that have been partners with us and collaborated with us through other research, certainly the UMWA, NMA, NSSGA. So there's several other components that we definitely don't want to limit ourselves to this list, but it's really a starting point. Jeff mentioned Barrick, Anglo Coal, Rio Tinto being some of the big examples of having gone through it or are working, gearing towards going through it, and that's where we want to start. But we're also looking at other industries and other divisions of research, an example of which would be the NIOSH Division of Safety Research which has a robotics program that we will be looking to collaborate with and learn more from them about how it is that they're doing what they're doing at their level. We are also going to be reaching out to universities, academia, and actually tomorrow I'm scheduled to visit with the Robotics, Automation, and Design group at the Colorado School of Mines, which we're hoping to be able to start learning more about what everybody is doing and try to get a big picture overview of how it is that we're going to be able to contribute.

So what this means is, for this particular pilot, we have both short and long term goals. Short term goals being let's find out what it is that the mining industry is going through now. Why is it that there's some companies that are further ahead and why is it that limitations in terms of some of the technologies available in certain commodities—or how is it that the decisions are being made? We want to assess the intended and unintended consequences of automating these tasks, specifically looking at the mine worker. How is it that their lives are being impacted, whether it is through working directly with these systems or working in close proximity? Some examples of that would be looking at automating tasks that will need maintenance, so how do you factor in the maintenance personnel that will be working directly with those systems should there be any incidents related to needs for maintenance? Ultimately we want to develop those mining-specific best practices. And another long term goal that we're looking at is identifying what those knowledge gaps are, more specifics. What is it that we, as an organization, can contribute to directly and establish a strategic plan for how we're going to do that? RJ mentioned in his presentation trying to look at a five-year plan, so low-hanging fruit we mentioned earlier, what can we do now? What can we better prepare ourselves to address in terms of resource allocation, hiring of expertise, developing of expertise? And in reality, knowing that if there's something that we can't contribute to, focusing on what we can to be able to advance that research. Ultimately, coming up with a strategic plan and the short term goals of coming up with these mining-specific considerations, we feel that NIOSH is in a really good position to be able to contribute to that.

And so in conclusion, I do want to say that, with this pilot, the goal is to come up with that assessment before the end of 2018 and be able to provide that guidance in the form of scientific publications, but also looking at some of the materials that RJ passed around earlier, and try to get the information out as far as what we are seeing across the industry, not just in the United States, but in a global scale. So with that, I'd like to thank you for your attention and ask that, if you have any questions, you can ask those now.

Questions and Comments:

Mr. Watzman (C) - Thanks for the presentation. I have to tell you that, outside of this (inaudible) I don't think there's anything more substantive (inaudible) discussed. I hate to use the phrase because it's overused: the future is now, but the future is now. The changes that are going to take place in mining are almost (inaudible). I think you're on the right path (inaudible) companies that are already proceeding down

this path. I think ironically (inaudible) outside of (inaudible). Most of those companies that have chief technology officers or someone performing that function (inaudible). My only caution I would offer is (inaudible) the speed with which change is taking place (inaudible) before you get too far down this path (inaudible) discussion should be (inaudible) to get a sense from them (inaudible) why this is occurring, you know, it's not going to reverse itself. This is only going to become more and more and more (inaudible) communication abilities amongst (inaudible) we're seeing dialogue that takes place (inaudible) work with you to identify the right people you need to get around the table or converse with (inaudible) webinar or conference call, but get (inaudible) process so you don't run back at some point and say, well, you actually did this (inaudible) technology surpassed us (inaudible). So not a criticism, believe me, because I think this is (inaudible) to this and engaging everybody you are, so not a criticism, but just a precautionary, if you will, to make sure that your group has been aligned with how things are actually evolving out there.

Mr. Welsh (A) - I appreciate that comment, Bruce, and certainly we will take you up on the offer to help facilitate that meeting and get together. In the past, the Mining Program has interacted with the NMA Manufacturers and Services Division and we've in fact had meetings at our site in Pittsburgh. And whatever forum is best to get that knowledge and interaction across, we'd like to participate in that and, yes, certainly, that's a very good suggestion. We'll definitely take you up on that offer, Bruce.

Mr. Welsh (C) - Another thing that the team was doing, looking into who is involved with smart mine technology, and not only the government, but mining companies, some of the private research. One I'll point out in Pittsburgh is the National Robotics Engineering Center that is doing a lot in mining, and is taking different robotics technology and commercializing it and putting it in mines. They're doing some work with Anglo American on robotics in mining.
Dr. Nelson (C) - So spinning off of what Bruce said, what I had written down was consider maybe the next meeting, whenever it is, in Pittsburgh or wherever it is, might be a case where some of these people might be invited to come in and have the conversation with the MSHRAC, and I think that might work really well. So you might consider that. I wanted to bring up as well—and on our campus, we just are launching a new degree program in space resource development, and so the idea of pulling in—the way people are thinking about space resources, which is sometimes disengaged from the reality of mining, there may be some people over there in NASA and in some of the other agencies that are turning their attention towards what is certainly a robotics application for mining in even more extreme conditions than we have here.

Mr. Reyes (C) - And I believe that's one of the keys to not limiting ourselves to what's being done in mining. There is a lot out there that is rapidly advancing as well and we're wanting to know about it as well.

Mr. Zimmer (C) - I have a comment to make on the labor aspect of this. As you saw, we were a partner, up on your slide. I really think it's important to include labor in all these conversations also as it's going to affect our workforce from the dynamics that it's in now, and now is the time for us to have those communications, not when all of a sudden these pieces of equipment really start to show up at the pits and quarries and construction sites and stuff like that, and all of a sudden we have displaced workers.
Mr. Reyes (A) - And I think one of those examples will be proximity detection systems. Talking about lessons learned, we did see that early on in terms of introducing that technology where the change management could have been considered more so than it was in some cases. So how you introduce it, how do you communicate that to the workforce?
Mr. Zimmer (C) - I'm looking at it from the job aspect, just operators losing their jobs and displacing the workforce. So I mean, there has to be a shift and I agree with Bruce's comment that the time is now. It's here. It's not going away. But we all need to work together so that we can take a guy out of a seat, work on

the training aspect of him, retrain him for the job so he can continue to be employed, and without organized labor losing those jobs.
Mr. Reyes (A) - And to that point, from speaking to stakeholders that are in the planning stages, that's something that they were thinking of as well in terms of saying we'll develop a training program before we even have the mechanisms and the technology in place. Do we start working on training our workforce now, so that when we do get there, they're ready to go? And that's definitely something that they're looking at.
Mr. Zimmer (C) - And it's up to us to work with the owners and whatever to make sure we have those agreements in place so we can continue.

Dr. Miller (C) - And my comment was kind of along those lines. I mean, if you're going to do something like a systematic review of this and trying to see what's available, but also including what's the effects on labor? Internationally, how have they coped with some of those changes? And kind of capturing all that, both in terms of the reports, published literature, and then obviously your conversations with these groups will be really interesting, I think.
Mr. Reyes (A) - Sure, yes.

Dr. Luxbacher (C) - I just had a quick comment on data analytics. There wasn't a lot about that in here, and looking at the mine operators you're partnered with, they've got it figured out as well as anybody, but the smaller players in the US will tell you they're doing data analytics, and the truth is they really aren't. They often have servers filled with data they don't know what to do with. And I think there are some real measurable safety gains to be made in the short term in understanding what to do with those data, how to communicate them to engineers and supervisors and hourly workers. That would be just my only suggestion. It would probably be fairly cheap research to do too if you could get ahold of the data set.
Mr. Welsh (A) - Yes, I think a lot of the data analytics and what the companies are doing with the data now is related to maintenance and those type of issues, but you're right, all of the health and safety data is there too that could be a big area for the future.

Mr. Drysdale (C) - Not so much a question as a comment. I'm wondering if it would be possible to access the experiences of industries that have already gone through a major automation phase, for example, in the chemical process industry, a lot of that took place in the Fifties and Sixties, and in industrial manufacturing where they used to have people putting things in boxes and now it's all robots. And it may be, as you go to these different mining schools, you can knock on some doors and if there's any old chemical engineers who were around in the Fifties or Sixties, just see if you can access some of the lessons. And there may be literature on it, I don't know.
Mr. Welsh (A) - Yes, I think that's important, Dale. And the other thing with the new NIOSH Center for Occupational Robotics Research too, that we'll be able to interact with them and find out what they're looking at for some of the other industries, that can be brought back to mining.

Dr. Nelson (Q) - So I noted one thing on the slides and throughout here, the use of the word monitoring, which I presume relates to real-time data flows of some sort. And so I wonder why monitoring? Because the goal is not to monitor, but it's to apply data analytics to predict something. So is there a reason that the words stick with monitoring instead of moving on towards the application of what you're going to get out of monitoring?
Mr. Reyes (A) - I think in some cases it's the progression of the technology, where before you were using, sensor networks to monitor, atmospheric monitoring, for example, and now a progression to internet of things where you can integrate a control aspect of it and understanding that there's going to be a lot that

feeds into the final system, but I think that's really where a lot of the monitoring component comes in.
Mr. Bowersox (C) – I agree with Kyle. We definitely need to be at the table during these conversations.
Mr. Reyes (C) - Absolutely. And I think I've been fortunate enough to be involved with some partnerships and workshops and workgroups in the past related to proximity detection systems, refuge alternatives being another one, and it really does take aspects from every sector, every organization, whether it's the mining companies and research, and bringing everybody together to get all sides of it, and certainly that's a very critical component to it.

Welsh (C) - We had the Gemini-Scout robot at the United Steel Workers Convention. Mike had talked about having it there, because there is a lot of interest in some of the DOE waste cleanup sites, and the application of that particular robot to that situation.
Mr. Wright (C) - I want to say that was really well-received.

Mr. Francart (C) - I think we're excited about seeing the new technology come into various aspects, especially mine rescue. We've had meetings with NIOSH, with Carnegie Mellon. We see great possibilities here for really improving that sector for us, in particular. For other equipment, we're going to have to react to what comes along. The work that NIOSH is doing now with the approval of equipment, our regulations are so old and we have to really update them. We know that. Industry knows that. Everybody's aware of that. And we have to look at the international standards. The mine of the future is going to be a whole lot different than it was back in the Forties and Fifties, and our regulations are going to have to change to reflect that. So I think that's going to be the biggest impact on us is how do we change our regulations to account for the new technology? We haven't done a good job of that. We have to do a better job.

Mr. Wright (Q) - I'm going to make a couple of pretty simplistic comments. I just have to say that (inaudible) so if this has been said already, then I apologize. But one is we've had a lot of contact with (inaudible) mining industry so much being (inaudible) other industries, we have never (inaudible) robots. So what worries us about this, why we have to evaluate it so carefully is what we're essentially talking about here is a combination of robotics and mobile equipment (inaudible). But one of the most dangerous plants I was ever in was one that was enclosed, automated, clean, with hardly any worker exposure during normal operations (inaudible) process (inaudible) processed arsenic that had been (inaudible) cold, wet, enclosed process. You didn't see anything in the air. You didn't see anything on the ground. The workers had some of the highest urinary arsenic levels ever recorded. And the reason was that during normal operations, everything was quite clean, but people had to go maintain the equipment and that meant they had to crawl inside of it. And when we evaluate new technology, usually it's evaluated in terms of its effect on production workers, but (inaudible) who are usually the most exposed (inaudible) maintenance workers. (inaudible) you've got a bunch of equipment (inaudible) running around underground without drivers, without operators, but somebody's got to go down there and maintain it. We really can't afford to ignore those exposures. So again, (inaudible) very much for new technology (inaudible) all over the place and (inaudible) properly evaluate it (inaudible). That's it.
Mr. Welsh (A) - Yes, thank you, Mike. That's a good comment that we'll note.

Explosion Protection: MSHA and ANSI/ISA Standards, Mr. Dave Snyder

Good afternoon, everyone. I'm here to discuss a subject that's somewhat obscure relative to the mining community in general, but it's very germane to the discussion that we just had about automation as it relates to US coal mines. As many of you know, electrical and electronic equipment used in the coal

mines or gaseous mines has to be specially designed so it will reduce the possibility of that equipment igniting in explosive atmospheres such as methane or coal dust. In the US coal mines, we call that equipment "permissible" equipment. Outside of US mines and in other industries, that's referred to as "explosion-protected" equipment, and it is largely designed to specific country-adopted versions of international standards, whereas in this country, the equipment is designed to MSHA's approval criteria. I want to talk today about the comparison of the two approaches.

Our interest in this area stems back to the days of the MINER Act implementation when there were over 50 different communications and tracking companies that were trying to get equipment approved through MSHA. Many of them were saying that their equipment was already approved in other countries, and asking "Why can't we use it here?" Also, there was a huge amount of interest by the stakeholders relative to the possibility of using international standards for approval of this equipment. That led to a meeting that we had with then-Assistant Secretary of Labor Richard Stickler in which we discussed many of the MINER Act issues, of which the standards question was just one. He left office in 2009, but our interest continued for many reasons. Even if you just look at the market situation cursorily, the international or global explosion protection market has tens of thousands of devices approved, as opposed to a few hundred that are approved through MSHA, and there's 13 different explosion protection techniques versus 2. So if you look at it just from that broad perspective, you'd have to say, "Hey, there might be something there that could help us implement new technologies in the coal mines, if we were able to move in that direction."

In regards to what these 13 techniques are and how they line up, the international community views three groupings of equipment. One is zone 0 equipment which is designed to operate in atmospheres that are continuously explosive, so therefore they have the most stringent of explosion protection requirements. (Referring to the table on slide 3) The first technique listed for Zone 0 equipment is the focus of the studies that we've done. It is referred to as "2-fault intrinsic safety". Intrinsic safety means the energy is limited to less than 0.3 millijoules so that it cannot create an explosion or there's insufficient spark energy. The modifier "2-fault" means those levels of energy have to be maintained even if two intentional faults are introduced anywhere in the circuitry. We compared the international standards for IS – 2-fault and the MSHA approval criteria, and we believe they are equivalent. When I say we, I am referring to the authors who are Bill Calder, John Burr, and myself. There's also another zone 0 technique recognized internationally called encapsulation (Ma). MSHA does not have an equivalent of this, although they do allow podding (encapsulation) as part of their intrinsic safety approvals. Zone 1 equipment are those that are designed for frequently explosive atmospheres, and the international standards allow for the techniques listed there. Of those techniques, there's a containment approach called "flameproof" in which the explosion is contained within an enclosure which is similar to MSHA's XP approach. However we were unable to conclude that the international standard is as conservative as the MSHA XP requirements, and I'll be going into reasons for that. There's all these other techniques in the table here that there is no similar MSHA technique.

Historically, in the first half of the century, the explosion protection market was completely dominated by mining and the two techniques of explosion protection and intrinsic safety. It was during the Fifties and Sixties, when the proliferation of chemicals and the use of petroleum, natural gas, created a requirement for explosion protection by other industries, that these new techniques were developed. Today, these techniques are well-documented in a series of IEC standards referred to as the 60079 standards, and there are country-specific versions of these used throughout the world. OSHA is required to use these types of consensus standards and that's fundamentally the gist of the issue we have here. OSHA is required by statute to use consensus standards unless they can prove that they're not safe. MSHA has

exactly the opposite charter in which they can only use the new standards if they can establish that the new standard provides the same level of protection as the existing practice. As I mentioned, the primary interest in our study was 2-fault intrinsic safety.

Project summary timeline (slide 5). The comparison of the requirements took a long time and it was very difficult to do. Starting in 2008, when we had the discussion with Secretary Stickler, it became obvious that it was going to be a very difficult situation to deal with. Our resources were tied up implementing the MINER Act provisions, and it wasn't until 2011 that we were able to get the subject matter experts together to go through the 300-and-some provisions of the approval criteria and try to compare them to the international standard. That comparison yielded a subset of criteria for which these experts were not able to reach a safety conclusion. We then engaged a subject matter expert, initially we tried to engage Ken Klouse, who actually started the OSHA Nationally Recognized Test Lab program. He was very excited about trying to show that these criteria were equivalent. Unfortunately, he passed away during contract negotiations. Sometime later, we found another person who also had about 40 to 50 years' experience in this area and he was able to dig up the history of these differences in requirements and establish that, in fact, there is an equivalent level of protection. Those findings of the comparison report and the safety equivalency were published early this year, end of last year.

(Referring to slide 6) When you're talking about the level of protection afforded the miner in classical systems safety analysis or even how it's cited in the 101 section of the mining law *(Public Law 95-164, Federal Mine Safety & Health Act of 1977; Section 101(a)(9), Mandatory Safety and Health Standards)*, you're really looking at all the things that prevent the event from occurring. So in the case of explosions, you have the ventilation controls, you have control of the electrical-powered equipment, et cetera, and all those would have to fail to result in an explosion. So we describe those controls as "layers of protection". Our analysis was specifically restricted to the equipment protection level because that's the layer of protection that these international standards address.

This approach of three zones of equipment grouping, mentioned earlier, lead to a plant (or mine) being physically broken into essentially four zones. The zone 0, zone 1, zone 2, and then an area where nothing is required. That's allowed in the US for other industries under National Electric Code 505. In the MSHA world, there's really only two areas. There's the inby area which is considered a hazard zone and requires explosion protection, and the outby areas where it isn't required. There's also another approach, that's of interest which is what OSHA allows, under the National Electric Code 500, which leads to a three-area approach in which you have a division 1, a division 2, and a no-requirements area. And the reason I mention that is because, when it comes to explosion proof and flame proof containers, OSHA is similar to MSHA in that it allows practices that are different than what the international community allows, and I'll come back to that point.

(Referring to slide 8) This shows a mine map of what this zone type system looks like in a Queensland longwall mine. The blue is where zone 0 equipment would be required, the red is where zone 1 equipment is required and includes the active working faces and the returns, and then defined distances from those areas, and then the yellow is what they call the NERZ *(Negligible Explosion Risk Zone)*, and the NERZ can consist of either zone 2 type equipment or subzones where no explosion protection is required. One of the interesting things is that they actually, in Queensland, have a tighter level of control on the layer of protection provided by automated monitoring and disconnect of the power than in the U.S. Between each one of these zones they have methane monitoring, and the levels at which those monitors cut the power to the downstream section of the mine is set based on whether it's a transition between the no-requirements

zone and the zone 1, or zone 1 and zone 0. So they have a lot tighter control of the level of protection provided by the monitoring of the methane levels in the mine and the de-activation of electrical equipment.

The next slide shows what the zone system looks like at the longwall face. The zone 0 is the gob and the areas immediately adjacent to the gob. For the working face, their mining law says the active faces (mining areas) are considered zone 1, but I believe when they are not mining on a longwall face, it would be considered zone 0 during the non-mining period because it immediately adjoins the gob. Also between these zones, they require signage and, as I mentioned, they require this methane monitoring with integrated power disconnect between the zones.

Summarizing the findings for discussion today, the main one is that we've published two papers relative to 2-fault intrinsic safety and we believe that the MSHA criteria and the US criteria are equivalent. The second point is that in regards to XP, explosion-proof versus flameproof containment, we could not come to a determination that there's an equivalent level of protection there based solely on the equipment protection level considerations. In regards to the other techniques, we only looked at that enough to know that it would be very difficult to accept those other techniques the way the current regulations are today. Additionally we don't really see an immediate compelling reason to rationalize such a radical change in how we look at areas in the mine to accommodate those techniques. More specifically, when you look at 2-fault intrinsic safety and all the comparisons we did, we were lucky relative to the key safety aspect; that is the subject matter expert was able to conclude that in regards to controlling the level of energy, the IEC is much more conservative. Therefore we can conclude it's at least as safe as the MSHA current standard. It's also interesting to note that 2-fault intrinsic safety is a zone 0 technique, so by extension, you might argue that MSHA should be able to consider accepting the other zone 0 techniques, which currently is only "encapsulation (Ma)", but in the future zone 0 techniques may be a combination of zone 1 and zone 2.

MSHA did a comparison of the XP and flameproof in 2006. The comparison concluded that their criteria is more conservative than the flameproof, and we looked at that enough to agree with it. It's also interesting to note that OSHA, as well as MSHA, have a difference in their acceptance of the use these containment enclosures versus the international community. Under the NEC 500, they will actually allow a UL version of explosion-proof in a continuously explosive environment, whereas the IEC does not allow that as an application (under the IEC containment approaches are limited to Zone 1 equipment where the presence of an explosive atmosphere is assumed to be less than continuous). So that's just one of the many reasons, when we looked at the MSHA XP versus IEC flameproof issues, that we felt we could not really make any headway in coming to an equivalency determination due to the complexity of those issues. We decided that there really wasn't much benefit into analyzing that further.

In regards to the other techniques, we've looked at that and, in order to move to accept those zone 1 techniques, you'd have to have some way to say that, collectively, the net effect of what we are accomplishing by switching to those techniques is not going to reduce the level of protection of the miner. That may be by saying that, as an example, "it's going to lead to better safety technologies into the mine". Or it may be by saying that "we have decided the differences between flameproof and XP aren't enough to actually be a difference in level of protection" or maybe there is an offset by some additional layer of protection like monitoring as they do in Queensland. It's interesting to note that, in the future, these other techniques may replace 2-fault intrinsic safety as the preferred method of protection. One case in particular is communication handsets, cellphones, and smartphones. It's quite possible that they *(designers, manufacturers)* will move in the direction of combining powder fill and increased safety to

achieve the explosion-protection, in which case then it would be quite a dilemma because we wouldn't be able to use those in the mine unless something pretty radically was changed in terms of the regulations.

To sum it up, based on the work we did, we believe that the IEC standards relative to 2-fault intrinsic safety provide an equivalent level of protection relative to the MSHA criteria. We passed these findings along to the MSHA Approval and Certification Center (A&CC), so it's really a policy question at this point. In terms of the acceptance of the other standards, it would require significant changes to the regulations and how we go about classifying these areas. And finally, we believe, to the extent practical, that we've met the intent of the Assistant Secretary's request, although a little bit later than we thought we'd be able to do that.

Questions and Comments:

Dr. Nelson (Q) - Are you ready to continue the fight or...? I'm just amazed at the 10, 12 years overall that was invested in this.
Mr. Snyder (A) - In regards to the timeframe, the effort was not continuous. There were break periods. We lost three years in the early outset; we realized that there was nothing we could do that would affect anything within the timeframe of the MINER Act. We knew it would take at least five years to execute such a project, so we really didn't start on it until three years later when resources could be allocated to do so. Then there were transition periods between the changes of leadership within NIOSH that extended the timeline, as did the waning stakeholder interest over time. There were periods where stakeholders were very interested and other periods when they weren't, and resources were re-directed. In regards to further work, I personally see nothing more to be fought relative to what we have focused on, which is the equipment protection level comparison. I think there's nothing else to be gained by focusing on that. For instance, if you look at that, you can't say that, in the case of the explosion-proof, for instance, that a one-inch flame path is better than a one-and-a-half inch flame path because a longer flame path is going to cool the explosion more than the shorter one; so there's nothing you can do along that line of argument. Consequently, relative to this effort, I don't think there's much more to be fought.
Dr. Luxbacher (A) - Let me inject one comment here. Dave, John Burr and I have been talking about this for quite some time and we put together a roadmap as if we were actually going to continue the research through implementation—if we were going to impact policy change, how would we go about this? So we sat down and we drew up a very detailed flowchart on the various different research activities and things we'd have to do to get somewhere. And then Dave and John Burr had several meetings with A&CC to try to further define that. And I think we've come to the conclusion that the intrinsic safety is really the only thing in this realm that we can do, that if we move into the flameproof, there's too many requirements for change in policy regarding how you define equivalent protection for us to do that kind of work. So I think the intent of this was the summarize where we're at right now and basically say we don't intend to go any further at this point in time.

Mr. Watzman (Q) - *Transcript unavailable, summary of comments from notes:* Bruce Watzman asked about the impact on products available on the market and expressed frustration with the approval process.
Mr. Frankhart (A) - Our regulations allow us to accept other standards if they are determined to be equivalent or as equivalent to the MSHA standards. The work that NIOSH is doing is going to allow us to do that. But the fact is we have had no equipment cause an explosion in the history of US mining that has been approved by MSHA, and it's hard to go away from that standard. In addition, we are not allowed to diminish the effectiveness of current regulations by law. So in that sense, our hands are tied as an agency unless we have regulation change, and that is very difficult. A lot of people don't want to see that happen

at all, and in this administration, you don't want to see any new regulations unless you eliminate two for every one you create. So how do we move forward from that? The politics enters into the technical area on this issue in a very unfortunate manner. I guess that's the best I can say.
Mr. Watzman (Q) - T*ranscript unavailable, summary of comments from notes:* Bruce Watzman then stated that MSHA A&CC has passed us by – we must do something different.
Dr. Nelson (C) - This reminds me, I was just at a summit that we had on campus on abandoned mines and people end up always talking about the good Samaritan legislation possibility, and some of its archenemies of getting something passed are the environmentalists because they're afraid it's going to affect the Clean Water Act, which they don't want to have affected, so everything is stalled in terms of getting anything through, and they are two best intentions that are juxtaposed oppositely.

Mr. Green (Q) - *Transcript partially inaudible, comments paraphrased from notes:* I think there is an opportunity to reexamine this entire issue and I share Bruce's sense that we should take a look at it and make sure that it makes sense.

Modeling Fatigue Management Systems in Mining, Dr. Tim Bauerle

My name is Tim Bauerle. I'm a behavioral scientist with SMRD. My background is psychology, but mostly quantitative research methods, psychometrics, macroergonomics. The main takeaway that I want to give from this presentation: fatigue is complicated, fatigue is very complicated. And the reason why that is is it's what's called a latent construct. If I wanted to measure someone's height in this room, I'd get out a ruler, we have sort of an agreed-upon way of measuring that, either centimeters or inches or what have you. With fatigue, it's different. How do you assign numbers to an idea, right? And that's kind of what this pilot project is about a little bit. And the story behind this is fatigue first interested me when I got to go to Mine Expo in 2016 and there was all sorts of very interesting technology available to monitor and assess fatigue in a lot of different ways, with eye tracking or with body tracking, different caps that measure different brainwaves. And the sort of technology-driven, geek side of me, very excited that there's all these numbers and data to play with, but then the research side was, you know, how are these being implemented and used? What's the research and science that these are based off of? And going into the literature and finding a lot of noise around fatigue. There's a lot of voices and not a whole lot of consensus when it comes to fatigue, and that's kind of my main point with this slide.

We have some estimates that fatigue is impacting not only our health and safety, but our economy at sort of a national level. And when you look at factors that mining as an industry has in common with factors that we know can lead to fatigue, it's kind of like a check-check-check-check in terms of long hours, long shifts, long commutes, hot temperature, long hours, but the exact burden and nature of fatigue in mining is not necessarily known. It's sort of like, well, we know mining factors prevalent in some commodities and some operations in mining have some commonalities with factors that we know can lead to fatigue, but other than that, from a scientific level, there's not a whole lot of consensus there.

So what should we do? Well, like I said, fatigue is one of these areas where there's an awful lot of noise, right? And when I was first interested in this topic, I wanted to go and find some kind of model, some kind of meta-analysis, only to come up really empty handed. There's so many different disciplines that study fatigue as a construct and all of these different disciplines have their own way of measuring it. And so what I thought, as a first basis, as sort of in a pilot project, get a more scientific, systems level grasp on worker fatigue, you know, not try to solve all of the issues in terms of measurement and operational

definitions of fatigue, but at least try to use an evidence-based approach for how to potentially address fatigue and also gain a more practical, feasible understanding of fatigue in mining. Fatigue is very well-researched in transportation, in nursing, and with a lot of different solutions and different outputs and trainings, which is fantastic, but taking a step back too and seeing what's out there that has been developed for some of these industries and what may or may not potentially work for mining instead of maybe jumping in with a full project and kind of a cookie-cutter approach, taking something from one industry and just sort of plopping it into another. So not reinventing the wheel here. The methodology sounds very similar to what Miguel is doing in terms of taking really a year, year-and-a-half to get our arms around what we're talking about when we mean fatigue, get a good understanding of what fatigue might mean for mining, and therefore have a greater likelihood of success, which is one of the other reasons why I'm glad that I was asked to present here in terms of getting more feedback and input.

So what is the pilot project aiming to do? Well, two things. One, kind of synthesize research in a fatigue model. Now, why are we creating a fatigue model? One of the things that I wanted to do was create at least a conceptual understanding of how fatigue might operate within the mining sector, to kind of understand what are some different predictors and different outcomes that either contribute to or result from fatigue that kind of represents a best-guess approach for how fatigue might manifest in the mining industry. And then also compile some of the evidence-based interventions that are already in existence and sort of match them to certain—and I'll show you what I mean here by some of this in a minute. This pilot project is really guided by three main research questions. One, what is mine worker fatigue and why does it happen? For example, is fatigue the same as lack of sleep? Well, not necessarily. Fatigue might be more of a perceptual thing. And if it's something that is something how we feel, how do you measure something that's more of how we feel? Getting into more of integrating not only the biostatistics, but also self-report indicators of fatigue. Why are fatigued mine workers more likely to be injured? We've heard a lot about situational awareness. Is situational awareness an appropriate model for talking about why there seems to be this connection between fatigue and accidents and injuries? And then third, what are some potential ways to reduce mine worker fatigue? Is the mining industry unique enough to warrant a unique approach or are there some interventions already in place in other industries that we could maybe borrow and use, instead of reinventing the wheel?

So what this is is this is kind of a conceptual model of fatigue that's sort of based off of a couple of different psychological theories that are out there. On the left-hand side, we have potential sources of fatigue, and on the right, we have potential outcomes of fatigue. And the reason why it's important to have a model, kind of what I was saying earlier, there's nothing as practical as a good theory. Your theory is your best guess approach for what is happening with a construct that's as complicated as fatigue. So what the idea here is is using this model as a start, going back into the scientific literature and saying, for each one of these little, I think red, bubbles that represent different areas or sources of fatigue, what is the amount of evidence? What is the strength of the relationship? And how does that map onto how different researchers have operationally defined fatigue? How many of those research articles have taken place in mining, in construction, in oil and gas, et cetera? So just trying to find out where the literature is in terms of these different areas and pockets of fatigue, the strengths of relationships, and identifying different places that we can intervene. So in terms of the three kind of driving questions that I was talking about earlier, what is fatigue and why does it happen? Kind of looking at this connection here. You know, obviously, fatigue, a lot of it has to do with sleep, right? But there's different things that can either intensify or diminish that relationship between sleep and fatigue. So to what extent are—what are the problem areas in here? Why does there seem to be a connection between fatigue and injuries, injuries and outcomes? I have a couple of ideas here in terms of cognitive depletion, situational awareness, and ego depletion. Knowing

the exact mechanism there I think would be really helpful in terms of an intervention standpoint. And then finally, where are the appropriate places to intervene? And you'll notice I have some green boxes here: primary, secondary, and tertiary interventions. What am I talking about? This is something that's more from occupational health psychology, but when we talk about interventions, we talk about intervening at different places. So for this example, a primary intervention would be more of preventing fatigue from even occurring in the first place. Some simple solutions that obviously both mining and other industries have implemented are shift scheduling practices and some job task analyses. And if we move on to secondary interventions, well, okay, maybe we assume that fatigue is going to happen, but maybe we lessen the impact of fatigue. So you'll see in transportation industries, and rail in particular, they'll create break or nap rooms, for example, or sign people up that are interested for a sleep clinic for getting diagnosed with insomnia or what have you. And then tertiary interventions, okay, if we assume that fatigue is going to happen in sort of these critical moments with these safety-sensitive job tasks, then how can we manage those fatigue-related outcomes? And here's where those monitoring, or perhaps a different word there than monitor, systems come into play.

So anyway, planned activities, more to come. Just finished up with a proceedings document for the transactions at SME and I'll be presenting in a—if some of you know Emily Haas, in her symposium, and also a more academic-focused conference, the idea being getting input from industry as well as other researchers. Doing some mine site visits, and this is really important, I think it's important to the project to be informed by what's out there in terms of fatigue monitoring systems. So actually we have some things in place in terms of identifying a few possibilities for visits, but certainly open to some recommendations, so I would love to talk with someone, if that's a possibility. Also return on investment intervention analysis, the reason why I built this in is that I think it would be such a detriment if, at the end of this pilot project, the answer was, okay, we just need to have a $10,000, $20,000 piece of equipment at every mine and all the problems are solved. Well, no, that's not necessarily feasible, so what are some interventions that have a decent return on investment?

Project outcomes, there's more to come. Basically the bottom line for this is setting up a full project, again, very similar to Miguel's methodology, that will be more experimental once we've identified what are the major players in terms of predictors and outcomes of fatigue, actually going out and assessing and testing them.

Questions and Comments:

Participant (Q) - So is there any empiric data related to safety or accidents in any of these industries related to fatigue and those incidents, or is there opportunity to do a survey related to that?
Dr. Bauerle (A) - There is some data. A lot of the problem is that, on the one hand, it's sort of assuming fatigue means lack of sleep, so there is some association between, in some industries, fatigue and accidents and injuries. Actually there was a great paper in '08 or '09 from a professor out of the University of Washington that looked at the effect of the time missed from daylight savings and underground coal miners and increased risk for accidents and injuries. And I think it was that loss of 20 or 30 minutes of sleep led to something like a two to three times spike in accidents and injuries on the day after. But nothing that comprehensive from a surveillance point, because to be able to determine that an accident happened due to fatigue is quite a burden, so...
Participant (Q) - One thing we could do is interview mine workers and get a feel for what they—I don't know if they do shift work and stuff, like, that causes, obviously, messed up circadian rhythms and things like that. That's why the hospital workers and a lot of the truck drivers have been looked at.

Dr. Bauerle (A) - Absolutely, no, and that's what I'm hoping—that's where most of the data is and I'm hoping to get a feel for what's been published that's out there and see what's applicable. But very good point, thank you.

Participant (Q) - I've got a question. Do you go to the mine all three shifts?
Dr. Bauerle (A) - I would like to, ideally, yes, yes, sir.
Participant (Q) - The reason I'm saying that is just what you kind of said, some of the mines rotate weekly. Some stay steady. Some of the miners are working ten-hour days six days a week on the night shift, so...
Dr. Bauerle (A) - Oh, absolutely. That's a whole different—forward rotation, reverse rotation, shift length, and yes, absolutely, how much time you have to recover between your different shift periods, absolutely, extremely important. Thank you.
Participant (Q) - I mean, the low-hanging fruit would be the—if you looked at the shifts and then looked at the safety, you know, it might be off because of the shift work, so those guys working late shift may have a higher safety problem.
Dr. Bauerle (A) - Sure, sure, absolutely.

Dr. Kogel (A) - There was a project in Australia a couple of years ago funded by ACARP, A Risk Assessment Management Project, and they actually did a module on fatigue, and they brought in all kinds of experts, and they looked at what interventions they might develop for fatigued workers. So I could get you access to that module, if you'd like, yes.
Dr. Bauerle (A) - Oh, that's fantastic.
Dr. Kogel (A) - That might be helpful, a good starting place. University of Queensland
Participant (C) - Yes, to follow up on that, you could—David Cliff would be knowledgeable about all this stuff that happened there, so.

Dr. Burgess (Q) - Yes. One thing that we had done that perhaps could be something that you could consider was a combined what we call systematic review and then mixed methods in that we actually interviewed companies, in this case it was fire departments that had put in place interventions to reduce the number of crashes that they had. So there was some information out there, but it was extremely limited, but when we did the interviews, we found a number of different places that had information, they'd actually tracked the effectiveness of the things they'd done, but it'd never been published. So if it would be possible to get to that—in addition to whatever literature you're doing, to identify companies that would be willing to share the information directly and plan for that, I think it would be fantastic.
Dr. Bauerle (A) - That is a wonderful recommendation. Thank you. I didn't want to get too thick in the weeds on methodology, but we are doing a systematic review. Our first search of the first database gave us 50,000 articles, so we're going to have to whittle that down a little bit, but then informing the model based on what we're finding from that systematic review, and then going out into the field to different sites and saying, "Hey, here's sort of what we found. Does this match your experiences? Does it not?"
Dr. Burgess (Q) - Yes. And I think you could definitely limit your systematic review to mining and there's probably enough data right there.
Dr. Bauerle (A) - Sure, yes, yes, absolutely.

Mr. Wright (Q) - I've got a couple of things to maybe add. One is (inaudible) there is some research that was done by a large aluminum company, I'm trying to figure out who they are, (inaudible) but they looked at their own workers and they looked at the accident rate below 60 hours a week and the accident rate above 60 hours a week. They only dichotomized the workforce, only above or below 60. But they found that the accident rate above 60 was significantly higher than the accident rate below 60. That was not

terribly surprising, but what they did at that point is that they put into place a policy that nobody could work more than 64 hours. They chose 64 and not 60 because it was easier to (inaudible). And what they found was that—what we found was that the accident rate didn't budge, the overall accident rate, and we kind of determined that (inaudible). So what they did is they replaced the people who were willing to work above 64 hours with people who were not willing to work up to 64 hours. So they basically forced more overtime on people up to 64 hours which did not account for the fact that workers over 64 hours were told they couldn't work that amount of time. And what we concluded from that is that, while hours worked is certainly important, one of the real factors was were people willing to work those hours? Because if you're (inaudible) you'd probably refuse the overtime (inaudible). And if you were distracted by the fact that you wanted to be at the baseball game, but they just told you that you might earn double, you're probably not going to work as safely. So it's a willingness to work the extra hours that was clearly important, to us, anyway (inaudible). The other thing, and this is unpublished data, but it will be published soon, our alpha research looked at a number of (inaudible) together (inaudible) closer detail at four of them. And we didn't ask specifically about the (inaudible), we asked about many of the (inaudible), and the findings are pretty astounding. We asked (inaudible) four things from a large iron mine. So we asked: to what extent has downsizing reduced (inaudible) or contributing to unhealthy or unsafe conditions at the mine? 90% of those hourly workers answered that it was somewhat of a problem or a big problem. Astoundingly, 90% of the managers who worked in the mines answered the same way. And that's certainly a determinant of fatigue, the downsizing (inaudible). We asked to what extent long hours at work are causing (inaudible). And in this case, the finding was about 60% of managers, about 70% of hourly workers thought (inaudible) hours of work were a factor (inaudible). We asked to what extent shift work, which obviously (inaudible) a problem, and in this case it was about 55% of managers and about 70% of the hourly miners. And the last one, we asked to what extent excessive workload and job combinations were causing problems. And in this case, it was about 80% of managers and about the same for hourly workers. So all those are determinants of fatigue, so (inaudible) looking at what miners themselves think, including in many cases managers, they seem to think that it's leading to fatigue (inaudible) themselves problematic (inaudible). The (inaudible) where we looked in detail, our findings were similar, but not as dramatic. Salaried and the hourly workers thought that (inaudible) not by large margins (inaudible). So those are all things that indicate we've got to be looking at as part of this (inaudible).

Dr. Bauerle (A) - So thank you very much for that feedback. I really appreciate it. And you're speaking my language in terms of the participatory side of it, getting input from the employees in the workplace itself before implementing something that's a cookie-cutter, and especially with the first study you were talking about where it's a job fit, a job-person fit where we're taking into account morning-ness and evening-ness and who can—I'll say personally I'm a wimp when it comes to working 60-plus hours a week, but there's folks that might not be, and making sure that the work is consistent with the individual limits, I think that's very interesting. I'd be very interested in learning more.

Mr. Wright (Q) - (Inaudible) values were astounding. We got virtually 100% participation. In (inaudible) mines, we talked to more than a thousand people (inaudible) we gave questionnaires to more than a thousand people, and I think it was (inaudible). That isn't to say it was everybody who worked at the mines, it's just some people (inaudible) were on vacation or (inaudible). The injured people might have had a different response to some of the questions, but people who were on vacation or just weren't scheduled to work probably did not. So the people we got to were not just the dissatisfied ones. (inaudible) somebody surveyed (inaudible) to return the questionnaire. And we did this stuff on the mine site and (inaudible).

Mr. Zimmer (Q) - I support your research 100%. I think it's an awesome idea. It's long overdue both in the mining and the construction world where I come from. However, the culture of the workers themselves,

you need to tread very lightly when you go and you broach this subject.
Dr. Bauerle (A) - Absolutely.
Mr. Zimmer (Q) - I just had an experience in Connecticut, real quick, where we had the pipeline come through, and we historically don't do transmission pipeline, and these guys came into town and sucked up a lot of our workforce, and all of the sudden these guys were working 90-plus hours a week. And we were getting concerned not only for accidents, but substance abuse issues, all kinds of stuff. And I kind of quietly broached the subject with a few, and I thought I had a good, friendly relationship with them, and I didn't. Well, we've patched it up, but, you know, I get their message: look, you're going to impede me from earning. So that's a message that you're going to get any time that you start talking about cutting a worker's hours.
Dr. Bauerle (A) - Absolutely.
Mr. Zimmer (Q) - So I 150% get where you're coming from, but also on the other side, when they lace up their boots in the morning and they can afford to buy food and put Christmas gifts on the table, it's going to be a tough road.
Dr. Bauerle (A) - Absolutely, and thank you for raising that. I think it's hard with fatigue in particular because you get so personal so quick. Sleep is done at home, right? And then when you mess with someone's hours, you're messing with their income. Absolutely. And it's tough. I think with this fitness for duty umbrella of research topics, it's important that it's not just, well, fitness for duty, the onus is only on the worker. It's a systems issue and I'm hoping to tackle it as a systems issue. So yes, absolutely keeping some of that stuff in mind. Thank you.

Understanding & Mitigating Dynamic Failure in Western Underground Coal Mines, Dr. Dave Hanson

I am Dave Hanson, a lead engineer at the Spokane Mining Research Division. And this is a project on detecting and managing dynamic failure. This is the end of the second year of a five-year project. I took this over from Heather Lawson who is currently back at Indiana University in long-term training, getting her PhD degree.

I'd like to go over just in broad terms why we're doing this, how we're doing it, what our objectives are, and what some of the results to date are. Why we're doing it, I think that this plot has been shown last year. The severity of injuries from dynamic failures is considerably greater than, for example, roof falls. Over 60% of dynamic failures—and when I say dynamic failures, this is an umbrella term that refers to bumps, outbursts, mountain bumps, any of these sort of dynamic events that are kind of lumped into one big group. Again, over 60% of those events result in injuries, up to and including fatalities, compared to roof falls where that same percentage is 25%. Recently, since '83 to 2014, the other thing to note there is that most of the occurrences of dynamic failures have been in the Western US. So not to downplay the occurrences in the East, but it seems as though the occurrence of these events has shifted toward the West.

So how are we going to approach this problem? Dynamic failures are the result of a combination of mining layout, mining method, geology, stress regime, coal properties, pretty much pick a property and you could lay a dynamic failure at the foot of it. What we're trying to do is address this problem in a multifaceted approach where we have different teams working on the project who are looking at geologic characterization, coal engineering properties, geochemical assessment, seismic monitoring, noninvasive mapping, and numerical modeling. To say that this is ambitious I think is an understatement. There's a lot

of different aspects to this problem. And for a fuller understanding of the entire problem it's necessary to look at all of these. Any one of these six aspects could be an individual project by itself, but I think to do that, you lose the overarching context of the problem in trying to understand the ultimate cause.

Our objectives, first of all, we're trying to quantify the hazard related to geologic and other factors, and in so doing, we want to be able to identify any new tools or methods that would allow us to identify those. Ultimately what we want to do is change the approach to understanding dynamic failures from a reactive one where mines can get into a situation where dynamic failures, bumps and bursts, occur and then they deal with it, to more of an exploratory approach where, before the mine is ever put into the ground or the miners are exposed to the risk, there's an understanding of what conditions exist in that general area so that that dynamic failure risk can be better managed.

To that end, the first thing we've been looking at has been laboratory testing. The objective there is to supply more fundamental information on coal properties and their impact on stability. To date, we've looked at a number of triaxial tests that have tried to look at the influence of confinement, the influence of cleat, cleat orientation, and anisotropy on coal on different physical properties, specifically the strength of the coal and the effect on cohesion.

Once we have some of these new physical properties, we then import those into numerical modeling. The first step is pillar scale modeling where we look at a small scale, not a mine-wide application. The results that we have gotten to date suggest that an energy ratio may be an appropriate indicator of bump potential. That ratio is the ratio of the stored elastic energy in the coal to the dissipated plastic energy. Numerical modeling that's been done to date on this shows it to be a fairly consistent indicator of bump potential and it also matches up with what's seen on the effects of orientation of cleat and relative orientation between principal stresses and the cleat directions. There's hope that if this continues to pan out, this could be incorporated into the mine layout design so that you could examine this ratio in different pillar locations and determine whether your design is safe or whether it's an area you need to pay particular attention to.

In addition to this, in the field, we're doing seismic monitoring. As Todd mentioned, we've had some difficulty getting into the field with some mines that allow us to do seismic monitoring. The seismic monitoring is valuable because essentially it's a remote sensing technique that lets us assess the stability and mine condition in areas that just aren't accessible. To date, we've installed three temporary and two permanent networks. For the mines that are cooperating with us, we have memoranda of understanding and nondisclosure agreements in place with both of those, which have changed the dynamic a little bit in our interaction with the mines. They recognize the value of this work and have agreed to incorporate their mine staff into our efforts, so we can use their people to perform routine maintenance on the seismic system. We don't have to take trips again and again for minor repairs. They've also agreed to provide material, vaults, concrete, batteries, posts. So the mines are now an active partner in the seismic monitoring.

Geochemical properties may impact the seam behavior as well. There's been a number of contradictory articles in the literature. Some say geochemical properties affect propensity for bursting. Others say, no, there's no relation at all. We have seen some results that indicate that there is a correlation. So our current research is looking at scanning electron microscopy and Fourier transform infrared spectroscopy to look at the composition of coal, to see if there is a correlation between aliphatic, aromatic components of the coal and its history of bursting.

One of the big objectives of this work is to, as I said, shift it to an exploratory approach. And to do that, we've looked at a number of different noninvasive geophysical techniques to see what their strengths and weaknesses are in terms of what properties we may need to monitor. Pick a technique and we've looked at it, , seismic reflection, refraction, controlled source seismic, electromagnetics, ground-penetrating radar. We've got a laundry list of these techniques and we know what they're good for and know what their limitations are, so when we do come up with a list of properties that we want to examine, we have a toolbox that we can use. In addition, we have two certified drone pilots so we can use those drones to measure subsidence. We have done that over a New Mexico mine, which is this plot here, showing the difference between two photogrammetry surveys with GPS control. The yellow indicates something over two meters of subsidence over their longwall. This subsidence is valuable to us because it gives a measure of the overall response of the entire stratigraphic column over the mine and gives us information on post-peak gob behavior. And again, using all of this is an attempt to shift to an exploratory approach.

Finally, we're taking all of that data or trying to take all of that data or information from all of those different approaches as input into a parametric model of the mine. Essentially these parametric studies try to address the question of what impacts bumps? What impacts dynamic failures? As you can imagine, there's a ton of parameters. If you were to do a numerical modeling run of each one of those, you'd have literally thousands or hundreds of thousands of permutations. So what we've done is use a technique called robust design to limit the number of models that have to be run, but to still maintain statistical significance. We then take those results and do a multivariate analysis on that to try to quantify the effect of each one. And in addition, we are working with Itasca to get some new modeling algorithms in place that incorporate faults, topography, and anisotropy in development. Again, the idea here is to, given a mine's stratigraphy, model the effects of this geologic structure.

The dynamic failures depend on a lot of different parameters that you have to consider if you are going to understand and manage the risk from dynamic failures. All those balls in the funnel—rock properties, local geology, stress regime, mining methods—all need to come together somehow, by integrating those parameters, to come up with some sort of a dynamic failure assessment.
I think one of the big issues that we have yet to address, that people have mentioned before, is we can come up with this, we can come up with a technique that perhaps measures that dynamic risk, but if we don't make it understandable to the miner, if we don't make it so that it's usable, then we haven't really done our jobs. So one of the big things we need to look at it how do we present that to the user. I think that's a critical parameter yet that is still to be addressed.

Questions and Comments:

Dr. Nelson (Q) - I remember the presentation that we had last time that was on this, and I still have the same conclusion about the empiricism that's going on here, and it may come out with something interesting but I would still think it's largely empirical. (Inaudible) can do something for you but I still think that it's.
Dr. Hanson (A) - To a large extent, well, Bo Kim (inaudible) would argue with you about empiricism versus stochastic...
Dr. Nelson (C) - And I think maybe we should argue, yes. That would be a good argument. Don't worry.
Dr. Hanson (A) - Yes.

Public Comments

None.

Wrap Up and Committee Discussion on Future Agenda Topics and Dates, Dr. Priscilla Nelson

Dr. Nelson - We have skipped RJ and Todd's **"Mining Program Collaboration"** presentation and we have a suggestion to put it on the agenda for the next MSHRAC meeting. The next question is if we will do Jessica's **"Mining Research Program Strategic Planning"** presentation or are we going to spend our available time wrapping up and the future agenda?

Dr. Kogel – I suggest that we should postpone the stone, sand and gravel sector research priorities part of my presentation so that we have time, because I think one of the really valuable things about this meeting is this wrap-up discussion, and my presentation will probably take all of thirty minutes and we wouldn't really have time to have any discussion on that presentation or for the wrap-up for the meeting. I think that might be the best thing to do is postpone it till our next meeting in the spring if the Committee agrees with that. The other alternative would be for me to do a very quick, short version, but I don't want to rush through it, if the Committee prefers that. So I leave that up to the Committee.

Dr. Nelson - I just think that putting those off—and I do understand and I'm not saying no—but there are so many things that we thought we were going to see in the spring meeting that the spring meeting is—can it be longer than what it is?

Dr. Kogel - That's also up to the Committee and I think that should be part of our discussion is how do we want to configure the spring committee meeting. I believe last time we did a day and a half, and we had decided the fall meeting would be only a one day. That's something maybe we need to re-examine, because there's a lot happening right now. And of course we want to present it to you in a timely way to get the feedback. So I think that should be part of the discussion as well.

Dr. Nelson - Would it be most convenient if we have the discussion about issues that we think should be considered to be scheduled for the spring meeting?

Dr. Kogel - That would be very helpful, yes. And before we do that, Priscilla, one thing I was going to mention as part of the presentation that we are now postponing, that I wanted to bring up today, earlier you had a question about the slide with the incident rates for each of the sectors—and the question was if they are additive. They are not additive. So we were talking about that in terms of the stone, sand and gravel. So I just wanted to clarify.

Dr. Nelson - Right. Because if they are a percentage of a common total it's one thing. If they are percentages of subtotals then it's not...

Dr. Kogel - So what I can do though is I can probably get the stone, sand and gravel total incident rate for you. But it is not additive, so I just wanted to clarify that.

Dr. Kogel - Dale just told me that the number, the rate is 1.95, and that's according to your?

Mr. Drysdale - That's MSHA data.
Dr. Nelson - And that's SSG or just SG?

Mr. Drysdale - No, that's stone, sand and gravel because you got the two denominators—

Dr. Nelson - Are there any subjects that we hit on here that we would like to hear more about, or think we have a contribution to make?

Dr. Burgess - Sure. I think it's probably already on the schedule but the outcome of the NAS meeting, the spring meeting, discussing health issues. I think that deserves a fair amount of time for discussion because it will be fresh, and I think you'll be having to make decisions on how you operate on that based on the recent meetings.

Dr. Nelson - Good. Any other comments?

Dr. Kogel - Can I ask a question of the committee that might lead to a comment?

Dr. Nelson - Sure

Dr. Kogel - I did introduce to you the new strategic plan and mention that we would be sending that out. When we send that out to you, I would ask the committee to please review it—and I'll include this in an email. It would be really important for us to get the committee's feedback and I don't know the best way to structure that but I'm thinking we may even want to do some sort of meeting through a phone call with the committee. But we can make that decision.

Participant - And again, when is that coming out? A couple of weeks?

Dr. Kogel - I would say in a couple of weeks, yes. I think it's more likely right after Thanksgiving.

Dr. Nelson - Good. Any other issues that came up? I myself would like to—I know it's somewhat sensitive to you but we heard very little reference regarding the greenfield mine site and the idea of the mine in general, and I'd like to invite comment from the committee but to me, I think there is a vision that's being operated on of this mine being something that's sort of, I would say, not narrowly but precisely defined as something which the federal government owns and which is only for the purposes of safety and health research and that is it. I'm trying to figure out how to make an experimental mine viable, myself, and I know that Homestake is trying to do the same thing. The only one I know that does not have really strong support from the government is the one at Hagerbach in Switzerland; the one at Leoben has very strong state support. So I guess I'm thinking that we end up diluting our effort and if there is some way that we could just open the entire discussion up to how do you make an experimental facility in the United States work, and work well, while it provides all of the requirements that the NIOSH teams need, but perhaps partners with industry and other potential users to have a broader use. So to me, I think if you try to make it just be a sole-owned federal facility where all your money goes—having the money to keep up a mine is hard and so if the opportunity arises, if you decide to go for it, I think I and perhaps some of the other people would be willing to really sit down and think about how to make this facility viable and do what you want it to do and not kill yourselves, not become compromised by not having funds to reinvest in upkeep. Anyone agree or disagree?

Dr. Burgess - As you know, we also have a mine at University of Arizona, and obviously we probably share many issues. I do think that as part of the plan, making sure that you identify, should you choose to go forward, what is unique about this mine that you want to create and is not currently available in other spots would be a really important process to go through, just to make sure that the money is being well-spent, that you're not, again, it's just an efficient use of your resources.

Dr. Nelson - Yes, and although often the federal government does not appear to be highly entrepreneurial, there is actually a potential for an entrepreneurial activity associated with this investment that NIOSH needs to make.

Dr. Kogel - Yes, so I think we can—this is a process, this has been a process that's been going on for a long time. It's through GSA. And as we have had updates to share, we have shared them, and Jeff is actually the NIOSH representative on that team. So at this point, we've shared with you really what we can, and when we have the next meeting, we will certainly give you all updates. And is there anything else you wanted to add to that, Jeff?

Mr. Welsh - Hopefully by next May, we should have a very good idea if it's a go or a no-go. And if it is a go, of what the steps and the timeline would be. And also what it may look like and what it will do.

Dr. Nelson - Well, I would like to hear an update. I think almost, I think, at every meeting about the smart mine initiative, about what's happening, because that's very important.

Mr. Wright - Does this need to be a coal mine? Is it preferably a coal mine or is it any—

Mr. Welsh - The property that is being looked at is a limestone formation, which is the same that Lake Lynn was.

Participant - It sounds like a full agenda.

Dr. Kogel - Another question. Does the committee prefer the two-day approach like we did last spring, which gives us a little bit more time on the agenda?

Participant - One day is just not enough.

Dr. Kogel - Yes, I think that's what we're seeing. And I think we keep experimenting with the format and how we want to do this, the length of the meeting, locations, etc. I think today we found that a day isn't long enough. I think Skype is not what we had hoped it would be as well.

Mr. Welsh - For our next meeting in May, it sounds like instead of a day and a half, maybe two full days. And the location also, and what the format should be—it would definitely be an in-person meeting, and in the East?

Dr. Burgess - I would request a day and a half if possible rather than two full days. It allows you to get out that afternoon if possible.

Dr. Kogel - I think that's doable because if I remember correctly, last time when we had the two-day meeting, part of that was the tour, and I think we had actually a day and a half of meeting and then half a

day or a couple of hours of tour. So I think that would probably work well.

Dr. Nelson - So do you think of having it in Pittsburgh or—at one point you were talking about Washington as I recall? What does everybody think?

Participant - I like Washington.

Participant - Washington is good for me.

Participant - Easier to get into.

Dr. Nelson - So people here are happy with Washington?

Mr. Wright - I like Pittsburgh better though. The one thing I like is the facility or mine tour.

Dr. Kogel - Okay, Mike, we're going to try to see if we can come up with an option in the D.C. area.

Dr. Nelson - I know there's some underground construction so that would be good. You know, I also thought that sense of if there are some people in Washington who are the CTOs, right, that might see it as a discussion that bears upon the mine of the future regarding what they see being the transformative technologies that also have to be thought about from a health and safety standpoint, that might be an opportunity, because they always like to go to D.C.

Dr. Nelson - Good, okay. So I have one personal request. Can we have numbers on the slides in the future?

Mr. Welsh - Yes.

Dr. Nelson - Okay, anything else, do you have enough input from us? Yes?

Dr. Kogel - I guess one thing that we did this time that I thought worked well, and again would like to have the committee's view on that, is you heard about pilot projects and some new project initiatives so that you could give us some feedback early in the projects. I'm sure that was very valuable for the PIs, and is that something that we should continue doing for future meetings instead of presenting the more mature research?

Dr. Luxbacher - I think it's great. When I present to our Advisory Board, I do it for that reason, to try and get input.

Dr. Nelson - And I also think, whether you end up with four or five sectors, whatever the sector is, carrying that sense through of how the different topics map into the different sectors, it would be interesting. It would engage all the sectors, instead of somebody seeing a title and saying oh, that's coal, it's not something I care about. But in fact, there could be parts of it that are pertinent beyond coal.

Dr. Miller - Actually strategically mapping all the different things would actually be useful. I think for NIOSH as well as us, when we think about time and energies, so we can also think of a better spread—

Dr. Kogel - Are you talking about strategically mapping like I did in that slide?

Participant - Just with the discussions, to say—

Dr. Kogel - Right, how it fits in with the overall?

Participant - Yes, works out.

Dr. Kogel - Yes. So use that as our structure, yes?

Participant - That would be useful.

Dr. Nelson - Final comments?

Mr. Wright - No, good meeting.

Dr. Nelson - All right. I think we're done. We are adjourned. Thank you.

Meeting adjourned at 3:00 PM

I hereby confirm these Summary Minutes are accurate to the best of my knowledge.

_____
Priscilla P. Nelson, Chair

_____
Date