STATE OF NEW JERSEY

NEW JERSEY CLEAN AIR COUNCIL

DEPARTMENT OF ENVIRONMENTAL PROTECTION

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IN RE :

What Can Be Learned from Low Cost :
Air Quality Monitors: Best Uses :
and the Current State of Technology :

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SARA BLUHM
JEFF KNAPP
PAM MOUNT

A G E N D A

MR. OPIEKUN: Good morning, ladies and gentlemen and welcome to the Clean Air Council Public Hearing. My name is Richard Opiekun, and I am the chair this year. Our cochairs for the hearing are Toby Hanna and Len Bielory. We're going to go around the table in a minute and just have everybody introduce themselves and their affiliations so everybody knows who is in the room.

I just wanted to go through a little bit of housekeeping, so you know what's going on for the day. First of all, I just ask that, out of respect for our speakers, many of whom have traveled a long way, to please silence your cell phones, put them on mute, turn them off, whatever. If you do need to take a phone call, please step outside and do that, so we're going to ask that we don't have those type of interruptions.

Restroom facilities are out those doors and to the left. Ladies and men's room both to the left down the hall. You can't reenter through these doors, so you'll have to enter through the room there. We have a really packed schedule today. The agenda is basically set for us taking a lunch break today at around noon. Lunch will be provided for speakers and council members. For people who are in the audience, there are places along State Street to eat as well as in the DEP cafeteria that you can go and get lunch.

We will be taking a 30 minute lunch break at that time. You'll be able to also take a look at the air monitors that are on the side there and kind of touch, feel, see what's available. You'll be able to find out, see the technology first hand, find out what it's all about, so we do encourage you to do that during our break. The format for the hearing is that we're going to have formal presentations by our invited experts throughout the morning and afternoon followed by a discussion.

It's designed to engage the council and participants in a dialogue about the issues related to emerging portable technologies as well as Citizen Science and how the two work together. The goal is actually to develop recommendations to Commissioner Martin here at DEP. We are going to have a brief period of time after each presentation for a few questions from members of the council.

At the end of the day, where we have an open dialogue, round table discussion, we hope to engage discussion among the presenters as well as council members. There will be a comment period by the public, people who wish to address the council. You will be able to do that later on today after the round table discussion. Please register with Heidi at the front desk, just your name and your affiliation, so we know who to expect and we can also introduce you when the time comes.

We'd also like to thank our stenographer, Lauren Etier, for being here. The notes from today will be available on the website some time in August. We also hope to have the report that we're going to develop, based upon today's testimonies, available some time in August. It will be a PDF that will be downloadable, so you will be able to check back at that time. If there are no questions right now, I'd like to introduce our hearing cochair, Toby Hanna, who will go through the agenda and also have people around the table introduce themselves and their affiliations. Thank you.

MR. HANNA: Thank you, Rick. Good morning, everyone. Thanks for coming. Why don't we go around the table and do council introductions first. I'll introduce myself again. Toby Hanna. I work for a company called ERM, an environmental consulting firm and I represent the New Jersey Society of Professional Engineers on the Clean Air Council.

MR. BIELORY: Len Bielory, physician, allergist, immunologist. I do the pollen counts for the state of New Jersey. Rutgers University, Professor of Medicine Pediatrics and Ophthalmology.

MS. CONNOLLY: Maria Connolly, and I'm a planner. Department of Community Affairs designee.

MR. GEDULDIG: Howard Geduldig, retired Deputy Attorney General, and I'm a public member on the council.

MR. VALERI: Hi. My name is John Valeri. I'm an attorney from Chiesi, Shahinian and Giantomasi.

MR. OPIEKUN: You've all heard me. I'm Richard Opiekun. I represent the New Jersey Department of Health.

MR. EGENTON: Michael Egenton. I'm the executive vice president of the New Jersey State Chamber of Commerce.

MS. BLUHM: Sara Bluhm, vice president of the New Jersey Business and Industry Association representing us on the council.

MR. KNAPP: Good morning. Jeff Knapp, New Jersey Business Action Center.

MS. MOUNT: Pam Mount. I represent the League of Municipality.

MR. HANNA: Did we get everybody? There is a few members missing today, just two or three, but this group is always does a great job pulling together our annual hearing and our recommendations. More importantly, our recommendations to the Commissioner, to the state of New Jersey and happy to do that again this year.

This year we picked a topic that is, I guess my perspective on it, is I've been doing, looking at air pollution control problems for 27 years. And a constant challenge across those 27 years, that I've seen, is our ability to accurately and reliably, and most importantly, affordably measure, monitor air quality. We're able to do it but not cheaply. The outside environment is not a lab in measuring chemistry in ambient air.

It's something that has a scientific complexities that lend themselves maybe to the lab techniques but not in the outdoor environment with seasonal changes, and year in, year out, reliability. The advances in technology in the past few years seem to be changing that with lower cost air quality monitors coming on the market.

Mostly based with electronic sensors, so we're looking at technology that's developing in so many ways around the world right now in all areas of our lives, and air quality measurement is another one, so in the past couple of years, we've seen some emergence here, and the group of speakers, I think have all been involved in some of these in different ways, as you'll hear.

We wanted to bring together a hearing today, this year, on the topic to help understand really where this technology has come from, where it's going, what its potential uses are and its value, what its risks and pitfalls are, how advanced it is, how reliable it is and what we're going to be able to do with it and need to pay attention to around the technology in the coming years, so the speakers that we brought together represent some government agencies that are closely tracking what's happening here, USEPA, South Coast Air Quality Management District, represents some of the projects that are happening around the country that are interesting and new and have been through the selection process for technology, made choices based on their criteria, which we're interested in hearing how they've done those evaluations and what they've seen so far.

We also have some of the vendors for equipment presenting today and helping us with their perspectives, what they see the vision for the technology they're developing and the market for it, so that's a little bit of a snapshot of the agenda. We'll talk to each speaker, we'll introduce them as we come through, but that's the intent and the purpose and happy to get this kicked off.

We do have a little bit of time before the Commissioner comes in. We thought we might have that, but happy to take any questions on format, structure and otherwise, we can give you a little bit of a free time to see the props in the back. Paul, you want to stand up? Paul Roman from New Jersey DEP. He's the owner, the proud owner of the new low cost sensors. DEP has got -- where is Louis Slim? DEP has how many, not low cost, we'll call them air quality monitor stations?

MR. SLIM: We have 33 stations all over the state. We have over 100 monitors of various costs, most of them measuring air quality data that's up for comparison to the national ambient air quality standards.

MR. HANNA: So that's the traditional methods that we know are reliable and accurate, just not quite as cost effective as we'd like them to be so we can have more of them.

MR. SLIM: Or as mobile.

MR. HANNA: We can't park the trailers in the room.

MR. SLIM: No, we can't.

MR. HANNA: There is a question. Go ahead.

UNKNOWN SPEAKER: You noted

previously that there would be minutes and the video available I think. How about the presentation slides? Would they be available?

MR. HANNA: We're going to publish a public report. The Clean Air Council, on our website, which you can find off the DEP website, you'll see our public report there primarily with recommendations to the Commissioner, to legislature, to the state of New Jersey on this topic, so we don't typically produce, I don't know -- Rick? I don't think we typically post all of the presentations, do we?

MR. OPIEKUN: We do not. If we do get permission from our presenters, as far as the Power Point slides, we can look into that and post them as PDFs, but we will check with every presenter beforehand. It's traditionally, the stenographer's report as well the report to the Commissioner.

MR. HANNA: There will be a pretty thorough summary of the hearing all the way down to the actual transcript on the website if you're interested.

UNKNOWN SPEAKER: Thank you.

MR. HANNA: Any other questions?

Why don't we take a break. When the Commissioner comes in, we'll grab our seats real quick, take a few minutes to stretch your legs and check the air monitors in the room, talk to Paul and we'll reconvene as soon as the Commissioner is here. Thank you.

(Whereupon a break was taken.)

MR. HANNA: If everyone could take their seats, please. I understand the Commissioner is on his way down. Commissioner Martin is here, the man who needs no introduction. Come on in. Join us. We're ready for you. We heard you were coming down. Thank you for coming today. This is a great audience for us and very pleased to have you kicking us off as tradition allows.

COMMISSIONER MARTIN: Good morning. Nice to see everyone again. This is absolutely one of my favorite groups. I have two or three groups, as you know, I love to spend time with, and this is definitely one of them so thank you again for being here today. First off, thank you, Toby. I appreciate the introduction. I want to thank members of the Clean Air Council for your leadership and for what you do here.

I want to thank you for today's hearing. I also want to thank the speakers that are being included here today as well. I wanted to thank EPA, the South Coast Air Quality District, the universities that are here and technology leaders that are in the room as well for all being here and testifying today. As you are the leaders in innovation in your areas, I appreciate the work you do, and I know we'll get some great insight today.

I additionally want to thank Rick Opiekun for his leadership today, Sara Bluhm, Toby Hanna, as I just mentioned, as well and Leonard Bielory for your leadership as well in today's hearing. You know, while we're coming into the last nine months of this administration, this will be probably my last hearing with all of you given the schedule of things. I know we're going to have a follow up in the summer based on your report and all the rest of that.

So what I wanted to do is spend a couple of minutes talking about some of the things we've achieved together based on the input from all of you in this council over the years, which has certainly changed public policy and shaped the public policy of this organization. Over the past seven years you've advised me on topics, everything from transportation to power plants, interstate transport of air emissions, air toxics, cumulative impact of air pollution, climate change and many other topics that have helped shape this policy.

Your leadership and dedication have made Clean Air Council a great partner protecting the air quality in the state of New Jersey. New Jersey has made great strides with clean air, and will continue to do so, and be very committed to air quality in the state of New Jersey. The work that was started by previous administrations, and continued by this administration over the past seven years, has improved air quality immensely, and I'm very proud of the work that we've done over the past seven years.

This reflected in the trends of continuous lower air quality improvements in all sectors in the state of New Jersey. New Jersey has some of the lowest power plant emission rates in the country. We're 45th lowest in SO2, 45th lowest in NOx emissions and 40th lowest in carbon emissions from our power sector. New Jersey is also ranked fourth in the nation in total installed solar capacity. Our focus is now heavily on the transport issue that continues to impact the state of New Jersey.

Over 50 percent of the emissions comes from other state sources that are outside of New Jersey. Since day one of this administration, we identify a clear line to hold with other states and hold them accountable for their emissions. We have done this in several ways including litigation and petitioning the EPA. That led to the precedence setting 126 petition to reduce emissions from the Portland Power Plant in Pennsylvania.

At the same time, we continue to work with our partners in Pennsylvania to address all air emissions, especially NOx emissions. I'm happy to report that Pennsylvania has not implemented an updated RAC rules and implemented EPA's CSAPR Regs as well. As part of Pennsylvania's updated RAC rules, they have added a new requirement to operate existing air pollution controls that have installed, or curtailed, or not operated over the past three years.

DEP will closely track and operate the operation of all pollution control equipment in Pennsylvania and in other states this summer. Our air quality is much cleaner since the measurements began. Your recommendations have been helpful to many of the DEP's air pollution control initiative that have made this happen. In many cases, DEP was able to take your suggestions and turn them into programs that produce great results for air quality.

Your recommendation to implement stricter NOx emission limits for peak power plants used by high energy to mandate plants when ozone is the highest, has resulted in the shut down of more than 2000 megawatts of old high NOx emitting turbines. It also has resulted in NOx controls were added to another 500 megawatts of termites in the state of New Jersey. We set an example for other states with air pollution control performance standards, whether it's coal, oil or natural gas.

This council has also helped to focus on mobile sources. Based on your suggestions, we implemented the successful electric vehicle work place charging program, grant program. It Pays to Plug In is the name of that program. It's aimed to tackle mobile source pollution. So far, $850,000 is funded to allocate for 178 level two charging stations. It's my expectation that the grant program will expand in the future as other funding sources become available and we are committed to working with our partner, the BPU, to make that happen.

We have also tackled emissions for diesel vehicles by replacing dirty diesel engines. I am pleased to report that DEP continues to be a successful in obtaining grant money to do just that. Just recently, DEP received almost five million dollars from EPA, NJ DOT and the North Jersey Transportation Planning Authority to partner with C Street to repower three of their passenger ferrys that operate in the Atlantic highways.

This will replace poorly controlled diesel engines with the newest and cleanest marine engines available. Now, I want to shift gears. I want to focus on the topic of this hearing. What can we learn from low cost air quality monitors? You have put together an impressive agenda with experts from all over the country as well as New Jersey. I'd like, again, to thank the speakers for sharing their expertise with the Clean Air Council and my staff here at the DEP. Air monitoring is the foundation of our air pollution control program.

We are proud of our program which is robust and well respected amongst the states for a high quality data. We recognize that with low cost monitored devices available, the public will be more interested in collecting environmental data. I support local air quality monitoring. However, we need to tackle the authority issue of how and if we will use this data. We need to ensure that projects and data have integrity, and that are collected with valid, calibrated equipment according to protocols and scientifically valid methods.

I understand the Watershed Ambassador Program made a presentation to the council last month on how to promote community involvement. We're very proud of our program of Watershed Ambassadors. This program is an example of successful public involvement in collecting water and biological samples. It is a model for the council to consider as you prepare your recommendations later this year.

In addition, our CIO, Pete Tenabruso gave the council some insights over the challenges associated with accepting and managing large quantities of data and suggestions of other possible options for data repositories. Those are important points to consider as you listen to today's speakers and begin to draft recommendations. We have some experience with community air monitoring in Elizabeth and Newark.

I've had the opportunity to hear presentations by students who have performed air monitoring near busy intersections as they perform their exercises. I was impressed by their knowledge and excitement about the project. Even though the students monitoring will not be used for regulatory purposes, it was useful to help grow future scientists and install appreciation for environmental protection. Their enthusiasm was certainly something to respect.

As you discuss the specifics of aspects of low cost air quality monitors during your hearing today, I want you to consider the point I mentioned to you a moment ago. Specifically, in order for data to be useful, it needs to be collected with valid measurement devices and according to specific protocols. In addition, the purpose of monitoring can range from educational to data collection that is used to assess a situation or a concern. Please distinguish between the different types of local monitoring, and if and how DEP should be involved.

Advise DEP on how to best help the public interpret and understand the data collected from these monitors and how DEP can ensure that locally generated data is accurate. Discuss whether DEP should accept, review and use any of the data. And if so, how might the data be used. Just because someone is collecting data does not mean it is scientific or useful. We do not want to chase phantom problems based upon bad data.

Unstructured and unscientific data divert DEP resources from tackling legitimate air quality concerns. I see the value in local monitoring beyond educational purposes, but we need to ensure that data is valid and can be supported and that the work can support DEP's efforts in the long run.

In closing, I want to thank you for your service in the past. I want to thank you for your service today. Your dedication and your work with the state has been unparalleled by more of the other environmental organizations I've dealt with. You've been a great team to work with over the years, and I want to thank you.

I've enjoyed working with all of you and I'm looking forward to your work and the recommendations that are going to come back to me, I think in the summertime is the game plan right now. So with that, I thank you all and I appreciate all the efforts you're doing and looking forward to the outcomes of today's hearing. Thank you very much.

(Applause)

MR. HANNA: Thanks very much, Commissioner Bob Martin. That's a great way to kick us off. Andrea, you want to step up? Andrea Polidori is joining us from the West Coast. Welcome to the East Coast.

MR. POLIDORI: Thank you.

MR. HANNA: I understand, were you part of Rutgers at one point?

MR. POLIDORI: Yes, Ph.D. at

Rutgers.

MR. HANNA: All right. Wonderful. I'll do a quick introduction for you. Andrea is the Atmospheric Measurements Manager at South Coast Air Quality Management District, and the thing I really appreciate the most about him is, if you haven't seen it already, the Air Quality Sensor Performance Evaluation Center or AQ-SPEC. Google that, look it up, if you haven't seen it already. It's something we need badly, and it's very nice to see it coming together so well.

I think of it as a consumer reports for the low cost air quality sensors evaluation of reliability and effectiveness, long term too importantly, and Andrea is responsible for running that, the vision to create and conduct comprehensive performance tests of commercially available long cost air quality sensors, so a great way to kick us off I thought, as we were preparing for the hearing, is to have Andrea come up and tell us about his work and orient us around the technical options that we have out there.

MR. POLIDORI: Thank you very much for the introduction. So, yes, I've been in

California for the past 11 years, but my first five years in the U.S. were here in New Brunswick, so I got my Ph.D., I think you might know, Barbara Turpin. So today, I will tell you about our AQ-SPEC Center, Air Quality Sensor Performance Evaluation Center. And so the center was, we started it back in 2014.

And again, it's not a certification center so we do not certify the sensors, but we want to basically, you know, try to communicate with the public how well these sensors that you can find on the market perform and kind of give an indication whether or not they can be used for different purposes. So as you all know, you can find low cost devices for measuring air quality pretty much all over the internet these days.

You can go on Amazon and buy the -- and I don't know if you can find the -- but you can definitely buy cheaper air quality devices on Amazon, other specialized websites. You can find them anywhere. As the Commissioner was saying, these devices have tremendous potential, both because they are low cost and most of them are easy to use. So if you have a scientist that is interested in monitoring air quality at the neighborhood level, you can buy this device on-line and start playing around with those.

We have multiple potential applications. They are not as accurate as reference methods that we use at our monitoring stations, but somehow they can give you an indication of temporal and spatial air quality information in the area you're interested. You can definitely use successfully for fence-line applications and I'll show you a few examples of those fence-line applications later in the presentation.

So one of the problems is we started back two, three years ago. We started to get phone calls from citizen scientists that were telling us, I bought this device, I turned it on and somehow the PM level in my back yard went through the roof, so what's going on. So more often than not we found that maybe they were using this device five feet from the diesel truck or very close to their barbecue, so then you have two problems. A, the device is not very accurate.

And at the same time, it's used inappropriately, but also we got phone calls and we got approached by citizen scientists that put their own sensor package together themselves and they were actually conducting real science for this. A couple of instances of people leaving down wind over refineries and they were able consistently to track, for example, some of the emissions from the nearby refineries or from nearby facilities. So the main question here becomes, A, how reliable and accurate are they.

So can they be used for monitoring the air quality, and if they can, which kind of measurement can you conduct and how reliable are they. So we saw kind of an opportunity here to develop a center to systematically evaluate the performance of both particle and gaseous air quality sensors. So background. The AQ-SPEC sensor was established first in July of 2014.

The initial capital investment was about $600,000. We have maybe three FDEs there that are not included in the estimate, but the main goals of the center were to provide guidance and clarity over this ever evolving sensor technology, try to catalyze the evolution and the use of the sensor technology and especially minimize confusion among the users.

In terms of sensor selection criteria, we basically decided to test pretty much everything that is on the market. In terms of technology, the main three technologies for these low cost sensors are optical sensors for the measurements of particulate matter. Electrochemical sensors to metal oxide for measuring gaseous pollutants. Most of them can provide a real or near real-time information.

Some of these sensors that you see in the picture, can provide air quality information at the one minute level, sometimes even lower than that, and we are mainly targeting criteria pollutants, but also in some cases, air toxics. We did an evaluation of H2S sensors. We are trying to evaluate the performance of DOC sensors, but those are a little more difficult to test and I will show you why when I describe of some of our laboratory equipment.

So this is just, there are two main components in the AQ-SPEC Center. One is the field testing. So every time that we buy a new sensor, we buy three units for each sensor to get some statistical power. Of course the higher the number of sensors that you test, the better the results of your evaluation. So we deployed in the field at one of our monitoring stations and we compared them side by side with, you know, a federal reference or federal equivalent method, so EPA approved methods.

So after two months worth of testing, for those sensors that, you know, showed some promise, we read them back in the lab and we do some more detailed testing using laboratory chamber, and later on, I'll show you some of the characteristics of our environmental chamber. So at the end of the evaluation, we are able to basically segregate all these sensors and those that are basically random number generators, and believe it or not, there are many of those and opt to those that basically correlate quite well with the EPA approved methods.

So we also have a website, and you know we basically publish reports, testing reports, showing the details of our field and laboratory evaluation, what we have found, so if you are technically inclined, so to speak, you can find all sort of details about our field laboratory testing on the website and if you're interested in maybe reanalyzing our data, we can provide data to you so that you can take a closer look maybe at the data that we have or basically gather through this field laboratory exercise.

So the main purpose of the AQ-SPEC is actually trying to bring the three major players together and of course we want to provide the vendors, the manufacturers and potential developers with the information that they need to basically, you know, to fully evaluate the performance of their sensors. We want to tell the community what we found so that if there is either a community group or a scientist, and you know, they can take a look at everything that is available on the market and make an appropriate selection so they can measure air quality using an instrument that works.

And of course we also want to communicate the results of our testing to air quality officials because of course you know there is New Jersey DEP, South Coast AQMD, Bay Area AQMD, and several other environmental agencies across the country, trying to basically use these devices to compliment the air quality measurements from their network. So for the field testing we started back in 2014, as I mentioned at the beginning, all of the sensors are tested in triplicates, so we take three units for each sensor model that we evaluate.

We deploy it in the field for approximately two months, and generally speaking, if a sensor costs less than $2,000, we tend to purpose it. If it costs more than that, you lease it, borrow it, steal it, acquire it. So we have two main locations where we do this testing. I would say 95 percent of the testing is done at our Rubidoux station. It's an inland site. It's fully instrumented.

We find every sort of federal reference instrument that you can possibly imagine, so we can test for particle, pollutants. We have instruments there and so on and so forth. Then on the top left is our chicken coop so to speak. So we basically employ all of the sensors inside of the enclosure and basically we connect them to either a laptop or to like a central server to download all the data in real-time, and after a period of two months, we basically take a look at how the sensor data compares to the reference instrument data.

This is a few pictures of our

environmental chamber. It's a custom made chamber. One of the few, I think in the United States that is capable of, you know, doing this type of laboratory testing. We can test for both aerosols or particulate matters and also for different gases. On top of the chamber, I'll try not to be too technical, but just to give you a few details. We have two different particle generation systems. One for generating small particles.

Another one for generating larger particles and we have a reference monitor for measuring particle concentration like under the chamber, maybe not in the $45,000 instrument on the bottom of 2,200 pound chamber, but in terms of technically speaking, that configuration works quite well. We also have, you know, other instruments for measuring the particle size distribution so we can fully categorize the particles that we generate.

In terms of gaseous testing, we have basically a stand up gaseous dilution system. So basically, we can re-create different gases at different concentration and we can control exactly the type of gases we inject in the chamber and the concentration of that gas or of those gases. Sometimes, for example, for ozone sensors, it's well known that ozone sensors are also sensitive, some of them at least, to NO2, so we can play around with different concentration of ozone and NO2 to see if there is any interferences, and if that sensor is subject to interference issues.

In terms of one of the main characteristics of the chamber is that we can vary both the temperature and the relative humidity inside the chamber. So one of the -- field testing is that, you know, California, we have two seasons. Warm and warmer, so we cannot really evaluate how a particular sensor works under very cold condition or very high humidity or a combination of both, so the chamber, we are able to basically change and vary the temperature between almost freezing and 50 degrees C and the relative humidity can be varied five and 95 percent.

We never push it to 95, for obvious issues. We don't want condensation. We don't want to ruin the chamber, but at the moment, we basically do the testing using three combination of three different concentration, so if it is PM, we use a low, medium and high concentration. Three different temperature and three different relative humidity settings so we have this matrix of 27 values that gives a pretty good idea of how the sensor is working in different kind of environmental conditions. So as I said before, we can test for particles, for all pollutants, gases and, you know, we can't test for EOCOS, but we are trying to get that.

So this is, you know, the address of our AQ-SPEC website. You can go, you know, you see the address there. You can go there and take a look at our website. I think it's very informative. There's a lot of information about all of the sensors that we have tested. As I said before, there is a link to basically a full report for both, you know, the field and laboratory testing. If you're interested, we can send you the data and there is a small movie there that shows some of the background about the sensor, what we do, our main goals and objectives, how we select the sensors and so on and so forth.

I think this is something that the

community likes quite a bit, and so under sensors you can basically take a look at all of the particle and gaseous sensors that we have tested so far, and I think at the we have tested about 30 different particle and gaseous sensors. And if you click at one of the pictures there, there is another web page that shows you the general description of the sensor, the principal operation, some of the main technical features and sometimes we also have links to You Tube videos, when available, that kind of teaches you how to set it up, how to start measuring air quality and some of the information about that specific sensors.

So as I said, you can find reports and documentation about all of the different sensors, but in general, if you're interested in comparing the performance of all of these sensor devices, we have a summary table for both the particle and the gaseous monitors, so this is a summary table for PM sensors, and you can take a look at the picture how it looks, the manufacturer, approximate cost. Actually, there is the type of sensors, if they are optical.

Most of the PM sensors are optical,

so in this case, it really doesn't make a difference. So there is a column there for the type of pollutant that they measure. Most of them measure PM1, PM 2.5 or PM10. There's an approximate cost, the cost might vary, so if you really are interested in purchasing one of these sensors, you should possibly contact the manufacturer, but as you can tell, for particle sensors, they go anywhere between a few hundred dollars to I think there's one that costs several thousands, but the price is also very variable.

So in terms of how we report, you know, the results, we chose this R square, this correlation -- so if the R square is zero, there is zero correlation between the sensor and the reference monitor. And if R square is one, there is perfect correlation between the two. There is, you know, both R Square for the field and for the lab, we report all the laboratory R square results for ambient conditions to do like a side by side comparison and there is a link to the corresponding summary report.

And so in general, after about two years and evaluating these sensors, what we saw is that most of them at the middle down time, so impressively enough, you have the Dylos there, and I can't remember the result for that Dylos, there is a $400 device that only gives you particle count concentration that you can work to get the corresponding particle mass concentration, but I remember that running three of those units for two months, we were able to record about more actually than 99 percent of the data, which is quite impressive for a device that costs only 400 dollars.

Most of the PM sensors, the moderate intra model variability, meaning that if you basically operate three different units of the same model, more or less, you get the same type of results from all of those units which is also important. Generally speaking, there is a fairly strong correlation between PM sensors and, you know, EPA reference instruments which is also very encouraging.

However, of course, there are a few issues. Sensor calibration is needed in most cases. That is because of course if there is a good correlation, it is possible that the sensor is reading higher or lower than the reference monitor, so it's highly advisable, if you want to use these type of sensors for practical purposes, you want to deploy them in the field, it's always recommended to calibrate the sensors before use. Most of the sensors measure, they do not detect the very small particles.

Most of them do not detect particles below 0.5 microns, so if you want to come back for example on roadway emissions and you want to basically capture and figure out the particle, ultra fine particles, very, very small particles. The technology is not quite there yet. Although, I know there are a few vendors that are working to resolve this problem. One of the other issues is that there might be bias in the algorithm that is used to convert particle number to particle mass concentration.

So different vendors might develop their own algorithm, and even if they use similar technology, the end result could be quite different. So the gaseous sensors, the results are a little different. Most of them have acceptable little recovery. Now, we're experienced at least, not as good as the recovery for PM sensors. In general, there is a wider intra model variability between different units of the same gaseous sensor model.

If you want to measure primary combustive pollutants such as CO, NO, ozone, when measured alone, there is definitely decent correlation between these sensors and the corresponding EPA approved methods. Sometimes, as I mentioned before, for ozone sensors, there is some interference between ozone NO2, so some of these electrochemical sensors are effected by this kind of interference which needs to be taken into account.

Other more exotic, so to speak, air pollutants such as SO2, H2S and especially VOCs are more difficult to measure with available sensor technology. So again, we do not endorse any of these instruments but kind of give you an idea of how this technology is progressing. There is an instrument on the top left of the graph. It's actually the only sensorish device. The only portable device that we have found so far that is FEM approved.

It's a Federal Equivalent Method so it actually can be used for regulatory purposes. It's $4,500, but it's portable. You know, you can basically move it from place to place and very easily. And if you can take a look at the correlation that it's one and it's possibly the best performing device that we have encountered so far. On the other hand, if you take a look at one of those devices there, it's about $10,000. I believe now the price point is a little less.

It's about 6,000 possibly, but it includes CO, NO2 ozone, I think they include that PM monitoring as well, but it is higher price doesn't always translate in higher performance and that's something to be aware of. In general, I think, I don't want to say that there is a universal relation between the size of the company and the performance of their sensors, but in our experience, there is companies that definitely, they go all in, they try to commercialize their product right away without properly evaluating the sensors, without properly taking the necessary step to bring it to a point where it's performing well.

So we are seeing instances where companies are trying to get into this business and some of them are not into this business anymore after a few months just because, you know, that model is not really working well. On the other hand, there are smaller companies that I think, they are approaching this problem, one step at a time, they work with us or with other organizations or with other community groups to make sure that, you know, they address every single issue that there is with these sensors and I think that model is a lot more successful so they're building their business model one bit at a time and very slowly.

So we often are asked, so what is the best sensor, what should I buy, right, so what people, generally speaking, have in mind is what is the sensor, which sensor correlates the best to the EPA reference methods, so for most people, that's the definition of the best performing sensor, and I don't think that's the right question to ask. I think that possibly the question should be reversed, so you should possibly try to identify the type of application that you have in mind, and then select the sensor for that specific application.

One of the examples that I always tell people is that if you live down wind of a refinery and you want to know whether or not you can open the window in your bedroom, so if you have, you know, a VOC sensor that tells you, there is no VOC, there is some VOC, there is a lot of VOC, that's the perfect sensor for that type of application, right, so you don't need to get a $4,000 VOC monitor for that type of application. It's way too much. If it's more accurate, definitely, but it doesn't really address your needs.

So there is this graph here that was put together by EPA, back maybe five years ago or so, and so they identified basically the required data quality from the sensors with specific application for each category, so you have for sensors that don't perform very well, that possibly are very cheap. They can still be used for quality personal monitoring, for science education and then all the way up, you have, like the ozone sensor that I was showing you before, that can already be used for legal compliance purposes.

You can use it within your network and it can be used for regulatory purposes, but this whole category in the middle that I think is very interesting, there are several interesting applications those sensors can be used for, including characterize spatial variations, and I show you an example of that, but basically if you have only one station in a very wide area and you want to take a look at how the concentration of PM or some other pollutant varies spatially, then you can definitely deploy some of these local sensors and get a better sense of how PM or some other pollutants varies in space and time.

One of the other interesting applications is fence-line monitoring. I have a good example of that later on, and you can use it also to address community concerns. For example, local impact on freeways, airports, refineries and other facilities. So in addition to evaluating the performance of these sensors, we also, you know, deploy some of those in the field to specifically address some of the problems, so we run this pilot study back in June, July of 2016 and so what you see here to the left is a waste disposal facility in Huntington Beach and down wind of that facility.

So on the right hand side of the facility, there is a school. It's really more than 50 feet from the facility, and the school was complaining about emissions of PM coming from the facility, so we worked together with the facility and we installed a network of nine different sensor boxes. I guess I have to find a better name for them, but basically that's what it is. You see there on the right hand side of the central part of this slide, so we built these boxes and each box has a low cost PM monitor.

This is an Alphasense. This is manufactured in the UK, and this tells you basically concentration of PM1, PM 2.5 and PM 10, which we are particularly interested in, in this case. There is a GPS and all of the data are streamed to a central server in real-time, so anyway, we installed nine of these devices on light poles around the facilities, and so basically what we do here, we are able to measure the concentration of different PM fractions in real-time.

And you know, we are able to tell and confirm that on the southern part of the facility, where you see that big red dot, in the southern part of the facility, they have, the public, a lot of construction builders, they dump their construction material there, so there's a lot of crushing. There's a lot of moving around of old bricks, all kind of construction material, so it makes sense that the PM concentration is very, very much eliminated.

So one of the other things -- the project benefits of course, we are able to correlate PM measurements with on site activities, so in this case, as I told you, there's a lot of fugitive emissions in the southern part of the facility, but if we can also correlate PM emissions of course with wind direction with a number of trucks coming in and out of the facility because we have that record.

And the facility now is going through a 10 million dollars renovation plan and they're going to enclose some of this, you know, areas where they know already that PM10 levels are the highest, so this is kind of to give them confirmation that their emission plans are working, so one of the other things to consider is when you're basically measuring a one minute data, in 95 locations, you have hundreds of thousands of different points in a very small period of time.

So for those of you and us that are used to take a look at, for example, like the one that I showed here, you know, it's okay if you're interested in a very narrow period of time, but generally speaking it's a lot better to use fancier ways of taking a look at data like maps in this case. So this is just an animation that shows you, so it is a quick animation. Just to give you an idea.

You can take a look at a whole lot of data in a relatively small period of time, so that gives you an indication of where the highest PM concentrations are. So this is another pilot study that we started a while back and so we deployed 25 low cost PM sensors in the Redlands area. In that area we only have two monitoring stations and inland we notoriously lee have PM 2.5 problems.

So in order to expand our network and to try to understand the spatial variability of PM 2.5 there, we basically deploy 25 PM sensors so that gives you a better idea of maybe consider moving one of these station where the PM 2.5 is higher. We don't always pick the best location for our monitoring stations so all of these sensors are wireless. The only thing you need to do is plug them in and they transmit data to the server right away.

We are working with Microsoft actually to extract all of this data so that we can do better data analyzation, data analysis, different mapping, and so as you know, there is a lot that can be done when you have massive amount of information like we have here. So the project goals are test sensor durability and also show the ability to scale up in the future.

So if this type of model works for 25 local sensors, can we get it up to 100, 200, 300, possibly a thousand and one of the things we just won a grant from NASA and we are going to use these type of sensors to validate satellite data that provides PM information. So this is very exciting, this is just the beginning and I think that you know it's a very good pilot study.

So this is some other -- we won an EPA grant a couple of years ago, and as I told you before, the sensors for measuring VOCs are not quite accurate but that doesn't mean you cannot use it for specific application in this case. This is a fence-line monitoring application. This is extremely important, especially in the LA area.

We have six major refineries in a small, you know, basically facility that has like storage tank, oil pumps and they're located right in the middle of communities. This is not from Los Angeles. But you have a facility with potentially high VOC emissions that is located right next to a community, so what we did, is we put together what we call SPODs. It's just a small sensor device.

It is one sensor, detector that measures VOCs, and on top of it there is a 2D anemometer for measuring wind speed and wind direction, so as we go on the next screen, we have built four of them and we deployed them at the fence-line of this small facility where we have identified already that the concentration of VOC are through the roof.

Every time that you get a VOC hit, every time the VOC concentration goes up and is high, we are not interested in how high it is. We are interested in the variation from background, so every time the VOC concentration is really high, then we can take a look at the wind direction and wind speed and by means of some inverse social algorithm, we can try to potentially the source of that emission within the facility and by granting some model, we can try to see whether or not there might be an impact in the nearby community.

We are also using some optical remote sensing instruments run by a Swedish company actually verify some of the data you can get from the sensors. So this is another quite exciting project. It's basically, you know, it's a STAR grant that we got awarded a STAR grant from the EPA. We got 100 percent of the money, so I'm very happy about that.

We won this grant back in 2016, about July and the main goal here is working with, to working with communities to try to educate the community members in the use and operation of low cost sensors, so the educational aspect is also extremely important. There are four specific aims. Develop educational material for communities. We are going to work with teams groups on technology.

For this, second bullet, try to evaluate candidate sensors for deployment in six California communities, and the south coast is very equipped for this. We will deploy all of the sensors in six California communities. Our communities are growing. We already have eight to nine, I believe. We will put together this educational package that hopefully will set as a model for other communities that are also interested in this kind of work, so this work is conducting collaboration with UCLA, Sonoma Technology and other air quality agencies in California.

In terms of, as you see, we start to basically from there are community members that are purchasing individual sensors, but then they can be used maybe in a small group to create small sensor networks, and the goal really is to develop this wide sensor network that can measure air quality in wide areas throughout the state and throughout the country.

I just read this article maybe on March 22nd, so this is a new article like a couple of weeks old and there is a company Weather Underground. Maybe some of you are familiar with it. Weather Underground users, I think have they have 250,000 users, so they are basically private individuals. They own their own meteorological station that they operate in their back yard and they stream the weather data into the Weather Underground platform.

So they are basically, they have this massive weather network that is throughout the United States, I believe throughout the world actually and they're able to get, you know, almost neighborhood level weather information. So what they are trying to do and you will not find it in the article, but this is some inside information, I guess, so Weather Underground purchased about, I believe 10,000 PM sensors from a company that shall remain unknown.

But basically what they are trying to do, they will give the PM sensors to their top users for free and they will start streaming PM data into their platform with the hope that maybe the remaining 240,000 users will get interested and then maybe purchase one of these sensors, so this is extremely interesting and it has some potential to become, I don't know, the very first, you know, large PM network in the world.

So last but not least, again, I guess the journey throughout this presentation went from a single user to the development of large sensor networks. Something to be aware of, you know, most people when they hear, you know, the word low cost, they get super excited, so your project can be relatively low cost if you have one sensor and if you're interested in measuring air quality in the back yard, definitely it is a low cost project, but if you start building up to your network, just as an example, nine sensors.

But if you have more than 100 sensors, there are huge costs that are associated with the hardware, the maintenance and calibration of the sensors is also a huge factor and you need to be able to know that basically all of your 100 plus sensors are measuring air quality correctly. Sensor connectivity, building your sensor network is not cheap, making sure that all of these sensors connect into a server.

The server transmit the data back to where your central location. Data logging and management, data validation and analysis. It takes a lot of manpower to do that. And even visualization and reporting, too, they don't come for free in most cases. So you see what started as a low cost project ended up being a high cost network, so it's something to be aware of, especially for air quality agencies get excited about low cost sensor technology, but at some point you're going to have to face the costs associated with building a network. And with this, I conclude and thank you very much.

(Applause)

MR. HANNA: Do we have one or two questions from the council?

MR. OPIEKUN: From the instruments that you have tested, consumer grade instruments, do they come with adequate documentation on the limitations that users should be aware of? Because you mentioned earlier in your presentation that there are some users that you find out are using instrumentation inappropriately or pushing the boundaries of that equipment, so is there documentation associated with that?

MR. POLIDORI: There are some documentation that tells you, possibly the basics, of how to operate the instrument. When it comes to the application, my feeling at least, if you're dealing with like a larger company, maybe you're left on your own. You know, for some of the other smaller companies, Purple Air, I think the advantage of working with the small groups is you can contact them and I found, especially the personal interaction of gathering the information that you need to basically apply the sensors, it's a lot better. It's lot, but generally speaking, it is very variable.

MR. BIELORY: So you mentioned earlier that you do not specifically endorse any of these products. Do you do the opposite where if you find problems, do you, and maybe not recommend the product, but at least identify those problems on the website?

MR. POLIDORI: Yes, great question. Before I showed you like under in some of the gases, you know, we don't specifically say do not use this product, but in the table when you see $10,000 of square 0.1, I think that says it all. And in fact, one of the few problems that we have found, you know, one of the only requirements is if you give us your sensors, the program is free. You don't have to pay anything, but the only requirement is whatever we find, we'll publish, so that's kind of an implicit recommendation of what to use and what not to use.

MR. BIELORY: One other question.

You assess them, how well they work, how long do they last? Meaning, scientifically, the degradation of a product, maintenance, any information that you provide?

MR. POLIDORI: Yeah. And that's a huge problem. For example, if you're using a sensor for measuring ozone, it's pretty well known that the sensor head should be replaced every two, three months. Particulate sensors may last longer, and that's a problem. We don't specifically publish that kind of information there because we don't have the testing usually last two months and the chamber is a week worth of measurements.

MR. BIELORY: So you do not assess degradation?

MR. POLIDORI: We do not.

MR. BIELORY: Thank you.

(Applause)

MR. HANNA: We will have some time, we're going to have a round table at the end of the sessions today and we will be able to, at least the speakers will be able to ask each other some more questions. I have a lot more questions for Andrea. It was great. Thank you. To me, it was worth the cross country flight. Thank you for coming.

Leslie, come on up. Thank you. Leslie Cronkhite is US EPA lead for the Next Gen and Compliance team. Leslie has been with US EPA for 18 years. Has experience in regulatory and voluntary based programs spanning most of the environmental statutes. She has collaborated with stakeholders for meaningful environmental results on issues related to drinking water, underground injection, clean water, wetlands and chemical safety. Welcome, Leslie.

MS. CRONKHITE: Thank you. Thank you very much. I'm really pleased to be here today, very excited to be in New Jersey. It's the longest amount of time, from last night to now, that I've ever been in the state, so it's very interesting. Architecture is super, friendly people, so thank you for having me. My presentation is going to be from the perspective of the EPA as a regulatory agency.

Policy issues associated with sensors and I really appreciate Andrea's presentation which explained very nicely a lot of the technical issues, so I think my presentation will be shorter but yours was very effective and great and helpful for me, too, so it's nice to see you. So the working definition of advanced monitoring. We have a team of EPA people that works across all the EPA media offices looking at use of advanced monitoring and we're considering that to be any type of monitoring that is newly on the market, but that is not yet a part of a standard method or considered a federal reference method.

So today I'm just going to focus on sensors, the type of monitors that Andrea addressed and that you guys are asking about. We believe that sensors will create a paradigm shift in environmental monitoring. We think that because they're more portable, they're less expensive and they're easier to use and they're cheaper, citizens will start to use them in GOs, facilities, researchers and it will move from the current technology to new technology.

And this will change having the EPA regulators or the state regulators being the ones that typically dictate environmental monitoring to everybody conducting, lots of people conducting monitoring and having environmental data out there that is not controlled by the regulators or qualified by the regulators and so this slide just shows two different comparisons, current technology and the new technology. So we already addressed the first one. Typically, the traditional methods of monitoring big footprint and require dedicated power. They may require expertise to use that monitoring technology.

There are often delays for lab analysis, and that analysis is typically associated with the quality assurance requirement. It's usually collected by either government or regulated facility or researchers, and then the data that's generated is stored by government agencies and then published on their websites. The new technology has a smaller footprint, is more mobile, battery powered or solar powered.

Perhaps easier to use, depending on the performance capability and the intended use which Andrea spoke to. There is no, the information frequently comes as real-time because there's no laboratory wait, but then there's also not the standard quality assurance protocols associated with that information can be collected, as I mentioned, by communities and GOs and facilities, researchers or citizen, and then the data is shared and accessed through non governmental sites.

So I think that we believe there's a lot of promise in sensor technology for environmental programs. Primarily, because it makes the invisible, visible, and once the pollution is visible, will tend to be reduced through mechanisms listed here. Either it attributes to the more effective regulatory monitoring by regulated communities or government.

It can enhance the ability of a facility to prevent, reduce and treat pollution if they can use the sensors, as Andrea pointed out, to target areas that may be -- that may show where the high sources are. If the data can be collated and merged and then published and given access to the public, it will enhance the public's ability to make personal behavior decisions to avoid hot spots.

There's a public accountability issue if the public sees the data they will hold facilities more accountable and that will drive improved performance. We also think sensors could be used to improve effective permits and inspections and then under pending all that is the idea that the sensors are generating real-time data which is very powerful. So the opportunity as regulators for EPA and for states is to transform environmental programs.

First, by using sensor data to supplement the gold standard or the federal reference methods, monitors with richer data on air and water quality. So the data that gets generated by sensors, no matter what the source, if it's merged and useable, it can fill in all the spatial gaps for the standard monitors, and the new devices can be powerful tools for screening or assessment of sources and their impacts.

So I wanted to step away from the slide for a minute and just tell you about a couple of projects I recently heard about in Baltimore. The city is starting three research projects using sensors. They're going to outfit volunteer citizens, about 50 of them, with their own personal monitoring devices and have them wear them throughout their regular daily activities, and through the data collection, on those sensors, they'll be able to see what the effects are on peoples exposure as they walk amongst traffic and also they're going to be looking at the effects of exposure to people from changing energy sources.

It's a really interesting use of sensors. They'll be using that information to help inform their public health policies. So the other opportunity is just having that rich body of data from many different sources can give a vast body of environmental information that can be used by everyone. However, there are some challenges that the regulators are already starting to face.

First of all, the pace of the technology is moving so quickly, that it's difficult for the EPA and states to stay on top of what's out there, how the devices perform and what they can be used for. Citizens and communities are using the new technology, but the results, the meaning of the results are unclear because we don't know the quality of the devices.

So if we get a call from a citizen asking about a higher reading, it's hard for us to really respond to that if we don't know what the device is really capable of giving in terms of this performance. So this could lead to false positives which could suck up a lot of time for a facility or for an environmental agency to try to reconcile what people are seeing with what the device is actually able to read, or false negatives could be a problem as well.

So some people may have a false sense of security thinking there's nothing there because the device isn't sensitive enough or isn't able to perform in the condition they used it and it didn't detect something that really was there. So we have our Office of Research and Development at EPA does in depth studies similar to what South Coast does. They do very, very thorough looks at devices.

However, we're limited in how much we can do. We have found, as Andrea said, that some of the results indicate that manufacturer claims are not always confirmed through those studies. I think I already addressed number three. So another issue that we see is trying to speak to data that comes in one minute, five minute or 15 minute increments for instance when the health standard is based on long term exposure.

It's hard to explain to somebody what the meaning of that short term data is. And another challenge is our EPA's approval methods for using or coming up with the standard that we think is useable in our rules and our permits and in our enforcement. So we are looking at trying to make that process a little bit more streamlined so that we can incorporate some of this new technology into our compliance programs.

There may be a need for us to expand on data systems to collect the data, display the data and then publish it back out to people. We've got some different groups that are working on that issue, and then finally, learning how to extract useful information from larger datasets, and we're thinking in terms of statistical tools, that may be able to pull lower quality data together and make something out of it.

So these are challenges that we're trying to address because we see the opportunity and the sensors for EPA to be able to use these, in EPA and states, to be able to use these in rules and in inspections and enforcement and compliance programs. We wanted to address the challenges, so we met with the E-Enterprise for the environment council, which if you're not familiar with the E-Enterprise, it's a business strategy that was started in 2014.

It has states and EPA working closely together to identify problems and solutions across the environmental enterprise rather than as federal and state, so the E-Enterprise Leadership Council consists of 10 EPA senior executives and 10 state commissioners and they looked at this issue and agreed that states are struggling with some of these challenges as much as the EPA is and possibly more, and so they asked us to form a team of EPA and state folks to address five objectives.

One is to explore potential, a potential for an independent third party certification program. A second objective is to form a network of EPA and state scientists and engineers who can help inform each other and share information. The third is to address a question of how you communicate the results of short term monitoring data that are based on long term exposure.

And the fourth one is to develop data standards so that data can easily be merged and shared. And the fifth one is to consider whether or not our methods approval processes can be streamlined using the lean process. So I'll talk about those very briefly. Why are we looking for a third party certification? So this is our first need that is -- trying to address some of these issues that Andrea brought up.

Technology is advancing at a rapid pace. The environmental sensors market right now for 2014 was estimated to be 13.2 billion dollars and it's expected to increase to 19 billion by 2019. Some of the high tech companies like Google and other data mining companies are getting involved and environmental monitoring, and so we feel that there needs to be an independent body that can do some of the work to certify the quality of the devices.

Because, as we mentioned, some of the untested sensor technologies is strained, government resources is also strained facilities that have to speak to some of the results. So the team that looked at the options for a third party certification project looked at certification versus evaluation and verification. And the difference is that evaluation and verification looks at the performance of a device against what the manufacturers say.

Whereas, the certification looks at predefined standards that all devices are tested against, so a certification body might be similar to underwriter laboratories which when you buy an electronic device with a UL stamp on it shows that the device has been tested against safety standards and has passed, so we're thinking of something similar to that. The folks who are working on this at existing certification programs, and they're also considering looking at creating new program and partnering with other federal agencies and with the private sector.

While we think that the government may need to fund initially getting the program started, we intend for this type of program to be self sustaining. So for the second objective, establishing a network amongst the states and EPA's engineers, the idea behind this is we have a group of people who are interested as part of their regular job, scan across city and environmental enterprise, what is the interest in sensor monitors and then find devices and use the market that may meet their need and then do a screen on the information that is readily available.

So this would be manufacturing information that we would gather, possibly digest and then put into a clearinghouse to be shared among network members. The network is focused on EPA and state regulators and would probably be a temporary body until a third party certification were established. The type of information the standard network would gather is not a substitute for the in depth testing that our Office of Research and Development does or that South Coast does.

But it would just provide easy access to the information that is out there and also in cases where we know of states that have done some testing, we would like to be able to share those experiences as well. We're piloting the networks, so right now we have 25 members. We just kicked it off last week, and once we figure out the processes and how it's going to work, we'll be expanding it across the country.

So objective three is the team is

working on that question of how you do comparison of one minute data to help the standards. They've developed a mock up that looks at sort of presenting the data in terms of high, medium and low. So if you have a reading of ozone for instance that is 25 PPM, what do you make of that as a citizen. Is that like off the charts? Is that barely detectable? And so just to give people a sense of scale, this team is sort of stalled at this point.

They'd like to make some visualization tools and develop those statistical tools that I talked about before that would allow merging data and then making sense of it and possibly making it useful, even if it's not the highest quality, but we're kind of waiting for resources in the budget to be handed out and when we figure that out, they'll be able to pick back up on their work.

The fourth objective is to create data standards and this is a very techy IT, slough through the mud kind of work, but the leads explains it using more every day experiences. When we are turning in our taxes electronically through Turbo Tax or H and R Block or your accountant system, we're able to do that because there are data standards that they're all complying with, so it defines how the data should be formatted.

And therefore, people who comply with the standards, they can send the data to the IRS. And the same is true with banking. We do electronic banking. There are standards that have been developed with the data and that allows us to do business trance actions electronically, so the same idea for sensor monitoring data.

This is an effort to define, are we going to report a certain concentration of PPM or PPB, and having sort of data quality information of when the last time the device was calibrated, et cetera. Having these standards will allow us to use the numerous and diverse entities and leverage all that monitoring that is being done. There is ongoing work in the private sector to make use of sensor data, and our team has been reaching out to the people that we know of that are already doing that work so that we can be sure to merge or duplicate their efforts.

And then the final team is working on leaning the methods approval process, so monitoring methods for regulatory permitting and compliance purposes have to be approved by EPA and state environmental agencies. And so in order for us to try to make sure that that's working, those processes to approve methods are efficient and flexible, we're going through a lean process.

We've identified five monitoring approval programs in the EPA, and so far we have completed a lean exercise for the Clean Water Act monitoring approval and there should be a report of that coming out in a couple of months. I want to end with talking about the benefits of this work. I have some of them listed here. We see a lot of benefits across the Enterprise. We think it's good for industry. It's good for communities, and it's good for good government to have the third party certification, to have data standards, to have a framework for communicating results.

So all the work that we're doing has benefits that could be far reaching. And first of all, as I've mentioned, we will reduce time spent on false negatives or false positives. Having some of the standards in place and being able to use sensors in a robust way consistent with environmental programs allows for more important decisions, i.e., the work being done in Baltimore. It will enable communities to formulate more meaningful plans.

It will, we believe, could stimulate markets to develop new technologies to improve their advanced monitoring devices if we have performance standards that we're saying for a particular use, this is the standard you need to meet. It gives manufacturers a target.

And finally, and maybe most importantly, if the data can be high quality merged and shared, it could empower individuals to make personal behavior decision such as avoiding hot spots, so we are -- about the possibility of moving forward with sensors and starting to incorporate it more into EPA and the state programs. And here is my contact information. I'll be happy to take questions.

(Applause)

MR. BIELORY: Two questions. One, have any of these formal monitors used by your states or private parties been approved under any of these programs under air, water? So, you know, to the extent they need to be approved or methods need to be approved, has that been done in any particular state?

MS. CRONKHITE: Yes. I think one has the 2B Technologies ozone monitor I think. I'm not sure, but I believe that one has been approved, but we have not been able -- because there hasn't been an ability to approve a lot of them yet, we haven't -- that's why we haven't been able to incorporate them into rules.

MR. BIELORY: And that's used both the state government and or private parties?

MS. CRONKHITE: So the states typically rely on federal reference methods. There may be some states that develop their own methods processes, but I think typically they rely on what EPA comes up with.

MR. BIELORY: And does EPA enforce relying upon private party, but private party air monitoring for enforcement actions?

MS. CRONKHITE: We're not relying on private party results, but we have been incorporating sensor monitoring into some of our settlement agreements.

MR. HANNA: Leslie, I was interested

to get your thoughts, maybe pros, cons on the 10,000 sensor deployment that Weather Underground was planning that Andrea told us about.

MS. CRONKHITE: Well, I think it's very exciting. I think that the real potential of sensors is the democratization of environmental monitoring. I think it has fantastic potential to sort of revolutionize environmental monitoring and having people be more interested and more involved in their environmental quality. I guess a question that came up to me, when I heard him talking about that, was again the quality of the sensors, the ability of the people using them to ensure that they're calibrated properly and that they're used properly, and then finally, what the conditions are, as this gentleman asks, what the conditions, the performance is over time, so those are sort of the questions that came up to me, but I think it sounds very exciting.

MR. OPIEKUN: At some point does EPA envision publically collected data flowing directly to EPA, or do you envision the use of something like partnering with the exchange network? Since I know that every state has a node on the exchange network, do you envision some sort of pass through system where it would go to state government first before going to a federal repository? Is there any thoughts on that?

MS. CRONKHITE: Yeah. Actually we have a project, another project under E-Enterprise with states and the EPA, looking at how to collect sensor data from different sources, and we do not intend to do is have a central depository that EPA mans or we don't expect the states would be able to do that, or EPA, because it's a huge amount of data that would be coming and expensive, and maybe not really where we should be spending our resources.

Instead, what this group is looking at is having a central, I think they're calling it a catalogue of the data that's available, so if you've collected sensor data, and you want to share it, you would register with this catalogue and give a little bit of detail what the data is, you hit that catalogue, which we would intend to maintain, and the catalogue would send you to the owner of the data and you could retrieve it in that way.

MR. HANNA: Thank you, Leslie.

(Applause)

MR. HANNA: So we've heard from a couple representatives from government agencies and we're going to move to a few presentations of owners of projects, so Holger Eisl is the research associate professor at Queens College, and Dr. Eisl is currently principal investigator of the New York City Community Air Survey in a joint project with New York City Department of Health and Mental Hygiene. He oversees all activities related to the collection of ambient air monitoring data, lab analyses and data validation procedures for the New York City Community Air Survey. And under his direction, works on new and innovative air monitoring instruments to perform field testing of environmental monitoring services.

MR. EISL: Thank you. I want to thank Chairman Opiekun and council members for the invitation to have the opportunity to testify, so what I was asked to sort of give a presentation or an overview of our work in New York, so I'm a faculty at the Barry Commoner Center for Health and the Environment so we are doing research on environmental issues and also on environmental health related problems. What I plan to do is, again, give you an overview of the program.

The NYCCAS program, if I have time, I'll also briefly address a new program that we're doing deploying network of real-time instruments for PM 2.5 in New York City and we also plan to do, start a Citizen Science project at the Commoner Center with funding from the New York City Department of Health. I show this slide simply here to indicate being exposed to air pollution is unhealthy, causes serious problems, and that's the reason actually the city of New York decided to do a detailed study.

The seriousness of the problem is actually documented on this slide where the World Health Organization estimates that in the world seven million people die every year because of exposure to air pollution. 3.7 million die because of exposure to outdoor air pollution. And another study published indicates that ambient exposure to PM is the ninth leading risk factor for all diseases in the world.

When it comes to New York City, the

health department estimates every year 2,000 people die prematurely because of exposure to PM 2.5. In addition to that, you have issues with hospitalizations and emergency room visits, so hospitalizations, we have roughly 1500 in New York City and 4,800 emergency room visits which also overloads at times the hospitals. Now, the start or the reason that NYCCAS was created came out of the PlanYC which was basically, the idea came from former Mayor Blumberg, and the plan was launched in 2007 and it's sort of the plan that creates a vision for the City of New York, how it should look like by 2030.

In fact, based on the fact that the population will increase and the plan asks for improvements on water problems, solid waste issue and climate issues and of course also problems with air quality in New York City. Now, the key sources in New York City for air pollution is traffic and emissions from buildings. These are the key sources. We don't have too many problems with manufacturing. We have some critical point sources, transfer stations and also some power plants.

Now, at the time in 2007 when the

plan came out, the city didn't have the tools to sort of understand the spatial variability from neighborhood to neighborhood in New York City, so the mayor's office charged the Department of Health to design the study and the Health Department approached us and we basically -- the NYCCAS program. The critical goals, we have four objectives for NYCCAS, so we want to assess the year round variation of the multiple pollutants across New York City neighborhoods.

And we want to identify potentially additional sources that contribute to the urban air pollution within these different neighborhoods, the data being used to inform the public and the government to potentially develop strategies to reduce air pollution, and as a byproduct, we create dataset off high quality spatial data of air pollution for etiological studies and health surveillance programs.

So the NYCCAS program started in 2007. In the first year, we developed the program, designed the program and we also developed an instrument that can do the work because there was nothing existing at that time, so monitoring began in the winter of 2008 through

2009. Initially, we had 150 sites and over time, we reduced the sites for two reasons. First of all budgetary constraints with the Department of Health.

Remember, 2008, 2009 was the time of the economic crisis, so there was some pressure on the Health Department to save money so they cut back on the budget, but we also, we are also combining the monitoring data with the latest repression model and realize there was some redundancy in the monitoring sites which we could eliminate and still have a robust model. What we are doing actually is totally different than what we have discussed so far.

We are not doing real-time data. We are doing integrated sediment. Why do we that? Because when it comes to health outcome, long term exposure is a significant problem, so the Health Department was more interested really in sort of seasonal averages and annual averages, and so it can be seen what we are doing, we are sampling at each location four times a year, during each season, and the samples placed at the monitoring site for two weeks and collect the data and we have also reference sites.

One in each of the five boroughs where we continue to sample and target pollutants are PM 2.5, the gaseous pollutant of the Oxide of Nitrogen, ozone and Sulfide Oxide. Now, the monitoring date are integrated into a land use regression model which allows you basically to take the pattern from the monitoring site with the surrounding land use to forecast pollution levels in the area where you don't take the measurements, so here it shows you basically how it compares on the maps on the right side.

It's basically the monitoring sites from DEC, from regulatory agencies, a total of 27 sites. The majority of them are -- 17 focused on one pollutant as PM 2.5. There are three sides in New York City, two in the Bronx. The Bronx, one at a school and one at Queens College where they target all the same pollutants that we are targeting. These are regulatory monitors and they're real-time instruments. On the left side are the monitoring sites from the NYCCAS program.

There are a total of 150 sites listed there. It is difficult to see what we are monitoring at 75 sites. There are also some sites in what's called the Environmental Justice

Zone where they target certain low income and economic and disadvantaged sites where we often do some, so I won't go into details but you can imagine, in a city of 8.5 million, the Health Department says, now monitor and tell us what the spatial variability is. It's not an easy task, so we developed a model to tell us what the critical locations, where we should place monitors.

So we used a model and that helped us sort of identify 120 locations where we did some monitoring, but the models are never perfect so we had what we call purposeful sites where we use expert opinions, some missing here, some missing there, so there was some gaps for example on the model. We also had to go, at least one monitored site for each community district and some other areas of concern.

For example, we had one monitoring site next to the World Trade Center. We also targeted some schools where we wanted to have the monitoring sites. Now, at that time there was no instrument available so it took us a year to develop that instrument. It's basically, we are sort of collecting samples for the gaseous pollutants using -- basically, this is the housing units for the ozone. This is for noxious SO2 in the middle.

There is a sensor where we collect data on the relative humidity and temperature. It is important in the lab analysis for coming up with the results for the gaseous pollutants. The PM 2.5, with a Harvard impactor which is connected to a pump that is connected to a smart controller which sort of collects samples on PM 2.5. We did extensive testing over the years, so this is in the Bronx.

We also placed multiple of these units and make sure they compare well and they're also -- they are precise and tweak the units over a year period and eventually produce a total of 90 units in the New York City program. We set up a laboratory at Queens College where we basically prepare the units for deployment and we have fill data sheets. We develop all the protocols, and once the units are coming back after two weeks, they get basically processed.

The filters get harvested, data gets downloaded and so that is why we need the laboratory facility. Basically, we have field teams. Basically, typically on a Tuesday the field teams go out and deploy the units. We are going to deploy units in the middle of the night because of traffic concerns. Typically, it takes us, for a team, four to five hours to deploy 10 to 12 units. We have two teams going out doing this work and typically on a Wednesday then, teams go out again overnight and retrieving the units from the previous session.

We modified a vehicle, we modified the vehicle here. There is the compartment where all the instruments are located and in the lower compartment we have foldable scaffold which we need to -- we are setting up at each lamp post to reach a height of 10 to 12 feet to deploy the unit. That shows you basically once we initially defined where we go, we preinstalled mounting plates, which allow for rapid deployment and retrieval and here on the right side you see one of our staff members being on that scaffold and he's deploying or retrieving one of the units.

That's the way it looks when you zoom in. It's actually in Manhattan. That's the way the unit looks. Once it's deployed, it's locked to the mounting plate. The unit itself is locked and that's what it looks like from the sidewalk. You don't even recognize. However, it was a big issue when we set up the study. You can imagine, since September 11th, there are changes to New York City and an open unit looks like a bomb basically, so we had to talk to the Homeland Security and NYPD, to get all special permits.

Vehicles have special lights, so normally I use students to go out so they have sort of necessary documentation because if they get stopped by police, over the years now they know us, so that's a logistical challenge. So once the samples come back, they basically harvested them and there are all types of different lab methods are being used to extract and come up with the results.

Now, when we decided to study to outsource all of the lab work because of quality assurance, quality control issues, so we are using the same laboratory EPA is using. We use research lab in Arizona, so that shows you. This slide shows you the sampling activity over the last, 2009 to 2016, so far -- 13,000 samples. We have the majority of samples for PM 2.5 and NOx because we only focus, when it comes to ozone, we only sample the summertime and SO2, we sample in the winter time.

So it's critical for the data is that we look at precision and comparability, so whenever we deploy instruments at certain sites, normally two sites, so two units on one lamp post and we also co-locate at all times DEC reference sites, so basically this shows you sort of a correlation of co-located NYCCAS units on the top. These are the co-located NYCCAS units at point 95. These ones are compared the data with DEC of .88.

These are some results that shows you here, basically the maps from 2009 and 2015 for the five year results. It shows you what we have a decline in New York City by 16 percent. Here is the map on NO2. What you have to remember is we have 75 sites and a strong model and be able to determine the spatial variability of the whole city. That's interesting in the discussion where you guys are talking about thousands of monitors and discussion will be what models should play an important role.

This is simply a map of S02. So

because of our activities and our findings, there were a number of sort of actions taken by city council. One of the important ones was the phasing out of number six for boilers in high rise buildings, and that had a significant impact in New York City to reduce SO2 levels. We are also setting up a network of real-time models. We use PR 1500 which is used typically for indoors and sort of create an environment for this instrument to also be able to monitor outdoors, and here we have deployed so far five units in New York City.

We plan to have deployed 12 units by basically August of this year. Now, we got funding from the Health Department for two year program of Citizen Science. We will hire basically a post op position and then basically work corporation with the DOH on the Citizen Science project. What's unique and interesting will be to use some of these new devices within an environment where we have a pretty good understanding of the spatial variability.

I wouldn't call it a gold standard, but a pretty good standard to compare what we get from Citizen Science. So let me stop here. I only want to show it's not my work. It's really work of a huge group outside consultants, health department and of course our group at Queens College is doing this work. Thank you.

(Applause)

MR. HANNA: Questions from the council? Holger, I think you got to it at the end, but the use of 2007 technology passive non real-time, now you're supplementing that one with established network with electronic sensors. Where do you see those choices? Do you think if we roll the clock forward, how would you do this project differently with today's technology?

MR. EISL: I think we still would do it the same way, but what helps us now, in the Citizen Science project what we will do, we will probably select a high traffic zone ora marine transfer station, and basically let -- we probably add additional NYCCAS units there and also sort of have monitoring with Citizen Science instruments, and then having additional NYCCAS units, we can later see what the NYCCAS model predicts, do we actually represent with the model.

Also what we suddenly measure with

Citizen Science or the additional NYCCAS models. That tells us how accurate our models. We are very confident, but the question is, when you look at hot spots, do we really capture that with the NYCCAS program, and if it turns out with help from Citizen Science instrumentation, maybe we are missing a hot spot, we may tweak the system, add additional sites and modify the model to make it even stronger. So we won't use the actual numbers from Citizen Science, but it helps to scan it and see whether we are missing something.

MR. HANNA: A screening tool.

MR. EISL: A screening tool.

MR. HANNA: Thank you very much. Continuing with our discussion about ongoing projects, Anna Scott, who is currently a Ph.D. student at Johns Hopkins is joining us to talk to us more about the Baltimore project that Leslie highlighted briefly for us, and Anna, you stand between us and lunch so we'll keep you on schedule. No pressure.

MS. SCOTT: Thanks, everyone. I'll try and be a little brief. Before I start I was kind of curious. Could I get a raise of hands of how many people here have an air quality and a meteorology background? Okay. That's like five people. How many people have a regulatory background or work for a state? A couple. That's more. Maybe 10.

And then how many people are with health sort of exposure stuff, public health? Great. That was like four. And how many people are here in their capacity as interested citizens or other? Two people. People are playing hooky like me. I'm going to talk today about project that we're working on in Baltimore, and one of the projects that Leslie identified.

This project is called Baltimore Open Air, and this is more of DIY I guess Citizen Science version of a lot of the monitor research activities that are taking place at John Hopkins. This project is really a community driven and partially funded project to monitor air quality using open source, off the shelf technologies and using this to develop a network of air quality monitors, and then the software network infrastructure around those to be able to read and use that data.

Our project has a couple of goals, and these are in no particular order, but we're hoping to first we've got to design and build the monitors themselves. We have a shoe string budget. I think we got about $40,000 from the EPA and we supplemented that with a couple thousand dollars from funding. We got some matching funds from the Institute at Hopkins, so we have to basically design our own stuff from scratch. Everyone like me is working on this as a volunteer, so we have free mental labor, not so free other stuff.

So the engineering challenges are to design and build the monitors and put that data on the internet and manage it. We hope to use this to do some science and specifically to do some of the stuff they've done in New York, to quantify the spatial variability within our city and air quality, and that's something that's been identified of interest to our partners and in the city and additionally, this is not last.

This is in conjunction with all these activities, we hope to work with citizen scientists and community groups and environmental justice organizations to build and deploy the network, so we can make sure that really everyone is a part of this and can learn, not just about maybe what the sensors are saying but learn some of the difficulties that are inherent in doing some of the monitoring because I think that can sort of improve the relationship is I think I hear from a lot of state regulatory agencies, we're really worried, we're really worried about this data quality and the social justice and environmental groups, they take it that a little bit of the wrong way.

A lot of people I met in these environmental groups don't necessarily have a science background. They haven't spent a decade of their life dealing with lab equipment, and I feel like getting people on board with some of those challenges, for me, it's a little cathartic emotionally, but I think that can sort of help get everyone on the same page. So I guess getting on board with this project does require getting on board with this new monitoring paradigm.

But I think Leslie touched on it a little bit. First on our project we are going to, number one, prioritize understanding spatial variability. It's really critical for us to understand, not necessarily the absolute level, but to say things like this neighborhood is more or less, you know, polluted than another neighborhood and maybe not be able to tell you the PPM level, but to be able to identify where those hot spots.

Second, rather than thinking about point source accuracy or live report accuracy, we're thinking about the accuracies of the overall network, sort of the idea that maybe one sensor isn't going to be as precise as we might like, those of us who do have that science or monitoring or measurement background, but when you think about what is the network as a whole saying.

So how are we going to do this. Step one is we still do have to ensure the reliability of our sensors. We have a couple of strategies to do this, and I'm happy to talk more if people have good ideas. And Andrea was talking about some of the measurements that they took, STAQMD, and I think you guys were treating these -- at least what I heard from you guys, that you were treating these like consumer products, off the shelf products.

That is not our approach. We've

gone through the documentation. We think it's okay, it's boring, and I think you have to be an engineer to be able to read it because I think it was written by engineers, so we've gone through this documentation, and we're like, okay, great, our sensors are going to be cross sensitive to four or five other species, let's measure those, let's do some sort of analysis, let's figure out the sensitivity and we'll correct our raw data to get a final estimated air quality product.

The second strategy, which is something that we've tested out before with some of the monitoring that I've done and we've done a lot in Baltimore at looking at understanding temperature variability within the city. It's to ensure the network reliability. One by clustering monitors so we can quantify the variability of the sensor to sensor or monitor the monitor variability.

And then second would be co-locating reference networks, which in this case would be the state run networks with the reference, the federal reference standard equipment. I guess I should note here for this presentation, as a group that is building our own devices, I draw a distinction between a sensor and a monitor.

So for us, the sensor is really just the device physically interacting with the air pollutants to give out some sort of electronic signal and for us to monitor the entire product that we've put together because we're building our own we can make that distinction. I totally understand that a lot of people aren't in that position. So here we get to the details. Like I said, we don't have a whole ton of money for this. But we're planning on building about 300 of these things.

The first cost is for our circuit boards, our solar panels, our batteries, our boxes, our screws, I think we have like one screw zip tied, et cetera part, I guess. If you're interested in air quality monitoring, that's the et cetera part. That costs us about $120. That includes our assembly labor. Then we get to the sensors, so the sensors that we're going to use for this, we've been testing out the ones from SPEC.

We have actually had -- these do not do so well on Andrea's measurement test, but we think in part that was the case because they have significant cross correlation with some of these other species and we think we can improve the measurements we get by taking those into account. Secondly, we have been terribly not impressed by some of the circuit boards that come with these, so we think the sensors are working okay, but already we got five of our -- like the company's microprocessors and we've had to like, we had a clock that wasn't working correctly, like the clock was drifting.

We had another circuit that we had to re-solder ourselves, so I think this is something to keep in mind is that the performance of the sensors is maybe slightly different than the performance of the microprocessors and everything that is processing the data, and I think that is something to keep in mind, especially for these newer companies that probably started us out with expertise in sensing and not necessarily all of the low cost electronics, so these are sensors.

Once we get that data, we will pipe this up to a database on the Cloud. We have proposed to be using an Amazon web service product. These products have tiered pricing.

They call it infinitely scalable which means if you have a lot of data, you can still use their products. For us we're on the free tier and it would take us a lot to be able to get up to where we would be paying anything more than a couple hundred dollars a year.

We're going to be sending them data in what we call semi real-time, so that means that we are solar powered so we can only afford to transmit data, we think once a day and maybe more than that depending on the sun exposure, so we'll be able to use the Amazon web service products to manage our data, log the location. DynamoDB is what's called a no sequel database.

It's a non relational database that you can put data into and it's like widely used in the industry which is why we picked it. There is also a web service that's an IOT platform which manages individual sensors and will connect the sensor data that you send to the Cloud or to the internet and pipe that up DynamoDB. There is another service that we're also planning, I haven't mentioned, which works with cell phone connectivity.

It's called Tulio. I think it was

recently filed by Amazon, but that's a service. This is like a technology if you're interested in and you think you won't have wireless connectivity, but you might have cell service, that's a product, not me personally, but some members of our team have had experience and then the last part is to visualize this and make the data available to everyone. For this we're using products that's been an open source platform that's been developed in particular with the hyperlogical community. That's called Tethys platform. I haven't had experience with it.

Some of our colleagues are using it and we're combining this website building with some of our projects in order to save money. So we're really just going to start at phases of our project. This is kind of like the first data that's coming off one of our first monitors. It's just sitting outside of my house. This is not corrected for cross sensitivity on the top is NO2.

On the bottom is ozone and you can see they're really, really -- because these are current are exactly the same. When we ran this through our regression model this morning, this is pretty new data, we found that the sensitivity that the manufacturer was reporting to these additional, they also did temperature and humidity, as well as the other gases, were pretty spot on, so far we're pleased to see that that seems to be matching what the manufacturers is advertising.

We have a number of partners on this project that I need to thank. Johns Hopkins, which is like this behemoth university. We're involved with four schools at Hopkins, a number of professors and there's been all sorts of people who haven't worked theoretically on this grant, but give us advice so it's been really great. We've got a number of non profit partners.

Over on the left I'm showing pictures from some of our workshops, and I think most notably, by using this sort of open source technology, we've been able to leverage support from the maker space community, and if you're not familiar with maker spaces or the maker movement, it's a movement of people who use -- they do electronic building for fun, sort of the way some people like to build cabinets.

Some people like to build weather stations and they've been a really great resource and a great way to engage people that wouldn't necessarily be interested in the environment per se. This is us, a lot of this is me. These are photos on my phone. This is our first monitor. I took that last night. This is kind of the level that we're at right now. We are building things. We're engaging people, and we're excited to start rolling this, ramping this up and rolling this out later in the summer. So with that, I think I can let everyone go to lunch early, but I'm happy to take questions and feel free to contact me.

(Applause)

MR. HANNA: That was a great perspective, Anna. Thank you. Very grass roots. What's the duration, or what's the expected time to see results?

MS. SCOTT: Well, to see results, I think there is two results we're going to see. One is the proof of concept, like can we do this and that will be something that will be abundantly clear in the next couple of months, I would say by August. If these things aren't out, that would be a bad sign. I think that we're planning to get data later on in the summer that we can use to then make statements about spatial variability. I think the EPA Smart City Air Challenge, which funded half of this project, is a one to two year project. We would be excited to maybe see if we could extend it beyond that, but we would need funding to do that.

MR. HANNA: So we're talking about 2017, '18, '19, in that time frame, we'll be getting subsequent information?

MS. SCOTT: Yeah.

MR. HANNA: Are you planning to send Andrea a couple of your monitors?

MS. SCOTT: Yeah. I don't know if you did but your colleague said that you guys would be happy to test them out, so putting you on the spot. We are really trying to do this in an open source sort of fashion so we're going to have all of our data. It didn't make it yet. We're sharing code and we're sharing our circuit code design, and all that is going to be available on our Get Hub website.

Get Hub is a code sharing platform, if you're not familiar with it, but apparently you can share circuit board designs. But working with, if anyone, since we're like resource limited, we're really happy to work with anyone and test in any laboratory. We're really excited to, I don't know. We're doing this for fun. This is something that's exciting. I feel like I'm in parks and recreation. One of the questions, how can you do some of these low cost monitoring things.

We have student at Hopkins who will work for free. We offer to pay them and they turn it down. You guys in New Jersey, I'm sure these Princeton students down the road, or Rutgers students, if you can make contact with some of these people, I think they're excited young people who are really excited to engage. I'm happy to put you guys in touch, too. We've got plenty of students from the area.

MR. HANNA: Any other questions for Anna? Thank you.

(Applause)

MR. HANNA: So as Rich mentioned at the top of the session today, lunch is provided for the speakers and the council here. Others, DEP has a pretty well stocked cafeteria down in the hall. If you go straight across the lobby, you'll find it. There's some local restaurants. There are slimmer pickings than there used to be, but we can certainly get you references for that. We're going to break for a half hour and reconvene at 12:40.

(Whereupon a break was taken.)

MR. HANNA: We're going to reconvene. Because we want a full room, when our former Clean Air Council colleague, Dr. Rob Laumbach, comes back up to talk to us. Rob just left the Clean Air Council last year.

MR. LAUMBACH: Yes.

MR. HANNA: We're glad to have him back, so we invited him back in. Rob is an MD and associate professor in the Department of Environmental and Occupational Health in the Rutgers School of Public Health. As I mentioned, he's been on the council with us doing air quality issues in New Jersey and around the world for how many years?

MR. LAUMBACH: Too many to count.

MR. HANNA: Let me introduce Rob, and appreciate you joining us, Rob. Thanks.

MR. LAUMBACH: Thank you very much.

So as Toby mentioned, I'm at Rutgers University. I've been doing air quality research, really focusing on health outcomes, trying to make linkages to create exposure to air pollution and health and focusing a lot on clinical type studies with individuals, so I don't know that I have that much more to add in general about some of the capabilities and the challenges of using low cost monitors.

But I have a little bit of experience, both observing communities here in New Jersey who are engaged in some Citizen Science and also low cost sensor monitoring studies and then also a small study that we started to dabble in this area ourselves, and we've been particularly interested, both at my group in Rutgers as well as in the community, in traffic related air pollution and how people move through environments where there's near roadway environments say for example where there is more or less traffic related air pollution.

And then in particular, we've been looking at in vehicle exposures, so peoples exposures, traffic air pollution in cars which comes from primarily surrounding vehicles and the general on road -- environment, so I want to talk a little bit about those experiences and try to give a little perspective. I think one take home message. It's not really as easy as it looks to do any of these studies. I think any of us who have done them, can acknowledge that.

But especially for I think community members, who may not, again, have the technical knowledge and background that we have, the ability to analyze and interpret data. I think the context is really important. We've talked a little bit about the technical specifications for monitors, and a little bit about also the data management and the challenges involved with that and the interpretation and site design.

So we did a little study using the CairPol CairClip monitor which was, I'm not sure if it was back there, but it was on the screen a couple times already which measures nitrogen dioxide and also ozone and other oxidant gases and we did a survey of employees at Rutgers, so our Rutgers community, 18,000 surveys sent out, got about 5,000 back and about 2,500 people agreed to be contacted for future studies.

So we want to characterize in some

way future studies the exposure that employees have at Rutgers located in the center of New Jersey, as they commute all the way up to Scranton, Pennsylvania all the way down to the state of Delaware and we can do that that with modeling. As Holger mentioned, the models can be very valuable with this, but inside a vehicle, there's a lot of factors involved in terms of what's happening at the microenvironmental level, windows open, windows closed, the modal of the vehicle, filtration, et cetera.

So we had, in a pilot study, 16 Rutgers faculty and staff volunteer to wear these CairClip monitors and do it for a week of regular commuting and do some daily time activity logs during that week and also wear GPS monitors along with the air monitor. So we used the CairClip monitor. The EPA, the Citizen Science tool kit and obviously verified by AQ-SPEC found that really high precision, or certainly correlation with a reference with the Rutgers monitor, as well as between monitors, between two monitors, intermodal and measure nitrous oxide, as well as ozone, but we presume inside a vehicle where ozone is quenched, even during the summer by nitrogen oxide that are in high concentration on the roadway that we're measuring NO2.

But again, this is one of those technical questions in terms of what the context is, what we're measuring, what it means, so we did this, they're pretty small. They weigh a little less than 50 grams. They're about seven or eight centimeters long, about three centimeters in diameter, little cylinders. People wear them on lanyards. Here's some of the real-time results mapped with, sort of like a heat map, just single commutes here just to give you some idea, and you can see that again the star is our campus, that there is different levels and the levels, the scale is hard to see, but the darkest circles, the darkest circles there are 50 to 100 part per billion.

We did that all over Staten Island and so on. We made more congestion, levels are higher and indicating we're not just measuring ambient ozone either, we're measuring NO2 and some other oxygenated gases there, so I think that illustrates, like we talked about already, the capabilities of those monitors. If you can deploy them widely, you can get information about exposures that people are having in the real world environments that wouldn't be available otherwise, and I'm not going to go through this again.

I think these are all things that we mentioned earlier about the capabilities of these monitors, what we can do with them, and the things that enables in terms of doing local scale and personal monitoring, crowd sourcing the data. I think those are all very valuable, but in some ways, I think it's also been touched on that these instruments are too easy to use in the sense that you just turn it on and you're collecting data.

And some of them have real-time displays like the CairPol CairClip that we use, so then there's an issue of people are looking at the display and now they're getting really real-time data and maybe not that much context to what that means. As was mentioned, when we look at short term exposures, it's really hard to apply those values to standards that may be based on as little as an hour for NO2, which is not necessarily a health based standard, but up to either eight hours, 24 hours or annual standards.

So what does this number mean when I leave my house and the ozone level is over the 75 part per billion, should I do something.

And I think also, users, again, needing to have some appreciation for statistical values about precision and accuracies and about planning and hypothesis testing and what the questions are that they're trying to answer and then it was mentioned, I think also, that the true cost of these monitors may be much more than low cost. To some extent due to degradation or deterioration. For example, the CairClip CairPol model, they say it lasts for a year because it has a metal oxide sensor, and it costs 1100 dollars for each one.

So in long term, that may not be very low cost. And I think what I found working with communities who have been interested in using low cost sensors and other methods to measure exposure on the finer scale in their neighborhoods and a lot of those have been around traffic related air pollution, there is a lot of potential for frustration and then ultimately distrust, if things aren't done right, essentially.

Meaning, that if their expectations aren't met, I think that's the most important thing is that we have limitations to the technology and that people who are using the technology, whether they're scientists or whether they're regulators, or whether they're people in the community need to know about those limitations at the outset and need to know how the information that can be obtained can be used and the diversity or the spectrum of different ways that it can be used ranging from, as Commissioner Martin said, at the outset, from education, from making air pollution visible in a way through to regulatory compliance.

Somewhere along the way the kind of things I'm interested in, and people in the community, including individuals who have health conditions might be interested in, which is, whether or not there's an association between some measurement of the environmental quality and some health outcome, so I think that the most important question, I think it's already been touched on, is to start off with defining very clearly what the question is that's being asked and that's obviously related to what the ultimate purpose of the monitoring.

And that will lead to designing an appropriate measurement campaign or study and that will lead hopefully ultimately to gathering this information that can then be used by communities or regulators or scientists for whatever purpose that they set out to accomplish. I think that some people at the EPA I think, I think it might have been Ron Williams at a recent meeting at NIAHS, I think this is probably close to a quote at least, said that instead of trying to get communities to give us data, we could use that our approach maybe should be to learn how to use the data that communities give us.

And I think that was touched on a little bit by Anna about how perhaps with crowd sourcing and other ways, there is innovate ways of using data that might not be as accurate and precise as we would like as scientists or regulators. So again, different purposes. I think we've gone through this quite a bit already. So here's a little bit of data. Again, we're just dabbling with this ourselves.

So one off the first things we did was take these monitors and test them against some test atmospheres and we don't have a sophisticated set up as SPEC AQ or AQ-SPEC, but we have a chamber, an exposure chamber, which Andrea may remember from his days around the EOC where we can do an exposure or create an atmosphere that is diluted diesel exhaust, so this is our monitor, a couple of monitors in orange and the gray there relative to the reference monitor in blue.

And actually, this is probably not a very fair test against the reference monitor because the reference monitor, you see that jagged blue line for the first hour or so, that took a while to stabilize. But after that, it was a little bit better, but the two monitors against each other, if you look at, you can see they pretty much traced each other and then the R square for that is greater than point 99, but then relative to the reference monitor, the regression line there indicates about a 20 percent bias to the positive side.

And again, I think it worked a little bit better at the higher concentrations there because the reference monitor had stabilized by that time. That's just the same data. So I think, you know, again, it's managing expectations that's the most important. I think AQ-SPEC is dealing with community groups because in the end then, I think if you don't manage expectations, there is no way for people to be satisfied in the end.

I think that involves though setting up the limitations initially very clearly. They might be disappointed initially, but at least they're not going to go through a process of potentially of collecting, doing it themselves huge amounts of data and then in the end come away with nothing or helping regulators or helping scientists to collect huge amounts of data and then in the end not get the answer that they were hoping for.

And also I think defining roles, and again, I think that as a scientist and or regulator, academic science or a regulatory scientist, it's really important to educate and help people get that background that they need to make decisions and be involved in decisions about doing community based science with low cost sensors. So here is one last thing here. So again, a little bit of our data, again, very informal so to say than we did recently.

Here we co-located seven different monitors, and you can see even though they really well correlated, even between monitors, there's bias of about probably 20, 30 percent, but this is data on one of our subjects in this little study who took the monitor home in the evening from the university. It was home in their apartment and then commuting in the morning. Can anyone give an interpretation of what's happening here?

MR. BIELORY: Turning on the oven?

MR. LAUMBACH: Yeah. So this is a community where relatively low levels, and we found actually overall that the levels of NO2 that we measured, presumably NO2, during the car ride was a bit lower than we thought. Maybe up to 50 to 100 PPB at times, but in general, 20part per billion. This is someone commuting on the turnpike, so she gets home in her apartment and then turning on the stove and a nice little decay and then limited ventilation in her home.

And we're not sure what the sources are, talk to the subject a little bit and back when she leaves and goes commuting, it's low again. I think the point is even if it's not quantitative, it's an example of useful relative information that in this case could inform an individual or could inform people in a study. And I think your husband worked at Johns Hopkins using samplers, area samplers, in peoples kitchens of showing levels of well over 100 PPB on a continuous long term basis on the average which may be a point obviously in terms of health impacts like asthma.

So again, I think depending on what the use is and depending on what the question is, you can get an answer. You want to make sure the answer actually answers the question that you set out to. So I think my recommendations would be, I think I'm not sure at this point where the department is going in terms of, you know, supporting community science.

I know there's been several projects that have been done, as Commissioner Martin mentioned, educational type projects, the EPA has done that the Citizen Science air monitoring project in the ironbound. Again, an example of similar to Holger's study more sophisticated equipment set up to be mobile, so not so much on the -- not so much the grass roots Citizen Science approaches to using low cost sensors.

But the extent to which the DEP can get engaged early and provide resources and to help people that are interested in doing this to help them to establish what their purposes are and what the right questions might be and then how to answer those questions I think could be extremely valuable in providing technical assistance along the way.

And then finally, when the data is collected, to help with analysis and interpretation because in another study that we've done, we had 37 children in the ironbound where not low cost sensors, but microthermometers that cost 6,000 dollars each but wear them up to 30 days each and collected up to a million data points and we spent the last year trying to unravel that and get that together in terms of cleaning up that data.

Again, a relatively sophisticated instrument but still having issues when kids between the ages of nine and 14 are wearing them on a daily basis. So again, I think there's technical issues. There's issues with use, there's issues with data interpretation, but it all starts with asking the right questions.

(Applause)

MR. HANNA: Thank you, Rob. Questions for Rob? On your last point, Rob, I just have to ask, to think about the agency supporting the results, the analysis, the QA and helping with that or your challenge with 30 something students, what happens when we get the scale of I'll go back to the Weather Underground employing 10,000 units and directly uploading to their Cloud, to their database, what goes through your mind when you think about that?

MR. LAUMBACH: Well, I think that's big data scientists are the ones that need to deal with that I guess, and that I'm not a big data sort of person and I'm not sure if anyone else here is and can have a comment on that?

MR. HANNA: That's a fine answer. That's my answer too, Bob. Anything else? Pam.

MS. MOUNT: I think all this is great, so still when you say, well, you have to communicate some kind of clear expectation of what might come of this project or whatever and what kind of clear expectation did you give anyone when you were working on this stuff? Because obviously you're not going to do anything about it. You're not going to stop cars from driving. There's sort of a gap there.

MR. LAUMBACH: Yeah. So this little project was not a community based project in the sense of community driven project. It was like a pilot project. Part of it was to see if people would wear these monitors and how they would work and so on. So we've limited peoples expectations initially and that we cautioned them that the monitors were not to be used for, not to over interpret the data relative to any health outcomes or whatnot.

MS. MOUNT: What would you suggest that if you were going to do a community thing, what would the outcome be to convince somebody to do this stuff or what or whatever?

MR. LAUMBACH: Well, in our study, commuters at Rutgers, many of them, we had six or 700 written in comments about like commuters killing me, and we're interested in not just air pollution, but also stress and how stress and air pollution may interact. I didn't really get to mention it. I think what's really exciting about this new technology, it's not only new environmental sensors, but physiological sensors, new sensors that can stress; new sensors that can measure things or develop things like an exhaled breath, combining those things together can give people interesting and informative general information about associations between health and exposure.

But also personally, as other speakers I think mentioned, personal information about whether I'm sensitive as an asthmatic to ozone, a certain level of exposure, that might be achievable some time in the future. I don't have a year.

MS. MOUNT: Thank you.

(Applause)

MR. HANNA: So maybe the next couple of speakers will have some help for us on the big data side of this, too, but I'll introduce Michael Heimbinder who is the founder and executive director of Habitat Map. He's a community organizer, educator and information designer. And Habitat Map is a non profit environmental health justice organization whose goal it is to raise awareness about the impact the environment has on human health. Want to come on up, Michael. Thank you.

MR. HEIMBINDER: Thanks for inviting me to testify today. So as Toby said, my name is Michael Heimbinder. I'm the founding executive director of Habitat Map. We're a Brooklyn based environmental justice non profit, and the primary thing we do is we work with schools and community based organizations to grade planning and advocacy maps. One of the community mapping platforms we operate is called Air Casting. Air Casting is a platform for recording, mapping and sharing health and environmental data.

This is a platform diagram that shows you a bit about how it all works. At the top you've got the Air Beam, your air quality sensor. We've sold over 1500 Air Beams to date. It's an instrument we developed for measuring fine particulate matter or -- 2.5. It's low cost. It costs 249 dollars and it's open source. Meaning, all the codes for the firmware and all the schematics are available on-line, again, through Get Hub.

The Air Beam connects to an Android app called Air Casting, which is free, available through the Google play store where the measurements from the instrument are mapped and graphed in real-time and passed to our web server at Air Casting Dot Org where the data is crowd sourced, brought together, averaged, displayed as a heat map. Below that you've got LED wearables, so we've got wearable items that light up in correspondence to the sensor measurements.

And the reason we did this is because this isn't just a scientific project for researchers, but it's also for communities and for educators and for young people, so it's a great way to get people involved and engaged instead of looking at their screen, they can actually light up their vest or hold something up that lights up.

And it says at the bottom there, it says individual community and government change. These are some screen shots from inside the Air Casting app. On the far left you've got the sensor's dashboard, and this example we're reporting Carbon Oxide particulate matter, breathing rate, heart rate, activity level. And so each of those tiles represents a measurement coming in real-time.

Next to that you've got the measurements over time. It's just a simple graph. Next to that you've got your sessions map, so it looks like a line of many colors. It's actually a line consisting of many colored dots, and those dots are laid down one per second, and they correspond with the intensity of the measurements.

So in this case, red is highest, green is lowest and yellow and orange are in between. And then on the far right you've got the Crowd Map. You've got your individual measurements from the session, as you're going along taking measurements, and then you can see underneath that, here is your session route and underneath that is the Crowd Map. So those are all the measurements taken over all time that have been averaged together and displayed as colored blocks.

It looks the same when you go on-line, just a bigger screen. You're able to put more things on the screen at once. This is an E cycling from Brooklyn over into downtown Manhattan, and you can see, let me see if I can shoot a laser. I got one spike here which corresponds to this spike here, and that's me behind a dirty diesel van going over a roadway that's recently been ripped up to be repaved.

And so it's not as long in duration, and the peak is not as high as this next with one which is the confluence of sources from the FDR Drive, subways entering and exiting because they travel over the Manhattan bridge. And every time they enter the tunnel, they eject particles and then also the traffic backing up going back ways in the Manhattan bridge. So you can really start to see these patterns again and again, you'll see this background concentration and then you encounter a source, background concentration you encounter a source.

So you see that again and again when you're recording mobile data. This is actually sound levels. This is a very clean example. We record sound levels because every phone has a microphone and it's also the number one complaint in the New York City 341 hotline. And so here's Prospect Park, a big park in Brooklyn, you get more green block. A neighborhood right here, Park Slope, you get more yellow.

Come down to the Oswego Canal where

you've got residents mixing in with commercial and industrial and you get more of these orange blocks. This is the Air Casting family. These are some of the instruments that connected in the Air Casting platform. I mentioned the air beaming instrument that we created, but there's lots of different instruments that connected with Air Casting platform. I want a show a few of those.

This is something called the Terrier. It was made by a gentleman named Nick Vasong who some you may know. At the time he was working for a company called Multitude which then got bought by Q-Sense. They developed this instrument which measures NO, CO and CO2 and then they plugged them into the Air Casting platform to be able to provide some real-time feedback for the people that are using it, and they pull their data out the other side. So here, the Air Casting platform had a utility for them because they could focus on making their instrument, and they could focus on what was really important for them which was taking the data out and doing third party analytics on it.

So the Air Casting solved a problem

for them in the sense that they didn't need to create a platform for visualizing and storing the data. This is a Zephyr Bio harness. So like I said, it doesn't just take air quality measurements. It takes physiological measurements as well. This is a commercial product from a company. It costs about 500 dollars, and it does come in the parameters I mentioned earlier, such as activity level, heart rate, R to R.

This was a device that's commercially available that had something called a software development kit that we use to patch their measurements into our system so we are have instruments that people create to intentionally patch into Air Casting. We have instruments that are already available on the market and you can adapt and then we have things like the Air Beam that we created ourselves.

Comparing the Air Beam to this instrument, this is the instrument that Holger is using now with the now with New York City Community Air Survey. It costs 5,000 dollars and weighs two and-a-half pounds. The Air Beam costs 250 dollars, so one 20th the price and one fifth the weight at half a pound. It's not as accurate and doesn't have as big of a range as the Thermo Scientific BR1500, but it compares comparably well.

So this is an example of how these instruments are coming down in price and disrupting these types of instruments. This is not an -- instrument, but it's another portable that wasn't that portable and wasn't that accurate, so something like the Air Beam can actually compare to it in terms of performance. This is Air Casting Luminescence. We've created a number of different wearables and this is one we most recently created called a Light Beam and we don't sell it, but it's a DYI project, you can do it yourself project, you look it up, follow the instructions and build it.

And then I want to provide a few examples. So now you got an idea of how the platform works, all the different instruments you can plug in and here is people actually using it for different applications. This was a collaboration between Columbia University's Mailman School of Public Health and WNYC, the NCR affiliate for New York City. And this woman right here is wearing a vest that probably has 10 or 15,000 dollars worth of equipment on it.

It's measuring physiological parameters and air quality parameters, and what they're doing is biking and breathing. Well, it doesn't come as a big surprise to people in this room that when you're biking, you breathe harder than if you're walking which means you're getting a bigger dose of these air pollutants, and this is something that's been widely studied, and so what they're doing is they're seeing, you can see in the physiologic, does the breathing rate change, what's happening with people's physiology when they're encountering air pollution.

And they've got bicyclists doing it because they're obviously exposed. They're riding in traffic, but they've also got good spatial coverage. They're covering a lot of the city. So that's what the folks said Columbia University is doing, Steve Chilrod and Darby Jacki. And so what does it allow them to do, right. They have maybe 10 of these vests. They're very expensive.

They were able to enlarge a number of the people who were participating by not putting everybody with this 10,000 vest, but equipping them with 250 dollar Air Beams and 400 Terriers which is that other instrument I showed earlier, and then it also solves the problem for them in terms of collecting the data, visualizing it for the participants and be able to pull it out the other end. These are two projects.

First one run by the Minnesota Pollution Control Agency and the second one by Auvergne Rhone Alpes which is a regulatory agency in France that does work in and around Bernabe. And what they've done is they've bought over a dozen Air Beams and Android phones and they run workshops where they check out Air Beams and Android phones to every day folks and they go out and they take measurements and it's primary education and outreach oriented.

They're not making policy decisions based on this information. They're not make regulatory decisions but they are doing public outreach and they're educating the public and I think, to a certain extent, they're experimenting, like a lot of people in this room are interested in let's start using this technology to see where it leads us to we can evaluate it ourselves.

One of the neat things is not only did they buy Air Beams and are checking these things out and running programs, but they've also are coded, so they've taken Air Casting and they set it up on their own servers. When they collect data with the Android device, it doesn't go to our server at Air Casting Dot Org, it goes to their own server and then gets displayed on their own website, so they can own it. Tim might talk about this later. This is Kids Making Sense. It's a curriculum that Sonoma Technology put together that uses the Air Beam. Here is another example.

This time it's a private company that says there's some utility for this. We don't have to invent a device that makes air quality measurements. We don't have to create a platform for visualizing it. We can focus on the curriculum, so they've put together a teachers guide and a curriculum that they've been working with schools and kind of opened up a new line of business for themselves.

Closer to home, so it's really exciting for us to see folks all around the world literally using the Air Beam, using the Air Casting platform. But of course we also do our own work and run our own programs mostly in New York City and so this is a report that was put out maybe about a half a year ago. It's called Clearing the Air, How Transforming the Commercial Weight Sector Can Address Air Quality Issues in Environmental Justice Communities.

So it was put together by an umbrella group called Transform, Don't Trash, and then this report that we're all members of and this report had assistance from New York Lawyers for Public Interest, New York City Environmental Justice Alliance and Align. And what we did is we partnered with New York City Environmental Justice Alliance and we trained folks, mostly young people from community based organizations, EJ organizations in the Bronx and Brooklyn.

So those groups were the point in the South Bronx, El Fuente and Williamsburg and East Williamsburg, Clean Up North Brooklyn in Bushwick and Uprose in Sunset Park. And what we did is we had these people stand at truck intensive intersections, intersections that saw a lot of diesel traffic and they counted trucks and they measured air quality at the same time.

And what we found, when we compared their measurements with the measurements taken by the closest DEC, Department of Environmental Conservation monitoring site, was that the pollution over a half hour, the maximum half hour concentration was up to seven times higher than it was at the closest DEC site. And we chose to present as seven times higher as a magnitude as opposed to an absolute value because we were conscientious of the fact that, yes, our instrument is not a reference instrument.

But if we're off by an order of magnitude and it's only six times, it's still really bad. This is a map we put together, so a lot of the things some of the people have been mentioning that you collect the data but it's not enough. You have to textualize the data and that could be bringing meteorological data, it could be co-locating with reference instruments.

In our case, it meant wherever the truck routes and wherever the waiting transfer stations, so you can see the intersections. One showing the six to eight times ambient here as the maximum half hour concentration and four to six times the ambient here. And all the brown is the truck routes, so this is an incredible density of truck routes, probably more dense than anywhere else in the city.

And of the dense concentrations is waste transfer stations in the city. So this report was done to buttress the administration's decision, the De Blasio's administration's decision to do garbage zoning in New York City. What that means is that currently if you're a private business in New York City, you can contract with any private carter to come pick up your waste. For instance, in a single block in midtown Manhattan, you have 79 carters servicing a single block, so that means you're getting 100 truck trips, maybe over 200 truck trips a week.

So if you zone that, that means that those businesses can now only contract with maybe two, three different carters and those carters win that district by not only having the lowest cost but also having the best environmental performance in terms of what trucks they're running and how they operate their waste transfer stations and also workplace safety, so it's a way of raising the bar at the same time that we're reducing truck traffic which means that we're also improving air quality and reducing air pollution.

And so the reason I bring this in as a last example. You were talking about earlier that there's a gap, right. We do this research and people say, did you make a policy impact, did you change people's behavior. That's what we're very much hoping is done now, is to say, we've been doing this since 2011 and the platform works very well now. Certainly all these improvements to be made, but we can really go the next step and we can say how can we leverage this data to inform public policy and change behavior.

I'll wrap it up there. If you want to e-mail me at Info at Habitat Map Dot Org. We've got our two community mapping platforms. Habitat Map and Air Casting. Our blog is Taking Space Dot Org, and you can find us on Twitter, Twitter Dot Com Slash Habitat Map. Thank you.

(Applause)

MR. HANNA: Questions?

MR. OPIEKUN: I love the concept of wearables. I think it's a great idea to get people involved in that, but has anybody ever looked at the sustainability of that? In other words, when I used to do industrial hygiene work, a worker at a factory site would not be bothered too much by wearing a monitor for a week, but after that, they'd say it's burdensome or it's getting in the way of what I'm trying to do. When it comes to the public, people who are volunteering to do this, have you seen that it's sustainable over a long period of time? Somebody willing to do monitoring for a week, two weeks, a month, or is it something where interest wanes over time?

MR. HEIMBINDER: I think it matters what kind of institution you're embedded in and so you could take the example of Fit Bit fitness trackers. There is a lot of data showing that people will use those for a little while and then throw them in their drawer and never used them again. I'm sure that's happened to a lot of Air Beams bought by individuals who are more interested in seeing what the pollution was like in their house or going for a walk with it and didn't really -- it wasn't sticking for them.

So what we've seen is that the groups that are using them consistently and over the long term are embedded within community based organizations, schools, regulatory agencies, and so it's not a wearable in the sense that you're right, it's uncomfortable. You have to make sure it has an air stream so that you can't be putting it in your purse or putting it in your pocket, and it's big.

It's still about the size of a hand, so you're absolutely right that I don't think that this is something -- and I think that's one of the reasons why we haven't seen more innovation in this space because there is not a mass consumer market for it, so I think what you're seeing is that the groups that are really using it are the groups that have an agenda and that might be advocacy, that might be outreach, that might be education, but there is something else going on that's driving. It's not just curiosity about one persons individual find.

MR. HANNA: Michael, can you give us an idea, and if you did already, forgive me, but the number of subscribers to Air Cast, how many Air Beam units have you sold, how big is the world there?

MR. HEIMBINDER: So we've sold about

1500 Air Beams and we've got probably over a 150 million data points, which seems like a lot, but it's not certainly not even what would be considered big data and that's across all types of -- sound level, air quality and what we see now is we've started setting it up so you can actually do fixed monitoring.

Originally the architecture was based on the idea that someone would be wearing it, moving it around. So now we're starting to look towards creating another way of getting data in the platform which is put in this in your house or outside your house and just stream the data 24 hours a day. And what we're seeing is there's a few people who are doing that, not very many, but there are a lot of people who are running projects all around the world.

So if you go in and log into Air Casting, every day you'll see anywhere 10 to 30 new sessions contributed all around the world and so like anything, it changes over time, so if you look at total downloads for our ap, it's probably 10s of thousands, but if you look at people who are actively using it, it's around a thousand, so people are coming on the platform, at the same time people are leaving. It's slowly growing and certainly not astronomical, but incremental over time.

MR. BIELORY: The question I have, whenever you have an app or technology, it wears off and the question is, retention you say about 1,000 users out of 10,000. Are you saying about a 10 percent retention?

MR. HEIMBINDER: I'm saying anybody can download the app even if you don't have an Air Beam, and you can imagine you probably got a lot of apps in your phone. They sit there, you haven't used then. So the thousands are people who are actively using it, like using the app every week at least. Whereas the tens of thousands where the people, historically, since 2011 who have downloaded it and used it even once.

MR. BIELORY: On an annual basis, you can tell how many downloads you have per year and how many retentions from those few years, usually by e-mail address, you still have data coming in. You can see retention. I'm just curious because as much as kids are into Nintendos and parents are on their iPhones and everything, the retention to an app or to commitment, either you're a scientist or a physician scientist or you're just a peripheral, it's still about 10 percent or less than.

MR. HEIMBINDER: I don't know what it would be percentage wise. One of the things we run into being a small non profit is that you're swamped with analytics. We got analytics for our app, we got analytics for our website. You could dig through the data and do more analytics, but we don't have the resources to do that.

So all I can say is my observations are anecdotal as opposed to be based on all the analytics that are available that we haven't actually delved into, but again, it's the groups. It's the individuals who are anchored by an institution who continue to participate and it's the people who are dropping out tend to be people who are not part of an institutional effort.

MR. BIELORY: Thank you.

(Applause)

MR. HANNA: We'll keep moving. Jeff Knapp is the president and CEO of Smart Connect Technologies, and Jeff has significant experience with technology companies offering a wide array of integrated hardware and software and services solutions. I think we'll talk about some more about data, big data. Welcome, Jeff. Thank you.

MR. KNAPP: Thank you, Toby, and thank you to the council for inviting me to present and testify. Let's see if I can figure this out. We are a bit different than who we've been hearing from, although everybody, virtually everybody has touched to some degree, if not significantly on the importance and the value of actually being able to utilize the data that's generated from these various sensors, these monitors, leveraging the platform and there's been some great discussion and presentation of a lot of alternatives.

What we are is a company that is focused entirely on accessing and capturing data and facilitating the presentation and delivery of that data to the Cloud, to analytics platform or to a customer platform and facilitating a dashboard, presentation, if you will, so that the client, the customer, the user can really take advantage and leverage the information that comes from the data.

We're completely agnostic as it relates to the hardware. We work with literally any device and that's one of the real differentiators between us and I think some of the other solutions that I'm familiar with. So Smart Connect Technologies was formed to create this platform to leverage the data automation and analytics opportunity, if you will, and requirements that people have in this big data world.

We do have a proprietary solution. The software is patent pending. The actual gateway that we offer to interface with the sensors that we work with or the machines or the equipment that is the software in and off the shelf hardware platform. I'm going to go through some of the more sales oriented elements here, but it has been recognized with a number of different awards which really speaks to the value of an application that a customer derives from the data.

It always comes back to how are we utilizing the data. We have invested a lot of time and energy in creating a strategic relationship with IBM and integrated with all of their Cloud applications, if you will, Cloudant, DashDB, the Watson Analytics platform. We present ourselves as an industrial internet of things, IOT technology company. Although we work with virtually any platform, any company.

As I said, completely agnostic as it relates to hardware. So as I was saying, we enable connectivity to any device, any platform, any machine. And what's really interesting is it can be an existing sensor a ray of sensors or monitors. It could be existing IP enabled devices or it could be legacy equipment. It could be machines, it could be boilers in a smart building or smart infrastructure environment. It could be HVAC systems.

It could be cameras, and it's all able to be aggregated into a single platform, if you will. First a single database, which we will clean the data and normalize the data and prepare it for presentation to the Cloud or to a client application platform. We have a significant relationship with Dell as well, but again, any system works, any hardware platform works, and the value is in the opportunity to make decisions.

Obviously, as it relates to air quality in the environment to make decisions regarding utilization, traffic flow, adjustments in population areas, you know, obviously health and wellness related decisions as it relates to larger corporate opportunities, if you will, there's a huge preventive maintenance opportunity in a lot of these areas.

And as you can imagine, the opportunity to optimize performance and leverage resources makes a lot of sense. I mentioned the relationships with IBM and with Dell. And what's really interesting, if you look at a lot of the studies, and I'm sure most of you have, the value proposition associated with how the big data marketplace is evolving is truly immense.

Clearly, IOT is the next wave of opportunity. We, as an organization, are focused on transportation, manufacturing and smart city, smart infrastructure where air and water quality fit, if you will. And the value impact as quantified by McKinsey is obviously so significant. It's incredible and interoperability is critical as well if you're going to allow municipalities or corporations to really leverage, efficiently leverage input from a whole array of different sensors and different devices and machines effectively.

That's where we're focused. We're on that front end of the continuum, if you will, and I'll show you that. And obviously, the differentiator for us is the fact that not only are able to access and capture data from any device or any machine, we can do it much more quickly and for much less cost than traditional solutions, if you will. We don't require any programming, no proprietary driver to access and capture data from the edge, even if it's not an IP enabled device.

I'll say fairly unique. I'm not aware of anybody else that does it the way that we do it. So we don't require integration on the frond end. That's a huge cost component when you're trying to capture data from a diverse array of machines or devices or sensors, if you will. If you look at the continuum, if you will, the IOT data access and transfer continuum, we really are focused on the connectivity and management side of the equation which is the front end at the edge, if you will.

And then we will hand that data off to an analytic platform, whether it's proprietary platform or Watson Analytics, whatever it might be or we can deliver that directly to a client application. It could be an asset management system. Like IBM's maximal access management system, for example, if you're familiar with it, we can deliver data, integrate it with Maximo, so they can actually monitor.

We have gateways on buses that are monitoring all the different sensors on the bus so we can literally help the client predict when maintenance is required and mitigate breakdowns, obviously, enhance customer satisfaction and route performance, if you will, but mitigate break downs, completely virtually eliminate false alarms and proactively schedule maintenance so the deployment of resources is enhanced dramatically and the data is delivered directly to their asset management system, for example, and automatically will create, print and generate a maintenance statement, schedule resources, and it's all automatic, so that's where we are in this continuum, if you will.

The other thing that's very

interesting is, there's the opportunity to aggregate data from all these different data sources, different machines, different devices, different sensors into a single database. And the user, if you will, the customer, the municipality, whatever the user might be, can actually, you know, manage via the phone or remotely or from a command center or console, whatever it might be, can control the devices, if you will, can control the sensors, can control the machines, can actually turn them on or off, can change the parameters.

We'll calibrate, working with a customer, the sensor parameters, if you will, and automatically generate an alert or a message or an e-mail or a text message to whoever the recipients need to be, whether it's executive management or a command center or emergency response, whatever it might be. And if a customer wants to adjust remotely the parameter settings for any of these devices, they can do so.

I think this is, I've talked through most of these points. As far as the business model goes, we are as flexible as we can be and work with the client environment. Sometimes software as a service model makes a lot of sense, depending upon the client environment. Sometimes a more traditional license model makes more sense and we are able to work in both of those areas, if you will.

I think I've addressed most of these points. I don't want to be redundant. We can also aggregate data from a variety of different sources, so I mentioned we will access and capture data from the various sensors. We can obviously aggregate that with weather station data for example. We can be collecting information on particulates or hydrogen sulfide, whatever you're monitoring, any number of those monitors and aggregate that with weather data, if you will and other it could be data generated from cameras or other surveillance technology and present that to the analytics platform.

So again, let's talk a little more specifically about air quality. This is just a visual that talks about collecting the data from the edge, delivering it to the Cloud and ultimately having it reflected in the dashboard view, and we've seen a couple of really exciting dashboard views, some great platforms today already. It's really a very simple limitation. We've deployed a sense of the gateways.

We set up our server which is really our software in this off the shelf hardware. We configure the sensors, we calibrate them, we establish the diagnostic codes, correlate them with the parameters for measuring, if you will, the thresholds for messaging and alerts, test it and that's it. From an implementation point of view, it is as simple as it could be.

It's really, relatively speaking, not costly at all because, again, no programming, so we don't need technical engineering support on the implementation side. There is no programming, there is no proprietary driver being written. It's all configurable and to actually install a gateway, oftentimes we'll spend half a day, train a customer, electrician, if you will, and then they can actually implement gateways across the organization, or of course we can do it, but the customer doesn't need us to do it.

Everything is configurable and very intuitive. So what are some of the real world deployments. You know, the one thing I'll preface this with is ignore the dollar figures because this is pre our software services model. It may or may not be really applicable, and of course every environment is different. We did a project for the EPA actually where we actually outfitted a vehicle with various sensors and they asked us to drive across the country.

We spent six weeks going around the country and they were capturing data on air quality and obviously different levels of different substances, if you will, across the country. Southeast, southwest, literally six weeks driving around the United States. And that information is obviously was captured, put into a database and then delivered to an EPA platform. This is an implementation in Australia. In fact, this implementation received an award.

This was Department of Environmental Conservation in Australia won an award for the best use of broad banding government by deploying our G pack system which is our smart connect gateway technology and using it for real-time pollution monitoring. What happened was there was a number of constituents in this area of Australia, residents of this area were really upset because there was significant hydrogen sulfide.

Obviously, the smell was overwhelming. There had been some reconfiguration of the coast and they were really upset and it became a whole political -- they could not seem, for whatever reason, monitor effectively and persuade the citizenry of exactly what the status was and we instrumented there and they were able to capture information and validate to the citizens that in fact, it was a safe environment and of course they were able to also rationalize some adjustments in some of the seashore, if you will, beach construction, let's call it.

We have an implementation in California. This is the California Department of Primarily Health Laboratory. It's actually a Homeland Security facility, and they were having a very difficult time. This is strictly a software implementation. They used their own internal existing sensors and existing hardware and they were having a very difficult time alerting and reacting to changes in the local air environment.

There are some oil distilleries and manufacturing facilities is right next to this facility, and they were very sensitive to changes in the air quality, if you will. It was important for them to be able to manage and monitor that, so this facility was able to use our system to monitor both the weather and specific pollutants in the air, if you will, and mold, air traveling mold as well and now they have an opportunity and an ability to issue alerts literally when the wind changes and they're concerned about the air quality over their health facility changing significantly.

They issue alerts and they make the adjustments operationally that they need to make whether that's shutting windows, whatever that might be. So there is a limitless number of different applications, any application in any sense. We've actually worked with and tested literally hundreds of sensors and if a client, I don't know that that's the case here, and there is some great alternative, if a client or a municipality wanted us to provide the sensors, we could do that, but we would be looking to some of the folks that are in that space. We are providing a gateway. We're accessing and capturing data and we're agnostic as it relates to everything else. And that's it.

(Applause)

MR. HANNA: Thank you, Jeff. Questions for Jeff?

MR. BIELORY: You're integrated or you're supported by IBM at this point in time?

MR. KNAPP: We work with them on various projects. They actually have involved us in some water quality projects in the Atlanta area and in fact invited us to --

MR. BIELORY: The reason I'm asking, IBM has purchased Weather Underground, so I was wondering whether you're integrating that information into your system.

MR. KNAPP: Yes, we can as any other data source.

MR. BIELORY: You haven't yet.

MR. KNAPP: We have not, no.

MR. BIELORY: I was just curious because of that relationship.

MR. KNAPP: But that's simply another source of data. There's nothing unique about that.

MR. BIELORY: Okay.

MR. KNAPP: Thank you.

MR. HANNA: Thanks, Jeff.

(Applause)

MR. HANNA: Tim, come on up. Tim is senior vice president at Sonoma Technology. Tim directs his knowledge in creativity towards the design and development of innovative information systems such as Air Now, Air Now International and Smog City Two. He's a recognized leader in low cost citizen based air quality monitoring and has led many efforts involving low cost air sensors.

MR. DYE: It is a pleasure to be here and to testify in front of everybody. I've got to disclose something because 37 years ago I was actually doing some Citizen Science here in New Jersey because I was a high school student and I grew up here, backyard weather measurements and we crowd source that information with a North Jersey Weather Observers and I think it's really from that start that I got a little passion for making measurements and making personal measurements and taking that responsibility and that really continues today.

I work at a company and I have worked at a company since I graduated from Penn State, Sonoma Technology. We are an air quality consulting firm, do a lot of measurements, modeling, various things for industry government and so forth, and what I want to talk about today. I've got lots of information here. So what I want to talk about is a couple of things.

One is just where are we at in this path of development and use of sensors, and then I want to talk about five projects that we've done. These are real world projects working for the industry, state and local air quality agencies as well as the education, a couple education projects. And lastly I want to conclude with some lessons that we've learned that you can take away in using this technology.

So those are the five studies I'm going to talk about. They're all focused on PM, and with a good reason because those are the sensors that are working reasonably well right now as Andrea talked about this morning. This is our path kind of forward as a big picture. The first issue is how good are these sensors. There's lots of work that's been done by Andrea, EPA, folks in Europe. Some of the sensors are actually working quite well and encouraging.

The next question we all need to ask is how useful are these and that's where I want to talk about. We've deployed these on a range of different projects and show you some potential applications of this technology. And then lastly is going to be the question is how sustainable is this, and I'll come back to that at the end of the talk.

The first project that we did for the industry and this was for the Electric Power Research Institute. They were interested in looking at this technology and putting to test dust that's blown off of a coal pile near an electric generation facility, so what we did was we deployed reference equipment and then we also in that little teepee there, we deployed a couple of sensors.

One was the Air Beam and the other one was the Dylos that sits in the back of the room. We ran this for a two month study and then what we found was these bursts of coal dust that were coming off the pile were very short in duration, only lasting about a minute or two minutes and we were able to detect that with the micro sensors and the reference instrument that we have there which is shown by the blue line provided hourly measurements and that was a BAM 1020 for measuring PM 10.

Interestingly enough, it only measures about 52 minutes in the hours and doesn't measure eight minutes, so it actually misses some. When we do a scatter plot, we compare the reference to the sensor over on the left is a non event. It doesn't do that well, but if we just single the data out and just look at the events, these one or two second little bursts, we can see there is some correlation, and the sponsor of this, they said, well, this can be used as an event detector. Maybe we can see if it's low, medium or high.

So we're doing a follow on study with them deploying some sensors around the coal pile and all that data streaming in six times a minute and available to be viewed on our web site. The second study was for the Santa Barbara Air Pollution Control District and they were interested in setting up a PM monitoring network at schools in an agricultural community to monitor dust and when dust was kicked up by agricultural activities.

So the first phase of the project was to ask the question how reliable are the sensors, so we deployed two sensors. One was the Air Beam and the other was an Alphasense sensor. We put those in those tin cans that are there and then ran that co-located next to a bunch of reference equipment and what we found out was the Air Beam didn't do quite as well for measuring PM 10 for mag test, but the Alphasense sensor performed quite well, very good correlation with the reference sensor.

And then when we compared one Alphasense to another, saw a very good precision, and that was enough to finish that study and to say, okay, it is possible to then deploy a network of these lower cost sensors in this ag region for monitoring dust as it's kicked up. So that's one study. This is another one, actually that we just completed.

It was for the Sacramento Metropolitan Air Quality Management District, and the district has a residential wood burning program where they will voluntary and then also mandate citizens, not to burn during certain nights during the winter, burn their wood stoves or fireplace, and the idea is to reduce PM levels. This study is utilizing sensors to look at the spatial representativeness of wood smoke in that area and what they also wanted to figure out was their communication strategy to all the different communities who speak different languages and bring in information different ways.

How effective was that, so we're coupling both low cost sensors, some high cost instruments along with a community survey to try and tease out that information about how effective their communication is. This is showing the set up. They recruited some citizens from the community. That's one of their back yards. It has a little -- Michael showed the Air Beam. The Air Beam sits on top of that white box and it's got a little hood to protect it from rain.

That data is then streaming in via cellular about every minute or so to our data center. We also, in all the studies that we've done, and continue to do, we always co-locate sensors next to reference instruments. That provides a really good base and comparison, absolutely critical right now. The technology can't be used solely by itself. With this slide, this is showing the dashboard that we developed and used so we could monitor the data streaming in every minute from the sensors as well as the reference instruments and look down at the bottom and see how things are trending and identify areas that had higher PM or lower PM.

So we've set up the whole data system to bring all that information in real real-time. This is kind of a very different study. We purchased about 30 of the Air Beams for our program that I'll talk about in a minute, one of our education programs. Actually, we purchased 50, but we wanted to use 30 to just do an ad hock study with a local community. We decided to give out these sensors to citizens, school kids and some employees and we said, hey, just go out and start measuring, see what you find.

There was no objective. What we actually wanted to do is we wanted to collect a bunch of data and to see what are some of the messy things that we're going to find on this data and how are we going to manage this data, and what are the things that we need to start thinking about in terms of managing these data sensors in the future. So I want to share with you a couple of things. This is showing the crowd source map.

We ran it over a couple of days, and this is using the platform that Michael talked about, the Air Casting platform and then it's showing you collectively each day, as more and more people are out driving around, walking around, sitting in their house making measurements, all of that information gets crowd source and the map gets filled in. This was one of the interesting things. Someone walked down in the city and we looked at the data and actually went inside. Outside the PM levels were relatively.

Once they walked in the coffee shop, PM levels went really high. Once they walked back outside, they went down again, so we started looking at the data and trying to figure out, how are we going to tease out that information because now all of a sudden we're blurring outdoor air and indoor air, so we found some differences in relative humidity and temperature that we could key in on and write some analytics to tease out that information from the data.

This was someone walking around and each little blue dot they're making notes. When they made the notes, you could actually look in there and it said wood smoke and one of the things that's kind of interesting is the wood smoke is not spread over the entire city. It's very isolated initially when it's coming out. Now, ultimately, it does disperse. The last program here is Michael talked briefly about it but it's Kids Making Sense.

It's purely an educational program. Michael and Sonoma Technology developed it originally. We've taken it and developed a whole curriculum around it. We've given these courses in New York, all parts of California, Taiwan, Thailand and other areas. It's basically we go in and teach kids about particulate matter, pollution, the sources, what to do about it, the health effects and then they take an Air Beam and go out and measure.

They break up into teams, say you

have five or six or 10 teams, they go out and make measurements. They discover things like this was one group in the New York City subway system and they were wondering why there is high concentrations there, so we did that. The crowd sourcing information. Here is all the materials. There is training materials, there's sensors, there is a website.

You can learn more at Kids Making Sense Dot Org. So key challenges that we face. Technology is changing really rapidly. Lots of hardware issues we've had to deal with, but lifetime is unknown of these. We've had things last minutes. We've had an Air Beam that we deployed all winter long in Northern Minnesota outside. It was kind of reckless what we did but it worked all winter. We don't endorse Air Beams or any of the instruments here. I'm just giving you some anecdotal information.

Data logging is an issue as where does this information get stored locally, how do you communicate it. We heard from the previous speaker about how do you communicate that. That become very costly and is still challenging. This is an area that we're really focusing on is data management. How do we get all this data in, quality control it, average it and interpret it and it's an area that we're focusing on, we've developed some software and systems to do this.

Andrea touched on this earlier today about the cost. While an individual sensor may be relatively low cost, looking at all the complete operations, over the whole life span of a project, all of a sudden becomes a lot more intensive and more costly. And one of the things that we're starting to pay more attention to is scale. It's one thing to run three sensors of 10 or a 100 or a thousand or even 10,000 and we have to start thinking about different paradigms.

Normally we think about repairing instruments or equipment. Maybe we need to start thinking about it's partly disposable. If it breaks, you just send them a new one and it's broken. I don't like to think that way, but in order to handle the scale of a thousand or 10,000, we have to start to think about things differently. So I think many groups have evaluated this, us, and many, many others and finding that there is some good promise there.

There's lots of groups that are

starting to do pilot projects to figure out useful is this information and how do you use and when can we not use. That's going to happen for the next three to 10 years or so as we discover new technology. I think one area we need to watch is how sustainable is this. What sort of businesses and organizations in this eco system are established to help provide quality instruments, provide quality data management, provide quality interpretation.

Ultimately, that's what's going to make this sustainable over the long term and that's the continuum we're on. That's my information. I'm very passionate about this topic, excited about it. I'd like to talk to you more about it and thank you.

(Applause)

MR. HANNA: Tim, I'm interested in the evaluation you worked on, the private sector. Any other work that you know of that, or that you've been involved in that's been really on the private sector side? So much of what we've been talking about has been public in the community or the government agencies. Do you have any other examples that you know of?

MR. DYE: There is no examples. I'm trying to think right. There are no examples of projects that I have. There have been a number of discussion about that and it's mostly for monitoring what's going on to make better decisions. That's, I think, why everyone is interested in this. What sort of decisions can be made about processes of handling coal, and there's also, without this technology there's actually not an easy way to figure out cause and effect relationships.

What on a particular coal pile is causing the dust to be elevated and then where does it really impact. And that association is hard to do. With sensors, now, all of a sudden we have real-time data. There have been similar discussions with some other groups about forest projects and handling forest projects like paper pulp mill and there's lots of particulate matter there and how they might use this information.

A lot of it boils down to first doing a pilot project to evaluate the quality of the data in that particular environment because what works in south coast may not necessarily work in environments say in a very tropical area or a really dry area or a cold area, so that's how these are starting a number of discussions.

MR. HANNA: That's a way to build the trust around the technology and the reliability around it. I think lightly put, that private sector is concerned about finding more problems with the technology, but the glass half full is that you're going to find solutions easier, too, I think.

MR. DYE: Right, yeah.

MR. HANNA: That's the point. Okay. Any other questions for Tim? Thank you, Tim.

(Applause)

(Whereupon a break was taken.)

MR. HANNA: Just to remind everybody, Geoff Henshaw is the Chief Technology Officer and founder at Aeroqual, and we have one of your units in the back of the room, Jeff. We've been checking them out all day. It's shown us that we have pretty good air quality in the room today. We haven't spoiled that. Welcome. We'll have you on for 20 minutes or so, and then from there, we're going to break into a round table discussion and you're welcome to stay with us for that. That will go another 40 minutes or so, but give everybody here a little more chance to talk together, but go ahead, Geoff. Take it away. Thank you.

MR. HENSHAW: Thank you very much for this opportunity to speak with you. My presentation this afternoon involving the performance and application of low cost instruments for Ozone NO2 and PM. The work with these standards in terms of developing new instrumentation. Just a little bit of background. We've been going for about 10, 15 years looking at developing instruments for measurements of air quality, and we've been working for about 10 years now.

So I'll start off talking about some of the motivations for low cost instruments in the actual ambient space. I think there is a growing awareness from the public that they're aware of the health impacts of air pollutants. Questions like what am I exposed to, and how do I reduce my exposure, and urban landscapes are very complex and pollutant levels have been shown to vary spatially and temporally.

Looking at existing NAMS stations may not adequately portray the air quality situation on the street, and what I mean by that is, you know, within communities and with the people moving about, so I think around people and enabling people to get information around what they are exposed to and along the line, ideas around more data spatially, we develop greater insight into the causes of pollutants and through greater insight we have the potential to develop new mitigation means and hopefully generate (inaudible).

Those are some of the motivations for lower cost measurements. This is based on the evolution of the air quality monitoring. Very quickly, existing systems, large stations, they're expensive. We have stack monitoring and then public reporting and the systems which are much more community focused and shorter duration, perhaps rapid response and then leading into ideas around putting into (inaudible) their station and generating more insight that would enable cities to produce more (inaudible) spaces.

So that's really the evolution from expensive relatively low density measurements to less expensive and high density measurements. I think it's important to understand what we mean by low cost. When we talk about sensors, these are typically in the range of a few dollars to up to a hundred dollars, and they, you know, produce an output into voltage of power into a pulse in response to an analyte. They're very much a device that needs support. They're not calibrating normally.

They don't have any packaging around them, and you need to add all those things to make instruments generate (inaudible) those things already designed into so they're a little bit more expensive. They should be calibrated and output of into parts per million from, data logging or communication system, and encourages enabling them for them to be deployed. And I think what's interesting, and a challenge for manufacturers, is what it's often thought to be synonymous or simple to use, small portable reliable easy to (inaudible) which people are looking and users ahead of low cost to buy.

And this could be a challenge, and should be a low cost system. Low cost instruments can actually perform pretty well and I was thinking back looking at the data from 2005 where a community group at Houston, an example of

their (inaudible). They turn them upside down
and stuck them underneath a plastic water shelter
with the bottom cut off and a beam to the top.

We're interested to see how they
performed because they had some questions around
the validity of data coming from their monitors
in the region. They have deployed these units
and located them in a station, ran for a couple
of months. (Inaudible) produced over every
couple of months. This is the hourly average of
the 500 monitors, one of the two monitors
operated in Houston.

Two time period and then a few
minutes later, apply a project or look at the
data quality, and this, which is described within
the European Union framework for equivalent.
They have a copy. It is an instrument, meet
criteria associated with potential quality meets
the (inaudible) can be considered equivalent.

These are one of the cases of --
where you determine the frequency between the
candidates and the region instruments and listen
for (inaudible) and if we use it later on, we can
see that it passes at a limit value of 75 PPB.
This is indicating a low cost design can produce

data of a quality that meets the equivalent requirements for us, so this is an example where there's been a real improvement in the quality data coming from the low cost instruments.

Not all sensors are the same, and I'm sure around some of the issues around taking the system and making them work to a wide range of sensors. They often have stability issues around temperature and humidity which needs to be mitigated. But what's interesting is generally, that these facilities are pretty good (inaudible) which is appropriate for deployment and measurements. So it's really a challenge around developing needs to be selective, using these devices and trying to overcome some of the interferences. I'm going to talk a little bit about NO2 in more detail.

One of the things we've been looking at is our ozone is actually pretty selective and we're looking at ways in which that is coming (inaudible) NO2 electrochemical have very strong deterrent from ozone and NO2 chemicals measure both ozone NO2. By ensuring both side by side and using the ozone vapor ozone, we can remove or remove that ozone.

And even an example of calibration, calibration data and the chamber where we have offers in orange, the calculated NO2 which is the measurements from chemical from the ozone sensor, and then we can remove it moving them with the ozone and keeping them with the measurement, so it's now following the red line to analyze it. So yeah, we have been developing a new design for measurement of ozone, and this is a unit which we're looking to deployed in larger with high (inaudible).

It's using AQY, NO2 which has corrected. Low cost optical PM 2.5 and trying (inaudible). They come factory calibrated and calibrated those instruments. It comes cellular communication and switching the (inaudible) with the data, which then has a data down buy the associates with that. Factory calibration is something that is a significant cost to an overall instrument cost, and it's something that -- and when you start doing of inter calibrations, it's a trade off around if you want to make that calibration.

So you think about heading (inaudible) and you would set manufacturers towards whether you're capable of zero and standard deviation and happening up there, the variation between devices means that you are at a higher, higher precision and the cost implication and we are looking at standard deviations and the mentions of devices.

Two PPB and the deviations of slope of about .03, so we exceed that, so these are the sort of trade offs that we need to consider as a manufacturer when you're manufacturing pieces and instruments, what we will be able to look at the calibrations that you want to produce. So taking this prototype, we will be able to do two things and we have a 10 units co-located at a station beside near our motorway passes and Auckland, New Zealand and what we're looking to do is take the lab calibration, selectivity and stability during this six months.

You can see it's above the station. That's typical of Auckland and so this is the fifth week of data from our ozone NO2 sensors where we are measuring ozone and at the PPB. And you can see you have the unit, the line is in (inaudible) you see very good correlation, you know, to also showing that if we remove the ozone and now tracking you know, so very well. So after a month of data you can still see the beginning of stability and of these conditions.

In both, the reference is very well. PM data one week. That continues operating at the same cycle, and variations of a couple of micrograms. That PM 2.5 is a little bit more for PM 10 indicating there is some instruments variations, but it looks to be mostly around this correlation and here is the data for a month. Under these conditions it is starting to be clean and we do see good stability of the zero. So the correlations of that period, again, there is a reference .98 for ozone, point 82 for NO2.

And those are 24 hour averages, and in the instruments, ozone 5.99, NO2, point 86. Levels for 2.25 is also a result of what we're measuring so that's close to the resolution of the instrument. That's very high PM 10. Very specific we can take pick up from temperature and humidity. These are plots of the difference between the reference and the instrument.

Reaction of either temperature or core humidity and these are correlations, so the instruments are not responding strongly to changes in more humidity over the range of -- as part of this project we've been working with the University of Auckland to see how these devices could be used. And what I want to point out is that this partnership was to deploy these instruments along our streets in Auckland and anterior route commuting straight people going into the city.

We put these instruments at various locations along the street on buildings, on the deeds of buildings or on the straight finish of the pole, and we were able to run it for six weeks, and during the time we were also collecting cell phone signals at various locations and the idea was to correlate (inaudible) with individual, individual, they were moving through this area to try and catch the exposure levels of pollution and people using in the street.

The data is still being utilized, but I just thought I'd show you some of the information that we're gathering. This is looking at the diurnal variation of the parameters at the various locations. Each photo is a different location. You can see very clearly that there is NO_2 PM at around three in the morning. That is the trend. There is a decrease in ozone at times into at maybe -- in the evening, and just saying we find it little higher levels.

I think this is due to a change in traffic and behavior, but also, an increase in emissions from -- in talking to the facilities, so we're still looking at that behavior that we get down our thinking. I just want to pick out one of the slides, so if you look at the blue line, and unit six, the bottom middle photo and that's the side of our bus stop, so we can see that there is little we are actually picking up information within the town. The next step on the project is to deploy 100 node network of these devices in America for 12 months and we have working with a partner including to put in place that project.

We're looking to develop automate automatic data validation algorithms. So we have these operating now, and it's around in the basic processing and we're looking at information coming from individual with the characteristics of network as a whole. We need to automate that.

The third area is to engage and develop information tools that are useful to federal community, and we're looking to partner in the United States and then we're thinking around commercial release 2018 for this.

This is just some tests in the last few days. We're doing a test in an Asian city that has pollutant vehicles and it's the top ozone, the red, blue. The pollutant is the station and we can see that we're now getting a wrap around 18 to 100 PPB. (Inaudible) So we're using this, if you like, trying to understand the best performance of the design test. This is controlling because it's important, as a manufacturer, we don't have any performance standards for the instrument and the emission of outdoor air quality, but it's very important that there are independent studies that are taking devices and evaluating and I wanted to draw your attention to two of those.

One I think that I -- AQ-SPEC program, which has been useful information and the other project is the MACPoll project at the JRC in Europe, and this information is available on-line to look upon as well. So in summary, low cost instrument performance for some pollutants shows some pretty high correlation with regulatory monitors, so we have confidence in the data.

If the data is of good quality and makes the down stream validation, so there's the hope that we can continue to push the devices and reduce that burden of the validation. We are, you know, in at least some instances, we're pretty good for short term duration of one to three months, but long term duration is all being six months. Part of doing this and surveying the long term behavior of these kinds of devices. And also very high pollutant levels is dill being determined from our point of view.

The laboratory calibration methods are becoming robust enough to transfer to the field. I think this is a really important activity because it's very difficult to see how you can deploy low cost and the calibration from the facts from the factory is not transferrable to the field meaning that you are really have to -- to feel calibration which is difficult for.

And I really want to make a -- the fact that we need to develop performance standards and guidelines to drive acceptance of the new technology, and that it's been talked about but it's quite slow and in the meantime it's really -- evaluations are important and it helps to keep many sectors on keeps us understanding. Thanks very much.

I just wanted to acknowledge the people in the Aeroqual research team and the people from the University of Auckland, Professor David Williams and Dr. Jenny Salmond. Thank you very much.

(Applause)

MR. HANNA: Thank you, Geoff. Are there any questions directly for Geoff? We are going to break into maybe more of a round table discussion. I think, Rick, if it's okay with you maybe we go until quarter after the hour for the round table discussion just to give us 30 to 35 minutes for everybody to speak with each other?

MR. OPIEKUN: That should be fine.

MR. HANNA: I have to apologize. I have to leave right at three o'clock, but I want to extend my personal thanks very much so. Thank know you all for being here, and I'll hang out at long as I can. I certainly like to give our speakers the opportunity to ask each other questions. I saw Leslie, maybe when Andrea was speaking or someone, but I'll give you guys a chance, but I'll steal the mike for one more minute.

The last slide that Geoff showed talked about longer term reliability, and I heard he expected to doing two month evaluations. Geoff's co-location study was six weeks, mentioned that longer term, six months plus is a concern. Has anybody studied that yet? Do we have any of that information yet out here to really know what it looks like yet?

MR. POLIDORI: I don't think there is anything --

MR. HENSHAW: We've done a study around endorsements looking over a 12 month period where we were doing 20 instruments around the Auckland region, and we were getting other data over periods of -- but rather nine months and that was of the design which we lose a lot from and have made improvements around, but it's that the opportunity too we're really --

MR. HANNA: So my traditional air monitoring whether it's CEM, Continuous Emission

Monitoring from point source, as we call that, drift over time and we've got to recalibrate and reset things, is that the alternative? Is that what we're looking for? Is that tipping point where you have to send it back to the lab for the formal calibration? Do we know that yet?

MR. HENSHAW: Yes. We have taken -- simply to replace. But the unit itself, so replace the sensor itself. That seems to work well. (Inaudible) I think once we can mitigate this issue, wait for it.

MR. POLIDORI: So I think that nobody has done anything past six to eight months, which this was a facility I was showing this morning where PM sensors that have been up for eight months, so you know, one of my staff was there, I believe every two weeks, to do some checks with referencing. They drive around basically location to location and actually they were quite stable even after eight months.

But I think long term, and again, then, you know, if you have -- then you can do like co-location using traditional techniques. You basically co-locate your sensor with an EPA approved instrument or device, right. But then if you have 500 or more, that model doesn't work anymore, so there have been a few, I think the best way of doing that, and I've seen a couple of examples, is basically using a valuable lead so you have a meteorological data.

You have data from air now, so it becomes a data problem, if you're in one area, you have 20 centers in one station, can you use data from those two stations to calibrate the 20 sensors and the people try to tackling that problem from the data point of view rather than from co-located at every location.

MR. HANNA: I'll stand back and let others ask each other questions. Feel free.

MR. HEIMBINDER: I have a question for you, Andrea. How did that particular waste facility get selected for monitoring? And specifically, what were the politics of that? Because I imagine there were a lot of people who would have liked to have something like that happen. And was it connected to any kind of policy initiative or change in the regulations?

MR. POLIDORI: So it's nothing glamourous. So the facility has received a lot of complaints from the local community.

Specifically, from the school, that is located down wind of the facility, so there's a lawsuit and they received a lot of notices of violation from the South Coast, so there is a way to basically try to help both parties to kind of get the better agreement to get more friendly in the process.

Some of them know this is a violation that was used to develop this, and it actually worked quite well. Because now the schools feel it is even more -- to basically check on whether or not deficit is taking measures to improve air quality conditions in the area.

MR. HEIMBINDER: You were talking about it might be enclosed. In New York City we're looking for something similar for construction to three facilities. Will there now be -- potentially could this data to used to support regulations that are enclosing these type of facilities, or is that outside the purview of your agency?

MR. POLIDORI: At this point, it's just case by case. This is more we're the pilot study, but I think ins of how it works, that's the first step, so eventually, I think it will lead to that.

MS. SCOTT: Robert, I thought the work was really interesting. I see a bit of divide between the groups here in terms of people who are working on personal exposure and the indoor exposure, people who are doing outdoor. So my question is, and you were talking about calibration, a lot of us have been talking about timing measurements to the several reference instruments. What do we do for the indoor measurements or the mixed measurements, indoor outdoor measurements seeing that some of these values are so high. You referenced some of the resources -- and these are crazy high values.

MR. LAUMBACH: That is a very good question. Your low cost monitor should be co-located with a reference monitor in the atmosphere where you're having measurements environments. And that particular case there, which I showed, which was in terms of how we co-located our instrument with diesel exhaust atmosphere. That was really not appropriate necessarily to be co-located in a vehicle, so I think that is a -- I'm not sure how to address that. Understanding better what the experiences are, and then understanding what the atmosphere is like, different locations obviously could help to be reassuring about the validity of measurements in these difficult occasions.

MR. EISL: I have a question with respect to calibration. When Citizen Science in this technology and they're not associated with groups, they want to do independent work, wouldn't that be a role in the EPA or the DEC in New York, maybe that they sort of take some of the technology to use the calibration and sort of have sort of a lending service or library that people can figure out if they know they are well calibrated and the data?

And after they have used the subway in the back and the agency can test the calibration again because not everybody has a high cost regulatory monitor to compare to, so you have to find something for citizens to make sure that that they at least have an instrument that works well.

MR. OPIEKUN: The one question I've got, I mean, there is a great level of expertise in this room. You've all worked with either academics. You've worked with community groups, environmental justice groups, but the one thing I didn't hear anybody mention is a community of practice because obviously, you know, if you're working within a region or a municipality, you may have control over what data are collected, how they're collected, how they're stored, how they're interpreted.

But as this grows, as this whole movement of community science grows, evolves, goes nationwide, it's inevitable that there will be an interest in groups from one region or one state trying to compare their results with other groups. Is there any thought of kind of spearheading a community of practice where standards for the country are developed, adopted, explored.

And you know, obviously you can't force this upon groups or state agencies, but something that's out there is usually something that people could discuss, tweak, and ultimately adopt to make these data more useful, more reliable, so anyone have any insights on that.

MR. HENSHAW: Calibrations, and the data, one approach, we've got a paper coming out shortly and one approach that we have taken is to use instruments and take advantage of the -- that is repeatable, not so much around whether they're accurate, whether it's repeatable, and use that text to take measurements and then use those measurements to rank different areas in the city or within a region and then ranking now allows you to identify hot spots, places where the vehicles are higher than other areas in the city, and that can create an argument that may be a problem there.

So the instrument is not being used to the instruments that is indicated. You're using an instrument to find where the problems are made, and you're using a ranking system to range that rank that particular area and with that approach gets around a little bit around the calibration.

MR. DYE: Regarding your question regarding community practice, I think there's some challenges we face. One is we're early on in kind of the game big picture. Secondly, it's moving pretty quick. Third thing is, this involves a lot of different people, not just the traditional air quality community. We're reaching out. We have big companies, Intel, Google, IBM and others getting involved and so it's a much broader community.

EPA has some early efforts with some workshops that they conducted that I think were really successful but they grew too quickly, too big. What I've seen emerge more recently is kind of a regional ad hock meetings that are popping up about whether we can get together and discuss things. I think the E-Enterprise initiative is probably one that's establishing, as Leslie talked earlier, some standards, some data standards, certifications, those types of things.

And I'm hoping that one outcome of that is kind of a platform or a community of practice that can form around that because they're developing some standards. So that's probably, you know, a couple of years away from happening, but hopefully it will form around that or maybe something else.

MR. OPIEKUN: As I've heard these presentations, I see this as a growing and rather urgent growing need because as more groups get involved with this, you kind of want to stem the tide of bad data, and by following or getting people to follow, the guidance of the community of practice, while you still will have voluminous data potentially coming in to a data warehousing type of facility, there's a better chance that you're going to get good quality useable data.

Somebody mentioned here that sometimes the best type of use for some of the instrumentation is just event viewing, trying to see where there is an event versus no, and that's great. I fully understand that there is a great need for that. The fear is that people will take event viewing type data and try to go forward with it. Try to do more with it than you should do with it, and we'd be concerned that that ends up, in a sense, going into that realm of junk science because you're using numbers to tell a story that isn't necessary there. You've got the false positives being developed and just trying to stem that tide with the community pride.

MR. KNAPP: I'll just add a thought. This is not specific to air quality or census in particular, but there is an industrial internet -- representation of across internationally, major companies, smaller companies and they actually are doing some good work in terms of creating standards and facilitating standards for connectivity for internet, transfer, if you will, big data exchange and they have work groups in a host of different verticals and with regard to application areas so they're trying to establish the framework for data connectivity and transfer standards.

MR. POLIDORI: There is another initiative in the US spear headed by ERG and they're working on data standards, and I think Tim and myself, we have been to a couple of those meetings. And in Europe, there is JRC is also trying to basically build like create standards to the standard that the way the standards are evaluated from an evaluation to a more rigorous application program so there is some effort here and there.

I think that possibly the biggest potential is from the E-Enterprise initiative, and so one of the limitations is because I'm part of the certification team and one of the biggest issues that we're encountering is the cost. You know, being able to kind of build the certification progress across the country, it's extremely expensive. You need to be able to do certification protocols. You need to be able to -- everybody needs to fall off certain protocol and tests. Like the one we have is not cheap at all, so I mean, all of these efforts are starting to kind of appear here and there, but they're still not the unified push behind it.

MR. VALERI: As the lawyer in the group and the one who represents the industry, I hear everyone about how the technology is moving fast and I'm not sure regulation, slash, the law is moving as fast as the technology is moving. And I suspect one day that this is going to be an area of controversy because people will use the data offensively or defensively, whether its for the attorney general or tort litigation.

I'm just curious, for the government folks in the room, or at least those that are affiliated with government entities, but I will put it even broader, has there been discussion or actual regulatory or legislation being used, the legislation being pushed in any of your jurisdictions, regarding the use of these hand held monitors or low cost monitors as we call them? Because I see them being the next area of controversy and conversely an area of defense.

My plant is being accused of something, I want to use a monitor, and I can blame it on the next door neighbor. I think that's one of our tasks as part of this council is we have all this great stuff, what do we do with it. Any thoughts? I'm very curious.

MS. CRONKHITE: When you say regulations regarding use of sensors, you mean to control the use or restrict peoples use of it?

MR. VALERI: Or for the purpose of approving an enforcement for a variety of things. Either one, sort of universal certification or calibration, whatever we want to call it such that it's used in enforcement, it can be, whatever the device or data, it can be relied upon. And then two, more broadly, whether that's something that's been subject to regulation or legislative thought because quite frankly, it will be John Q citizen or John Q company that's going to be using it, so the question becomes whether there's a need for some sort of regulatory construct, so it's used properly and that's what I'm curious about.

MR. LAUMBACH: I think the

situations have already occurred. In the sense of the templates I can think of related to chemical spills, issues like when the fire department goes out, it does some carbon dioxide monitoring. In the medical legal sort of -- the issues come up though about calibration, you know, and then I guess more experienced tort law than an occasion as an expert in legal medical cases where that's been an issue and then there's debate back and forth about expert opinion on whether or not the calibration of a particular monitor, typically a hand held type monitor, was accurate or not.

MR. BIELORY: You set the basis for the next question, the plural of anecdote is anecdotes, not evidence, so when you have a device and we don't have an audible trail that's calibrated, how do you validate it? Now, this is part of the question is who holds the data because if it's government, the government may be under political prejudice to release or not release.

In private where there can be self interest as well or do we go to something like the national chronology network, which is a government funded entity that has an advisory scientific council that actually bridges. It holds the data. It has an advisory group, which a pharma, or corporate entity, can participate as well as industry because it has to be an audible trail that's validated.

And it cannot be under political or commercial pressures for release or non release. And that's the question I really would love to ask because it's going to be a statement, and I brought this up in our council meeting a while back. And again, I used the sample because I'm a physician. Everybody goes to the internet. I come in with people with self diagnosis. They're allergic to air.

And the pleural of anecdote, like I said, is anecdotes, it's not evidence, so we have to say how do we get the anecdotal devices to be evidentiary. And that's, I think where we're going and that has to be one of what I would like to see a recommendation and we have the expert or some experts here listening, if you can give some guidance to the counsel.

MR. HEIMBINDER: One thing I would say about it. One thing I would say on that account, which I think has been touched on by several of the presenters today, is that quality assurance and quality control are platform wide or a system wide, so you have a sensor. Once that sensor is integrated into an instrument, if it's integrated in 10 different instruments from 10 different manufacturers, they're all going to perform differently.

Then you're talking about the firm wear that's running on those devices. Maybe you're doing post processing once it goes into the database, so you basically don't have a measurement. You have a measurement platform or a measurement system. And then beyond that, you have, not just an instrument, you have a network of instruments, and so when you're talking about whether the outcome of this system, which is a serious of measurements, is going to hold up under a certain -- hold up in a court of law, can it hold up in the screening tools, can it hold up to make regulatory decisions.

I think it becomes very complex because you're talking about quality across the entire platform. So I think what you'll end up with is that you'll have platforms that follow all the protocol that people are starting to develop that people can trust in a court of law and you'll have others that you will say, well, we need to use this. We're looking at what data can be used for and we were looking -- Andrea was showing what the EPA decides different data is useful for. And so I think it's not going to bee a clean dance. It's going to be platform specific, instrument specific, and there won't be kind of a clear cut answer.

MR. BIELORY: Thank you. Anybody else? I didn't think there would be a clear cut answer, but the point is we have to address the question.

MR. EISL: I want to say something. Not only is technology contact points, it's a human contact point. In New York we are using integrated sensors. We are mounting them to 10 to 20 feet height. There's a reason why we monitor them 10 to 20 feet height. We want to prevent vandalizing, but more importantly, we want to temporary -- so question of how are we gonna make sure once we get data on the platform, we have to actually measure them.

Our friend from Auckland, New

Zealand, they place some of the sensors right on the building. We would never do that because there is a building effect which can compromise the data, so you need some guidance, like a tool kit, which helps these people how to use, where to measure, when to measure, all these issues, so it's a technological issue and a human factor.

MR. POLIDORI: I think the best we can do at the moment is definitely using these devices for several purposes. In our experience in the South Coast, I'll give an example. We have a program for fence-line monitoring for refineries, and they reuse equipment that cost millions of dollars so there is one band -- technology is 1.2 million.

Then we use a dial, it's 2 million, so this instrument is very accurate, give you all of the information. So what we try to do is we try to basically compare emission rates from refineries of VOCs, so the best thing we can do right now that this is basically a well known practice for us which is inventory. So we create, for the technical point of view, that all the refineries are emitting between six and 12 times more what the initial inventories says.

So while we possibly were pushing to make reaction just based on the measurements, it was nearly impossible because every time that you talk to the refineries, the refinery representative, they say it's not -- so you can believe it as much as you want, but there's nothing at the federal level that says this is an improved level for measuring emissions.

So under those circumstances, the best step you kind of settle for, we definitely can use the instrumentation for vapors. We find a leading tech and then we can work with the refineries to address the problem, calculate it and move forward from there. So, again, I'm talking about very accurate, very sophisticated type of instrumentation. If you try to extrapolate that type of discussion to sensors, then you can understand that there's basically the same problem, but multiplied by a whole lot.

MR. VALERI: Therein lies the problem because I can tell you, and it is clear to me, particularly in urbanized areas where multiple certainly EJE communities, on top of the fact that there is a lot of industry and different types of industry and different owners;

that as these devices become more prevalent, less expensive and are accessible, they will be used for the purpose of supporting either litigation or an attempt to enforce and that may be a good thing at this point. It sounds like we're not there yet, but at the end of the day, maybe it's more of a statement or question.

It may be good for your agency when you start thinking about that because I think that's going to end up being the next step. And for us, I'm curious as to how we can deal with that because one that happens, most of you folks are going to be going through hours of deposition, going through hours of technology work and I think avoiding some of that at the front end it will be helpful for us, as a council, to make some recommendations.

And clearly to the extent that you have folks have any thoughts or additional information to particular schemes that you are thinking, regulation or otherwise, or ability to license people, I'm not saying this is the answer, but it's something I'd be interested in.

MR. POLIDORI: The regulations for the South Coast and for the monitoring it will take into account this new technology, so at the local level, I think the effort is already there, but I think it's more of the big area where the regulation, take into account this modern technology. It is more isolated case, more than a federal type of approach.

MS. CRONKHITE: I have one more comment to add onto what Andrea said. You know, I mentioned the fact that the EPA methods approval process is very restricted and rigorous, and with that reason that you end up in court, it needs to be defensible ultimately, so you're seeing the sensors, as people have indicated, all day, as screening, targeting, and you would imagine that community groups began to use these more often when it's raised to a regulator that it would trigger action for us to go and do deeper inspections.

MR. LAUMBACH: I don't know if it's a useful analogy here or not, but currently, the terms of odor complaints, the state here in New Jersey, I believe the regulation still is that, and the procedure is that people call, the county health inspector typically or somebody at the local health department comes out to where the odor is occurring and they look at the wind direction and they follow it back to a source.

So in this case, odor, our noses are pretty sensitive to odor generally, but they're certainly not calibrated and there is some validation that another person coming out, the inspector and verified and going back to the source. I did this before in a prior life as a sanitary and health inspector here in New Jersey a while back, longer than I hope to remember, but it's the same procedure today, I understand.

You know, so I think, and again, the state is pretty low in that case. I think it was an 800 dollar fine, but still it's useful information and led to some interventions when I was doing this a while back. So I mean, it might be different uses for different types of data, and it can be used in different ways.

MS. SCOTT: If I could maybe comment here. I think your questions raise a very good one for a very short term. But you should be aware that an eight year old girl came to a workshop and had a blast. She had built a weather station, a wirelessly remote like connecting to the Cloud weather station, this stuff is happening.

It's going to be very popular and people are going to do it, no matter what the standards and people are doing -- we're doing this for fun and they really enjoy it, so I wonder if there's not a longer term solution that maybe forward thinking. These low cost sensors, they're not super accurate, but they are measuring reactions.

And I know if I have a sensor that measures oxidation reactions, that's not something I want happening in my throat, that's not something I want happening in my lungs. But I wondered as a state agency, I know you guys are kind of limited to what the regulations we have now, but I wonder if it's not possible to start thinking forward and working with some of the health folks and saying, look, we have this low cost technology and it doesn't correlate super well with the federal reference standards.

But we think it correlates with things that can be indicators or effect peoples exposure, so I wonder if that might not be an alternative route head to toe for the future and get out in front of this technology. It's coming, it's going to be a Tsunami. And to start thinking about alternate approaches to other matrix, if it can't be in terms of these.

MR. VALERI: It's one thing to have the matrix. It's another to sue my client for a million dollars because you gave an eight year old kid cancer. I agree with you. I think it is a long term step. I think that's what we need to answer.

MS. SCOTT: I would say too, one thing. It is very public, so I think public is certainly going to be something that the total environmental justice people work with.

MR. OPIEKUN: To those individuals that work with community groups, have you had people try to find out how the data that they're collecting compares to a health benchmark? Because that's another concern is you've got people that might sample somewhere for an hour and wonder, you know, they see standards out there, there is eight hour standards and 24 hour standards. How does that compare?

I know the EPA did a study where they were trying to correlate some instrumentation with standards, but that's also another concern is how do you address that when people really want to know risk. You've done some fence-line monitoring. You've done some quick samples over the course of a day or so. People come to you and say, what is my risk of getting cancer or my child having an adverse birth outcome because of my exposure to this, my hand held device just said that it's 100 parts per million here and the standard is, you know, 50, so you know how do you get that messaging across.

MR. KNAPP: I think you raised a great point. I wonder if there's not an analogy that may be applicable and that is the database that's been established to help govern the application of pharmacological technology to these various tests that have been introduced, that companies introduce to indicate whether or not, you know, particular individuals will metabolize, particular medications well or not well or be exposed to adverse events, or of the negative effects.

So you have the ADG database that Stanford manages that the FDA and the NIA subscribed to and they established levels of evidence for each of these genetic tests, if you will, and if a particular product in that case or the health medical case a particular laboratory test doesn't meet certain levels of evidence, then they can't make certain claims that are legitimate. Maybe there's the same kind of frame work that's going to evolve here so that, you know, it starts with the sensors and then has to evolve and address the larger environment like Michael was describing.

MR. BIELORY: I've been doing this for close to a decade, but if we go back about four years ago, we did not have a new SPEC. It was just getting involved in evaluating the sensors and I think all that information has been public, pushed out there and that's put a lot of daylight on some of the things that were sensors out there that people were claiming outrageous things.

And now we know those don't work and the broadening community knows those don't work and the continuum, I think now we need to be in the mode of two big things. One is the E-Enterprise initiative, standards, guidelines, formats for exchanging data, putting that together as kind of here is what's needed to produce credible information. The second thing is doing lots of product projects, little ones, big ones and see more and more of that and publish and get it out there so we can figure out what works and what doesn't.

And probably after that point, we're going to start to see some more credible data surfacing and some things that could be used for your clients for using against your clients. That's probably four or five years away.

MR. BIELORY: As a physician, but here's where things are changing and I think that's not being addressed and what we are trying to assess now is public health. Meaning, when you do a blood test, you get your normal 2.5 percent low to calcium curve. However, when you have these devices, it now becomes personalized medicine. How does it effect me as an individual.

That is total different ball game, and we're entering that realm as we speak with these devices. Personal monitors going on, so there are individual effects, personalized medicine and what we're addressing here today is public health, but we're entering the personal realm, and again, that's another facet of which we're not going to tackle. This is not the US Senate Health Commission, but nonetheless, the state of New Jersey is interested, and the Clean Air Council is interested in where do we start, how do we see the future, can we set the platform. And I know Toby kind of set the stage at 12. It is 20 minutes after. If anyone has any final statements we would like to take them at this point in time.

MS. MOUNT: I would like to comment and appreciate the work that the council has down bringing these folks together and the fact that they came all this way to come and totally relevant to us with this whole process. We try to be down on the ground with this stuff and help through the process. At the DEP, I think we've had a great track record. It's because giving us the kind of information we need and we will sit it out and send it back.

MR. BIELORY: We're going to come to a close. I want to thank all the speakers and presenters, but I also want to thank the staff, Miss Hanna, Miss Sills who is hiding in the background who helped put this together. And Bill, you want to come up and make any comments?

UNKNOWN SPEAKER: On behalf of the department, I wanted to thank the speakers and thank the council for having another great hearing. A lot of work went into this. Council members, and by staff, Peg, Lewis Lanmark, he's very quiet. And Ruye Azole and Paul Ramon in the back room, all part of Peg's staff who were working behind the scenes, and Heidi of course, in the back room. I think we got William Ferraro back there manning the things and it was really great to get the gentleman from New Zealand.

MR. EISL: One more question. If we have additional comments, can we submit them?

MR. OPIEKUN: Comments can be submitted to Heidi up until May 5th. I'd also like the notes to reflect, while we did give the opportunity for general public comment period, nobody signed up to give comment, but people have the opportunity.

UNKNOWN SPEAKER: I started out 45 years ago and air enforcement hasn't changed much. Our main instrument are our eyes and our nose, and I went to smoke school to calibrate my eyes. I was on the stand in Superior Court for two days on the validity of my calibrated eye. It was calibrated. It did win the case, but it came with a lot of procedures and a lot of law and I see the same thing here, a little more sophisticated, but the same kind of things are being used here. Thank you very much.

UNKNOWN SPEAKER: Good afternoon. I'm a professor of environmental science at Rutgers and in my projects that I do, I focus mostly on air particles and air quality measurements, and recently, we started doing some projects that actually involve, what we call, consumer grade sensors and we are trying to pick one or two that, in our opinion, perform the best.

First of all, I appreciate everybody's presentation. I got a lot of new and interesting information about the sensors that we have not considered. But I just want to say a couple of comments. First of all, by the quality of sensors and their comparisons to standards that I saw being presented. In most cases, I saw that people just presented simple correlation of the square, but it's not just that.

I think we have to go a little bit deeper because the sensors could be off by a factor of 10 and they could give a perfect correlation so we have to look at relative and absolute difference between our standard and the -- so to speak. R square could be very deceptive, and also those R squares and those parameters should be broken down by the environment where the sensors were tested or the particle types, if they were tested in a specific chamber.

We have seen differences versus dust and then take the same sensors out and you get totally different because of the properties of the particle. Also we talked about sensors, mostly PM 2.5 because these are photometric sensors. That what's what they're able to sense. Very few of them are capable of PM 10 unless you have some more sophisticated mechanisms, but even then, if these automatic sensors, the physics will not allow to measure PM 10 very accurate.

PM 2.5 is a more accurate metric. However, in quite a few sensors out there, they present, not just PM 2.5, but they go to try to find the ordinary citizen by giving the -- the

EPA has AQY, so does some of the sensors, and they will display the AQY value on the sensor instead -- somebody sees the color green today, that air is good. Orange, not so good. There are sensors that display the AQY for the location where the sensor is in and also they connect to the nearest EPA monitoring station and display those parameters, those measurements side by side.

For example, it would say the air outdoors is excellent, you go outside for a jog or walk or the air today is pretty bad, close your doors and windows, stay indoors. I don't know yet how these messages would effect people's behavior, but that's something that could be investigated because you have that $200 gadget and it tells you open the windows or go outside and don't go outside, you might actually follow that action or be encouraged to do so.

If you are hesitating, do I want to go outside. The sensor say, well, the air is good, why don't you go outside. It might effect peoples behavior, so it's not just numerical values that we are -- but also the use -- more value that are geared toward ordinary citizens.

Now, also, I want to mention that amount of data is really high, but some of these companies like this air that sensor is being sold from Taiwan, you can buy for 200 dollars being shipped right here to us, or by 2:30 by Amazon. The data automatically uploaded into their website, and if you go there, you can see their measurements worldwide.

They can even give you the days, 10 worse polluted areas or 10 best areas of air quality, so they gather this massive amount of quality just using this small gadget. And probably the last comment, I want to mention about indoor measurements. Our standard outdoors because we don't have anything indoors, but people use these measurements for indoor measurements, and I think there was some discussion and that's what we should consider.

If the sensors they use indoors really depends on where they are placed. If they're in the kitchen and you start frying something, you know what happens, it just shoots through the roof. And again, how people will react after seeing that spike. Oh, my goodness, how am I going to cook forever in my life or I don't care, I don't know. That's also something to be considered and the technology is getting cheaper.

There is small gadgets from a company in Germany called Handynus. It is smaller than a box of matches. It attaches directly to your phone and it gives you instantaneous reading and it's just 100 euro's including shipping. I don't know, I have my doubts, but if the kitchen -- if you start frying things, the value needs to go up. Thank you for giving me a couple of minutes.

MR. BIELORY: You can submit any comments in writing for us to include. Again, I want to thank the members of the DEP. Mr. Ronald, please stand up so you can be recognized. Miss Roman, Miss Hanna. I want to thank the staff. I appreciate that. Thank you. I want to thank the speakers for coming and thank the council for their time. Have a good day. My motion is to adjourn.

(Hearing concluded at 3:29 p.m.)

C E R T I F I C A T E

I, LAUREN ETIER, a Certified Court Reporter, License No. XI 02211, and Notary Public of the State of New Jersey, that the foregoing is a true and accurate transcript of the testimony as taken stenographically by and before me at the time, place and on the date hereinbefore set forth.

I DO FURTHER CERTIFY that I am neither a relative nor employee nor attorney nor counsel of any of the parties to this action, and that I am neither a relative nor employee of such attorney or counsel, and that I am not financially interested in the action.

Lauren M. Etier

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Notary Public of the State of New Jersey

My Commission Expires June 14, 2018

Dated: May 1, 2017

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